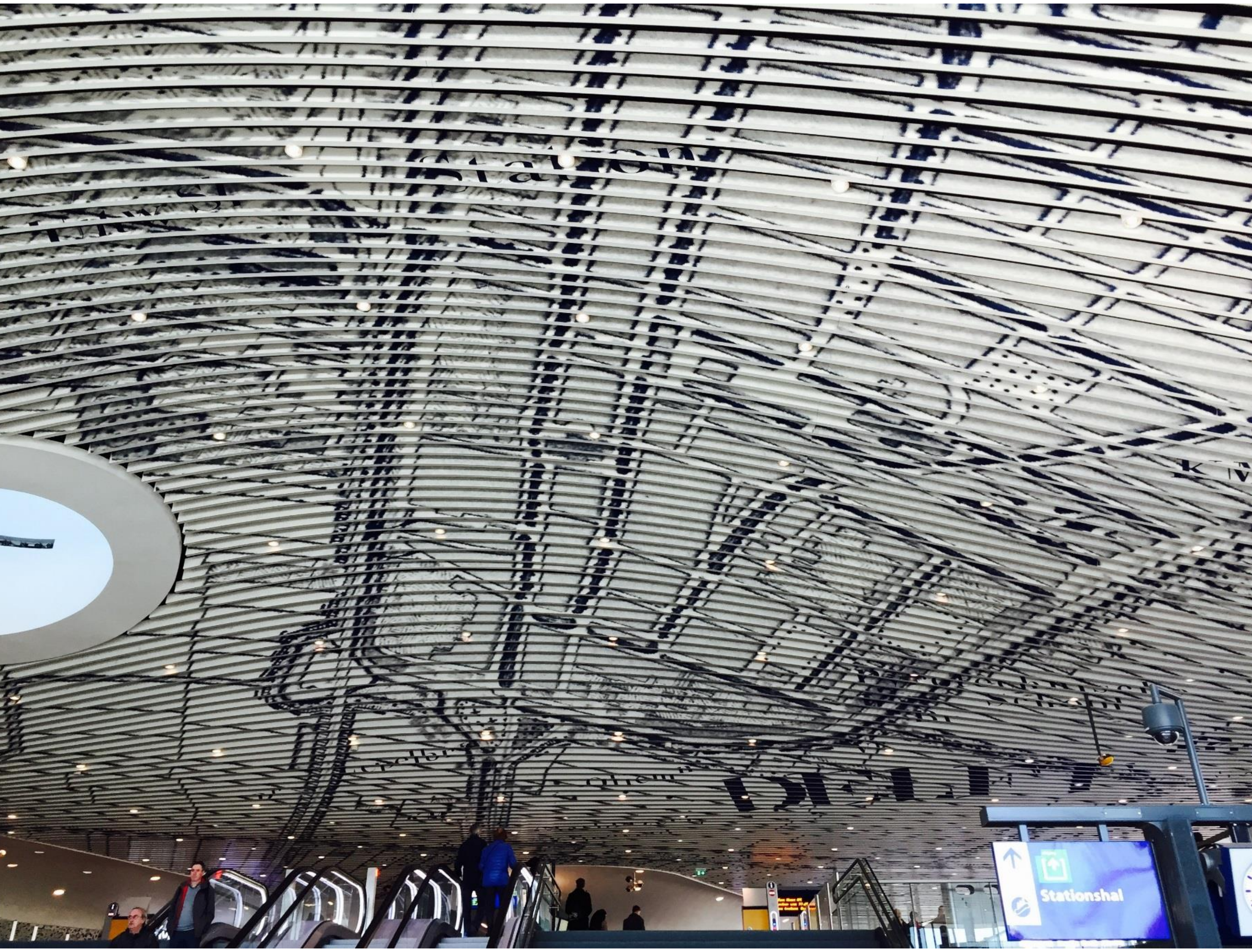
Impact of comfort enhancement measures on traveller satisfaction and ridership

An ex-post analysis for the Province of North-Brabant



Enzo Bronzwaer (s1460102)
University of Twente

Thesis committee: Prof. Dr. Ing. Karst Geurs, University of Twente, Centre of Transport Studies
Dr. Ing. Lissy La Paix, University of Twente, Centre of Transport Studies
Drs. Marcel Brok, Provincie Noord-Brabant, Ruimte en Mobiliteit

"Our culture, our prosperity, and our freedom are all ultimately gifts of people living, working and thinking together – the ultimate triumph of the city."

- *Edward Glaeser*

Preface

The thesis report in front of you is the result of my graduation research. This is the final report to complete the Master study *Civil Engineering and Management* at the University of Twente. The Master research enabled an in depth study of one of the many fields of public transport: customer satisfaction.

First of all, I would like to thank the colleagues at the Province of North-Brabant for helping me write this thesis report, and for their continues support and interest in my research. You have helped me to the best of your abilities and interesting conversations about the research topic and other matters. By the way, the view over the ‘s-Hertogenbosch and surrounding is amazing!

Special thank you for NS Stations for providing me with the *Stationsbelevingsmonitor* and the answers to the questions I’ve asked. Furthermore, thank you for allowing me to interview travellers at Almelo, Eindhoven and Helmond station. This allowed me to collect more detailed information about the comfort enhancement measures and have interesting conversations with respondents about the topic of comfort enhancement.

During the writing of thesis I’ve met several experts in the fields of public transport and customer satisfaction. These conversations provided me with useful insights and helped me to create this thesis report. Thank you all for your interest and time to help me.

Finally, I want to thank my girlfriend, my parents, and my friends for their endless support, interest, and patience during my entire study. Thank you for convincing me to continue in the good and the bad times. Again, thank you! I’m finally ready to start a new chapter in my life.

Enzo Bronzwaer,
Weert, April 2017

Summary

Travelling by public transport may involve having to change modes of transport and thus having to wait for transfer. In many cases waiting for the next modality to arrive is experienced as taking three times as long. To reduce the perceived waiting time, the Dutch Railways (NS) are using comfort enhancement measures to improve the waiting experience and customer satisfaction at railway stations. The comfort enhancement measures are expected to improve the travellers' comfort and experience at the railway station by improving the travellers' emotion (e.g. architecture, ambiance, colours, light, etc.) and/or physical activity (e.g. spending time usefully, comfortable waiting, etc.) allowing waiting to be a comfortable and pleasant experience for travellers. These two needs account for 21% of the customer satisfaction of travellers and are expected to become more relevant as emotional experience becomes increasingly important in society.

The Dutch Railways together with ProRail have implemented a variety of comfort enhancement measures on many railway stations across the Netherlands, which aim to improve the customer satisfaction' and have been presented as an overall station assessment. Combined with this strategy, NS is cooperating with stakeholders to not only improve the quality of a railway station, but also to improve its direct environment. Referring to the transit-oriented development policy developed by Cervero and Kockelman (1997), NS and ProRail use the combination of three strategies: acceleration (improvement of node function), densification (improvement of place function) and comfort enhancement (improvement of the experience function). When all three strategies are successful, a synergy might occur. Vaessens (2005) found that railway stations, where all three strategies are applied, perform better than railway stations with only one or two of these strategies in place. If the advantages of public transport are noticed by non-public transport users, a model shift might be achieved and ridership might increase. The available literature provides little insights in the impact of comfort enhancement (measures) on the overall station assessment and ridership of travellers. This thesis tries to define the change in both dependent variables related to a comfort enhancement measure.

In order to research the impact of comfort enhancement measures on customer satisfaction and ridership, the following research question has been formulated:

What are the effects of comfort enhancement measures on overall station assessment and travel frequency at railway stations in the Netherlands, and how can these results help the province of North-Brabant in increasing customer satisfaction at public transport nodes?

Customer satisfaction and ridership at a railway station are measured using the Station Experience Monitor (Stationsbelevingsmonitor, or SBM). The SBM is a longitudinal questionnaire which captures the travellers' experience and comfort during their stay at a railway station. By asking multiple questions and statements, the SBM quantifies the travellers' experience regarding several subjective topics, e.g. the smell or cleanliness at a railway station. However, as every measurement of the SBM questionnaire uses different respondents, a change in overall station assessment and ridership is difficult to determine. This results in the fact that changes relating to the implementation of comfort enhancement measures are difficult to assess. To capture the data needed to determine the effects of comfort enhancement measures, a revealed preference (RP) questionnaire is distributed at three

railway stations in the Netherlands. Different comfort enhancement measures are implemented at the three recruited railway stations. The customer satisfaction data presented in the SBM is used for the station recruitment, resulting in the selection of the following three railway stations with the related comfort enhancement measures: (1) Almelo - green and planters, (2) Eindhoven - digital screens with infotainment or (RailTV), and (3) Helmond – lighting. To forecast the change in overall station assessment and ridership, choice models are estimated using Pythonbiogeme (Bierlaire, 2016b). In order to test all available variables present in both databases, a factor analysis is used to reduce the variable to a more manageable amount. The factor analysis conducted for both databases found in five factors, which are labelled according to the variables involved with each factor. This results in factors being labelled in relation to the hierarchy of customer needs (Peek & Van Hagen, 2003).

According to the descriptive statistics, over 90% of respondents at Helmond station stated that their overall station assessment was (largely) improved due to the comfort enhancement measure of lighting. For the measures of green & planters and RailTV around 50%, of respondents experienced a (largely) improved overall station assessment. Furthermore, a difference in perceived change between existing travellers (who were familiar with the before and after situation) and new travellers (who were only familiar with the situation including the comfort enhancement measure) was found. This indicates that comfort enhancement measures do indeed improve customer satisfaction. However, mostly for existing travellers. Nevertheless, the descriptive statistics resulted in incremental changes in ridership. The RP questionnaire revealed that for at least 79% of respondents their ridership was not affected by the implemented comfort enhancement measure. However, if a change in ridership was reported, this was caused by the fact that travellers can spend their travel time more usefully

To test which variables explain the changes in the dependent variables, several ordinal regression models were estimated for overall station assessment and ridership. Besides the personal and trip related characteristics, the five factors (factor 1: experience, factor 2: ease, factor 3 : comfort, factor 4: safety & cleanliness, and factor 5: speed) and the experienced changes were tested. The estimated choice models for overall station assessment found all five factors to be significant and thus improved the model. Furthermore, gender and the presence of the measure lighting are (dummy) variables that are estimated to be significant in explaining overall station assessment. However, none of the changed experiences, relating to one of the five customer needs were found to be significant and therefore did not improve the choice models being able to estimate overall station assessment. Estimating ridership with the available data resulted in choice models not fitting the data well ($r^2 < 0.35$), while estimating overall station assessment resulted in a high goodness-of-fit ($r^2 > 0.8$). Furthermore, not all factors were found to be significant in estimating ridership. Estimating ridership with the RP data resulted in only one significant factor (factor 5 – speed). No correlation was found between (high) overall station assessment and (high) ridership which was expected based on previous estimated choice models and the descriptive statistics. This suggests that comfort enhancement measures are useful for improving customer satisfaction, not ridership.

To forecast the change of overall station assessment, five of the least assessed railway stations in the province of North-Brabant were used to estimate the change in overall station assessment based on three scenarios (1 to 3), ranging from a baseline scenario (scenario 1), a scenario with the measure of lighting (scenario 2), and a combination of all three comfort enhancement measures (scenario 3).

Depending on the scenario, overall station assessment did increase with 3% for the combination of all three comfort enhancement measures (scenario 3). Furthermore, data indicates that the impact of a comfort enhancement measure might depend on the size of the railway station (station typology). The changes in overall station assessment for smaller railway stations (typology 4) used in the simulation were larger than the changes for larger railway stations (typology 2).

Comfort enhancement measures are useful for improving the customer satisfaction of railway stations, and will most likely improve the waiting experience. However, no direct benefits of comfort enhancement measures were found regarding ridership. Comfort enhancement measures mostly benefit existing travellers, where the impact is expected to be greater, when implemented on smaller railway stations compared to larger railway stations. The policymakers are responsible for determining how to improve the overall assessment of public transport nodes i.e. by implementing measures at larger nodes, where they affect more travellers, but also the average assessment is relatively high. In addition to this, the policymakers are responsible for focussing resources on small nodes, where a larger impact would be expected, however less travellers are affected. Nevertheless, to have a more objective measurement of the changes in overall station assessment which relate to comfort enhancement, policymakers should use a longitudinal panel survey. The panel can be used to define a baseline measurement. This measurement can also be used to validate the suggested comfort enhancement measures. Finally, policymakers should focus on the collaboration amongst all of the stakeholders. A collaboration on all aspects of a public transport node might result in not only an improvement in customer satisfaction, but also an improvement of ridership.

List of figures

List of tables

Table of contents

1. Introduction

1.1. Problem definition

Human beings want to participate in an activity, which could be working, studying, shopping, relaxing, etc. In order to complete this activity, people need to travel. In general, people do two things based on the time-space perspective: (1) stay and (2) move.

From a historical point of view, a railway station is designed for the second activity of space and time: to move. People wanted to travel from location A to B as fast as possible, because travelling means that you cannot participate in any activities. Therefore railway stations are designed to have the function of transferring travellers between mode and/or direction. Over the past few years, both the functionality and punctuality of public transport, as well as the experience gained when using such transport have become important.

The *Nederlandse Spoorwegen* (Dutch Railways or *NS* for short) started to renovate their major railway stations. During the renovation process a lot of attention is given to the travellers' experience. Railway stations are special locations in relation to space and time, because railway stations have both functions: *move* and *stay*. Travellers can reside at a railway station (to shop, meet, or conduct business), or travellers can travel to their destination by utilizing the railway station (boarding, transferring, alighting trains and/or buses etc..). This combination of functions provides a great opportunity for the NS to fulfil the needs of the travellers. The new and improved railway stations are expected to satisfy all the needs of the traveller.

People want to be satisfied. Maslow (1943) created the hierarchy of needs (see Figure 1-1). The theory Abraham Maslow states that people only want to fulfil the higher needs if the lower needs are already fulfilled. The concept behind this hierarchy of needs can be applied to a hierarchy of customer needs. The model has been developed by Peek and Van Hagen (2003) and is illustrated in Figure 1-2.

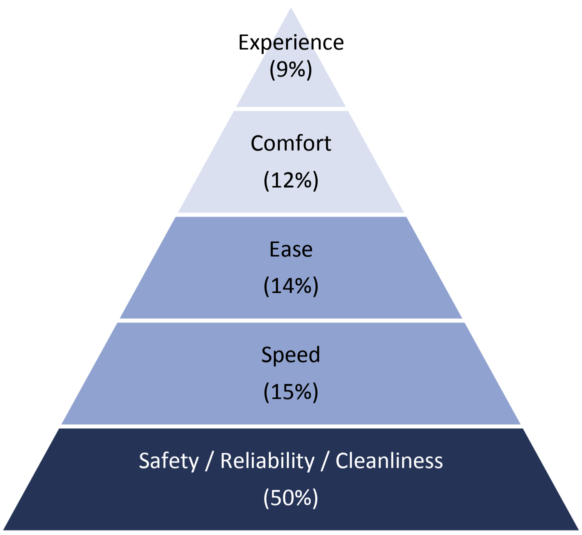


Figure 1-1 (LEFT), Maslow's hierarchy of needs. (Maslow, 1943)

Figure 1-2 (RIGHT), Hierarchy of customer needs. (Peek & Van Hagen, 2003)

In the hierarchy of customer needs the upper two levels (*experience* and *comfort*) of the hierarchy have been classified as *satisfiers*. The middle two levels (*ease* and *speed*) are classified as *dissatisfiers*. If the used service, for example, is perceived as too slow and/or is too difficult to use, the satisfaction rate will be valued as being low. The bottom level of Figure 1-2 needs to be fulfilled in order to attract the customer i.e. the basic needs of a service. If a railway station is unsafe and/or not reliable, the travellers does not consider the train as a feasible mode of transport. Research has showed that the two satisfiers contribute towards 21% of the total customer satisfaction (Peek & Van Hagen, 2003). If the demand of the traveller is met, the trip is experienced as satisfactory. The pleasant experience in combination with a railway station are likely to increase the revenues of a train station. Furthermore, locations where people meet and interact are known to generate higher revenues. These locations (e.g. railway stations) are usually more vibrant, but also more resilient (e.g. from a functional society to an experience society).

Today's society expects high levels of comfort and overall experience. These expectations are part of the waiting time experience at railway stations. Studies have found that waiting at a transit hub (e.g. railway station) is experienced as being three times as long as the actual wait (in clock time). In other words, when a traveller waits for one minute on a station platform (s)he experience this one minute as being three minutes. Resulting in the fact that the wait must be experienced as being pleasant in order improve the satisfaction of the traveller. The waiting time for a trip, and other aspects of a public transport trip can be related to the their amenities. For example, duration (time) is set against the amenity. In Figure 1-3 the amenity of transfer is visualized. During this stage of the PT trip, Peek and Van Hagen (2002) found a relatively low amenity for the transfer.

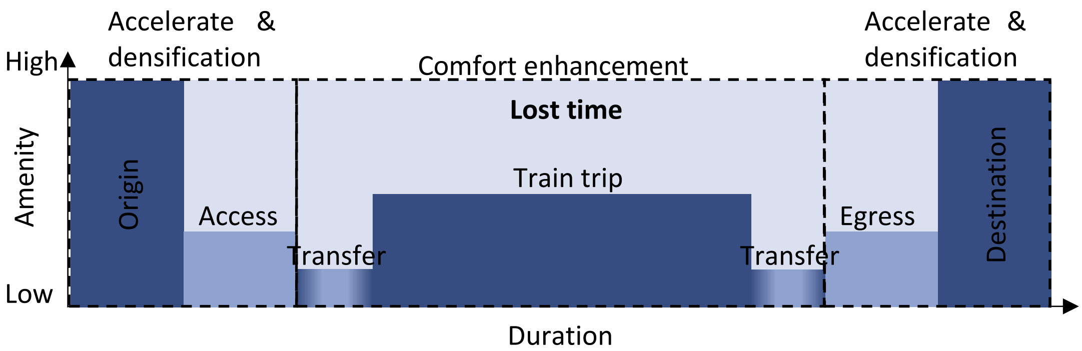


FIGURE 1-3, TIME VALUATION OF PT TRIP (PEEK & VAN HAGEN, 2002)

In order to improve the amenity of the different stages of a PT trip (e.g. waiting at a platform) the Dutch Railways developed the policy of "3V's", consisting of three strategies: (1) *versnellen* (to accelerate), (2) *verdichten* (densification) and (3) *veraangemanen* (comfort enhancement). NS Stations expects a synergy when these individual strategies are combined. In Figure 1-3 the areas where each strategy is applied are illustrated. Acceleration is aimed to reduce the travel time between origin to the actual main mode of transport (e.g. train) and by reducing the travel time between A and B. At the destination a more mixed/dense land use is needed that will fulfil all needs of the traveller (e.g. working, shopping, relaxing, or even housing). The last strategy focusses on the main mode of the trip. By enhancing comfort and experience (e.g. by offering free Wi-Fi, more comfortable seating) the perceived waiting time and travel time should decrease and be more compliant with the clock time. Furthermore, the customer satisfaction will improve.

In his Master thesis, Vaessens (2005) studied the effects of NS' synergy-policy for different sizes of railway stations in the Netherlands. It was found that railway stations which have implemented all three individual strategies ranked the highest on the performance indicators used in his study. The last couple of years NS started implementing these strategies on their railway station. The strategies *accelerate* and *densification* need to be implemented with the help of (local) governments and businesses. While *comfort enhancement* can be implemented by the NS alone, as they are the owners of all railway stations in the Netherlands.

Furthermore, policymakers find the definition and measures that relate to comfort enhancement difficult to comprehend. Acceleration is relatively easy to improve i.e. by speeding up trips (e.g. increase top speed of rolling stock or dedicated bicycle lanes). The same is true for densification. Measures include creating more floor space on the same square metre, or increasing the population density of a city. However comfort enhancement measures are difficult to define, implement and assess. Comfort enhancement measures are usually very personal i.e. something that I experience as being pleasant might have only have a small influence on you. For example measures such as comfort, ambient lighting, cleanness are affecting the overall experience of a traveller which may be perceived in different ways by various people, but generally have a positive effect on the majority of travellers.

Recently, the province of North-Brabant began the development of their public transport agenda. For this agenda (*Ontwikkelagenda spoor, HOV en knoopunten*) the railway, high quality public transport and transport nodes are being redeveloped. This redevelopment uses five strategies which are: (1) densification (*verdichten*), (2) accelerate (*versnellen*), (3) comfort enhancement (*veraangenamen*), (4) node (*verknopen*), and (5) disentangle (*ontvlechten*).

For the agenda, several propositions of comfort enhancement policies are presented. Most importantly is the collaboration between the (many) stakeholders which is affected by a railway station or public transport node. A combined vision between station, station environment and the community ensures that comfort enhancement will impact the majority of travellers. The province is looking for tools and measures that will improve the customer satisfaction at all of their transport nodes (railway stations and bus stations). However, little information is available about the effects of comfort enhancement measures. An ex-post analysis will be conducted for several comfort enhancement measures which are implemented by NS Station at multiple railway stations. The ex-post analysis will determine the change in customer satisfaction and ridership based on several implemented comfort enhancement measures. The results of the analysis are used to support the recommendation of comfort enhancement measures for a variety of public transport nodes in the province of North-Brabant.

1.2. Research objectives

The goals of this Master thesis, both (1) theoretical and (2) practical, as follows:

1. To conduct an ex-post analysis which is able to quantify the effects of comfort enhancement measures on overall station assessment and travel frequency at railway stations in the Netherlands.

2. To provide recommendations to the province of North-Brabant about which comfort enhancement measures are most effective at improving overall station assessment at public transport nodes.

The added value of this study for the current literature will be: (1) the effects of comfort enhancement measures on customer satisfaction, (2) and the effects of comfort enhancement measures on ridership. The latter is the most important, because of the relatively short time period that policymakers have been using this strategy. These results will help policymakers, public transport companies, developers, and everyone else related to public transport in deciding which comfort enhancement measures most suits them.

1.3. Research questions

Research questions are needed to complete the objectives presented in the last section. The following main research question needs to be answered at the end of this thesis:

What are the effects of comfort enhancement measures on overall station assessment and travel frequency at railway stations in the Netherlands, and how can these results help the province of North-Brabant in increasing customer satisfaction at public transport nodes?

In order to conduct this study more efficiently the main research question needs to be split up into smaller questions. These questions are stated for each part of the thesis below.

Section 2 – Literature

1. What are important customer needs that influence overall station assessment?
2. What is the relationship between customer satisfaction and waiting experience?
3. How does time valuation of a public transport trip relate to ridership and customer satisfaction?

Section 3 – Data

4. Do social-economic characteristics (age/gender/trip purpose) have an effect on the overall station assessment of a railway station?

Section 4 – Model estimation

5. Which comfort enhancement measures affect the change in overall station assessment of a railway station and how big is this change?
6. Which explanatory variables account for the change in overall station assessment and ridership using the *Stationsbelevingmonitor* and a *revealed preference survey*?
7. What is the explanatory power of overall station assessment, in relation to ridership based on the available databases?

Section 5 – Application

8. Which comfort enhancement measures should be implemented to improve public transport nodes in the province of North-Brabant, based on the available data and estimated models?

Once these questions have been answered, it must be possible to answer the main research question. Together, the main and sub questions create the basis for the conclusion and recommendations of the thesis, as presented in chapter 6.

1.4. Scope

The estimated models in this thesis are aimed to be generic, and thus can be applied to any transportation node in the Netherlands. However, not all public transport nodes (e.g. railways stations or bus stops) are surveyed with the *Stationsbelevingsmonitor* of NS Stations, only railway stations with 1.000 passengers or more per day are included in the survey. Furthermore, NS Stations have implemented a wide variety of comfort enhancement measures over the past years. Some measures are situated temporarily at railway station that are being reconstructed. Other comfort enhancement measures are implemented permanently. Because the effects of temporarily measures are more difficult to define (due to external factors present when a railway station is being (re)constructed), this thesis only uses comfort enhancement measures that are implemented permanently. To define the effects, three comfort enhancement measures are used in the revealed preference questionnaire. These measures are related to three railway stations, each with a different station typology. The measures selected, are: (1) Green and planters at Almelo station (typology 2), (2) RailTV which are digital screens with infotainment at Eindhoven CS (typology 1), and (3) lighting at Helmond (typology 4).

1.5. Conceptual model

To answer the (sub)research questions, three databases will be used. Two of which are available: (1) *Stationsbelevingsmonitor* of NS Stations and (2) a list of implemented comfort enhancement measures of NS Stations. The last database (3) will consist of data collected during a *revealed preference* survey. Presented in Figure 1-4 is the conceptual model used to determine the change in *overall station assessment* and *ridership* by the implementation of comfort enhancement measures. The questions and statements used to construct the *Stationsbelevingsmonitor* are categorized in eight fields of attention, labelled as *themes*. These *themes* are related to the current literature about the hierarchy of customer needs (Peek & Van Hagen, 2003), which is a model based on Maslow's hierarchy of needs to fit the customer needs of public transport. Combining the SBM and the list of implemented comfort enhancement measures results in a selection of railway stations that is suited to be surveyed using the revealed preference questionnaire. Resulting in the selection of the following three railway stations: (1) Almelo, (2) Eindhoven, and (3) Helmond and captures the changed station experience (*overall station assessment* and *ridership*) by travellers related to one specific comfort enhancement measure.

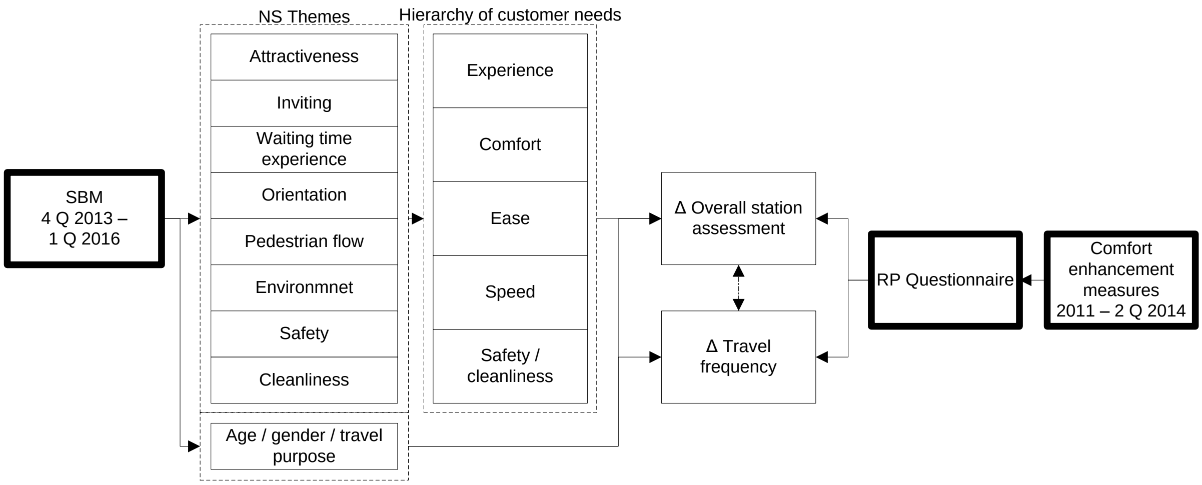


FIGURE 1-4, CONCEPTUAL MODEL

1.6. Thesis outline

The thesis report is structured in the following way. In chapter 2 the available literature about *customer satisfaction*, *waiting time experience*, and *ridership* is reviewed. The literature will be used as a guideline for this thesis research. Results from statistical analyses and model estimations will be related to the literature. Once the literature has been reviewed. The data used for this thesis is presented in chapter 3. In this chapter, the available databases, and to be collected databases are discussed in more detail, and used to answer the relating sub research questions. In total, three databases are used: (1) the *Stationsbelevingsmonitor*, or Station Experience Monitor (SBM), (2) a list containing *comfort enhancement measures* implemented at a variety of railway stations throughout the Netherlands, and (3) a *revealed preference* questionnaire (RP), that is distributed at three railway stations. For the SBM and RP databases, a descriptive analysis is performed to present the empirical evidence related to *overall station assessment* and *ridership*. The available databases (chapter 3), will be used to estimate multiple ordinal and nested logit models in chapter 4. Chapter 4 highlights the estimated models used to estimate *overall station assessment* and *ridership* using the explanatory variables present in the databases. Three regression models are predicted for both *overall station assessment* and *ridership*: (1) multinomial logit (MNL), (2) scaled MNL, and (3) nested logit. The MNL models are estimated to find out which explanatory variables are significant in estimating either two dependent variables. The scaled MNL models are used to find how each *comfort enhancement measure* relates to the other two measures and explain the variance of each comfort enhancement measure. The NL model is used to estimate the correlation between high *overall station assessment* and *ridership*. In chapter 5, a simulation will be performed to estimate the change of *overall station assessment* for five railway stations in the province of North-Brabant using three scenarios. The scenarios are based on the models estimated with the SBM and data collected during the RP questionnaires. In chapter 6, the conclusion and discussion of this thesis report are presented and elaborated. The final chapter, chapter 7, contains the list of all literature used in this report.

2. Literature

In the previous chapter, the time valuation of the transfer between two transport modes is considered low. How can this low amenity be improved and result in higher satisfaction levels and ridership? The hierarchy of customer needs of Peek and Van Hagen (2003) have defined five levels of customer needs that influence the customer satisfaction. This chapter will provide insight to the available literature on the relationship between station quality and ridership, and the modelling of customer satisfaction relating to ridership. The following sub research questions answered in this chapter are:

1. What are important customer needs that influence overall station assessment?
2. What is the relationship between customer satisfaction and waiting experience?
3. How does time valuation of a public transport trip relate to ridership and customer satisfaction?

The first section will provide information about the topic of customer satisfaction and its relation with public transport and how customer satisfaction is measured. Secondly, is the relationship between waiting experience and the effects of waiting on customer satisfaction. In section 2.3 the ridership of passengers is highlighted and explained which attributes determine ridership. Section 2.4 will present information regarding capturing customer satisfaction and station quality. The last section of this chapter will answer the sub research questions presented above.

2.1. Customer satisfaction

The hierarchy of needs (see Figure 1-1) developed by Maslow (1943) was the basis on which van Hagen (2011) based the hierarchy of customer needs (see Figure 1-2). In this hierarchy the perception of quality set by the Dutch Railways is related to the hierarchy of needs. The hierarchy of customer needs translates the universal needs, that every human being has, to the needs that are expected by travellers at any given railway station of NS. The bottom level (which accounts for 50% of customer needs) is composed of three basic needs: (1) *safety*, (2) *reliability*, and (3) *cleanliness* (Peek & Van Hagen, 2002). If people perceive a railway station as not safe, they will not consider the train as a viable mode of transport. The second level is the customer need of *speed*, which accounts for 15% of customer needs (Peek & Van Hagen, 2002). Speed is important for travellers because speed is directly related to time: the duration of a trip. If the duration of a trip is an acceptable amount of time, a traveller will consider using the train as a mode of transport. The third level of the hierarchy of customer needs is *ease* (14% of customer needs (Peek & Van Hagen, 2002)). Ease is, for example, the amount of luggage a travellers carriers with him/her, or the information (e.g. routing, departures) on a train station. Both *speed* and *ease* are labelled as dissatisfiers; if one does not meet the customers expectation the journey will get negatively affected. The second to last level is *comfort*. Peek and Van Hagen (2002) found that *comfort* accounts for 12% of the customer needs. Heating on station platforms, shelters, and comfortable seats contribute to the level of comfort a traveller experiences during their journey. The last and top level of the hierarchy of customer needs is *experience* (accounts for 9% of customer needs (Peek & Van Hagen, 2002)). The overall experience increases if travellers walks through an well-designed station. Light, smell, and music, all contribute to the customer experience. The last two needs (*comfort* and *experience*) are, in contrast to *speed* and *convenience*, satisfiers. If these needs meet the expectations of the traveller, the traveller will express a positive opinion regarding their satisfaction levels on the journey.

The last need (*experience*), is found to influence all underlying needs. In her Master thesis, Boes (2007) mentioned that *experience* is not just one need. All needs are in some way influenced by experience. For example, if statistics show that the service provided is reliable, but the traveller experiences a low level of reliability, it is possible that this mode of transport does not satisfy the traveller's needs.

The quality of a railway station and the station environment are essential to the experience and thus the customer satisfaction. In Hine and Scott (2000) multiple suggestions are made in order to improve the interchange experience on light-rail trains stations. These improvements are found using in-depth interviews with light-rail users. Six major areas of improvements were found: (1) *waiting area*, (2) *information provision*, (3) *service*, (4) *customer care*, (5) *ticketing*, and (6) *queuing*. A recent study by Eboli and Mazzulla (2015) found almost the same service quality categories as Hine and Scott (2000). Their Structural Equation Model (more advantaged regression model where latent variables can be introduced) found that s*ervice*, *cleanliness*, and *information* are the top three most important factors contributing positively towards customer satisfaction.

Studies that have assessed the quality factors of railway stations in the Netherlands found similar results (Brons, Givoni, & Rietveld, 2009; Givoni & Rietveld, 2007). Brons et al. (2009) found factors like *travel time reliability*, *dynamic information*, *personal safety* etc. are important for railway stations and train journeys. For all passengers, *accessibility* has a relatively low satisfaction and importance score. However, infrequent train passengers value *accessibility* as more important, and find it more satisfying if their expectations are met (as illustrated in figures 3 and 4 in Brons et al. (2009)). Furthermore, Brons et al. (2009) found that *accessibility* is more important, compared to *transfer* between two modes of transport.

In Figure 2-1 the customer needs are related to different travellers activities. Passengers of a public transport service need to have trust in the provided service. Trust can be found in the reliability of the service ("does my train arrive on time?") and the safety and cleanliness of the railway station and in the train. Why would you travel in a dirty, smelly train? If travellers have trust in the PT service, they will consider this mode of transport as one of their available options. The available transport modes are assessed based on *speed* (travel time, accessibility, space) and *ease* (travel information, signing). If the travel time of mode A is two times as mode B, the traveller will most likely not considering choosing mode A.

The moment the functional part of the journey is experienced as expected (*speed* and *ease*), the subjective features of the journey (*comfort* and *experience*) become important. The car encapsulates you, and provides your own private space with your desired ambient temperature, your music and volume. Which is hard to achieve in public transport. Therefore the *comfort* and *experience* of a public transport journey become relatively important. Interesting, *comfort* relates to the travellers' physical activities. *Comfort* can be found in spending time usefully, e.g. by shopping at the railway station, or the fact that is possible to wait in (heated) waiting areas protected from the weather. The *experience* can be influenced by the attractiveness (e.g. light, colours), architecture of the station and the ambiance. These attributes stimulate the positive emotions of the travellers.

To capture the travellers' satisfaction of a railway station, NS Station uses the *Stationsbelevingsmonitor* (SBM) or *station experience monitor*. Using a variety of statements, travellers must mark their level of satisfaction on a 1 to 10 Likert scale (1 = completely disagree, 10 = completely agree). The statements can be generalized into different themes. A total of 9 themes are defined in the SBM questionnaire; (1) attractiveness, (2) inviting, (3) waiting time experience, (4) orientation, (5) pedestrian flow, (6) cleanliness, (7) safety, (8) environment, and (9) construction. In order to improve the travellers assessment, or *overall station assessment* (as used in the SBM) of railway stations, different comfort enhancement measures are implemented by NS Stations (usually in association with ProRail and Bureau Spoorbouwmeester). For each of the available comfort enhancement measures, the expected fields of improvement are defined. These fields of improvement are related to the themes found in the SBM questionnaire. The last theme *construction* includes the temporary comfort enhancement measure which focuses on minimizing the negative experience travellers encounter during construction. The comfort enhancement measures presented in this research are permanent, therefore this theme will be excluded from the all further steps in this thesis.

Using the travellers attributes found in Figure 2-1, the eight themes used in the SBM questionnaire and fields of improvement of each comfort enhancement measure can be related to the five customer needs. In some cases the 'NS' themes are related to two customer needs. To establish the link between the NS theme and customer needs the statements of the SBM questionnaire provide more insight. For the complete list of statements found in the SBM questionnaire, see Appendix A. For example, the theme of *waiting time experience* (abbreviation *WACHxxxx*) is used to define variables relating to the waiting time experience of the traveller. One of the questions (*WACH1134*) is: "I can spend my time pleasurable". Using the attributes presented in Figure 2-1 this variable (and the relating theme) can be related to the customer needs of *comfort* and *experience*. In Figure 2-1 the complete relationship between attributes, the hierarchy of customer needs and NS themes is presented.

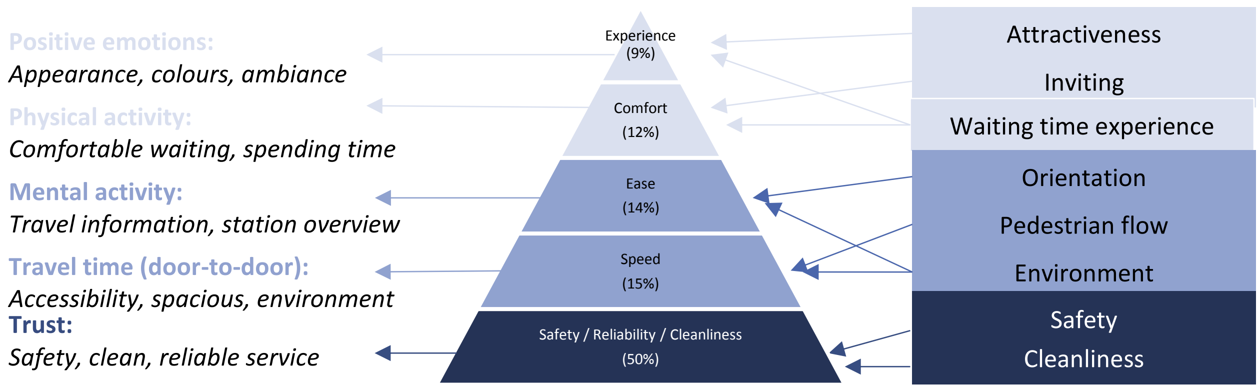


FIGURE 2-1, RELATION BETWEEN INFLUENCED ATTRIBUTES (CROW, 2014), HIERARCHY OF CUSTOMER NEEDS, AND NS THEMES.

2.2. Waiting time experience

In today's busy society, time is of major importance. Interesting is the fact, that the majority of people have difficulty estimating time correctly (van Hagen, 2011). The perceived time we use to engage in activities can differ depending on the activity. Boring activities, like waiting, can seem to drag on and on, while an interesting activity (with an equal clock time) might be perceived to be shorter. Both these time perceptions can be called *subjective time perception*. *Subjective time perception* is how long people experience time, and how this can be influenced. Opposite to subjective time perception is *objective time perception*, which for everyone is the same and can be measured e.g. in hours, days, weeks etc. The comfort enhancement measures target the *subjective* time perception of travellers by providing an comfortable activity besides passively waiting.

Early studies (Cottle, 1976; Hornik, 1984) found that people exhibit a tendency to overestimate passive durations and underestimate active durations. Hornik (1984) found that the level of enjoyment was more significant than all background variables (age, gender, etc.) together. With the subjective time perception two main theories occur that explain the overestimation of perceived time: (1) *assimilation-contrast theory* and (2) *stress management theory*. The former theory argues that when people have too much time on their hands, that people have a tendency to exaggerate the length of time when there is a difference between the expected and experience duration of an activity. One example mentioned by van Hagen (2011) is: "I have been waiting here for an hour!" Whilst the person making this statement is has only waited a few minutes (clock time). The latter theory states that when people are experiencing some sort of stress (emotional or physical) they tend to overestimate the duration of their activity. During these situations, when people are informed about, for example, the waiting time, they are likely to be more understating and tolerant; thereby reducing the stress level (Nie, 2000).

The information provided gives travellers a sense of control. This control is of vital importance for schedule-based public transport. van Hagen (2011) mentions that with this level of control passengers can easily and quickly find their way to and from the railway station. Furthermore, they know the exact departure time of the train. Once on the platform, the waiting can begin. Waiting can cause a variety of negative reactions towards the service requested. In turn, these negative reactions might influence the *customer satisfaction* and *service quality evaluation* of the service. The longer someone thinks he/she is waiting, the more disappointed this person is about the provided service (Kramer, 2009). At train stations, travellers are per definition preoccupied with time. At arrival on the station platform, the traveller checks the time and at what time the train departs (Peek & Van Hagen, 2002). The time valuation for waiting is valued as the lowest of all aspects of the trip, as Peek and Van Hagen (2002) have illustrated in Figure 1-3.

The reasons mentioned above make waiting one of the more important time periods during a trip. The waiting of passengers does not contribute to the *speed* and *ease* of the traveller. The comfort and experience (see Figure 1-2) are perceived as positive when the adequate facilities (are available, or negative when the expected facilities are not present. Facilities shops, customer information desks, elevators, also comfortable waiting arears or other activities, such as, a piano or interactive lighting are perceived as activities by travellers.

2.3. Ridership

Ridership defines the number of travellers that use a specific public transport system e.g. the train. For a railway company like the NS, ridership is the most important source of income. According to the annual report of Nederlandse Spoorwegen (2014) 86% of its income was generated by transporting passengers. The rest of its income resulted from station redevelopment and exploitation (e.g. Kiosk or Smullers). This clearly links an increase in revenue to more travellers. Furthermore, more travellers will also increase the changes of those travellers visiting and purchasing some goods or services at one of the shops at the station, thus increasing the station revenue.

The topic of ridership has been widely studied over the past decades. The development of the computer and with that computer models and simulations resulted in more sophisticated ridership prediction models. The result of these studies can be found in the many factors that are likely to influence ridership. One of the most influential factors is *density*. Cervero (1993) found that citizens in station-areas are 5 to 7 times more likely to travel by rail, compared to citizens that live outside the station areas. Besides *density*, the factors *diversity* and *design* determine travel demand (Cervero & Kockelman, 1997).

These so-called 3D's of Cervero are widely used in (green) transit-oriented development (TOD) policies. The strength of combining the strategies *density*, *diversity* and *design* can be found in the result of a synergy, in which society is the main benefactor. NS uses the policy strategies *accelerate*, *densification* and *comfort enhancement* which, when compared with the 3D´s of Cervero, they focus on the same topics. The NS, and other parties (e.g. local governments) want to increase the variety of shops, services, and businesses in and around railway stations by *densification*, which aligns with Cervero´s factor of *diversity*. To make a trip more pleasurable, the NS uses the *comfort enhancement* strategy to increase the experience during a trip. Cervero refers to *design* as a way of making land use and transport more attractive (e.g. by creating more green spaces). The last strategy of the NS is *accelerate*, getting from A to B quicker or changing modes more easily. Cervero uses *density* as a strategy to create more demand for transport, more demand makes faster and more frequent transport possible. In Figure 2-2 the *waiting experience* is related to the three policy strategies of NS. For each policy strategy the urban region is defined. The urban regions each contribute to the transport and land use factors present in the most common TOD policies. The Place-Node Model of developed by Bertolini (1999) can be improved by including a third factor: *experience*.

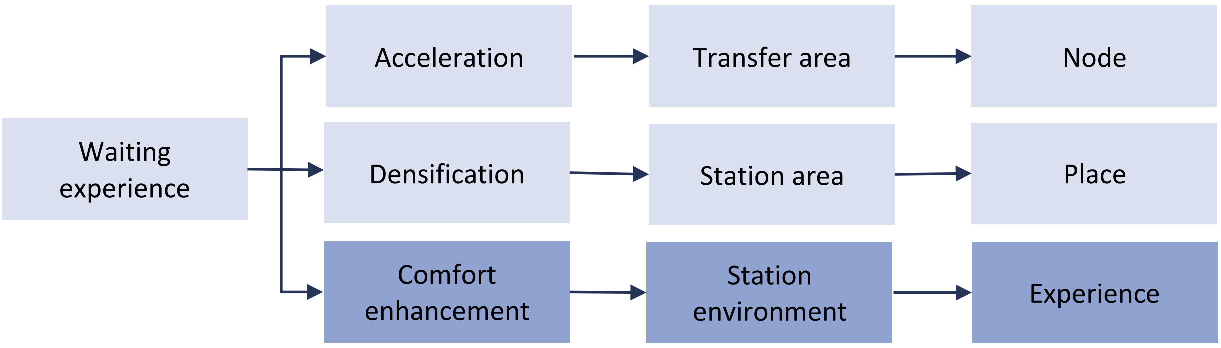


FIGURE 2-2, RELATIONSHIP WAITING EXPERIENCE, RIDERSHIP AND CUSTOMER SATISFACTION (ADOPTED FROM GROENENDIJK (2015)).

Besides factors determining land use and infrastructure, mode choice does influence ridership as well. Early studies have shown that mode choice is mostly based on the travel time of a mode (Goeverden & Van Den Heuvel, 1993). In their study Van Den Heuvel and Schoemaker (1989) developed the travel time factor (TTF or in Dutch *verplaatingstijdfactor*). The TTF is calculated by dividing the travel time of public transport by the travel time of the car. For example, travelling from Weert to Enschede by car takes 2 hours, and by train 3 hours. The TTF in this case is 3 divided by 2 is 1,5. This TTF can be plotted against the share of PT. Goeverden and Van Den Heuvel (1993) found that the TTF is equal to 1, the share of PT is around 60%. But once the travel time of the car becomes faster (TTP >1) the PT share drops to around 20%. Higher and lower percentages of PT share is difficult to reach due to the captives.

Captives are travellers captured by one mode of transport. For example, a car fanatic will only consider the car as mode of transport. While people who simply do not own a private vehicle have no choice other than public transport.

In the previous example the car fanatic might have a bad image of public transport. In a Dutch study about the attractivity of transport modes Harms, Jorritsma, and Kalfs (2007) found that 67% the Dutch population values the car as the most attractive mode of transport. The second most attractive mode of transport is the bicycle (27%). And at third place, valued by 4% of Dutch is public transport. This study also found that travellers value their most used mode of transport higher compared to rarely used modes. 62% of respondents who never or rarely use PT were found to have a negative image of PT. The differences in attractiveness of modes of transport are found to have different causes. Harms et al. (2007) found that causes like *flexibility, comfort, independency, speed* (relation with TTF) and *cost* are experienced less positively. Generally these factors are experienced less positive for public transport compared to the car or bicycle. Personal characteristics have less influence on mode choice, but special considerations must be made for the differences in perception of men and women, and experience due to age (e.g. younger adults generally prefer the car, while elderly people prefer the comfort of PT). Lastly geographical characteristic, for example in rural areas the car is preferred over PT, which is caused by the lack of decent PT in those areas (Harms et al., 2007).

It can be concluded that ridership is determined by many factors, including but not limited to: *density*, *design*, *diversity*, *travel time factor*, *attitude*, *perception* and *experience*. Because the build environment is well established, the focus should be on the traveller and not on buildings. The perceived travel time and (perceived) advantages of public transport (including access and egress modes) must be presented to non-public transport users (e.g. captive car users).

2.4. Revealed customer satisfaction

In the paper '*De emotionele reis van onze klant. Waarom een 56 minder is dan 45.*' the peak-end rule is explained by Hagen and Bron (2013). The peak-end rule explains why customers value their trip almost entirely on two particular moments of that trip: (1) the highest (most positive) peak, and the trip end. The total sum of all experiences (how positive and negative) are mostly ignored in the final assessment of the trip experience. The RP questionnaire has to make sure that the questions presented to the respondents capture the most positive peak of the travellers experience. It is important that the most positive effects of the arrival and stay at a railway station are captured.

The customers' experience is difficult to capture, and unfortunately personal. The answers of the SBM are all subjective, respondent 1 might have a totally different experience compared with respondents 2. Furthermore, how can someone's' experience be captured and measured? An example of such quantitative analysis can be found in the paper of Cascetta and Cartenì (2014). In this paper they explain how the hedonic value (architectural quality) of railway terminals could explain the user perception of route choice, based on the services provided (thus including the hedonic value). The models used in this paper contain an Alternative Specific Constant (ASC) which include the variables related to the station quality (architectural standards, ease of access, safety, security, lightning, climate control, comfort) (Cascetta & Cartenì, 2014). All models developed by Cascetta and Cartenì (2014) show that the ACS is the second most important variable of the model. The most important variable was the ticket fare.

In their research in the effects of music, wait-length, and mood on the (low-cost) wait experience of customers. The researchers Cameron, Baker, Peterson, and Braunsberger (2003) used several subjective questions to determine the effects. For each of the categories (e.g. music, mood, overall experience) three sub questions were designed. These sub questions must be answered using a 7-step Likert-scale, for example, ranging from very annoying (1) to not at all annoying (7). The purpose of this paper in this literature review is to support the use of subjective questions. With the correct sample size and distribution the results of the statistical analysis and modelling should be reliable. The paper of Cameron et al. (2003) did mention that they sample only contained college students whom volunteered to participate in this experiment, and to have a more improved result, the sample should be more diverse (e.g. same distribution found among train travellers).

Checking the customers response in a RP questionnaire is also important. In the paper of dell'Olio, Ibeas, and Cecín (2010) a two part survey was used which is mend to verify the respondents answers. The first part of the survey askes the respondent for his/her personal information (age, gender, occupation etc.) and to score the overall assessment. The second part focusses on the separate variables (e.g. as can be found in the SBM database). By answering the questions, the respondent is forced to think what he/she thinks about this specific question. At the end of part two, the overall assessment is asked again. This second scoring of the overall assessment is used by dell'Olio et al. (2010) to analyse the possible change in the respondents valuation of the overall assessment.

In a recent paper Mouwen (2015) emphasised the use of customer segmentation based on customer characteristics. Customer assessment of a PT service is depended on two factors: (1) sacrifice (monetary and non-monetary costs related to the use of the service), and (2) the customer's frame of reference (Zeithaml, Berry, & Parasuraman, 1990). Each customer segment results in a different assessment of the PT service. These differences are likely caused by the different attitudes customer segments have towards monetary costs, non-monetary costs, prior experience, current situation, and socio-economic characteristics. Mouwen (2015) noted that two fundamentally different means of segmentation can be described: (1) priori segmentation and (2) post hoc segmentation. In the former approach, customers are selected in advance, based on the known characteristics (e.g. gender, age, trip motivation). The latter approach defines customer segments according to their multivariate profiles present in the data. Therefore, the researcher does not decide, the data is leading. But as Mouwen (2015) mentioned correctly, this might result in segments that are meaningless, thus hard to interpret.

In the research of Friman (2004) the quality improvements of Swedish public transport companies where examined. In order to capture the change in experienced quality Friman (2004) used two samples (Sample I n=1250, sample II n=1547). Sample I is used to capture the experienced quality level before implementation, sample II is used to measure the experience quality after implementation of the measure (ranging from behaviour of employees, to information, to cleanliness). For both samples, 2600 respondents were randomly chosen and asked to fill in the questionnaire. An interesting finding of Friman (2004) is found to be the limited influence of the quality enhancement measures based on the pre- and post-satisfaction ratings.

2.5. Conclusions

This chapter has highlighted the theories behind customer satisfaction, waiting experience and ridership of public transport. Besides functionality and punctuality, is customer satisfaction found to be important as-well. Travellers will base their perceived satisfaction on five needs. These needs are part of the hierarchy of customer needs which defines five different needs based on the Hierarchy of needs developed by Maslow. The hierarchy of customer needs, categorises five needs into three main categories. The first category and also the first needs is labelled as *basic needs*, including aspects as safety, cleanliness, and reliability. The second category consist if the customer needs *speed* and *ease*. These dissatisfiers, have a negative impact on the customers' satisfaction when the expected need is not expected as such. The top two needs; *comfort* and *experience* are part of the last category labelled as satisfiers. When these needs are not experienced by the traveller, the customer satisfaction is not affected (positively or negatively). However, when these needs are experienced, the customer satisfaction will be positively affected.

Part of the customer satisfaction, is how traveller perceived certain aspects of a trip. The satisfiers of the hierarchy of needs, aim to improve the physical and mental comfort of travellers. When travelling with public transport, travellers have less control over their trip. This control and the availability of time (e.g. during waiting) are both influencing the customers' satisfaction. It might be the case that travellers over exaggerate an event that they've encountered during their stay at a railway station. Which can cause an negative, but also positive impact of the travellers experience.

When public transport is perceived as positive, people tend to consider public transport as an alternative to using the car. The value of using public transport might increase by using strategies relating to transit oriented development. The Dutch Railways uses three strategies to improve the experience of a public transport trip; (1) densification, (2) accelerate, and (3) comfort enhancement. These strategies improve the node-function, place-function, and experience-function of any public transport node.

The literature relating to comfort enhancement is minimal, but the used sources are sufficient to clarify what is relevant in relation to comfort enhancement. However, to quantify the change in overall station assessment and ridership by using the strategy of comfort enhancement is missing in literature. Several databases are available to quantify the change of comfort enhancement measures, such as the *Stationsbelevingsmonitor* (SBM) of NS Stations. In the next chapter, Data, the used databases are presented and elaborated.

3. Data

Since 2001, the Dutch Railways started measuring the travellers satisfaction at railway stations. Between 2001 and 2013 NS used the *klanttevredenheidsonderzoek* or KTO to capture the travellers station assessment. The KTO focussed on the *dissatisfiers* of the hierarchy of customer needs (Figure 1-2). In 2013, NS Stations replaced the KTO with the *Stationsbelevingsmonitor* (SBM). Compared with the KTO, the SBM focusses mainly on the customer needs: (1) *comfort* and (2) *experience*. This shift contributes to the synergy policy of NS, presented in section 2.3. The strategy of *comfort enhancement* is achieved by implementing one or a combination of comfort enhancement measures. NS Stations have implemented a variety of measures at railway stations all over the Netherlands.

NS Stations has provided access to the SBM database (4 Q 2013 to 1 Q 2016) and a list of comfort enhancement measures implemented at railway stations between 2011 and 2014. However, this information was not sufficient to provide a detailed analysis of the effects of comfort enhancement measures on travellers' overall station assessment and ridership.

A *revealed preference* (RP) questionnaire is used to capture the travellers changed experience due to a comfort enhancement measures. The RP questionnaire has been distrusted on three railway stations, each with their own comfort enhancement measure: (1) Almelo, with *green and planters*, (2) Eindhoven CS, with RailTV, and (3) Helmond, with *lighting*.

3.1. Available databases

3.1.1. Stationsbelevingsmonitor

The *Stationsbelevingsmonitor* database includes 224 002 entries, collected between 4 Q 2013 and 1 Q 2016. The data was collected by asking waiting travellers to complete the SBM questionnaire on the station platform. Every railway station in the Netherlands is surveyed at least once per year (with at least 1 000 passengers a day). Larger railway stations (typologies 1 or 2) like Eindhoven CS, Amsterdam CS, 's-Hertogenbosch are surveyed every quarter, providing more detailed information over the relative short period in which the SBM questionnaire is used.

The SBM questionnaire uses statements to capture the travellers current experience of a railway station. In total 28 statements presented to the respondent, these 28 statements can be categorized among the 8 NS themes presented in section 2.1. Besides these 28 statements, 2 open questions are used to collect information about (1) the most noticeable element of the surveyed railway station and (2) the most important improvement needed. Lastly, the respondent is asked to provide miscellaneous personal and trip related information. Four personal characteristic are asked; (1) age, (2) gender, (3) disabilities, and (4) assessment of weather. A total of seven trip related questions are presented: (1) access mode, (2) transfer at this station, (3) usage of bicycle parking, (4) which type of bicycle parking is used, (5) assessment of most used bicycle parking, (6) trip motive, (7) travel frequency by train.

All statements and questions included in the SBM questionnaire can be found in Appendix A. For every statement/question, the corresponding abbreviation and values are provided.

3.1.2. Comfort enhancement measures

A list with implemented comfort enhancement measures between 2011 and 2014 is provided by NS Stations. Measures implemented after 2014 where not included. For each comfort enhancement measure a title (name), measure description, date (or period) of implementation and station of implementation are reported. Furthermore, for each measure the expected NS themes that will be improved are marked. The total list includes 100 measures, ranging from standard temporarily measures used at every construction site at a railway station, to permanent comfort enhancement measures like RailTV (digital screens with infotainment). An outtake of relevant comfort enhancement measures used by NS Stations can be found in Appendix B (original document is in Dutch and is not included in this document). The most promising (based on adaptability, costs, maintenance, expected effect, target audience) comfort enhancement measures are: *infrared heating columns*, *RailTV*, *green & planters*, *lighting*, and *station signing*. These measures are elaborated in the next subsections.

Besides the measures implemented by NS Stations, Bureau Spoorbouwmeester has published a report about the pleasure of waiting (Kruit, 2015). In this report, a total of 9 aspects of comfort enhancement are elaborated on 24 different railway stations. NS uses this report as inspiration for the selection, and implementation of comfort enhancement measures. Some examples of measures highlighted in the next subsections are also used by Bureau Spoorbouwmeester.

FIGURE 3-1, INFRARED HEATING COLUMN (SOURCE: WIKIPEDIA), LIVING WALL (GREEN AND PLANTERS, SOURCE: PRORAIL.NL), DIGITAL SCREENS WITH INFOTAINMENT (RAILTV, SOURCE: PRORAIL.NL)

3.1.2.1. Infrared heating columns

The infrared heating column (see Figure 3-1, left) is only used during the autumn and winter seaons. During these seasons the low ambient temperatures are not contributing to the comfort, waiting time experience and overall assessment of the waiting traveller at the station platform. The infrared heating columns have two drawbacks: (1) energy consumption, and (2) vandalism. These heating columns are mostly situated at larger railway stations, such as ‘s-Hertogenbosch CS, Amersfoort CS, Utrecht CS, and Schiedam.

3.1.2.2. Green and planters

Green and planters (Figure 3-1, middle) are used by NS Stations to increase the liveability at the station. The green and planters improve the attractiveness and waiting time experience for travellers. Railway stations used to be grey and dull, possibly related to the functionality of a railway station. But the last few years NS Stations and ProRail improved the station buildings with plants. At the end of 2013, the wall mounted real-time travel information screens (called ‘*TAS schermen*’) at Almelo station have been surrounded with vegetation to create a pleasant, attractive space. Larsen, Adams, Deal, Kweon, and Tyler (1998) mentioned in their paper, the effect of plants on mood and perceived attractiveness are higher in (office) space with plants. Surprising is the decreased productivity of people when plants are around (Larsen et al., 1998).

3.1.2.3. RailTV

RailTV (Figure 3-1, right) provides travellers with travel information, cultural information and advertisements during their stay on the station platform. In 2013, NS in association with ProRail started implementing the concept of RailTV on several large railway stations like; Eindhoven, 's-Hertogenbosch, Rotterdam Central, Leiden Central, Amsterdam Central. The screens show three fragments of information: (1) cultural information, (2) information, (3) advertisements. *Cultural information* can anything related to culture, e.g. information about museums, theatres, literature, (station) architecture etc. *Information* is a fragment about upcoming construction work, construction projects, and scheduled maintenance on stations and tracks. In a study of Kramer (2009) the influence of commercials and infotainment on railway stations are researched. It was found that the presence of screens (and wall advertisements) does not affect the perceived waiting time, but does positively affect the waiting time experience.

FIGURE 3-2, LED LIGHTNING (SOURCE: DAVIDPRONKFOTOGRAFIE.NL), STATION SIGNING (SOURCE: PRORAIL.NL), WALL STICKERS (SOURCE: BOUWWERELD.NL).

3.1.2.4. Lightning

Light (see Figure 3-2, left) is an easy to use comfort enhancement measure. Almost everyone experiences well-lit areas/spaces as positive. Architects can 'play' with light in their architectural design. Light not only contributes to the overall waiting experience, but also to the feeling of safety. Some travellers might feel unsafe in certain areas/spaces in a railway station, for example station tunnels. By combining lightning and the correct way of tunnel design, this negative unsafe feeling might be turned into a positive experience. The new station tunnel of Zwolle CS combines a well-designed tunnel with special RGB LED lighting and natural light. Besides indoor lightning, the station façade can also be improved by light.

3.1.2.5. Station signing

A less common, but interesting comfort enhancement measure is the use of station signing as wall decoration. At station Stijp-S (formally known as station Breukenlaan, see Figure 3-2 middle) the walls are decorated with infographics/directions. These infographics included the station signing (e.g. location of station platforms including numbers) and function as wall decoration to cover the concrete walls. The infographic walls at station Strijp-S create a fun, interesting to look at experience for waiting passengers but also for passers-by. NS together with ProRail and the municipality of Eindhoven also improved the accessibility of the surrounding neighbourhoods like Strijp-S, Limbeek and Woensel-West.

3.1.2.6. (temporarily) wall / store front stickers

The list with comfort enhancement measures provided by NS Stations included many construction related measures. Two of those can be used as permanent measures but also as temporarily measures. Both measures use decorative stickers/foil which are stickered on walls (e.g. dark walls of a passenger tunnel) or windows of empty shops. NS Stations used an adhesive foil – printed with a green landscape – as wall decoration for the passenger tunnel in Delft Station. At first, this passenger tunnel was perceived as dark, once the stickers where applied, passengers perceived the tunnel as more attractive. Furthermore, the tunnel was experienced to be more safe, compared to the situation without wall decoration. The wall stickers can contain any form of design, from landscapes as used in Delft to art as used in the Noordertunnel in Utrecht CS to simple coloured lines as in Boxtel station (Figure 3-2, right)

3.1.2.7. Overview measures

Not every measure affects all attributes of a trip. Some measure influence the comfort of a traveller while waiting on a railway station, others might affect the ease by which the traveller finds his/her way to the correct platform. For each comfort enhancement measure their relating NS themes (and customer needs, see Figure 2-1) are presented in Table 3-1 including a general comment on what needs to be considered before implementation.

TABLE 3-1, RELATION COMFORT ENHANCEMENT MEASURES WITH CUSTOMER NEEDS AND NS THEMES.

	Experience & comfort			**Ease & speed**			**Safety & cleanliness**		
Measure	Attractiveness	Inviting	Waiting time experience	Orientation	Pedestrian flow	Environment	Cleanliness	Safety	**Comments**
Infrared heating columns	X	X	X						Measure can only be used during the colder months (November to March).
Green & Planters	X		X			(X)		X	Needs maintenance, easy to be vandalised.
RailTV	X	X	X						Constant development of new content.
Lightning	X	X				(X)	X	X	Most effective when it is dark.
Station signing				X	X	(X)			NS Stations has a standard in station signing. If this measure is used, this means deviating from the standard practice.
(temporarily) wall / shop front stickers	X	X	X					X	Suited in both temporarily and permanent situations.

As mentioned in section 3.1.2.1, the *infrared heating column* is a comfort enhancement measure which will primarily be used during the colder months of the year (November to March). During all other months the heating columns are removed by NS. These labour costs will be added to the energy costs, making the infrared heating column a relatively costly and maintenance intensive measure. Nevertheless, the attractiveness, invitingness, and waiting time experience during the cold waits at the station platform might justify the costs. However, due to the limited presence of this measure at railway stations, make it a difficult comfort enhancement measure to be included in any RP questionnaire.

The second measure is *green and planters*. NS Stations predicts the themes of attractiveness, waiting time experience, and safety to be affected. The last theme – safety – is included because the presence of plants are often perceived as (a touch of) human attention/presence, increasing the perceived safety at the railway station. While most likely contributing to the overall station assessment, this does come at a price. Plants need to be maintained to keep the intended effect of green. If not taken care of the green, the plants might die (e.g. lack of water) or overgrow. Both might negatively contribute to the overall station assessment. For example the maintenance crew (also responsible for keeping the station clean) should be given the task of green maintenance. While relatively maintenance intensive, green and planters are easily adapted to fit a every railway station. In the cases of Almelo and Muiderpoort, the location of the planters has been the wall. But simple concrete flower pots can be used and located all around the station and might have the same effect on overall station assessment. Using green walkways the connection between city centres and the railway station can be highlighted and might result in a high quality connection. Which might contribute in increasing the travel frequency of passengers. In Table 3-1 this relation is visualised with “(X)”.

RailTV is a comfort enhancement measure which aims to improve the attractiveness, invitingness, and waiting time experience of travellers. If implemented, each platform will be fitted with one RailTV screen, although this is a one-time investment, it also includes a continues (e.g. monthly) exploitation costs. These costs are made because every 6 weeks the information presented on RailTV is changed. This information can be anything; planned construction work, cultural information, but also commercials. The advantage of allowing commercials are the fees payed by companies, which are used to pay the exploitation costs of RailTV. RailTV is enrolled nationwide, meaning that every railway station receive will display the same information on RailTV. This standard has two sides; (1) the standard is clear, which makes implementation straightforward, (2) adapting RailTV for each railway station is not possible (e.g. custom information). Analysing this problem from an economical perceptive the nationwide standard is more preferable. Nationwide broadcasting results in a higher audience, and therefore the broadcast time is more valuable for each commercial (less work, higher revenues). When allowing regional commercials, every region needs its own commercials, and might result in a commercial has a lower audience which lowers the revenues (more work and less revenues)

The forth highlighted comfort enhancement measure is light(ning). For most people, well-lit spaces are perceived as pleasant, clean, and safe. NS Stations defines lightning to influence; attractivity, inviting, cleanliness, and safety. Dark spaces, corners can easily be brightened up by placing energy efficient LEDs. The LED fixtures can also be equipped with red-green-blue (RGB) LEDs, when combined with a controller, the RGB LEDs can create (interactive) light effects. Different light scenes can be used during different parts of the day or during special events (e.g. orange during a football match of the Dutch national team). As with RailTV, an investment in (RGB) LED fixtures is needed and can be relatively costly. However, the maintenance of these LED fixtures is minimal. If programmed properly, the controller can be used year round without any changes. The electric bill is low and the LED do not need to be replaced for the next 7 to 10 years. The adaptability of light(ning) is unlimited. Every railway station is unique, for example light can be used to emphasise the unique characteristics of these railway stations. In Helmond the measure is not only used at the railway station but is also implemented as feature in the station environment. The street furniture is accentuated with RGB LEDs as well, creating a visual bridge between the city (as station environment) and railway station.

The fifth measure (Figure 3-2) is station signing. While not (directly) focussing on the customer needs *experience* and *comfort*, does the station signing contribute to *ease* and *speed*. With clear signing a traveller quickly knows here his/her train arrives and departs, and where useful facilities are located. In section 3.1.2.5 station Strijp-S is used as example for the use of station signing as comfort enhancement measure. Most will agree, that this signing is perceived as visually more attractive compared to the visual dull concrete walls. Despite the use of infographics, you want to make sure all travellers know where to go almost instantly. The Dutch Railways have a standardization in station signing (developed by Bureau Spoorbouwmeester). Here the fonts, font sizes, symbols, signing dimensions etc. are standardized. This standard is applied at all railway station in the Netherlands. Using different – custom – station signing is considered difficult to implement at railway stations in the Netherlands. The fact that Strijp-S is an area with many innovative businesses, might justify that Strijp-S has its custom station signing.

The final comfort enhancement highlighted in section 3.1.2.6 is the measure "wall / store front stickers". As mentioned earlier, this measure can be used in temporarily and permanent situations. When applied in a temporarily situation the two main goals are to ensure that travellers can find their way as safe and pleasant as possible. Temporarily walls with wall stickers or empty shop fronts with large inviting/attractive pictures (masking the empty shop) are thought to result in a positive experience in an already stressful railway station. Most railway stations that are under construction or where under construction did receive these measures (like Rotterdam CS, Utrecht CS, Amsterdam CS). The permanent application of stickers is usually found in wall decoration. Wall stickers can be used to increase the attractiveness of dark areas (e.g. passenger tunnels) or improve the attractivity of a waiting area / station platform. For both situations (temporarily and permanent) designs have to be made which fit the specific railway station. Next this design has to be printed and applied. While RailTV is a nationwide tool, the wall / shop front stickers could be designed specifically for a railway station, for regional events, for shops, for promotional purposes , awareness programs, etc. The costs related to these stickers is dependent on the frequency by which the stickers are renewed. Allowing store to promote their products might lower the exploitation costs, or share costs by sticking the city's event calendar on multiple locations.

3.2. Data collection

To determine the change in ridership and overall station assessment related to individual comfort enhancement measure, more detailed information is needed on how travellers perceived the change (if any) of a single comfort enhancement measure. The SBM questionnaire focusses on the overall station assessment of a railway station. To capture the effects of one individual measure a revealed preference questionnaire will to be distributed at various railway stations. First the comfort enhancement measures will be discussed. Secondly, the station recruitment will be elaborated. For every selected railway station, only one comfort enhancement measure will be selected to be included in the RP questionnaire. Finally, the distribution of respondent and the survey itself are elaborated.

3.2.1. RP questionnaire

In the previous section (3.1.2) an overview of comfort enhancement measures is presented. For each measure the railway station where it is implemented is listed. For each railway station, the (1) station typology, (2) the average number of respondents in the SBM database, and (3) the period of implementation of the measure are presented.

TABLE 3-2, OVERVIEW IMPLEMENTED COMFORT ENHANCEMENT MEASURES.

Comfort enhancement measure	Station name (station number)	Station typology	Avg. number of respondents (number or questionnaires)	Date of implementation ("*" = estimated, "–" = unknown)
Infrared heating columns	Amersfoort (162)	2	203 (10)	4 Q 2009*
	Nijmegen (133)	2	182 (10)	4 Q 2009*
	Amsterdam Amstel (241)	3	193 (10)	4 Q 2008*
	Leiden (291)	2	183 (10)	4 Q 2008*
Green & Planters	Almelo (96)	2	189 (10)	4 Q 2013
	A'dam Muiderpoort (240)	5	175 (2)	3 Q 2013
	Deventer (88)	2	317 (10)	–
RailTV	Eindhoven (390)	1	371 (10)	2 Q 2013
	's-Hertogenbosch (387)	2	181 (10)	3 Q 2013
	Utrecht (192)	1	361 (10)	1 Q 2014
	Zwolle (70)	2	346 (10)	1 Q 2014
Lightning	Helmond (391)	4	184 (2)	1 Q 2014
	Zwolle (70)	2	346 (10)	2 Q 2015
	Arnhem (127)	2	343 (10)	4 Q 2015
Station signing	Strijp-S (389)	5	112 (3)	1 Q 2014
Wall / shop front sticker	Utrecht (192)	1	361 (10)	1 Q 11 – 4 Q 16
	Eindhoven (390)	1	371 (10)	1 Q 13 – 4 Q 16
	Deurne (393)	4	132 (3)	1 Q 2015*
	Den Dolder (159)	6	172 (2)	1 Q 2013*

Of the six available comfort enhancement measures, not all are suitable to be included in the RP questionnaire. In the next section, each measure will be highlighted and elaborated why the measure is or is not included in the RP questionnaire.

3.2.1.1. Measure recruitment

Infrared heating columns are great examples of comfort enhancement measures, they provide warmth to the cold wait on a station platform. However, these measure can only be used in the colder months, as they are removed during the warmer month. Besides the limited usability, is the available data to test the effects of infrared heating columns marginal. Most heating columns are implemented around 2008, as the SBM was not used back then, no information regarding the change in experience and comfort is available. Therefore, asking travellers their perceived change of a measure almost 7 years ago provides very biased answers. Based on these arguments, the measure of infrared heating columns will not be used in the RP questionnaire.

Station signing is a problematic comfort enhancement measure as well. Bureau Spoorbouwmeester has defined a clear, simple, and recognisable station signing which is s used as corporate identity by NS (ProRail, 2013). This standard signing is preferred over custom station signing. Travellers are used to the standard signing, any deviation might confuse travellers. Secondly, only one railway station is known that is allowed to have custom stating signing. The station of Strijp-S in Eindhoven is allowed to used custom station singing at the station entrances. As only one railway station has allowed to use this type of comfort enhancement measure, no comparison is possible with other railway stations. Based these points, the RP questionnaire will not focus on the comfort enhancement measure of station signing.

What remains, are four comfort enhancement measures that could be used in the RP questionnaire. *Green and planters*, *RailTV*, and *lighting* are labelled as permanent comfort enhancement measures. Once implemented it is expected to increase the overall station assessment permanently. While temporarily comfort enhancement measures focus on minimizing the negative impact due to i.e. construction works. During these construction works, travellers are likely to encounter (major) hindrance; entrances closed, walkway diversions, changed departure platforms, noise, debris etc.. NS and ProRail use the term 'SITS' for these construction railway stations. SITS is an abbreviation for "*Stations in tijdelijke situaties"* or in *stations in temporarily situations*. To minimize hindrance for travellers NS and ProRail use a variety of measures to reduce the perceived hindrance. Included in Table 3-2 is the measure of *stickers* (wall / shop front). This measure is commonly combined with other measures, for example, a temporary façade which separates the travellers from the construction site. The combination of measures and hindrance will most likely introduce a bias among respondents. This bias might result in an inaccurate measurement of the overall station assessment. It is expected that respondents will weigh the experienced hindrance too much when evaluating the effects a single comfort enhancement measure on their overall station assessment. Based on these argumentations, the temporal stickers will not be used in the RP questionnaire. However, it would be interesting to know how passengers experience these temporarily comfort enhancement measures and completely reconstructed railway stations.

The permanent use of *stickers* as comfort enhancement measure are applied at two smaller railway stations: Deurne and Den Dolder (more are possible, but unknown during the research). At both railway stations the wall stickers are used to decorate the dull, grey, with graffiti covered (electric) substation buildings. In Den Dolder a forest (green) themes was chosen. While in Deurne a historic theme is chosen. At both railway stations the citizen participation is very large. The local community is rewarded for their collaborating in improving the station quality. In Den Dolder, the station building is renovated, and is currently used by local freelancers who are able to rent one of 16 desks in the station building. Due to the small station sizes (typologies 4 and 6), the SBM survey is only distributed once a year at both stations. The information collected using the SBM questionnaire is limited and therefore unsuitable to determine the changes overall station assessment and ridership related to the use of *stickers*. If one of the two railway stations was surveyed quarterly, a comparison between the results of the RP questionnaire and SBM database could be made. Unfortunately this is not the case.

Therefore, based on the lack of data, this comfort enhancement measure will not be used in the RP questionnaire. What remains are three (permanent) comfort enhancement measures: (1) green and planters, (2) RailTV, and (3) lightning.

3.2.1.2. Station recruitment

For every comfort enhancement measure, multiple railway stations can be used to distribute the RP questionnaire. However, not every railway station is suited. Limitations maybe present that would introduce a biases in the respondents answers (e.g. construction work, implementation was too long ago, etc.).

The measure of *green and planters* can be found a large number of railway stations in the Netherlands. Depending on the definition, the measure can include the use of only a single planter, or it can be scaled up to the use of prominent planters. The latter definition is used. Only those railway stations are selected on which a prominent green piece is implemented. In Figure 3-3 the trends of *waiting time experience* (WACH), *attractivity* (SFEE), and *safety* (VEIL) at Almelo (A), Amsterdam Muiderpoort (M), and Deventer (D) station are presented. NS Stations expects that these three customer needs are influenced by the implemented measure (as listed in Appendix B). As presented in Table 3-2, it is unknown when de measure of *green and planters* was implemented at Deventer station. However, this is before the use of the SBM questionnaire, any change related to *green and planters* is not visible in the SBM data. Amsterdam Muiderpoort is defined as a typology 5 railway station. A typology 5 station, is a railway station in the suburbs without a node function, and is primarily used in rush hour. Therefore, Amsterdam Muiderpoort is only surveyed once per year. Resulting in two observations in the SBM database. The decrease in *waiting time experience* in 1 Q 2015 (see Figure 3-3) might be related to the bad weather conditions. One of statements related to this theme is how travellers experience the protection against the weather. During the survey in 1 Q 2015 the weather was ranked with a 3,67 (n=189). This strongly indicates the conditions of bad weather during the SBM survey. The last railway station is Almelo station. In 4 Q 2013, one of the walls of the waiting area was redecorated with a 'living wall' (see Figure 3-1). ProRail uses Almelo station as an example of what the measure of green and planters can look like. The SBM data shows an increase of all three NS themes between the period of 1 Q 2014 and 3 Q 2014, which might be caused by the implementation of this measure. Provided by these indications, Almelo station is recruited to be included in the RP questionnaire.

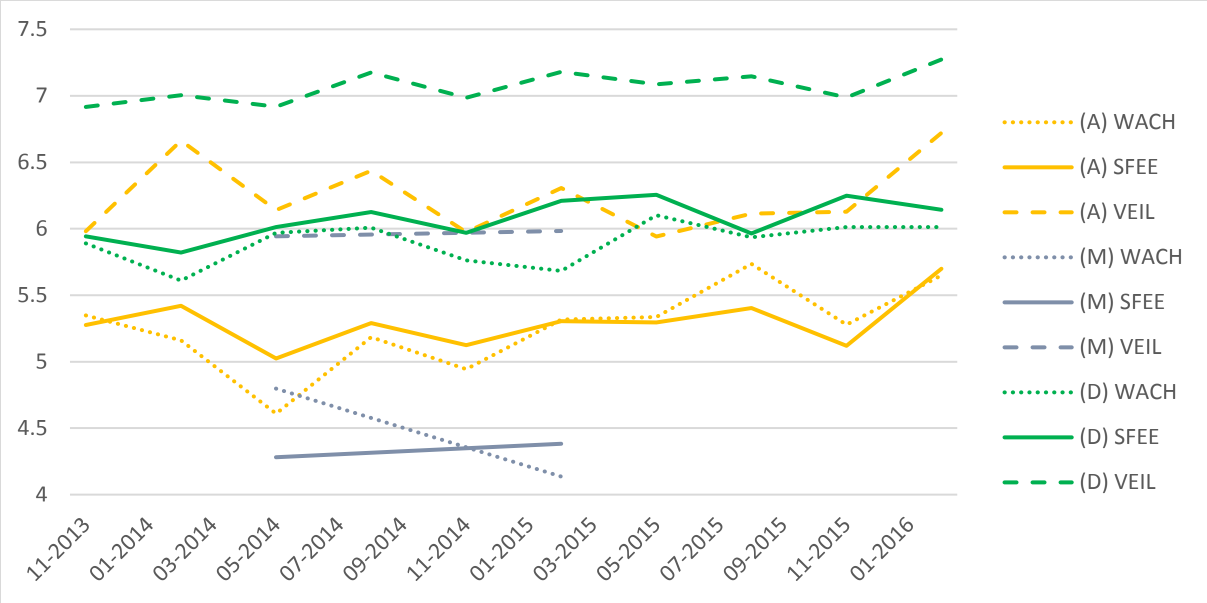


FIGURE 3-3, ASSESSMENT OF WAITING TIME EXPERIENCE, ATTRACTIVITY, AND SAFETY AT ALMELO, MUIDERPOORT AND DEVENTER STATION OVER TIME.

The second recruited measure is RailTV, see Figure 3-1. RailTV is a digital screen that provides infotainment to interested waiting travellers. RailTV informs travellers with useful information about topics i.e. construction works, expected hindrance, and cultural information. The themes expected to be affected by the measure are: (1) *attractivity* (SFEE), (2) *inviting* (UITN), and (3) *waiting time experience* (WACH). The first implementation of the measure was at Eindhoven (E) station, a few months later RailTV was enrolled at 's-Hertogenbosch (B) and Utrecht (U) station, later on Zwolle (Z) received this measure. In Figure 3-4 the assessment of each relevant customer need is presented over time. It can be noticed that the assessments of *invitingness* (UITN) are almost equal to all four stations. This is common for most railway stations of this typology (typology 1 and 2). The largest improvement can be found in the attractivity of Zwolle. In 2 Q 2015 the new passenger tunnel in Zwolle opened, which most likely the caused the major increase in attractivity (and waiting time experience). Because a reconstruction might affect the perceived change (e.g. external factors), the direct impact related to RailTV becomes more difficult to identify. This is also true for Utrecht CS. In early 2011, renovation started of the station building. Due to the constant strain of construction work, the assessment of the station could influenced by external factors (e.g. changing walk paths, noise etc.). Therefore the effects of RailTV at Utrecht CS might be biased by the reconstruction. For both Eindhoven CS and 's-Hertogenbosch the implementation of RailTV was just before the use of the SBM questionnaire, this results in the fact that the initial effects are not be captured and included in the database. The data for both railways stations do not provide specific changes that support the recruitment of the stations. In the development agenda of the province of North-Brabant, Eindhoven CS is categorized as 'international node'. As international node, Eindhoven CS applies for increased attention in policy development. Furthermore, Eindhoven CS is used as example on how RailTV can be used to enhance the customer satisfaction, combined with practical and cultural information. Based on the latter two reasons, Eindhoven CS is recruited to be included in the revealed preference questionnaire.

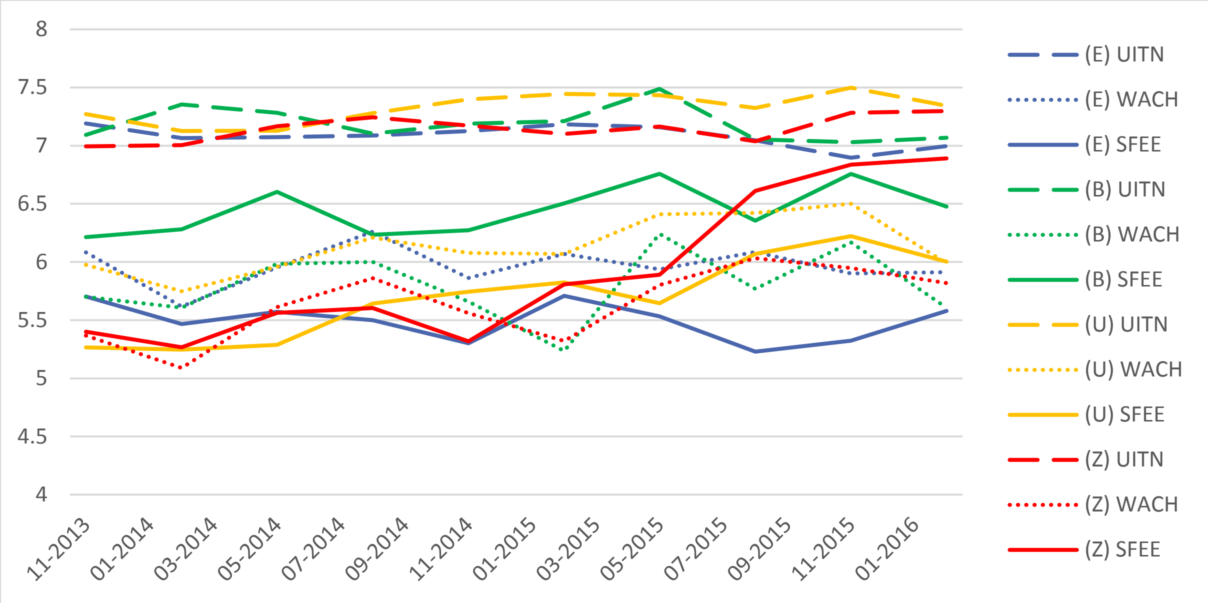


Figure 3-4, Assessment of invitingness, waiting time experience, and attractivity at Eindhoven CS, s-Hertogenbosch CS, Utrecht CS and Zwolle station over time.

The last measure to be surveyed is *lightning*. As stated by NS Stations the measure of *lighting* is expected to improve the NS needs: (1) *inviting* (UINT), (2) *attractivity* (SFEE), (3) *safety* (VEIL), and (4) *cleanliness* (SCHO). Three railway stations have been found at which the measure of *lightning* was used as comfort enhancement measure. Arnhem Station was completely reconstructed and reopened in the last quarter of 2015. At Arnhem, lighting is combined with a modernistic architecture which resulted in a large improvement in *attractivity*, as can be seen in Figure 3-5. The large change in overall station assessment is most likely caused by more than one comfort enhancement measure. The effects of lightning are therefore difficult to determine at Arnhem station. The measure of *lighting* was also used in Zwolle (as is the measure of RailTV). Part of the design of the new passenger tunnel of Zwolle, are coloured lighting fixtures. Looking at the customer needs *safety* (which is related to the statement of 'experience of lightning'), a positive change can be noticed in the data (same is true for Arnhem). However, other factors (e.g. the reconstruction) could have caused this improvement. Helmond station is also one of the many (large) railway stations that have been reconstructed in the Netherlands. Part of the reconstruction was the station environment. In the new design, station and station environment are seamlessly integrated. Included in this integration is the measure of *lightning*. However, due to the relative low number of passengers, the station of Helmond is only surveyed once per year, resulting in two measurements in the SBM database. Interestingly are the initial high assessments of all four relevant NS themes (see Figure 3-5). One year later, the assessments of two of the four NS themes (*cleanliness* and *attractivity*) changed negatively, while *safety* and *invitingness* are experienced equally. Furthermore, the Province of North-Brabant stated that the redevelopment of Helmond station and the station environment are part of their policy agenda. This importance in policy, combined with the, unexpected, large negative decrease in assessment of two NS themes resulted in the recruitment of Helmond for the RP questionnaire.

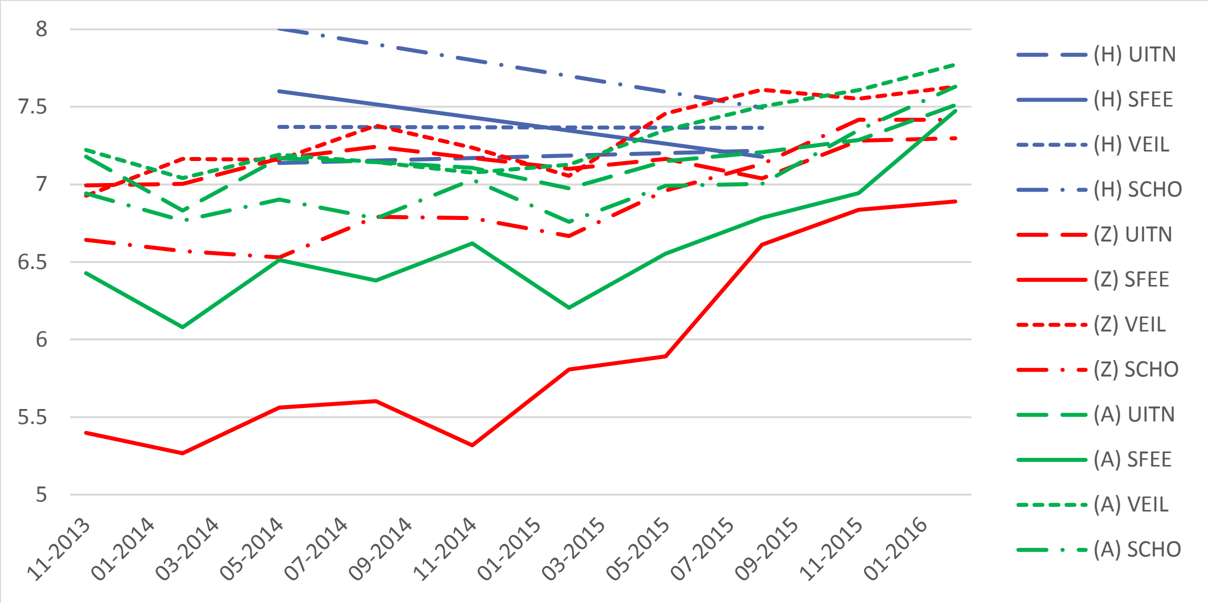


FIGURE 3-5, ASSESSMENT OF INVITINGNESS, ATTRACTIVITY, SAFETY, AND CLEANLINESS AT HELMOND, ZWOLLE AND ARNHEM STATION OVER TIME.

To conclude, of the nine railway stations only three stations will be included the RP questionnaire, each focussing on a different comfort enhancement measure. For *green and planters*, Almelo station is surveyed. Eindhoven CS is surveyed for determine the effects of *RailTV*. Lastly, Helmond station will be surveyed for the effects of *lighting*. The recruitment of each station is either based on noticeable (positive and negative) changes in relevant customer needs and/or the importance of the railway station in the development agenda of the province of North-Brabant.

3.2.1.3. Survey design

The revealed preference questionnaire is designed as an online survey. Using the open source survey tool LimeSurvey (LimeSurvey Project Team & Schmitz, 2015) the online questionnaire was created. LimeSurvey included an responsive web design, making the survey accessible for mobile devices as well as desktop computers. By using routing, one survey is used for the all three railway stations. A complete printout of the revealed preference questionnaire (in Dutch) can be found in Appendix C.

When the respondent has entered the URL, (s)he is welcomed and receives a short introduction about the intentions of the survey. The next page askes the respondent at which railway station they're asked to participate in the survey. Secondly, the respondent is asked to report the date at which they received the invitation. This information (station and date) will be used in to specify the questions and statements to come. First, the respondent is ask to state their current experience. Therefore, the respondents has to state their own trip characteristic: trip frequency, trip purpose, access mode, ticket type, car availability, and car as alternative mode of transport. Secondly, the respondent receives the exact same statements as used in the *Stationsbelevingsmonitor*. Using the exact same statements ensures the comparison between SBM and RP databases.

After reporting their current station experience, the respondent continues to define their changed experience based on one comfort enhancement measures. Because every traveller might notices a different measure, the respondent is asked which measure (s)he has noticed. Five options of comfort enhancement measures and a ‘other’ option are provided. The option list is static, and does not change based on the station reported by the respondent. It might be the case that some measures are not present at some railway stations, but are chosen. Once the explicitly noticed measure has been selected, the respondent is asked to report their experienced change in *overall station assessment*, *ridership*, and the five customer needs based on the selected comfort enhancement measure. The experienced change is reported on a 5-level Likert item, ranging from *largely worsened* to *largely improved*.

Once the effects of the explicit measure have been reported, the respondent is asked to rank eight (NS) themes in order of their personal importance. The order by which the themes are presented is random, to avoid a bias in initial assessment. The ranking will be used to point out the fields of improvement for future improvements (e.g. by comfort enhancement measures).

The previous questions could be answered by every respondent, independent of the first time the respondent has used the railway station. The following questions in this section of the survey can only be answered if the respondent has been using the railway station since 2013 or earlier. This is because the following questions and statements focus on one of the three comfort enhancement measures. First, the respondent is asked to report in which year (s)he first used the surveyed railway station. If this they stated 2014, 2015 or 2016 they are taken to the next section of questions. If respondents reported the year 2013 or any year before 2013, the respondent receives four or more follow-up questions. Secondly, the respondent is asked to state their average travel frequency, most common trip purpose and access mode in 2013. If the travel frequency and/or trip purpose has changed between 2016 and 2013 seven statements are presented to find you why the trip frequency of purpose has changed. Each statement could be answered on a 5-level Liker item (*completely disagree* to *completely agree*, and a *not applicable* option).

Once the respondent has mentioned their average trip characteristics of 2013, they continue to the implicit comfort enhancement measure. Based on the station selected in the first section of the survey, the correct measure is presented to the respondent (green and planters for Almelo, RailTV for Eindhoven, and lightning for Helmond). If the respondent has noticed the implicit measure as explicit measure, this question is skipped. As for the explicit measure, the same seven statements are used to define the change experienced by the respondent (overall station assessment, ridership, five customer needs). Respondents at Helmond station are asked to answer one more array of statements relating to the reconstruction of the station environment. These statements are used to underpin the statement made by the province of North-Brabant concerning the effects of the reconstruction.

Once the changed experience related to explicit and implicitly noticed comfort enhancement measures has been reported the respondent continues to the final section: personal characteristics. In this section five personal characteristics are asked: (1) age, (2) gender, (3) assessment of the weather, (4) level of education, and (5) employment status. To avoid early drop-outs of respondents (e.g. if they don’t want to provide personal information), this section is located at the end of the survey. Once completed, the respondent is redirected to the thank you page.

3.2.1.4. Respondent and survey distribution

To have a representative sample size, the number of respondents of each comfort enhancement measure should be between 150 and 300 respondents. This large variation is narrowed down based on the number of respondents for each survey in the SBM database. In Table 3-3 the expected number of respondents for each railway station are presented. These numbers originate from the SBM database. For Helmond and Almelo station, the maximum number of respondents of the available SBM data are used. In the case of Eindhoven CS, the average number of respondents has been selected.

TABLE 3-3, EXPECTED AND REALISED NUMBER OF RESPONDENTS FOR EACH RAILWAY STATION.

Station name	Comfort enhancement measure	Station number	Expected number of respondents	Respondents with completed survey
Eindhoven CS	RailTV	390	250 respondents	276 respondents
Helmond CS	(façade) lightning	391	180 respondents	173 respondents
Almelo	Green and planters	96	180 respondents	163 respondents

Personal and trip characteristics like age, gender, and travel purpose should be consistent with the distribution of the population. If the distribution of the RP questionnaire deviates too much compared to the distribution presented in the SBM the results of the questionnaires must be balanced. In Table 3-4 the respondents' distribution of the SBM database for the three railway stations (average of Almelo, Eindhoven CS, and Helmond) are presented (see label 'SBM'). In the same table, the respondents' distribution resulting from the RP questionnaire is presented. As can be seen, some difference in distribution are presented. However, no weights are added to the (personal and trip) characteristics. Adding weights, will also introduce unwanted errors. With the errors resulting from the to be performed factor analyses (see Analytical framework), biases might be introduced in the model estimations. To minimise the introduction of errors, the RP sample will not be weighted and is used directly in the model estimation.

TABLE 3-4, RESPONDENTS' DISTRIBUTION OF SBM AND RP DATABASES.

Age	0-20 y/o	21-30 y/o	31-60 y/o	61+ y/o	N
SBM	39%	32%	24%	6%	5992
RP	34%	34%	25%	7%	619
Gender	**Male**		**Female**		**N**
SBM	42%		58%		5968
RP	50%		50%		619
Travel frequency	**4 or more days a week**	**1-3 days a week**	**1-3 days a month**	**Other**	**N**
SBM	54%	22%	10%	14%	5774
RP	51%	24%	9%	17%	710
Travel purpose	**Work**	**Study/School**		**Other**	**N**
SBM	31%	41%		29%	5605
RP	34%	47%		19%	710

To distribute the survey, travellers waiting on the station platform where addressed to participate in a survey about the topic of comfort enhancement at the railway station. If the respondent stated that (s)he is willing to participate, the respondent was giving a leaflet with an URL and QR-code that redirects to the online survey, see Figure 3-6. Alternatively, respondents could provide their e-mail address and receive an e-mail with a personal invitation to the survey. In total 2 000 leaflets are distributed (the number of travellers agreeing to participate), of which 750 respondents started the survey. Eventually, 612 respondents did complete the survey (response rate of 30.6%). In Table 3-3, the number of respondents (which have completed the survey) per railway station are presented (see label "RP").


UNIVERSITEIT TWENTE.

Onderzoek naar de wachtbeleving op NS stations

Voor mijn afstudeeronderzoek aan de **Universiteit Twente** ben ik geïnteresseerd in uw reisfrequentie en uw wachtbeleving op dit station. De Nederlandse Spoorwegen en ProRail zijn bezig om het wachten op stations prettiger te maken. Het prettig wachten wordt onder andere gerealiseerd door veraangenamingsmaatregelen. Een aantal van deze maatregelen zijn te vinden op dit station.

Het invullen van deze enquête duurt ca. **7 tot 10 minuten** en bestaat uit 2 delen: (1) uw huidige stationsbeleving en (2) uw veranderde stationsbeleving. Deelnemers kunnen door het invullen van deze vragenlijst kans maken op een **VVV waardebon t.w.v. €25,-!**

Deelnemen aan deze enquête? Ga naar **bit.ly/veraangenamen** of scan de QR-code. Wilt u de enquête op een later moment invullen? Vul dan hier uw e-mailadres in en u ontvangt een uitnodiging per e-mail:

FIGURE 3-6, EXAMPLE OF A6 FLYER DISTRIBUTED TO TRAVELLERS.

Initially every railway station is surveyed over a period of two consecutive days between 07:00 and 17:00. However the first results showed an over representation of students (and thus from / to school related trips). To achieve the desired respondent distribution as presented in Table 3-4, two steps are taken. Firstly, Eindhoven is surveyed two more times during the evening rush hour (16:00 – 18:00), and the planned surveys of Almelo station are rescheduled to 08:00 – 18:00. Secondly, not every waiting traveller at the station platform is asked to participate. Seemingly young travellers are ignored, and middle age travellers are selected.

3.3. Descriptive statistics

In this section, the descriptive statistics of both the *Stationsbelevingsmonitor* and *RP questionnaire* are presented. The descriptive statistics will be used as guidelines to check which explanatory variables might be of importance for the model estimation in chapter 4. Furthermore, the statistics will provide insights on how the different types of travellers perceived certain aspects of comfort enhancement measures.

3.3.1. Stationsbelevingsmonitor

3.3.1.1. Socio-economic characteristics

The large SBM database, with over 227.000 entries is ideal to determine the significance of socio-economic characterises relating to the *overall station assessment*. Age, gender, and trip purpose are tested using with an independent t-test with a 95% confidence interval (CI). To graph the sample population of the SBM a population pyramid is used, see Figure 3-7. When compared to the population pyramid of the Netherlands, the SBM sample has an over representation of youth / middle age people. Furthermore, the share of female respondents (55.1%) in the SBM is higher to the Dutch population (49.6%, 1-1-2016).

Using the SBM data, the following hypotheses is tested, to test if *male* and *female* respondents have the same (average) overall station assessment.

H_0 : The *overall station assessment* between *male* and *female* respondents **are equal**.
H_1 : The *overall station assessment* between *male* and *female* respondents **are not equal**.

The independent t-test the analysis found that male respondents assess the station quality significantly higher (6.71 ± 1.378) compared to female respondents (6.67 ± 1,388), t(214 849)= 6.367, p = 0.000[1]. Therefore we need must assume H_1 is true for the complete SBM database.

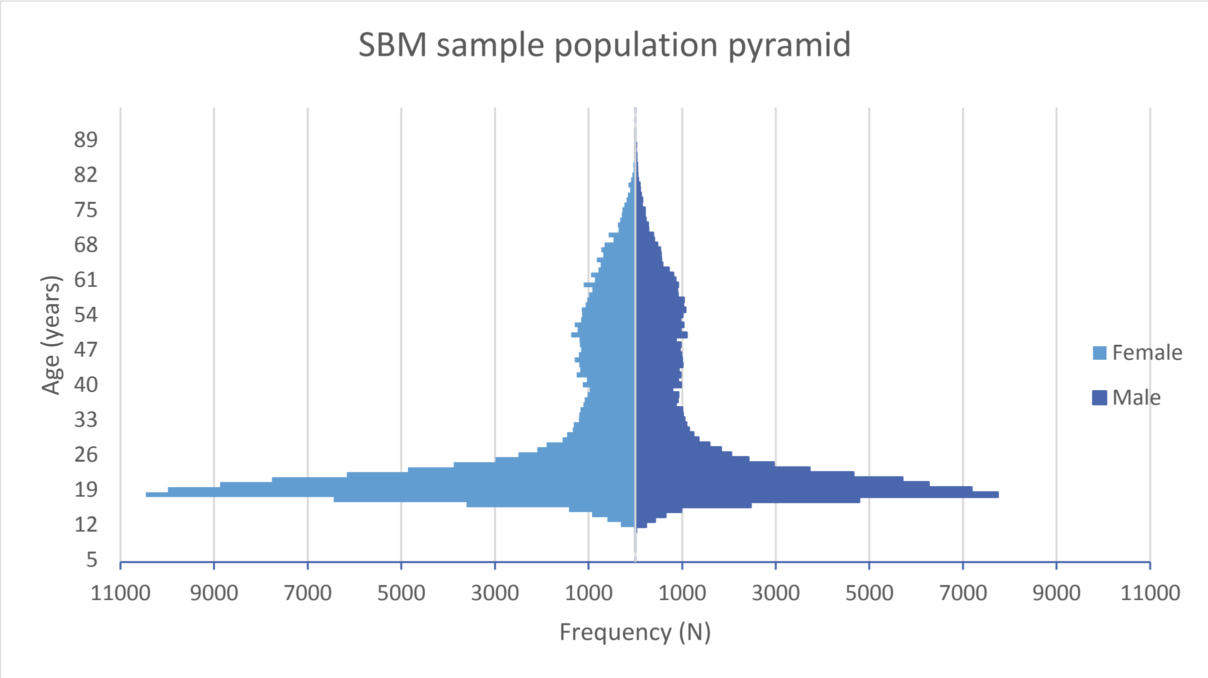


FIGURE 3-7, POPULATION PYRAMID SBM SAMPLE.

Besides gender, age (categories) might also result in different *overall station assessment*. Each consecutive age category is tested, using the independent t-test and follows the following hypotheses:

$H_{0\text{-}1}$: The *overall station assessment* between 11-20 y/o and 21-30 y/o respondents **are equal**.
$H_{0\text{-}2}$: The *overall station assessment* between 21-30 y/o and 31-40 y/o respondents **are equal**.
$H_{0\text{-}3}$: The *overall station assessment* between 31-40 y/o and 41-50 y/o respondents **are equal**.
$H_{0\text{-}4}$: The *overall station assessment* between 41-50 y/o and 51-60 y/o respondents **are equal**.
$H_{0\text{-}5}$: The *overall station assessment* between 51-60 y/o and 61-70 y/o respondents **are equal**.
$H_{0\text{-}6}$: The *overall station assessment* between 61-70 y/o and 71-80 y/o respondents **are equal**.
$H_{0\text{-}7}$: The *overall station assessment* between 71-80 y/o and 81-90 y/o respondents **are equal**.
H_1 : The *overall station assessment* between the age categories **are not equal**.

The results of the multiple independent t-tests are as follows: Respondents who are between 11 and 20 y/o (6.85 ± 1.262) prove a higher overall station assessment compared to 21-30 y/o respondents (6.68 ± 1.333), t(134 642) = 24.488, p = 0.000[1]. Therefore $H_{0\text{-}1}$ must be rejected. Next are the 21-30 y/o compared to the 31-40 y/o. Again, the younger (6.68 ± 1.333) age category rates the *overall station assessment* higher compared to the older generation (6.53 ± 1.465), with t(83 133) = 13.611, p = 0.000[1], resulting in rejecting $H_{0\text{-}2}$ and accepting H_1. Comparing respondents between the age of 31-40 y/o (6.53 ± 1.465) and 41-50 y/o (6.5 ± 1.505) the average *overall station assessment* is not statistically different resulting in accepting $H_{0\text{-}3}$, with t(42 494) = 1.604 and p = 0.109. The independent t-test between 41-50 y/o respondents (6.5 ± 1.505) and 51-60 y/o respondents (6.5 ± 1.515) resulted in a high significance score, meaning that both age categories rank the *overall station assessment* equally high. Here,

[1] SPSS rounds numbers during printing, a p value of 0.000 means that p is less than 0.0005. (IBM Support, 2010)

t(41765.9) = -0.089 and p = 0.929. Therefore respondents between 31 and 60 y/o can be seen as one category, ranking the *overall station assessment* on a same level. At this point a change can be seen, until now each age category is more critical in ranking the *overall station assessment*. For respondents between 51-60 y/o (6.5 ± 1,515) and 61-70 y/o (6.66 ± 1.520), the means are statically not different with t(27 017.8) = -8.913, p = 0,000. It can be seen that 61-70 y/o are more generous in raking the *overall station assessment*. This more generous ranking is also noticeable between the respondents 61-70 y/o (6.66 ± 1,520) and 71-80 y/o (6.82 ± 1,544). Here, also the means are statistically equal with t(6 701,8) = -5.738, p = 0.000. The final age categories to be compared are 71-80 y/o (6.82 ± 1.544) and 81-90 y/o (6.90 ± 1,7) are statistically not different, and thus do not assess the station quality statically higher or lower. The independent t-test resulted in t(656) = -1.112 and p = 0.266.

By comparing the mean assessment of each age category a distinction between age categories can be determined. Based on the average *overall station assessment* the age categories are labelled accordingly. What can be noticed from the independent t-test mentioned above, shift of the average assessment over once life. Young travellers, who seem to enjoy the train trip, rank the station quality relative high. Once travellers get older, they also get more critical towards the station quality. The most critical travellers are the commuters, presented in Table 3-5. They rank the *overall station assessment* the lowest compared to all other ages. Once people retire (somewhere between the age of 61 and 70) they seem to enjoy the train trip more. Because this age category includes the 'baby boomer' generation, the category has been labelled as the 'enjoyable baby boomers'. The last group in age categories are the relaxed elderly. Of all age categories, they have the highest *overall station assessment*.

TABLE 3-5, CATEGORIZED AGE CATEGORIES BASED ON INDEPENDENT T-TEST.

Age category	Category label
11-20 y/o	'Easy' youngsters
21-30 y/o	'Average' students
31-40 y/o	'Critical' commuters
41-50 y/o	
51-60 y/o	
61-70 y/o	'Enjoyable' baby boomers
71-80 y/o	'Relaxing' elderly
81-90 y/o	

When the average *overall station assessment* per age category is plotted, the results of the independent t-test is visualized (Figure 3-9). As mentioned above, younger travellers perceive the station quality higher compared to middle-age travellers. When travellers get older (60 year or older), their *overall station assessment* will most likely increase as well.

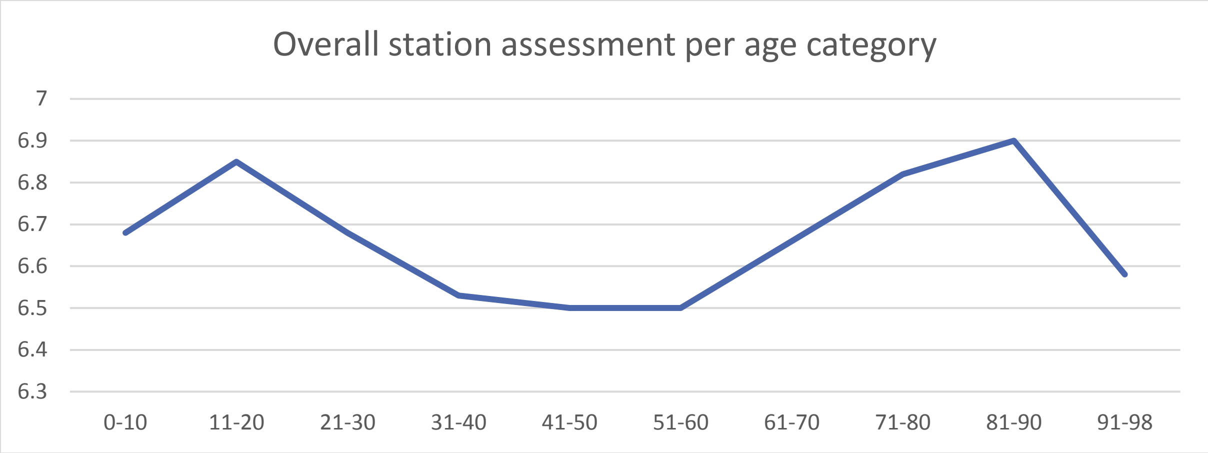


FIGURE 3-8, AVERAGE OVERALL STATION ASSESSMENT PER AGE CATEGORY (SBM DATABASE).

The final socio-economic characteristic that is tested is trip purpose. Of all available trip purposes, only the relevant combinations of trip purposes are tested i.e. *from / to work* with *from / to school* trips, or *holiday / outing / day trip* with *shopping* trips.

First are the two most important trip purposes: *from / to work* and *from / to school/study/education*. The following hypotheses are used:

$H_{0\text{-}1}$: The *overall station assessment* of travellers with trip purpose *from / to work* and *from /to school* **are equal**.
$H_{1\text{-}1}$: The *overall station assessment* of travellers with trip purpose *from / to work* and *from /to school* **are not equal**.

The independent t-test found that travellers *from / to work* (6.54 ± 1.439) rank the *overall station assessment* lower compared to students (*from / to school/study/education*, 6.79 ± 1.254), with t(141 348) = -340 732 and p = 0.000[1]. This means that the means are statically different and $H_{0\text{-}1}$ must be rejected. The difference in *overall station assessment* is in line with the findings of *overall station assessment* and *age* (category), where the difference between age categories can be related to the trip purpose; students usually between 16 and 25 y/o and commuters between the age of 25 and 60 y/o.

When *from / to work* trips and *business* trips are compared, the expectation tends to believe that both means are equal (significantly not different), the following hypotheses are used:

$H_{0\text{-}2}$: The *overall station assessment* of travellers with trip purpose *from / to work* and *business* trips **are equal**.
$H_{1\text{-}2}$: The *overall station assessment* of travellers with trip purpose *from / to work* and *business* trips **are not equal**.

Although the sample size of *business* trips (N=11 294) is much smaller compared to the *from / to work* trips (N=64 707) the means are almost the same: *from / to work* (6.54 ± 1,439) marginally ranks the *overall station assessment* lower compared to *business* trips (6.56 ± 1,434). The independent t-test resulted in t(155 526.566) = -1.681 and p = 0.093. Therefore $H_{0\text{-}2}$ can be accepted. This hypotheses can be supported by the fact that both trip purposes are related to work, which in general will rank the *overall station assessment* more critically.

Looking at the more recreational trip purposes: visit family / friends, go shopping, going to your hobby / sport, or going to holiday, the *overall station assessment* will most likely be ranked higher compared to work related trips. There might even be a difference among these recreational trips. The largest (highest frequency) recreational trip purposes are *visiting family / friends / hospital visit* and *holiday / outing / day trip*. For these trip purposes the following hypotheses are composed:

$H_{0\text{-}3}$: The *overall station assessment* of travellers with trip purpose *visit family / friends / hospital visits* and *holiday / outing / day trip* trips **are equal**.
$H_{1\text{-}3}$: The *overall station assessment* of travellers with trip purpose *visit family / friends / hospital visits* and *holiday / outing / day trip* trips **are not equal**.

The independent t-test resulted in the following statistical analysis. Travellers *visiting family / friends / hospital (visit)* rank the *overall station assessment* lower (6.71 ± 1.468) compared to travellers who are going on *holiday / outing / day trip* (6.83 ± 1.413), with t(29 199) = -6.729 and p = 0.000[1]. This difference might be exampled by the fact that visiting family or friends might somethings not be a positive visit, while going on holiday is almost always positive. This positive mind (which might be caused by the trip purpose) introduces a bias to the travellers ranking of the *overall station assessment*.

Another trip purpose which also contributes to a positive mood is *shopping*. It is expected that the trip purposes *holiday / outing / day trip* compared to *shopping* result in an equal *overall station assessment*. The following hypotheses are used:

$H_{0\text{-}4}$: The *overall station assessment* of travellers with trip purpose *holiday / outing / day trip* and *shopping* trips **are equal**.
$H_{1\text{-}4}$: The *overall station assessment* of travellers with trip purpose *holiday / outing / day trip* and *shopping* trips **are not equal**.

The independent t-test show that for *holiday / outing / day trip* (6.83 ± 1.413) the average *overall station assessment* is ranked higher compared to travellers who go *shopping* (6.77 ± 1.417). The independent t-test resulted in a t(14 310.572) = -2.801 and p = 0.005. Therefore the means of both trip purposes are significantly different and $H_{0\text{-}4}$ must be rejected, concluding that going on holiday or a day out positively affect the respondents mood and therefore their *overall station assessment*.

Both *shopping* (6.77 ± 1,417) and *visiting family / friends / hospital visit* (6.71 ± 1,468) might have a significantly equal means, although travellers who go shopping assess the station quality somewhat higher. To test this, the following hypotheses are determined:

$H_{0\text{-}5}$: The *overall station assessment* of travellers with trip purpose *visit family / friends / hospital visits* and *shopping* trips **are equal**.
$H_{1\text{-}5}$: The *overall station assessment* of travellers with trip purpose *visit family / friends / hospital visits* and *shopping* trips **are not equal**.

With t(24 502) = 2.702 and p = 0.007 the hypothesis $H_{0\text{-}5}$ must be rejected and the alternative hypothesis of $H_{1\text{-}5}$ is accepted. Therefore, both trip purposes rank the *overall station assessment* statistically different.

The last trip purposes to be compared are *shopping* and *hobby / sport*. Both are leisure related trips. Again the hypotheses assume the means to be equal.

$H_{0\text{-}6}$: The *overall station assessment* of travellers with trip purpose *hobby /sport* and *shopping* trips **are equal**.
$H_{1\text{-}6}$: The *overall station assessment* of travellers with trip purpose *hobby /sport* and *shopping* trips **are not equal**.

The independent t-test resulted in t(8 786) = 0.370 and p = 0.712. This means that the first hypothesis ($H_{0\text{-}6}$) is accepted and that travellers taking the train for hobby / sports (6.76 ± 1.41) or shopping (6.77 ± 1.417) rank the *overall station assessment* equal.

3.3.1.2. Trip characteristics

Using the *Stationsbelevingsmonitor* the different trip characteristics of train travellers can be determined. Age is an important factor in the changing trip characteristics of these travellers. In the upcoming figures *trip purpose, trip frequency, access mode,* and *overall station assessment* are presented for each *age category* and *overall station assessment*.

The trip purpose might be influence to the *overall station assessment* of travellers. For example, it could be that commuters (e.g. work/business related) are more critical in assessing the station, comparted to travellers that go shopping. The SBM differentiates in 9 trip purposes: (1) from / to work, (2) business trip, (3) from / to school / study / education, (4) visit family / friends / hospital visit, (5) shopping, (6) holiday / outing / day trip, (7) sport / hobby, (8) I did not travel by train, and (9) other. Interesting, is the 'I did not travel by train' option (8). It could be the case that respondents are waiving someone goodbye, and still are asked to state their station experience. However, as can be seen in Figure 3-9, this share is relatively small. It can be noticed from Figure 3-9 is the shift in trip purpose in relation to the progression people make in their lives. Young travellers (11-20 y/o) travel mostly for their study, when age increases the main trip purpose shifts to work/business trips (31-60 y/o) to more leisure related trip (61 y/o). When trip purpose is compared with the average *overall station assessment* (see Figure 3-10), it can be noticed that commuters have a lower *overall station assessment* compared to trips made to go to school. There is an significant difference in overall station assessment for commuters (6.54 ± 1.439) and travelling from/to study (6.79 ± 1.254) with t(141 348)=-34.732 and p = 0.000.

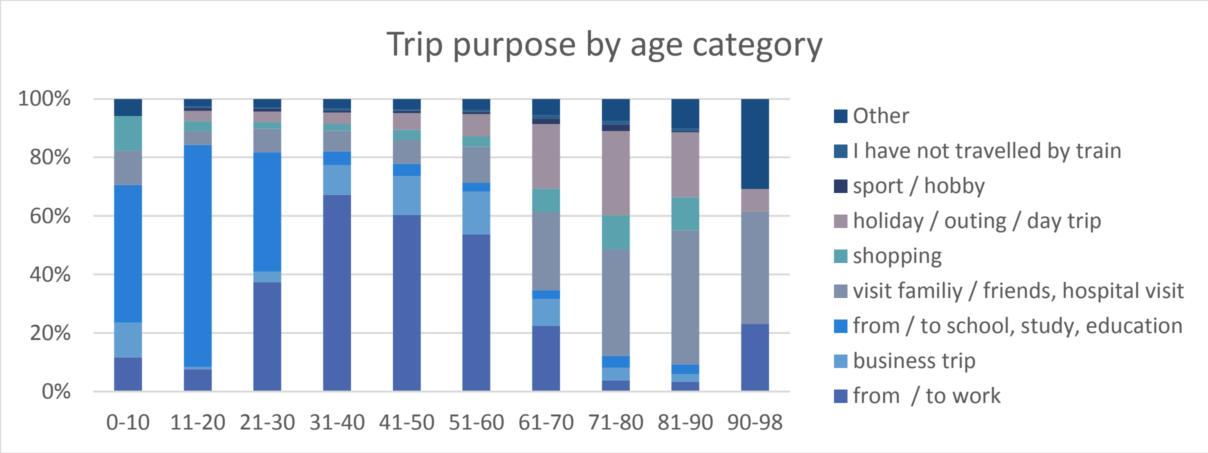


FIGURE 3-9, DISTRIBUTION OF TRIP PURPOSE BY AGE CATEGORY (SBM DATABASE).

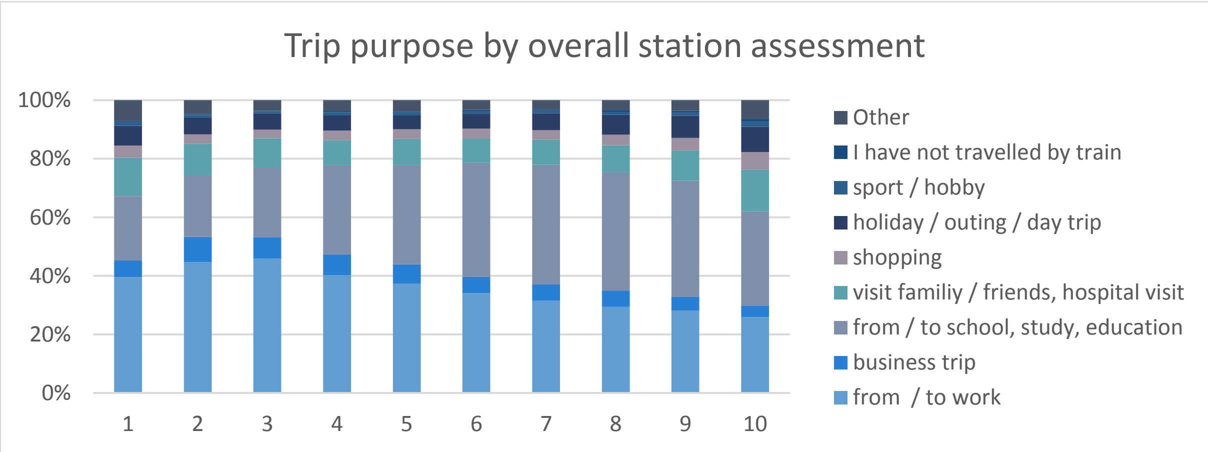


FIGURE 3-10, DISTRIBUTION OF TRIP PURPOSE BY OVERALL STATION ASSESSMENT (SBM DATABASE).

Besides trip purpose, the respondent is also asked to state their average trip frequency by train. On the national level, over 51% respondents stated that they travel at least 4 days or more per week by train. However, for individual railway stations this share fluctuates between 45% and 60%. No significant changes can be found in the share of “4 days a week or more” travellers between each consecutive quarter. In Figure 3-11, a decrease of travel frequency (ridership) can be seen when travellers get older. Respondents between the age of 11 and 20 year are the most frequent train travellers. Combined with the trip purpose (Figure 3-9), there is a strong indication that this age group are most likely students travelling every day between home and school. As age increases, the ridership decreases gradually. When ridership and trip purpose are combined, it is safe to assume that when people get older, they are most likely travelling less by train and more for leisure than for work. When ridership is set against *overall station assessment* (Figure 3-12), no noticeable changes can be reported. The data suggest that there is no difference in ridership between a respondent travelling e.g. 4 times a week or 7 days per year. However an independent t-test resulted in a significant change ($t(159\,779)=-4.357$, $p= 0.000$) in *overall all station assessment* and travel frequency between 4 days a week or more (6.66 ± 1.371) and 1 to 3 days a week (6.69 ± 1.353).

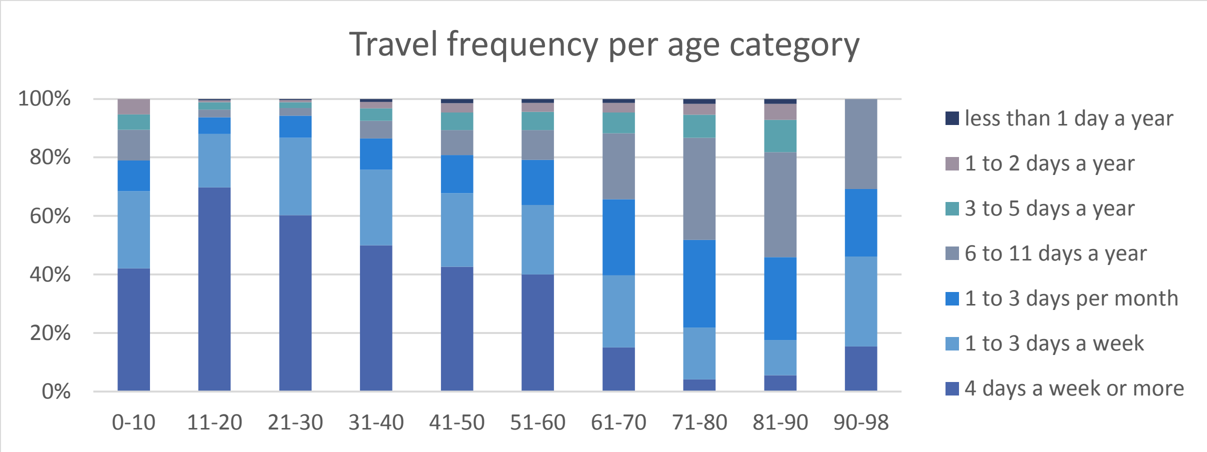


FIGURE 3-11, DISTRIBUTION OF TRAVEL FREQUENCY PER AGE CATEGORY (SBM DATABASE).

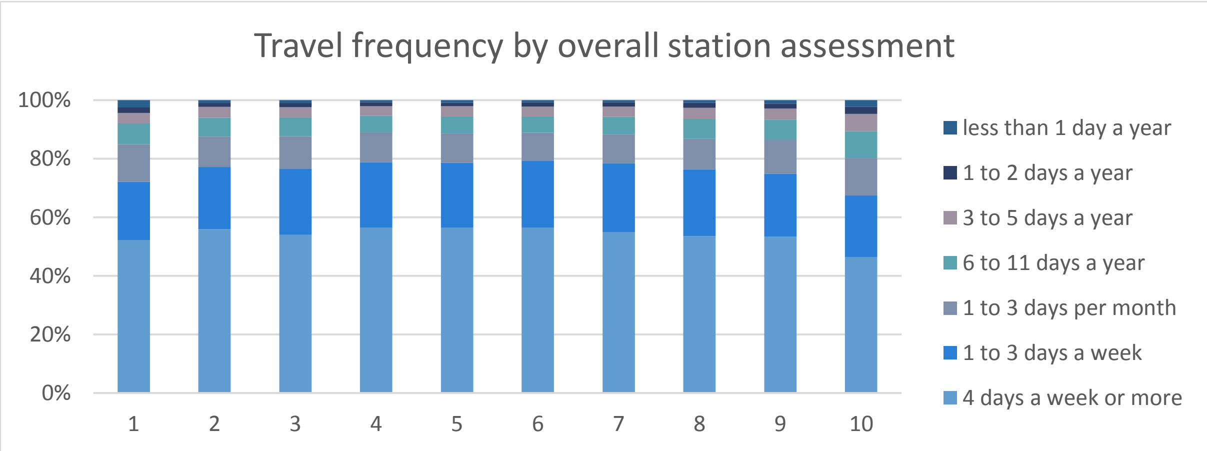


FIGURE 3-12, DISTRIBUTION OF TRAVEL FREQUENCY BY OVERALL STATION ASSESSMENT (SBM DATABASE).

Respondents of the SBM questionnaire are asked to report their access mode for their journey. A selection of eight options are provided: (1) by foot, (2) by bicycle/moped/scooter, (3) by car as driver, (4) by car as passenger, (5) by bus/tram/metro, (6) by train, (7) by taxi, and (8) other. Because the SBM focusses on the assessment of the railway station, the egress mode of the traveller is not included in the questionnaire. In Figure 3-13 the access mode per age category is presented. When travellers age, their mobility is affected. When age progresses, more travellers report to take the car (as driver) to the railway station. At the same time, less respondents take the bicycle / moped / scooter as access mode. If the used access mode is compared with *overall station assessment* relative small changes can be noticed. However, when the average overall station assessment between *walking* (6.64 ± 1.432) and *biking* (6.73 ± 1.353) are compared, a significant difference is found ($t(110\ 706)=-10.648$, $p = 0.000$), see Figure 3-14.

An important figure in the Netherlands is the use of the bicycle as access mode. The NS Group mentioned in their 2016 Annual Report (Nederlandse Spoorwegen, 2016) that over 40% of the passengers use the bicycle as access mode. The same percentage (nationwide) is mentioned by Fietsberaad (2016). Interestingly, the use of the bicycle as access mode largely dependents on the geographical location of the railway station. In the Randstad the bicycle alone is responsible for a 47% of all access modes (Stedenbaan, 2015). In the SBM the total use of bicycles as access mode (or moped/scooters) is 24.4%. The large difference might be caused by the difference in geographical location of the railway station. Within the Randstad large differences in the use of bicycle as access mode are noticed. Rotterdam Central station has a relatively low use of bicycles (10%), but a high usage of PT (60%, both bus/tram/metro and train). While the station of Delft has a bicycle share of over 40%. Over 24% of travellers arrive at Leiden Central station by bicycle (or moped / scooter), and 30% of travellers use Leiden Central as transfer station. The national share of 40% is based on the *klanttevredenheidsonderzoek* (KTO) of NS Reizigers. NS Reizigers is interested in the door-to-door trip, and therefore askes different questions in their KTO survey. This makes comparing the KTO and SBM results impossible.

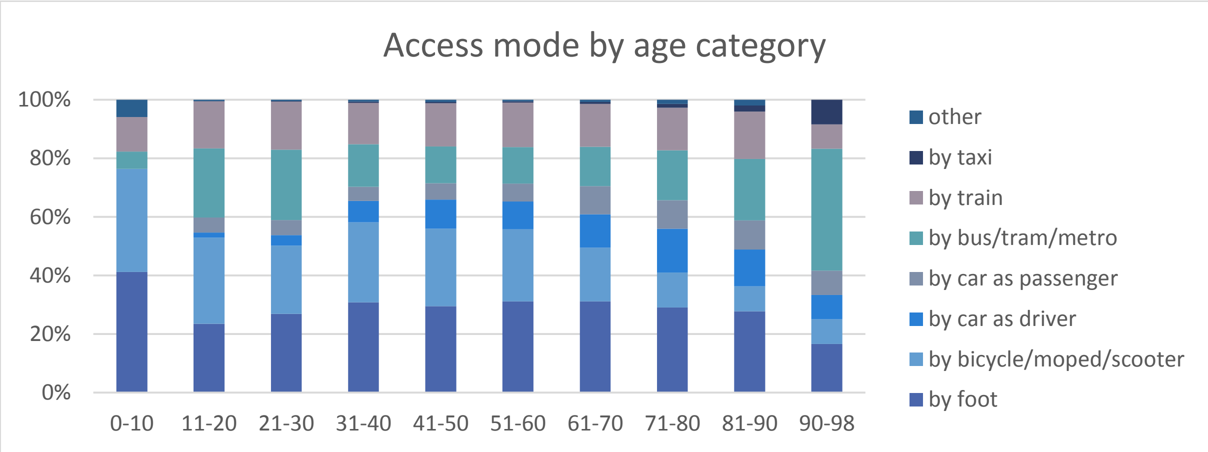


FIGURE 3-13, DISTRIBUTION OF ACCESS MODE BY AGE CATEGORY (SBM DATABASE).

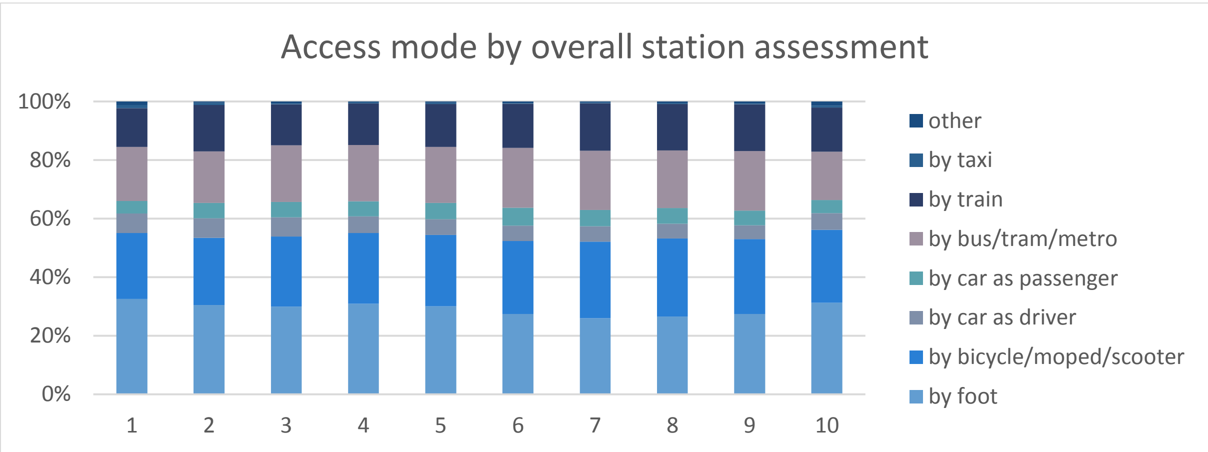


FIGURE 3-14, DISTRIBUTION OF ACCESS MODE BY OVERALL STATION ASSESSMENT (SBM DATABASE).

What is most interestingly of the SBM is the *overall station assessment* of each railway station in the Netherlands. As mentioned in the beginning of the report, the overall station assessment is the guideline for the customer satisfaction of a railway station. During this report, the average value of *overall station assessment* of each railway station is used to compare results. However, NS Stations (and NS Reizigers) use a different expression for comparing *overall station assessment*. In all NS reports the "percentage of respondents that value the railway station with a '7' or higher" is used. In Figure 3-15 both expressions of *overall station assessment* are presented. Over time (3 Q 2013 – 1 Q 2016), the customer satisfaction of all railway stations in the Netherlands gradually increased. Small (negative) changes in average overall station assessment are noticed in each first quarter of the year. It is assumed that during these months, a lower station assessment is reported by travellers due to the cold weather.

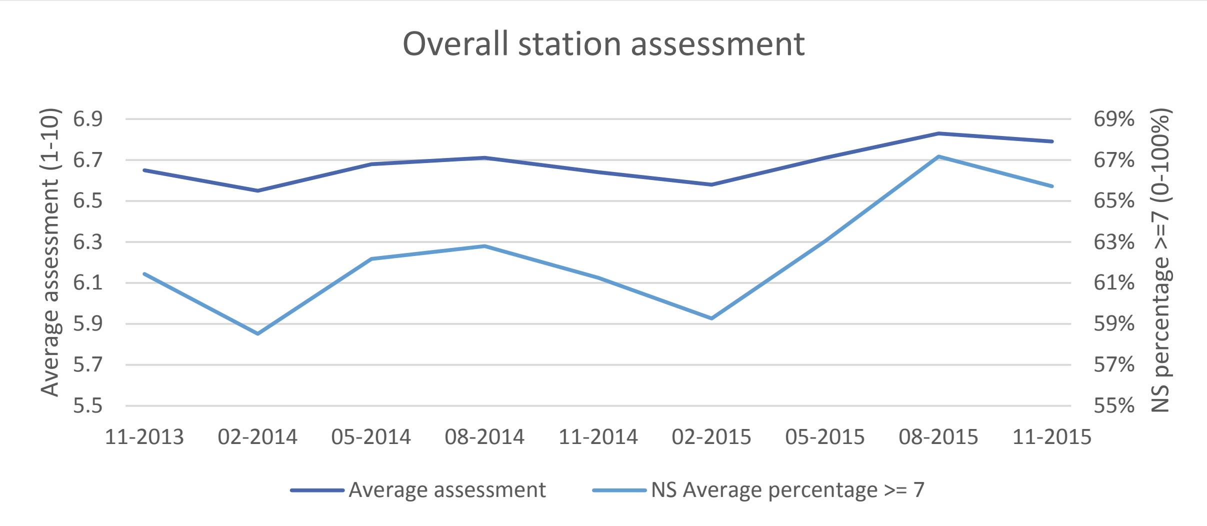


FIGURE 3-15, OVERALL STATION ASSESSMENT OVER TIME FOR ALL RAILWAY STATIONS (SBM DATABASE).

Overall station assessment might also depend on the size of the railway station, expressed as station typology. The Dutch Railways uses six typologies to categorize their railway station. A type 1 railway station is labelled as 'very large railway station in a large city', and type 6 as 'station in rural area of a small town' (Hagen & Exel, 2012). As can be seen in Figure 3-16, larger railway stations (typology 1 and 2) have an higher average *overall station assessment* compared to smaller railway stations. The difference between typologies 3 and 4 might be explained by the large difference in railway station associated with each typology. As the data suggest, it might be useful to invest in comfort enhancement measures at smaller railway stations, and do nothing at larger railway stations. However, around three quarters of all train travellers (1 Q 2016) use railway stations of typologies 1 or 2.

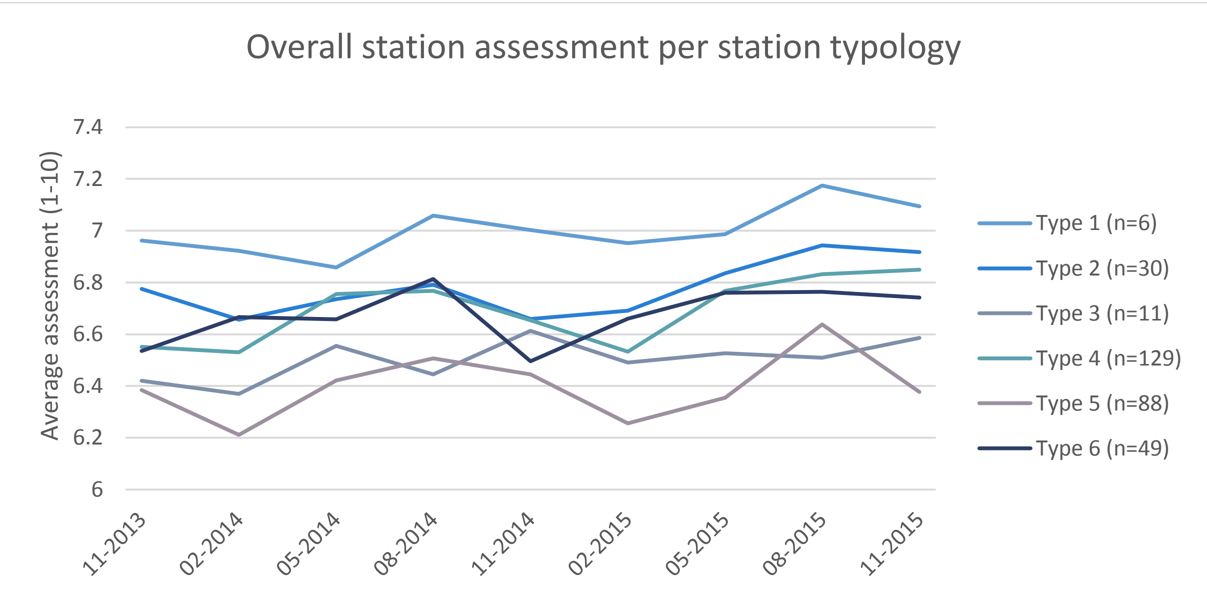


FIGURE 3-16, OVERALL STATION ASSESSMENT OVER TIME PER STATION TYPOLOGY.

3.3.2. RP questionnaire

The revealed preference questionnaire has been distributed to 2 000 respondents. Of these 2 000 respondents, 750 have started the online questionnaire. Eventually 612 respondents have completed the survey, resulting in a response rate of 30.6%. The descriptive statistics will be presented in the next two sections. First the socio-economic characteristics are presented. Secondly the trip characteristics of all respondents RP questionnaire are explained. Again, for each explanatory variable, the data is presented for each *age category* and *overall station assessment*.

3.3.2.1. Socio-economic characteristics

The distribution between male and female respondents in the RP database is: 49.76% male and 50.24% female. The age categories or the RP questionnaire are distributed as follows: 0-20 y/o is 33.93%, 21-30 y/o is 33.93%, 31-60 y/o is 24.88% and 61+ y/o is 7.27%. Comparing the RP questionnaire with the SBM database, there is a slight over representation of younger (0-30 y/o) travellers compared to the older (31+ y/o) travellers. While this is also true for male respondents. The RP sample has a 50/50 distribution, while the SBM database female respondents are represented with a 55% share.

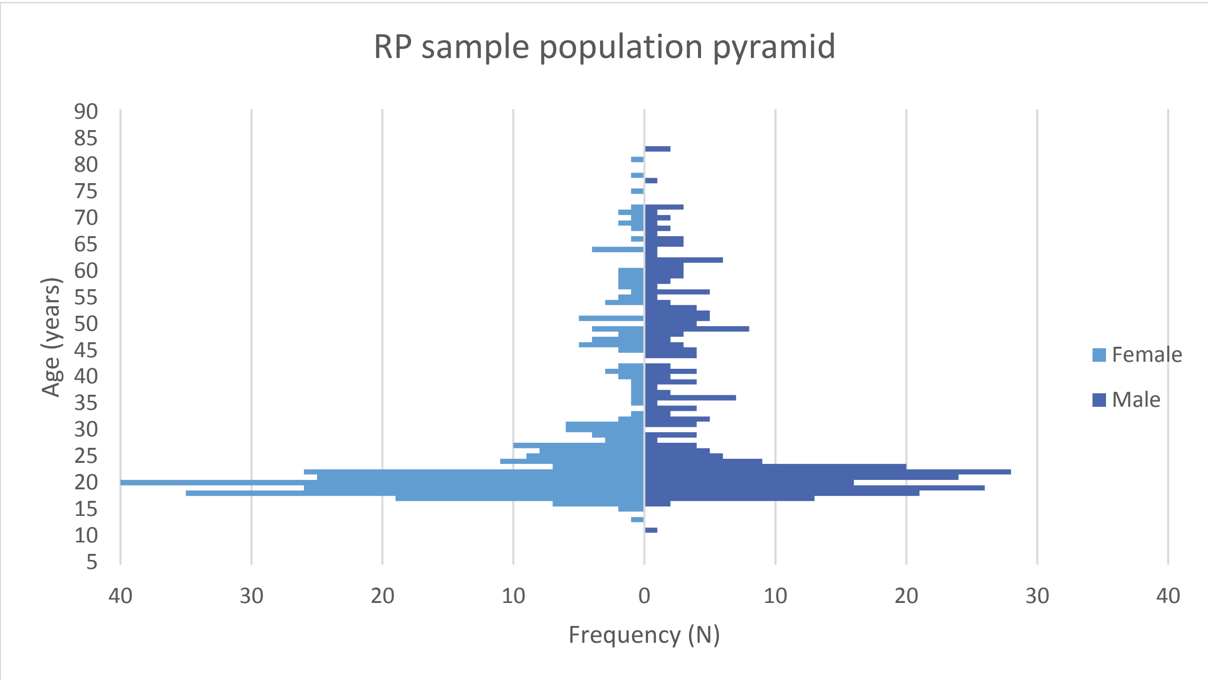


FIGURE 3-17, POPULATION PYRAMID SBM DATABASE.

3.3.2.2. Trip characteristics

As expected, the results of the RP questionnaire show similarities with the results found in the SBM database. However, due to the smaller sample size (n=612) overrepresentation of some variable categories are present. As presented in Figure 3-18, are the shares of each trip purpose for each age category as found in the RP database. For the respondents between 21 and 30 y/o, and overrepresentation is present compared to the SBM database (48% and 40% respectively). Furthermore, there is a slight underrepresentation of work/business related trips in the RP sample compared to the nationwide SBM sample (33% and 35% respectively).

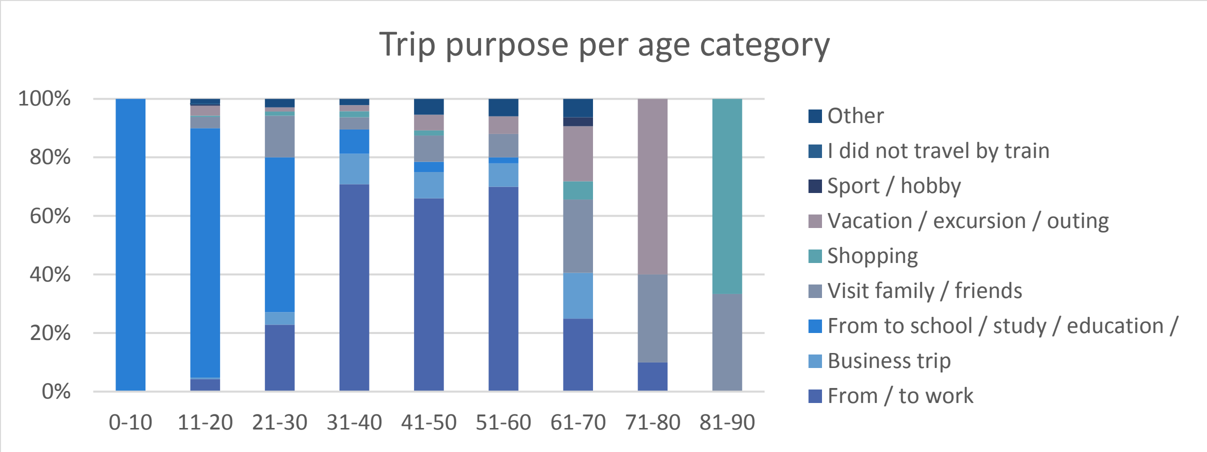


FIGURE 3-18, DISTRIBUTION OF TRIP PURPOSE BY AGE CATEGORY (RP DATABASE).

When presenting the trip purpose by the reported *overall station assessment* (Figure 3-19), a different figure appears. The lower assessments ('1' to '4') have been assessed only a few times by the respondents. When testing if there is a significant difference in average *overall station assessment* between commuters (6.77 ± 1.156) and from / to study (6.93 ± 1.199), no significant difference is found ($t(509)=-1.440$, $p = 0.151$).

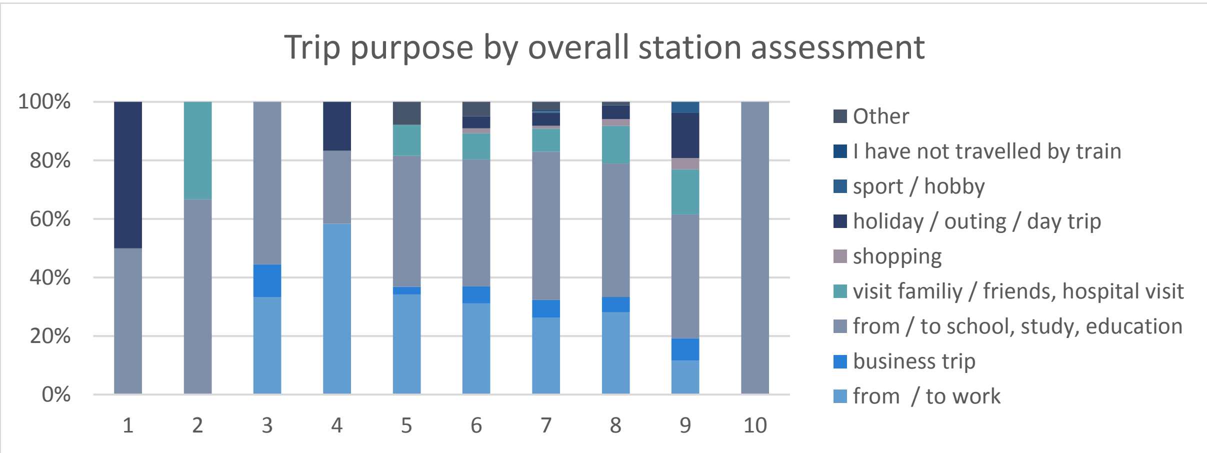


FIGURE 3-19, DISTRIBUTION OF TRIP PURPOSE BY OVERALL STATION ASSESSMENT (RP DATABASE).

In Figure 3-20 the ridership is presented for each age category, as mentioned by respondents of the RP questionnaire. When age increases, the ridership of train travellers decreases (same is found in the SBM database). Comparing the RP and SBM statistics, small differences (± 1%) can be found in the most important travel frequencies (1-3 days per month, 1-3 days per week, and 4 or more days per week), as can be seen in Table 3-4.

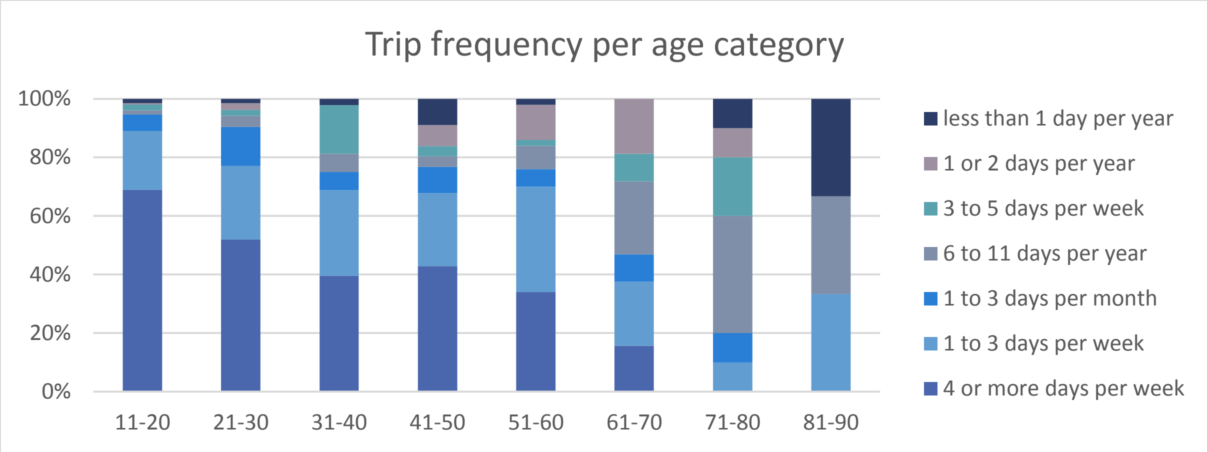


FIGURE 3-20, DISTRIBUTION OF TRIP FREQUENCY BY AGE CATEGORY (RP DATABASE).

Whereas the SBM data found a significant difference between the trip frequencies (*4 or more days per week* and *1 to 3 days per week*) in relation to overall station assessment, no significant difference is present in the RP database. With *4 or more days per week* (6.86 ± 1.220) and *1 to 3 days per week* (6.94 ± 1.146) not significant at t(506)=-0.667 and p = 0.499. In Figure 3-21 the RP distribution of trip frequency is presented.

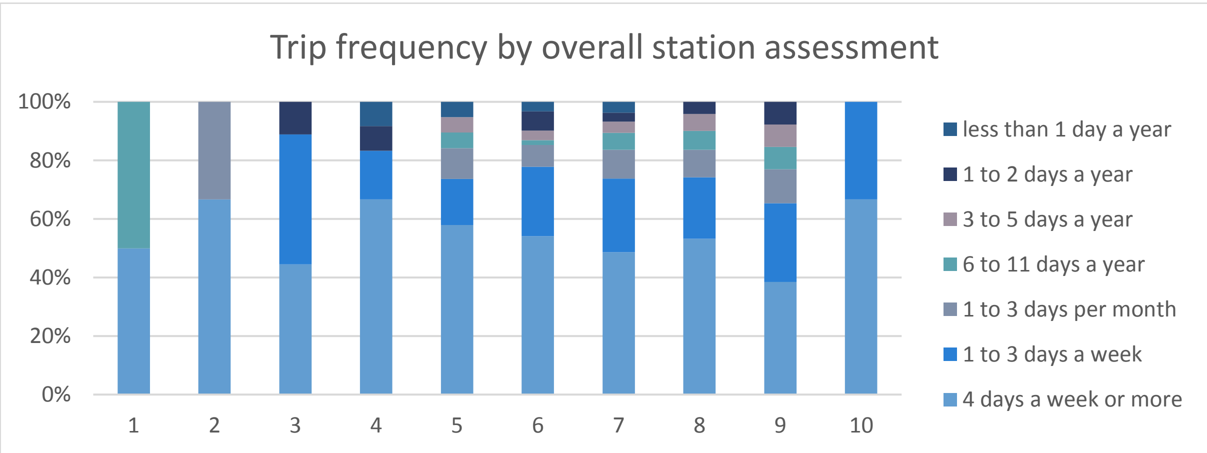


FIGURE 3-21, DISTRIBUTION OF TRIP FREQUENCY BY OVERALL STATION ASSESSMENT (RP DATABASE).

The access mode reported by respondents of the RP questionnaire, indicate an overrepresentation of transfer (access railway station by train) compared to the SBM database. This resulted in an underrepresentation of cyclists and car drivers in the RP database. See Figure 3-22 for all shares of different access modes for each age category. As for access mode related to *overall station assessment* (see Figure 3-23), the small number of respondents for the lower station assessment do not provide a clear picture compared to the SBM database. However, when conducting the independent t-test, the average overall station assessment between *walking* (6.77 ± 1.525) and *biking* (7.08 ± 1.076) was found to be significant (t(280)=-2.038, p = 0.042)

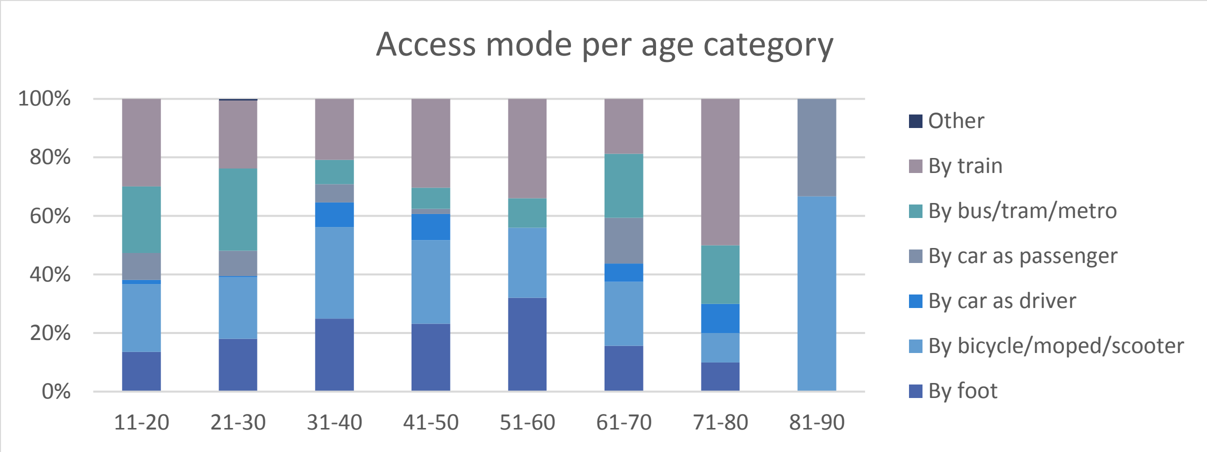


FIGURE 3-22, DISTRIBUTION OF ACCESS MODE BY AGE CATEGORY (RP DATABASE).

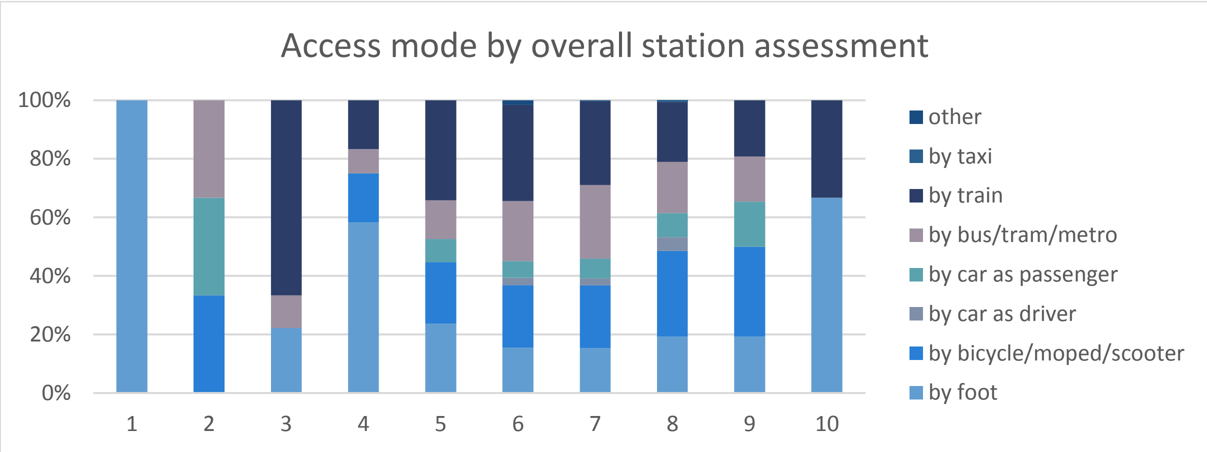


FIGURE 3-23, DISTRIBUTION OF ACCESS MODE BY OVERALL STATION ASSESSMENT (RP DATABASE).

Overall station assessment is one of the most important variables of the RP questionnaire. In Figure 3-24 the average overall station assessment for Almelo (96), Eindhoven (390), and Helmond (391) for 4 Q 2016 is added to the averages found in the SBM database. If the respondents are split in two groups: (1) travellers using the railway station since 2013 or earlier, and (2) travellers using the railway station since 2014. These two group either actively noticed the change due to the comfort enhancement measure (before measure) or did not see any change because they are using the railway station since the implementation of the measure (after measure). An independent t-test found that for Eindhoven and Helmond the average overall station assessment are significantly different (Eindhoven: before 2014 = 7.15 ± 0.86, since 2014 = 6.92 ± 1.02, $t(284)=2.1$, $p=0.037$. Helmond: before 2014 = 7.42 ± 1.16, since 2014 = 7.05 ± 1.09, $t(184)=2.216$, $p=0.028$). The average overall station assessment between the two user groups proofed to be insignificant based on an independent t-test. Furthermore, the trend of *overall station assessment* for Helmond, slowly decreases. One explanation might be that travellers do not value the novelty of Helmond station anymore. The 'new' feeling is fading away which might cause the downwards trend of *overall station assessment*. For Eindhoven the increase in *overall station assessment* is most likely caused by the continuing reconstruction of the new passenger tunnel and station building. The reconstruction might have introduced a bias in the overall station assessment of respondents.

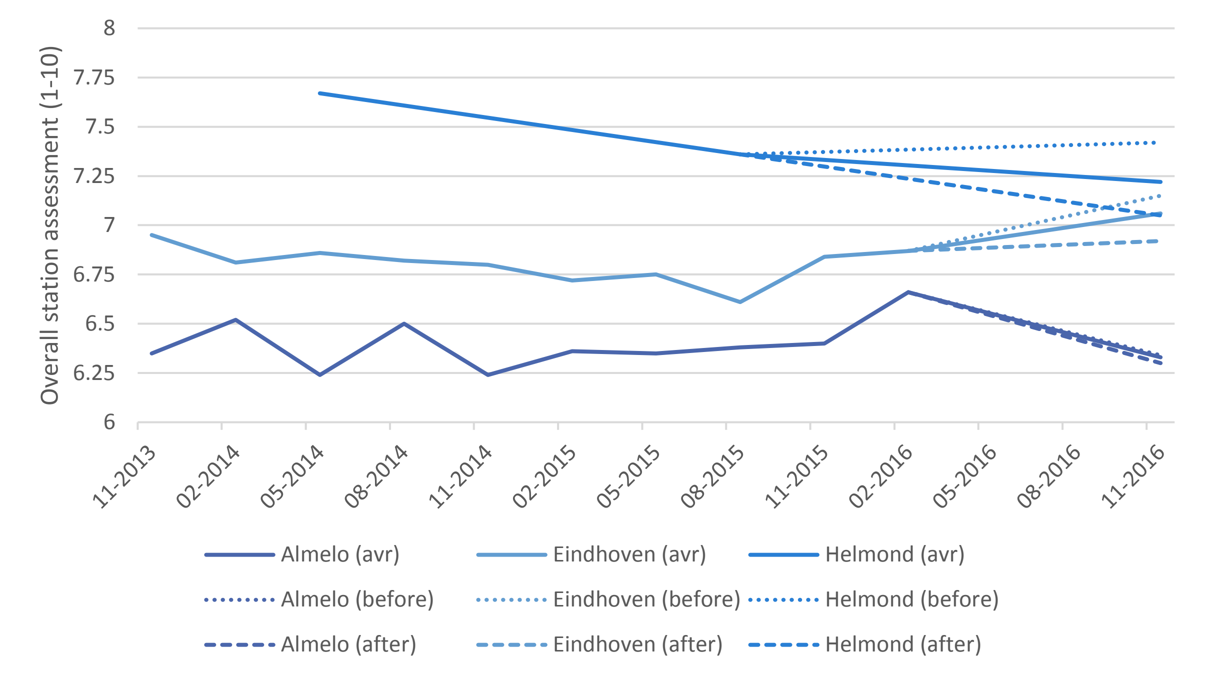


FIGURE 3-24, OVERALL STATION ASSESSMENT FOR ALMELO, EINDHOVEN, AND HELMOND INCLUDING RP DATA.

The last measurement of *overall station assessment* presented in Figure 3-24, is captured using the RP data. In Table 3-1 this the average overall station assessment is set against existing travellers and new travellers.

TABLE 3-6, CHANGES IN *OVERALL STATION ASSESSMENT* BETWEEN USER GROUPS.

Type of user	Green and planters	RailTV	Lighting
Existing traveller	100.16% (6,34)	101.27% (7,15)	102.77% (7,42)
Average	100.00% (6,33)	100.00% (7,06)	100.00% (7,22)
New traveller	99.53% (6,30)	96.02% (6,92)	97.66% (7,05)

The last variable in the RP questionnaire is the ticket type of respondents. Respondents are asked to report their ticket type for the trip they have made when asked to participate in the survey. The most important finding is the incorrect set-up of the question. As can be seen in Figure 3-25, the share of “other” among the available options is relatively large. Many students (11-30 y/o) stated to use some sort of other type of ticket (mostly referring to the ‘*studenten OV chipkaart*’). Furthermore, many commuters use some sort of discount tickets (e.g. *Dal voordeel* or *Altijd voordeel*) or alternatives to the NS-Business card (like *Mobility Mixx*). When ticket type is presented per *overall station assessment* (Figure 3-26) no direct relation between the two variables can be noticed. This might be caused by the higher number of respondents stating that they’ve used an ‘other’ ticket type. The fact that many respondents stated ‘other’ might be classified as a case of marginal survey design, and it underlines the importance of a well-designed questionnaire.

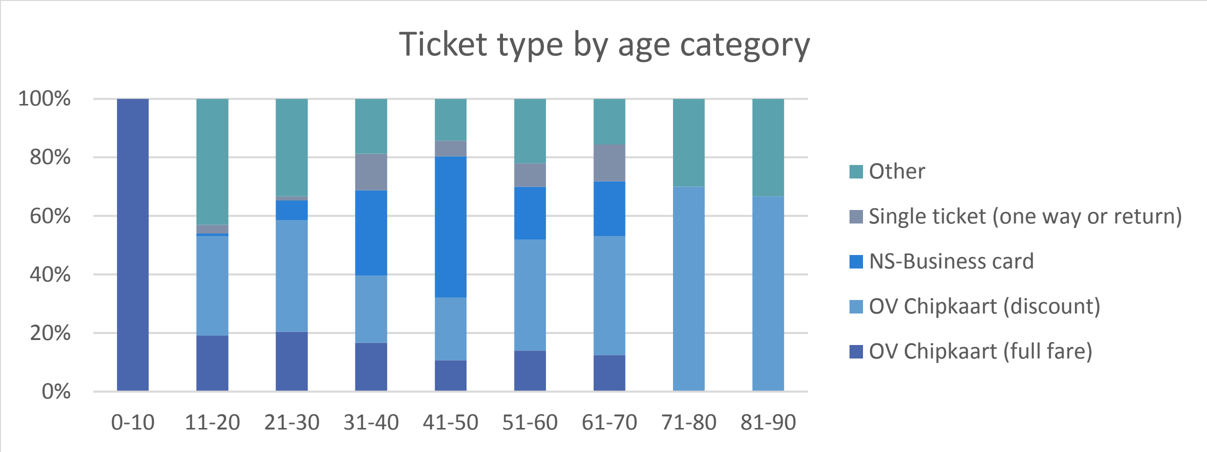


FIGURE 3-25, DISTRIBUTION OF TICKET TYPE PER AGE CATEGORY (RP DATABASE).

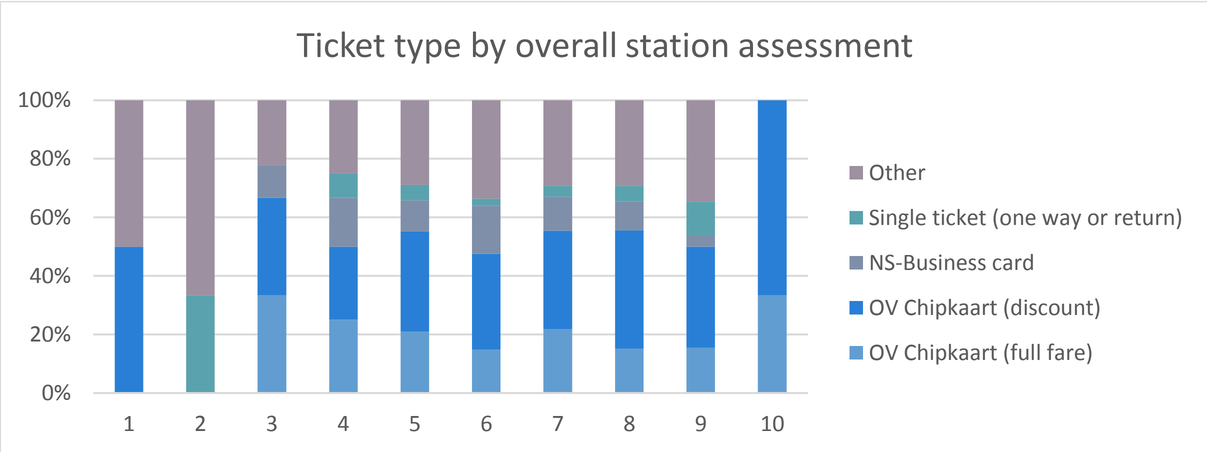


FIGURE 3-26, DISTRIBUTION OF TICKET TYPE BY OVERALL STATION ASSESSMENT (RP DATABASE).

3.3.2.3. Effects of comfort enhancement measures

In the RP questionnaire a distinction is made between (1) explicit comfort enhancement measures, and (2) implicit comfort enhancement measures. The former captures those measures that are noticed by a waiting travellers and are thus independent of time. This questions is presented to every respondent of the RP questionnaire. The latter focusses on specific measures at railway stations, and is only presented to those respondents that are using the railway station since 2013 or earlier. In this section the three comfort enhancement measures (*green and planters*, *RailTV*, and *lighting*) are presented (combing both explicit and implicit data).

Each comfort enhancement measure implemented by NS Stations is expected to influence at least one 'NS' theme. These NS themes can be related to the customer needs as defined in Figure 2-1. Every respondent is asked to rank each of the eight NS themes in order of their importance. Interesting to notice is the large share of *safety* in Rank #1 and the large shares of *attractivity* and *inviting* in Rank #7 and #8.

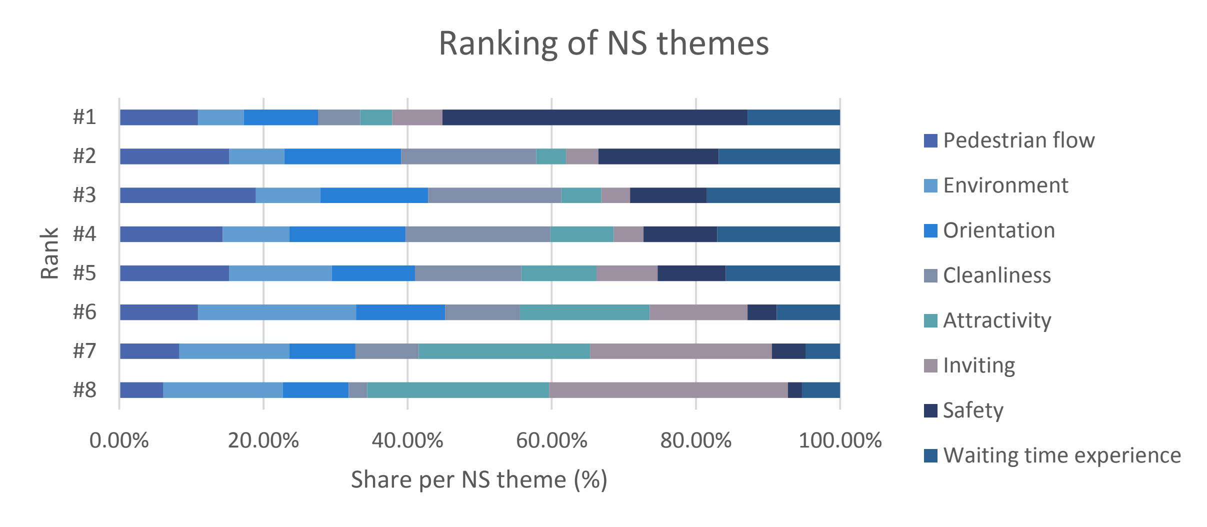


FIGURE 3-27, RANKING OF NS THEMES AND RELATING SHARES (RP DATABASE).

When themes are weighted to their level of importance, the ranking becomes more relatable. Including weights the following ranking is reached: (1) Safety (17.54%), (2) Waiting time experience (14.49%), (3) Cleanliness (13.89%), (4) Pedestrian flow (13.78%), (5) Orientation (13.25%), (6) Environment (10.39%), (7) Attractivity (8.61%), and (8) Inviting (8.05%) (see Figure 3-28).

The results of the ranking are interesting, as they indicate that factors like *safety* and *cleanliness* are still considered important by travellers. Experts also indicate that the basic cleanliness is still a challenge. The cleaning of windows, floors, furniture (seats, litter bins), removing of cobwebs, etc. is challenging due to (safety) regulations. While distributing the RP questionnaire at Eindhoven CS, some respondents indicated that they valued the *cleanliness* of the station platforms as low. However, the RP data showed an average assessment of 6.8 (n=255) for the statement “I experience the station as clean” (SCHO1134). Nevertheless, the statement focusses on the whole railway station, and not specifically for the station platforms. Similar conversations have been made with respondents at Almelo station. During these conversations, respondents stated that *safety* (especially during the night) was considered a problem. The RP data shows similar signs; for the statement “I feel safe after 19:00h at this railway station” (VEIL1134) the average mark is 5.6 (n=152). This indicates that *safety* might be an issue at Almelo station.

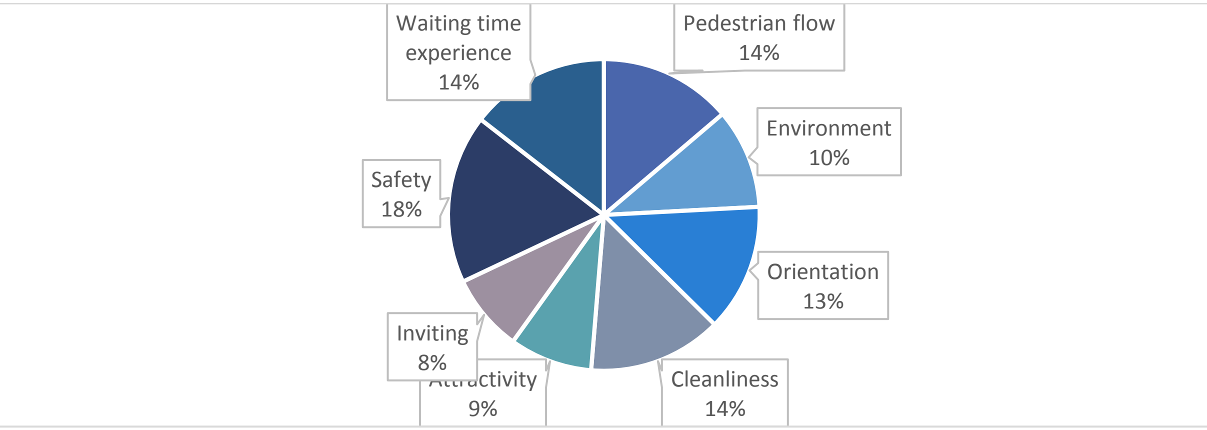


FIGURE 3-28, WEIGHTED RANKING NS THEMES (RP DATABASE).

For each questionnaire, respondents could report two types of measures: explicitly noticed measures, and implicit noticed measures. For both, the respondent is asked to state their experienced change on 7 indicators: (1) *overall station assessment*, (2) *ridership*, (3) experience, (4) comfort, (5) ease, (6) speed, and (7) safety & cleanliness.

In Figure 3-29 the changes experienced related to the implementation of *green and planters* are presented. Over half of the respondents stated that *green and planters* did contribute to an improvement of their *overall station assessment*. However, the majority reported that this measure did not influence their *ridership*. For all customer needs, the experienced change is marginal. As expected, the needs of *experience*, *comfort*, and *safety & cleanliness* are most affected by the measure. The impact of *green and planters* might have been greater if the living wall at Almelo was implemented throughout the whole railway station. Because it is expected that not every respondent at Almelo station knows about the measure of *green and* planters at Almelo station, as it is situated at only one entrance of the station building.

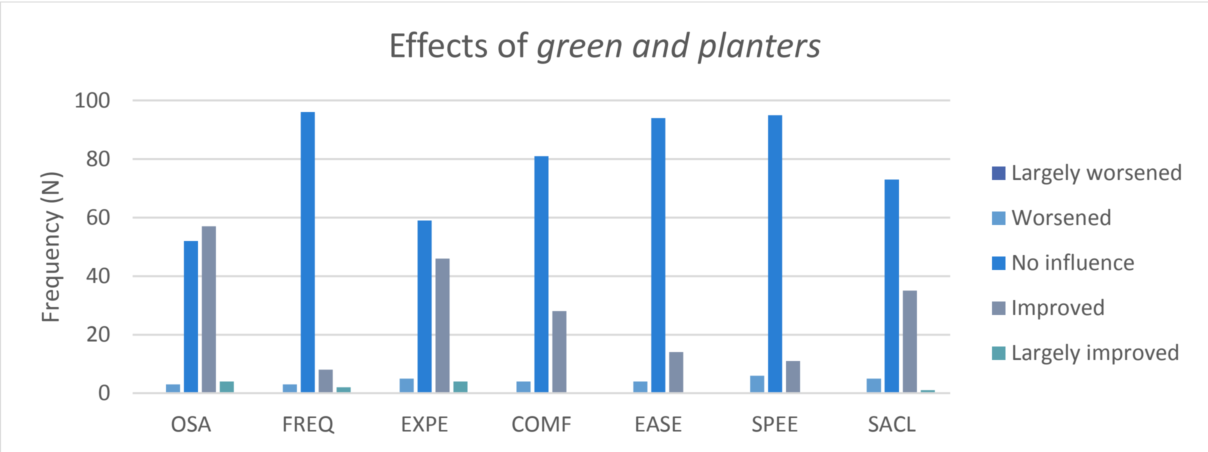


FIGURE 3-29, EFFECTS OF *GREEN AND PLANTERS* ON SEVEN INDICATORS.

At Eindhoven station, the impact of RailTV (digital screens with infotainment) has been measured. As for *green and planters*, over half of respondents stated that RailTV does (largely) improve their *overall station assessmen*t. However, it must be noted that the description of "digital screens with infotainment" might have perceived in a different than expected when creating the questionnaire. It is expected that some respondents have mistakenly seen the 'CAT schermen' (screens with information about the direction, departure time on the station platform) as RailTV. For ridership, only a few respondents stated that they travel more due to RailTV. Furthermore, both satisfiers are experience to improve the marginally. The majority of travellers still experience no change for any of the customer needs, as can be seen in Figure 3-30.

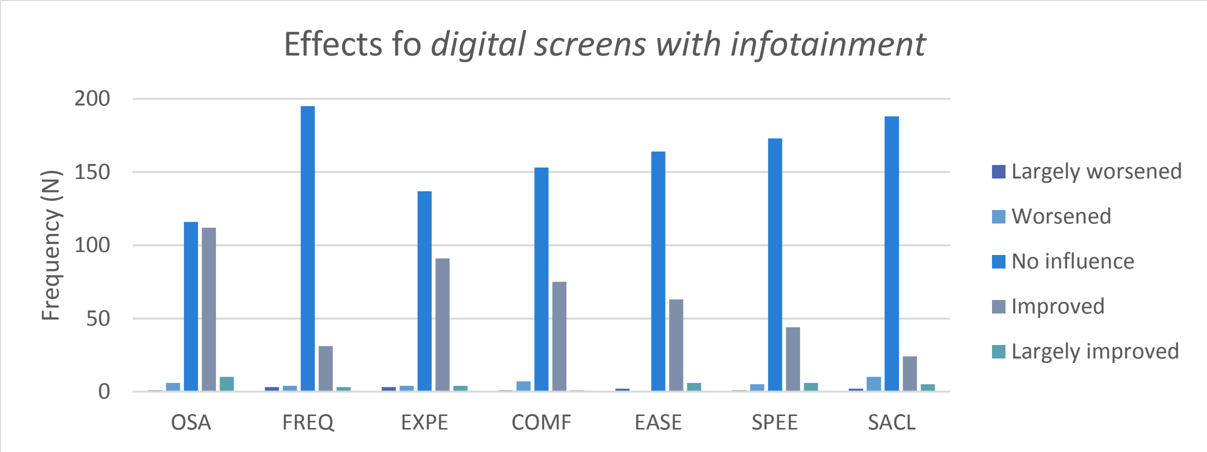


FIGURE 3-30, EFFECTS OF *DIGITAL SCREENS WITH INFOTAINMENT* ON SEVEN INDICATORS.

The final surveyed measure is *lightning*. In Figure 3-31, the experienced changes due to the *lighting* are presented. The data shows an (large) improvement of *overall station assessment* among the respondents. It must me noted that the measure of *lightning* was part of the reconstruction of the new station building and station environment. This might have introduced a bias into the respondents reported change. In the survey the question is formulated such that the respondent is asked to only state their change based on the measure of *lighting*. As for the previous two comfort enhancement measures, respondents have stated that their *ridership* is not affected by the measure. Interesting to notice are the changes in travellers' *experience* and *comfort*. Furthermore, there is a clear indication that *lighting* does affect the perception of *safety & cleanliness*. As expected, the needs of *ease* and *speed* are changed marginally. In contrast to Almelo, the measure of *lighting* was implemented as a key feature of the station building/environment. This station-wide use might have contributed to the positive changes reported by respondents.

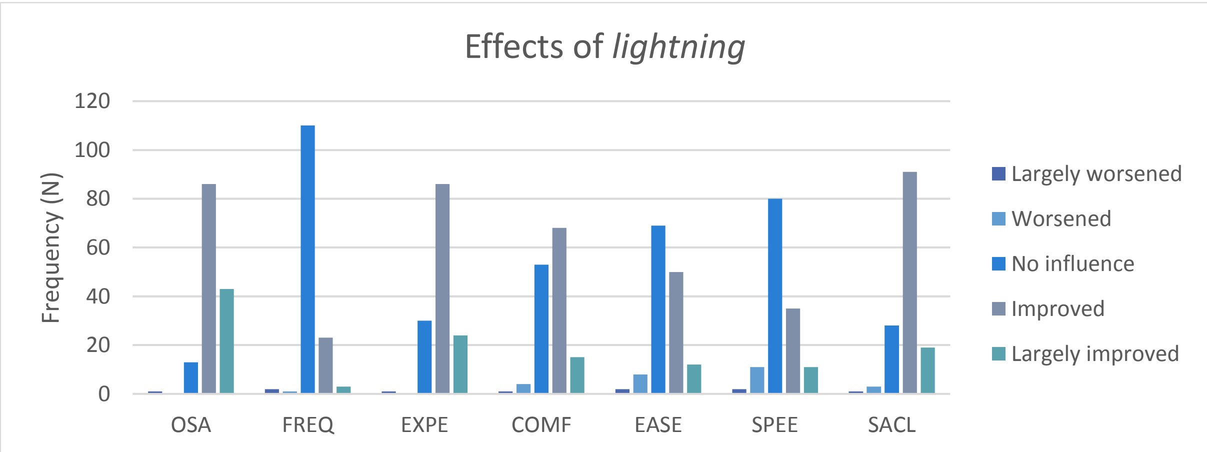


FIGURE 3-31, EFFECTS OF *LIGHTNING* ON SEVEN INDICATORS.

3.3.2.4. Changed trip characteristics

The revealed preference questionnaire included a validation of answers. This validation is used to check if the trip characteristics (travel frequency and trip purpose) have changed between 2013 and 2016. If a change in either or both trip characteristics is noticed, the respondent is presented with seven statements. Each statement describe a situation that could have been responsible for the changed travel frequency of trip purpose. The respondent is asked, using a 5-step Likert scale, to (completely) agree or (completely) disagree with each statement. If the statement did not apply, the option of *not available* could be checked. In Figure 3-32 and Figure 3-33 the frequency (N) of each statement is presented. The data indicates that *spending time usefully* is an important reason why travellers changed their travel frequency. Besides spending time productively, the need *to travel more due to study* is reported to be also contributing to a changed travel frequency. For changed trip purpose, the response was relatively low. However, the statements (1) *spending time useful* and (2) *travel more due to study* are the most important statements that contributed to a change in trip purpose.

However, the response on changing trip purposes might be higher, if different (more suited) statements are used in the RP questionnaire. The reasons for change in trip characteristics are important because a changed *overall station assessment* might be caused by not only the implementation of one (or more) comfort enhancement measures. Besides the descriptive statistics, this data will be used as variables in the estimated models presented in the next section.

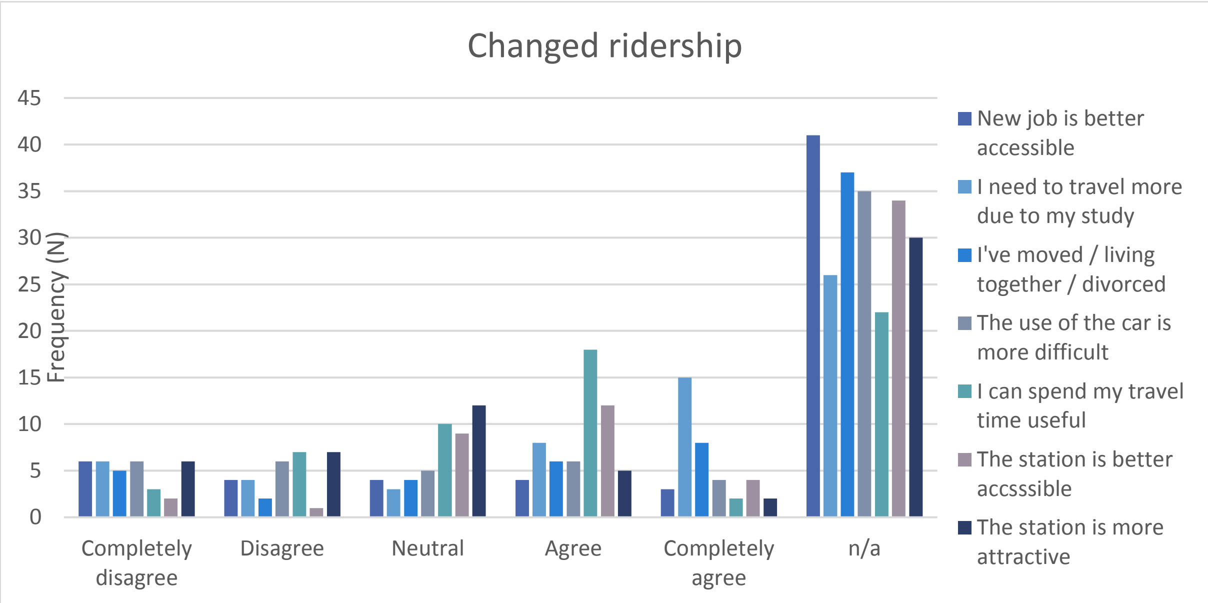


FIGURE 3-32, LEVEL OF AGREEMENT FOR REASONS TO CHANGE RIDERSHIP.

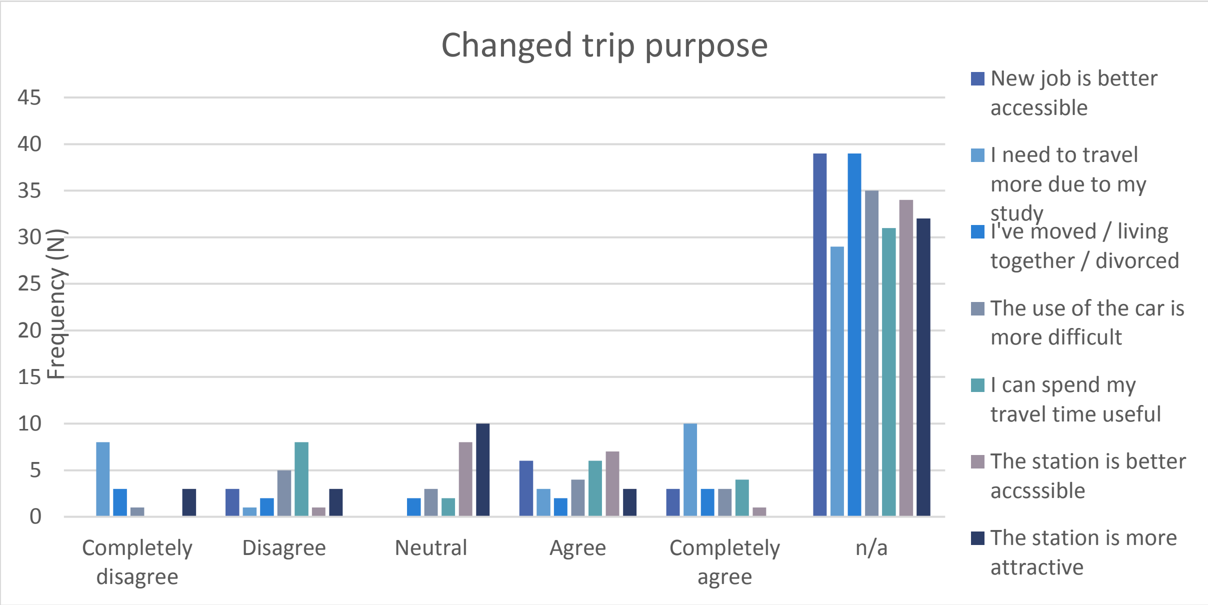


Figure 3-33, Level of agreement for reasons to change trip purpose.

4. Model estimation

The two databases contain valuable information to estimate *overall station assessment* and *ridership* using customer satisfaction information. In this section, the analytical framework and estimated models developed during the thesis are presented.

4.1. Analytical framework

The *Stationsbelevingsmonitor* (SBM) and customer satisfaction data collected using the *revealed preference questionnaire* (RP) will be used to determine the direct effects of *comfort enhancement measures* on two dependent variables: (1) *overall station assessment* and (2) *ridership*. Both the SBM and the RP questionnaire use a series of 26 statements and questions to capture the respondents current experience at the surveyed railway station. These statements and questions are categorized in 8 different *themes*. NS Stations uses these themes as performance indicators for the station quality. The 8 NS themes are related to one or two customer needs, as presented in Figure 2-1.

To use and test each of the 26 variables included in the SBM and RP database, might result in difficult to interpret models. To avoid misinterpretation, a *factor analysis* (FA) is conducted to reduce the available explanatory variables to a manageable amount of *factors*. To extract the factors from the explanatory variables, the principal factor analysis is used as extraction method. Once the factors are extracted from the data, the factors will be rotated to better fit the data. Here, the common rotation method Varimax is used. Varimax is orthogonal and results in independent (no multicollinearity) factors. The factors are extracted using the statistical software package IBM SPSS Statistics 22. If the raw SBM database was used only 11% of the SBM database was usable, due to the listwise removal of missing cases. To replace missing cases (e.g. respondents did not answer one of the statements), the *Missing Value Analysis* (MVA) of SPSS is used. To estimate the missing values in the MVA the estimation method of *estimation maximisation* (EM) is selected. The corrected SBM database is used in the FA.

The rotated component matrix of the SBM FA is presented in Table 4-1. In this matrix, all cases with an value of 0.55 or lower (not relevant for the factor) are excluded. Based on the second ground of Kaisers' Criterion the result of the FA may be considered accurate. The total number of commonalties (proportion of variance of one variable due to common factors) after extraction is equal to 15.6932 with a total of 24 variables, with results in an average communality of 0.654. The rotated component matrix presented below, is the results of three iterations. The first FA of the SBM database has been run without any limitations, resulting in six factors. To verify the need of six factors, a second FA is run where the number of factors are restricted to five. This second iteration resulted in variables relating to safety being insignificant. This might be caused by the factor temporarily labelled as *construction* (variables relating to the perception of hindrance during construction) is too strong. In the third and final iteration, the two variables relating to *construction* are excluded (as this research only focusses on the use of permanent comfort enhancement measures), and the maximum number of factors is limited to five. The final FA resulted in the rotated component matrix presented at Table 4-1.

TABLE 4-1, ROTATED COMPONENT MATRIX FA (SBM DATABASE).

	Factor name	Experience	Ease	Comfort	Safety / Cleanliness	Speed
	Factor #	**1**	**2**	**3**	**4**	**5**
SFEE2134	Warm appearance	0.845				
SFEE1134	Experience station as attractive	0.827				
SFEE4134	Colourful	0.776				
WACH2134	Experience waiting as comfortable	0.737				
WACH1134	Spend time usefully	0.692				
WACH3134	Enough protection against the elements	0.670				
SFEE3134	Station looks taken care of	0.598				
OMGE3134	Clear overview of station environment		0.764			
OMGE1134	Easy accessibility of station		0.750			
ORIE1134	Station overview		0.740			
OMGE2134	Experience station environment as nice		0.702			
ORIE2134	Signing at station		0.674			
ORIE3134	Clear travel information		0.589			
UITN3134	Enough shops are open			0.774		
UITN4134	Feel invited to buy something			0.750		
UITN2134	Friendly personnel			0.719		
UITN1134	Know where to find information			0.690		
SCHO1134	Station is clean				0.781	
SCHO2134	Smells nice/fresh				0.753	
VEIL2134	Pleasant lightning				0.622	
VEIL1134	Feel safe after 19:00u				0.615	
DRUK1134	Experience station as busy					-0.626
DOOR1134	Enough space at station platform					0.604
DOOR2134	Unhindered access to train					0.559

In the rotated component matrix each individual variable is associated with a factor. As the output was restricted to five factors, five factors are found. Using the attributes related to the hierarchy of customer needs (see Figure 1-2) and the relation between NS themes and the hierarchy of customer needs (see Figure 2-1), each of the five factors could be labelled.

The RP questionnaire included a section to capture the respondents' current experience at the surveyed railway stations. Here, the exact same questions and statements are used that are presented in the *Stationsbelevingsmonitor* (excluding the questions related to construction). Of the 24 variables included in the FA, four variables could not be associated with any of the five factors (value is below the threshold of 0,55): (1) *WACH2134* (experience waiting as comfortable), (2) *WACH3134* (enough protection against the elements), (3) *OMGE1134* (easy accessibility of the railway station), and (4) *OMGE2134* (experience the station environment as pleasant) are not included in the final FA. In Table

4-2, the results of the FA are presented. Kaisers' Criterion resulted in an average communality of 0.683. Therefore, the result of the FA can be considered accurate according to the second ground of Kaisers' Criterion.

The rotated component matrix presented below (Table 4-2) is the final iteration of four FAs using the RP data. The initial FA resulted in three unidentifiable variables and a total of five factors. In order to check if the distribution of variables will change when the FA is restricted so a set number of factors, a second FA is conducted at which the FA is restricted to five factors. The second iteration also resulted in three unidentifiable variables: (1) OMGE2134, (2) WACH2134, and (3) WACH3134. In the third iteration, these three variables are excluded and the number of factors is restricted to five. The third iteration resulted in one variable unable to identify with any of the five factors (OMGE1134). In the fourth and final FA the variable OMGE1134 is excluded. The resulting rotated component matrix is presented below (see Table 4-2).

TABLE 4-2, ROTATED COMPONENT MATRIX FA (RP DATABASE).

	Factor name	**Experience**	**Ease**	**Comfort**	**Safety / Cleanliness**	**Speed**
	Factor #	**1**	**2**	**3**	**4**	**5**
SFEE2134	Warm appearance	0.876				
SFEE1134	Experience station as attractive	0.860				
SFEE4134	Colourful	0.844				
SFEE3134	Station looks taken care of	0.615				
ORIE2134	Signing at station		0.776			
ORIE3134	Clear travel information		0.745			
ORIE1134	Station overview		0.743			
OMGE3134	Clear overview of station environment		0.704			
UITN3134	Enough shops are open			0.786		
UITN4134	Feel invited to buy something			0.731		
UITN2134	Friendly personnel			0.571		
WACH1134	Spend time usefully			0.521		
UITN1134	Know where to find information			0.518		
SCHO1134	Station is clean				0.841	
SCHO2134	Smells nice/fresh				0.777	
VEIL2134	Pleasant lightning				0.622	
VEIL1134	Feel safe after 19:00u				0.574	
DRUK1134	Experience station as busy					-0.747
DOOR2134	Unhindered access to train					0.706
DOOR1134	Enough space at station platform					0.634

Comparing the results of both factor analyses, some differences in the composition of the factors can be noticed (see Table 4-1 and Table 4-2). Factor 2, *ease*, includes the remaining variable related to the station environment (OMGE3134). This variable is related to the accessibility of the station environment, as it asks respondents if the walkways are station singing are clear. The third factor *comfort*, now includes the statement *"I can spend my time useful"* (WACH3134). As mentioned in Figure 2-1, spending time is a physical activity and is related to the *comfort* of a traveller. All remaining factors (#1, #4, #5) in Table 4-2 are unchanged compared to the FA conducted with the SBM data (Table 4-1).

For each factor analysis the explanatory variables are associated with a factor. These factors (also known as components) have no labels. In order to identify and use a factor, the researcher must label each factor according to the relevant variables. Because NS Stations have labelled each variable according to their themes (see Figure 2-1), these themes are used to label each factor. The NS themes are related to the five customer needs, the five customer needs are used as labels for both FAs (SBM and RP). For example, factor 1 of the SBM database (Table 4-1) has been labelled *experience*. This factor received this label because of the associated variables. These variables are labelled with *WACHxxxx* or *SFEExxxx*, corresponding with the NS themes *waiting time experience* and *attractiveness* respectively. As can be seen in Figure 2-1, these NS theme are both related to the customer need *experience* (a satisfier). In the case of the factor *speed*, this factor has been associated with variables relating to the NS theme *pedestrian flow* (DOORxxxx). Furthermore, the only non-NS theme variable DRUK1134, is associated with *pedestrian flow*. Using the statement of this variable, DRUK1134, asks respondents if they experience the railway station as being busy. When a railway station is experienced busy, travellers might be hindered while walking to the station platform which might have an effect on their station assessment. As this statement is formulated in a negative manner, the variable has a negative value in the factor analysis.

4.2. Choice models

The factors resulting from both factor analyses will be used as explanatory variables to model *overall station assessment* and *ridership*. To estimate the choice models, the open source freeware package Pythonbiogeme (Bierlaire, 2016b) is used. Pythonbiogeme is designed to estimate the maximum likelihood of parametric models, and especially discrete choice models.

In the next two sections the models estimated using the S*tationsbelevingsmonitor* and *RP questionnaire* are presented. All models are based on the ordinal regression models, also known as *ordered logistic regression*. For example, respondents have reported their *overall station assessment* on a scale ranging from 1 to 10, with 1 being "very poor" and 10 being "excellent". However, because the assessment is subjective, the 1 to 10 scale is arbitrary. Meaning, the relative ordering between values is important, not the value itself. The basic structural equation of any depended variable can be characterised as:

$$x^* = h(x; \beta^s) + \varepsilon^s \tag{1}$$

Here, x is the vector of independent (explanatory) variables, and β^s is a vector of K_s parameters which are estimated from the data. h is most common specified as a linear function as presented in equation (2) (Bierlaire, 2016a)

$$h(x; \beta^s) = \beta_0^s + \sum_{k=1}^{K_s - 1} \beta_k^s x_k \tag{2}$$

In a report of using latent variables in Biogeme, Bierlaire (2016a) reports that “utility is not observed, but estimated from the observations of actual choices. The relationship between a latent variable and measurement is characterized by measurement equations.”

$$z = m(x^*, y; \beta^m) + \varepsilon^m \tag{3}$$

Here, z is the reported value, the latent variable is presented as x^*, the vector with observed variables is denoted as y. Parameters K_s are denoted as vector β^m, which are estimated from the data using Pythonbiogeme 2.5. The most common notation of the function m is linear. Bierlaire (2016a) used the following specification (equation (4))

$$m(x^*, y; \beta^m) = \beta_0^m x^* + \sum_{k=1}^{K_m-1} \beta_k^m y_k \tag{4}$$

To determine the odds of each choice, another equation is needed. The measurements are represented by an ordered (discreet) variable I, denoted in equation (5) as j_i.

$$I = \begin{cases} j_1 & if\ z < \tau_1 \\ j_2 & if\ \tau_1 \leq z < \tau_2 \\ & \vdots \\ j_i & if\ \tau_{i-1} \leq z < \tau_i \\ & \vdots \\ j_M & if\ \tau_{M-1} \leq z \end{cases} \tag{5}$$

The parameters $\tau_1, \dots, \tau_{M-1}$ are estimated in Pythonbiogeme 2.5, such that they comply to the following condition:

$$\tau_1 \leq \tau_2 \leq \cdots \leq \tau_i \leq \cdots \leq \tau_{M-1} \tag{6}$$

To estimate a model that best fits the data, explanatory variables must be added. Using an iterative process, the alternative model compared with the null model. As presented in Figure 4-1, two conditions have to be met to accept the alternative model: (1) added explanatory variable must be significant (t-test and Robust t-test), and (2) alterative model must be a significant improvement (loglikelihood ratio test).

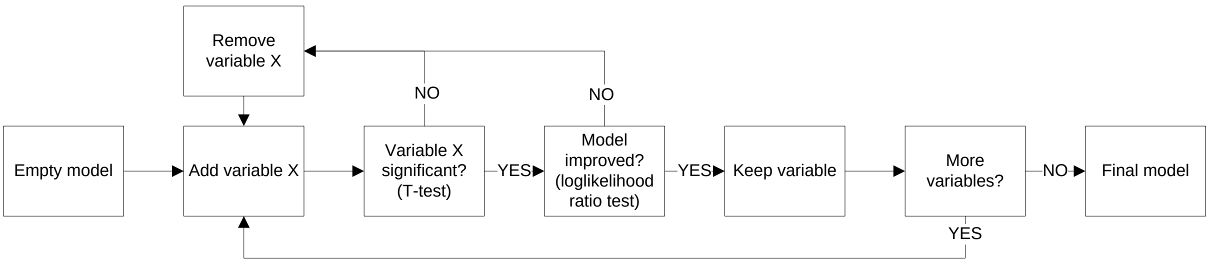


FIGURE 4-1, ITERATIVE PROCEDURE FOR CREATING ORDINAL REGRESSION MODELS.

In the next sections the estimated models for each database, and dependent variable are presented.

4.2.1. Stationsbelevingsmonitor

Using the iterative process, described in Figure 4-1, the ordinal regression model of *overall station assessment* using the SBM data is presented. The final model is presented is equation (7).

$$U_{OSA} = ASC_{OSA} + \beta_{age} * LEEF_{1134} + \beta_{male} * GENDER + \beta_{weather} * WEER_{1134} + \beta_{TM=1} * D_{TM=1} + \beta_{FREQ=1} * D_{FREQ=1} + \beta_{factor\ 1} * Factor_1 + \beta_{factor\ 2} * Factor_2 + \beta_{factor\ 3} * Factor_3 + \beta_{factor\ 4} * Factor_4 + \beta_{factor\ 5} * Factor_5 + \beta_{green\ and\ planters} * D_{green\ and\ planters} + \beta_{lightning} * D_{lightning} + \beta_{RailTV} * D_{RailTV} + \beta_{heating} * D_{heating} \quad (7)$$

The estimated parameters of each the explanatory variable are presented in Table 4-3. In this estimated model, all available data is used. The model contains 184 863 observations of which 39 139 are excluded (e.g. missing cases). The final r^2 = 0.806, and log likelihood = -221 228.435. In the choice model age, gender, and assessment of weather are all found to be significant. However, both age and gender negatively affect the utility of the estimated choice model. As do both significant trip characteristics: travel frequency (4 or more days per week) and travel purpose (from / to work). Furthermore, four measures are found to be significant: *green and planters*, *infrared heating columns*, *lighting*, and *digital screens with infotainment* (RailTV).

TABLE 4-3, ESTIMATED PARAMETERS *OVERALL STATION ASSESSMENT* (SBM DATABASE).

Sample size	184863			
Final log likelihood	-221228.453			
Rho-squared	0.806			
Name	**Description**	**Value**	**t-test***	**R t-test***
ASC_OSA	Alternative specific constant (ASC)	9.93	211.75	198.03
B_AGE	β_{age}, continues variable for the respondents age	-0.00850	-27.70	-27.74
B_F1	$\beta_{factor\ 1}$, continues variable for factor 1 (experience)	1.65	277.14	246.61
B_F2	$\beta_{factor\ 2}$, continues variable for factor 2 (ease)	1.26	226.40	182.10
B_F3	β_{factor} 3, continues variable for factor 3 (comfort)	0.717	145.52	127.69
B_F4	β_{factor} 4, continues variable for factor 4 (safety & cleanliness)	1.12	212.86	181.66
B_F5	β_{factor} 5, continues variable for factor 5 (speed)	0.215	46.11	41.22
B_FREQ_1	$\beta_{travel\ frequency\ =\ 1}$, dummy variable for travel frequency (4 or more days per week)	-0.0500	-5.10	-5.17
B_GREEN	$\beta_{CEM\ green\ and\ planters}$, dummy variable for presence of the CEM green and planters at a station (takes value 1 if present)	-0.123	-2.92	-3.02
B_HEATING	$\beta_{CEM\ infrared\ heating\ columns}$, dummy variable for presence of the CEM infrared heating columns at a station (takes value 1 if present)	0.266	11.33	12.17
B_LIGHTNING	$\beta_{CEM\ lighting}$, dummy variable for presence of the CEM of lighting at a station (takes value 1 if present)	0.149	4.26	4.30
B_MALE	β_{male}, dummy variable for gender (takes value 1 if male)	-0.0752	-8.34	-8.44
B_RAILTV	$\beta_{CEM\ RailTV}$, dummy variable for presence of the CEM RailTV at a station (takes value 1 if present)	0.196	9.75	9.95
B_TM_1	$\beta_{travel\ motive\ =\ 1}$, dummy variable for trip purpose (from / to work)	-0.0760	-7.65	-7.79
B_WEATHER	$\beta_{assessment\ of\ weather}$, ordinal variable for the perceived weather conditions during the survey	0.0392	18.08	17.08
delta1	Δ_1, threshold between τ_1 and τ_2	1.38	38.63	37.64
delta2	Δ_2, threshold between τ_2 and τ_3	1.39	60.15	59.28
delta3	Δ_3, threshold between τ_3 and τ_4	1.35	86.39	85.70
delta4	Δ_4, threshold between τ_4 and τ_5	1.65	136.35	134.23
delta5	Δ_5, threshold between τ_5 and τ_6	2.27	225.72	219.27
delta6	Δ_6, threshold between τ_6 and τ_7	2.79	293.51	284.94
delta7	Δ_7, threshold between τ_7 and τ_8	2.75	209.09	209.64
delta8	Δ_8, threshold between τ_8 and τ_9	2.06	90.62	92.94

** = significant at 95%.*

To estimate choice model for *ridership*, an ordinal regression model is used. The values used to define ridership uses 7 values ranging from "4 or more days per week" (value = 1) to "less than 1 day per year" (value = 7). In this case, the lower the estimated utility, the higher the ridership. In equation (8) the final utility function for estimating *ridership* is presented.

$$U_{Freq} = ASC_{Freq} + \beta_{age} * LEEF_{1134} + \beta_{male} * GENDER + \beta_{weather} * WEER_{1134} + \beta_{TM=1} * D_{TM=1} + \beta_{TM=2} * D_{TM=2} + \beta_{TM=3} * D_{TM=3} + \beta_{TM=4} * D_{TM=4} + \beta_{TM=6} * D_{TM=6} + \beta_{TM=7} * D_{TM=7} + \beta_{TM=9} * D_{TM=9} + \beta_{OSA} * ALGO_{2134} + \beta_{factor\ 1} * Factor_1 + \beta_{factor\ 2} * Factor_2 + \beta_{factor\ 3} * Factor_3 + \beta_{factor\ 4} * Factor_4 + \beta_{factor\ 5} * Factor_5 + \beta_{RailTV} * D_{RailTV} + \beta_{Sticker} * D_{Sticker} \quad (8)$$

As can be noticed in the function above, different explanatory variables improve the model estimation. The final goodness-of-fit is equal to 0.202 and log likelihood = -207 189.813. The low r^2 might be related to the explanatory variables (e.g. factors) used. The variables included in the factors, focus on the travellers' experience and not the travellers' ridership. To estimate *ridership*, other explanatory variables should be used which are not present in the available databases.

TABLE 4-4, ESTIMATED PARAMETERS *RIDERSHIP* (SBM DATABASE).

Sample size	190190
Final log likelihood	-207189.813
Rho-squared	0.202

Name	Description	Value	t-test*	R t-test*
ASC_FREQ	Alternative specific constant (ASC)	1.64	40.10	39.28
B_AGE	β_{age}, continues variable for the respondents age	0.0295	90.29	92.84
B_F1	$\beta_{factor\ 1}$, continues variable for factor 1 (experience)	0.0443	7.65	7.67
B_F2	$\beta_{factor\ 2}$, continues variable for factor 2 (ease)	-0.0386	-7.24	-7.29
B_F3	β_{factor} 3, continues variable for factor 3 (comfort)	-0.0150	-3.04	-3.08
B_F5	β_{factor} 5, continues variable for factor 5 (speed)	0.158	32.90	33.03
B_MALE	β_{male}, dummy variable for gender (takes value 1 if male)	-0.255	-26.53	-26.63
B_OSA	$\beta_{overall\ stations\ assessment}$, ordinal variable for overall station assessment	0.0337	7.20	7.22
B_RAILTV	$\beta_{CEM\ RailTV}$, dummy variable for presence of the CEM RailTV at a station (takes value 1 if present)	0.123	4.31	4.36
B_STICKER	$\beta_{CEM\ sticker}$, dummy variable for presence of the CEM wall decoration at a station (takes value 1 if present)	-0.0884	-2.52	-2.56
B_TM_1	$\beta_{travel\ motive\ =\ 1}$, dummy variable for trip purpose (from / to work)	-2.57	-105.00	-102.60
B_TM_2	$\beta_{travel\ motive\ =\ 2}$, dummy variable for trip purpose (business trip)	-0.516	-18.08	-17.41
B_TM_3	$\beta_{travel\ motive\ =\ 3}$, dummy variable for trip purpose (from / to school)	-2.34	-94.16	-90.17
B_TM_4	$\beta_{travel\ motive\ =\ 4}$, dummy variable for trip purpose (visit family / friends)	-0.479	-18.55	-19.01
B_TM_6	$\beta_{travel\ motive\ =\ 6}$, dummy variable for trip purpose (vacation / outing / day trip)	0.174	6.25	6.20
B_TM_7	$\beta_{travel\ motive\ =\ 7}$, dummy variable for trip purpose (hobby / sport)	-0.760	-16.04	-16.49
B_TM_9	$\beta_{travel\ motive\ =\ 8}$, dummy variable for trip purpose (other)	-0.219	-6.84	-6.56

delta1	Δ_1, threshold between τ_1 and τ_2	1.56	220.26	223.34
delta2	Δ_2, threshold between τ_2 and τ_3	1.04	145.56	141.83
delta3	Δ_3, threshold between τ_3 and τ_4	0.933	111.08	106.27
delta4	Δ_4, threshold between τ_4 and τ_5	1.07	82.10	82.54
delta5	Δ_5, threshold between τ_5 and τ_6	1.15	50.79	50.65

** = significant at 95%.*

4.2.2. RP questionnaire

The *revealed preference* questionnaire contains valuable information about the travellers' changed perception of the station quality related to comfort enhancement measures. To estimate the added value of each surveyed comfort enhancement measure a *scaled MNL* will be used. The scaled MNL will estimate the explanatory power of each measure related to the other two measures for *overall station assessment* and *ridership*. In both cases the difference between two user groups are estimated; high *overall station assessment* versus low *overall station assessment* and high *ridership* versus low ridership. High overall station assessment is been associated with assessments of "7" or higher. Low overall station assessment includes all values between "1" and "6". High ridership has been defined as "at least once per week". Low ridership includes all frequencies between "less than once per year" to "1 to 3 days per month".

Secondly, to check if a correlation exists between high *overall station assessment* and *high* ridership a *nested logit* model is estimated. Here, both methods are tested, *normalized from the top down* and *normalized from the bottom up*. As in the *scaled MNL*, high overall station assessment and high ridership are defined as "≥ 7" and "at least once per week" respectively.

4.2.2.1. Generic MNL

The *revealed preference* questionnaire has captured more detailed information about the travellers perception of station quality and experience. In equation (9) the generic MNL model using the RP data is presented. Here, only two personal characteristics are estimated to be significant: (1) gender and (2) employment status. In this model, the male respondents negatively affect the outcome of the estimation. The same is true for employment. If travellers are employed (either fulltime or part-time) their estimated *overall station assessment* will be lower compared to other respondents. In Table 4-5 all the estimated values of the generic MNL model are presented.

$$\begin{aligned} U_{OSA} = ASC_{OSA} + \beta_{male} * GENDER + \beta_{factor\ 1} * Factor_1 + \beta_{factor\ 2} \\ * Factor_2 + \beta_{factor\ 3} * Factor_3 + \beta_{factor\ 4} * Factor_4 \\ + \beta_{factor\ 5} * Factor_5 + \beta_{Lighting} * D_{\ Lighting} \\ + \beta_{employ\_1} * D_{emploument\_1} + \beta_{first\ use} * D_{first\ use} \end{aligned} \tag{9}$$

As can be seen in equation (9), all available factors are found to improve the model of which *factor 1* (experience) has the largest impact on the utility function. Furthermore, it is found that existing travellers have a positive impact on the model. Existing travellers are more likely to have a higher station assessment compared to new travellers. Only the measure of *lighting* is estimated to be a significant improvement of the model.

TABLE 4-5, ESTIMATED PARAMETERS *OVERALL STATION ASSESSMENT* (RP DATABASE).

Sample size	618
Final log likelihood	-731.089
Rho-squared	0.815

Name	Description	Value	t-test	R t-test
ASC_OSA	Alternative specific constant (ASC)	9.01	8.71*	8.57*
B_EMPLOY_1	$\beta_{employment = 1}$, dummy variable for employment (Employed (fulltime / part-time))	-0.402	-2.48*	-2.53*
B_F1	$\beta_{factor\ 1}$, continues variable for factor 1 (experience)	0.945	10.71*	9.81*
B_F2	$\beta_{factor\ 2}$, continues variable for factor 2 (ease)	0.764	9.23*	7.93*
B_F3	$\beta_{factor\ 3}$, continues variable for factor 3 (comfort)	0.561	7.2*	7.13*
B_F4	$\beta_{factor\ 4}$, continues variable for factor 4 (safety & cleanliness)	0.686	8.23*	6.74*
B_F5	$\beta_{factor\ 5}$, continues variable for factor 5 (speed)	0.349	4.56*	3.95*
B_FIRST_USE	β_{first_use}, dummy variable for travellers using the railway station before 2014.	0.473	2.82*	2.73*
B_LIGHTNING	$\beta_{lightning}$, dummy variable for presence of measure (takes value 1 if true)	0.382	1.82**	1.78**
B_MALE	β_{male}, dummy variable for gender (takes value 1 if male)	-0.376	-2.37*	-2.28*
delta1	Δ_1, threshold between τ_1 and τ_2	1.11	1.35***	1.36***
delta2	Δ_2, threshold between τ_2 and τ_3	1.34	2.59*	2.45*
delta3	Δ_3, threshold between τ_3 and τ_4	0.9	3.27*	3.16*
delta4	Δ_4, threshold between τ_4 and τ_5	1.3	5.74*	5.96*
delta5	Δ_5, threshold between τ_5 and τ_6	1.97	11.31*	11.11*
delta6	Δ_6, threshold between τ_6 and τ_7	2.79	18.23*	18.43*
delta7	Δ_7, threshold between τ_7 and τ_8	2.77	12.69*	12.64*
delta8	Δ_8, threshold between τ_8 and τ_9	2.38	4.26*	4.25*

** = significant at 95%, ** = significant at 90%, *** = significant at 80%.*

The RP data is also used to estimate *ridership* using the ordinal regression model. If the final two generic MNL models are compared the difference in goodness-of-fit (r^2) is large. The model for *overall station assessment* has a relative high goodness-of-fit (r^2 = 0.815), compared to the low goodness-of-fit for model of *ridership* (r^2 = 0.307). In equation (10) the generic MNL for *ridership* is presented. Here, many personal and trip characteristic are found to affect *ridership*.

$$\begin{aligned} U_{Freq} = ASC_{Freq} + \beta_{male} * GENDER + \beta_{age} * AGE + \beta_{TM=1} \\ * D_{TM=1} + \beta_{TM=3} * D_{TM=3} + \beta_{EMPLOY_1} * D_{EMPLOY_1} \\ + \beta_{ACCESS_1} * D_{ACCESS_1} + \beta_{ACCESS_2} * D_{ACCESS_2} \\ + \beta_{factor\ 5} * Factor_5 + \beta_{FREQ\_DE} * D_{FREQ\_DE} \end{aligned} \tag{10}$$

Personal characterises as *age* and *gender* are contributing to the model. As with the previous model (equation (9)), male respondents have a negative value, however as ridership is defined on an ordinal scale where a lower value means higher ridership, male travellers are likely to travel more by train. As for age, older travellers will travel less according to the estimated model. Interesting are the travel characteristics in equation (10). Most important are the travel motives, commuters (from / to work) and students (from / to school/study/education) are most contributing to a high ridership. Furthermore, the travellers access mode is also estimated to increase ridership. Travellers arriving at a railway station by foot or by bike (or moped/scooter) have a higher ridership compared to other access modes (e.g. by bus or car). Finally, it is found that a decreased travel frequency between 2013 (before the implementation of a comfort enhancement measure) and 2016 (year of survey) does contribute to the model. When this situation is true for a traveller, the model estimates that (s)he will travel less compared to his/her fellow travellers.

TABLE 4-6, ESTIMATED PARAMETERS *RIDERSHIP* (RP DATABASE).

Sample size		618		
Final log likelihood		-670.354		
Rho-squared		0.307		
Name	**Description**	**Value**	**t-test***	**R t-test***
ASC_FREQ	Alternative specific constant (ASC)	2.5	7.45	6.99
B_ACCESS_1	β_{access_1}, dummy variable for access mode (by foot)	-0.535	-2.32	-2.28
B_ACCESS_2	β_{access_2}, dummy variable for access mode (by bike/moped/scooter)	-0.745	-3.46	-3.54
B_AGE	β_{age}, continues variable for the respondents age	0.0336	5.33	5.47
B_EMPLOY_1	$\beta_{employment = 1}$, dummy variable for employment (Employed (fulltime / part-time))	1.08	4.6	4.29
B_F5	$\beta_{factor\ 5}$, continues variable for factor 5 (speed)	0.303	3.53	3.45
B_FREQ_DE	$\beta_{freq\_decrease}$, dummy variable for a decreased ridership between2013(before measure) and 2016 (moment of survey)	1.2	3.14	3.81
B_MALE	β_{male}, dummy variable for gender (takes value 1 if male)	-0.474	-2.81	-2.84
B_TM_1	$\beta_{travel\ motive = 1}$, ordinal variable for trip purpose (from / to work)	-3.7	-12.3	-11.44
B_TM_3	$\beta_{travel\ motive = 3}$, ordinal variable for trip purpose (from / to school)	-2.64	-9.78	-9.32
delta1	Δ_1, threshold between τ_1 and τ_2	1.91	12.75	12.76
delta2	Δ_2, threshold between τ_2 and τ_3	1.04	7.81	7.42
delta3	Δ_3, threshold between τ_3 and τ_4	0.738	5.94	5.9
delta4	Δ_4, threshold between τ_4 and τ_5	0.762	5.17	5.27
delta5	Δ_5, threshold between τ_5 and τ_6	1.19	5.01	4.82

** = significant at 95%.*

What is most surprising in the generic MNL models estimating *overall station assessment* and *ridership* are the insignificant variables for the experienced change. For every measure the experienced change (expressed as “largely worsened”, “worsened”, “no influence”, “improved”, “largely improved”) are asked for seven indicators ((1) overall station assessment, (2) ridership, (3) experience, (4) comfort, (5) ease, (6) speed, and (7) safety & cleanliness). In both estimated MNL models using the RP data, none of the experienced changes are found to be either significant of improve the model.

The descriptive statistics presented a major improvement of *overall station assessment* related to the comfort enhancement measure of *lighting* (see Figure 3-31). However, this reported improvement is not significant in estimating *overall station assessment* and *ridership*. Combined with the information presented in Figure 3-24 (change in *overall station assessment* for each of the three measures), it might be that the impact of one comfort enhancement measure has an incremental effect on *overall station assessment*. For ridership, the outcome of equation (10) is as suggested by the descriptive statistics: comfort enhancement measures have no effect on the ridership of train travellers.

Presented in the descriptive statistics, are seven explanations why travellers changed their ridership and trip purpose (if applicable) between 2013 and 2016. Respondents could indicate if these seven reasons did explain their change in trip characteristics. These seven reason are tested in the MNL model for *overall station assessment* and *ridership*. However, all reasons are estimated to be insignificant in both models.

4.2.2.2. Scaled MNL

To estimate the effects of each comfort enhancement measure related to *overall station assessment* and *ridership*, a multinomial logit with scale parameter is estimated. The estimated scale parameter (θ_x) is used to determine the amount of change a comfort enhancement measure has in relation to the other two comfort enhancement measures (Train, 2009). For each scaled MNL model estimating *overall station assessment*, the dataset is divided among two groups: (1) respondents with a low assessment (<7) and (2) respondents with a high assessment (≥7). For *ridership*, the following two user groups are created: (1) low ridership (less than once per week) and (2) high ridership (at least once per week). In both cases, a scatterplot was used to identify the two user groups.

Green and planters

$$\begin{aligned} U_{OSA\_1\_6} &= ASC_{OSA\_1\_6} \\ U_{OSA\_7\_10} &= ASC_{OSA\_7\_10} + \beta_{factor\ 1} * Factor_1 + \beta_{factor\ 2} * Factor_2 \\ &\quad + \beta_{factor\ 3} * Factor_3 + \beta_{factor\ 4} * Factor_4 \\ &\quad + \beta_{factor\ 5} * Factor_5 + \beta_{age\_6} * D_{age\_6} \\ &\quad + \beta_{Freq\_VERA6163\_IM} * D_{Freq\_VERA6163\_IM} \end{aligned} \quad (11)$$

The factors resulting from the factors analysis using the RP data, are all estimated to improve the scaled MNL model for *green and planters*. Here, respondents between the age of 51 and 60 y/o tend to assess the *overall station assessment* lower compared to all other age groups. Furthermore, if a respondent did change his ridership due to better accessibility, (s)he will assess the *overall station assessment* higher (7+) compared to other travellers.

TABLE 4-7, ESTIMATED VALUES OF PARAMETERS FOR SCALED MNL - GREEN AND PLANTERS (RP DATABASE).

Sample size	618			
Final log likelihood	-256.671			
Rho-squared	0.401			
Name	**Description**	**Value**	**t-test***	**R t-test**
ASC_OSA_7_10	Alternative specific constant	1.37	9.75	9.15*
B_AGE_6	$\beta_{age\_category\_51-60}$, dummy variable for respondents between the age of 51 and 60 years old.	-0.726	-1.99	-1.90**
B_F1	$\beta_{factor\ 1}$, continues variable for factor 1 (experience)	0.939	7.88	9.76*
B_F2	$\beta_{factor\ 2}$, continues variable for factor 2 (ease)	0.706	6.19	5.84*
B_F3	$\beta_{factor\ 3}$, continues variable for factor 3 (comfort)	0.665	6.07	5.74*
B_F4	$\beta_{factor\ 4}$, continues variable for factor 4 (safety & cleanliness)	0.646	5.86	4.14*
B_F5	$\beta_{factor\ 5}$, continues variable for factor 5 (speed)	0.325	3.30	4.21*
B_FREQ_VERA6163_IM	$\beta_{FREQ\_VERA6163\_IM}$, dummy variable for changed ridership due to a better accessible railway station (includes "agree" and "completely agree")	2.15	2.05	6.52*
SCALE_GREEN	$\theta_{green\ and\ planters}$, scale factor for the measure of *green and planters*	1.12	5.42	5.60*

****= significant at 95%, ** = significant at 90%.***

The same model structure is applied to estimate the effects of *green and planters* on *ridership*. The final model resulted in the following utility function:

$$U_{FREQ\_3\_5} = ASC_{FREQ\_3\_5} \quad (12)$$

$$U_{FREQ\_1\_2} = ASC_{FREQ\_1\_2} + \beta_{TM=1} * D_{TM=1} + \beta_{TM=3} * D_{TM=3} + \beta_{age} * age + \beta_{male} * gender + \beta_{Freq\_VERA6163\_IM} * D_{Freq\_VERA6163\_IM}$$

All tested factors resulted to be insignificant, thus did not improve the estimated scale MNL model. As presented in the descriptive statistics, it indicates a weak relationship between the factors (which are more related to the *overall station assessment*) and *ridership*. Furthermore, trip purposes related to travelling *from / to work* (TM = 1) and *from / to school* (TM = 3) (both expected to be high frequent travellers) are estimated to be significant. Besides several trip characteristics, two personal characteristics are estimated to improve the model: (1) age and (2) gender. In the final model (see equation (12)) the *alternative specific constant* resulted to be insignificant (p=1.08).

TABLE 4-8, ESTIMATED VALUES OF PARAMETERS FOR SCALED MNL – GREEN AND PLANTERS (RP DATABASE).

Sample size	618			
Final log likelihood	-204.100			
Rho-squared	0.692			
Name	**Description**	**Value**	**t-test**	**R t-test**
ASC_FREQ_1_2	Alternative specific constant	0.562	1.38**	0.75**
B_AGE	β_{age}, continues variable for the respondents age	-0.0290	-2.95*	-2.25*
B_FREQ_VERA6163_IM	$\beta_{FREQ\_VERA6163\_IM}$, dummy variable for changed ridership due to a better accessible railway station (includes "agree" and "completely agree")	2.43	1.98*	2.16*
B_MALE	β_{male}, dummy variable for gender (takes value 1 if male)	0.681	2.46*	2.24*
B_TM_1	$\beta_{travel\ motive\ =\ 1}$, ordinal variable for trip purpose (from / to work)	3.57	9.48*	5.85*
B_TM_3	$\beta_{travel\ motive\ =\ 3}$, ordinal variable for trip purpose (from / to school)	3.29	9.25*	5.82*
SCALE_GREEN	$\theta_{green\ and\ planters}$, scale factor for the measure of *green and planters*	0.957	6.37*	2.87*

** = significant at 95%, ** = insignificant.*

Digital screens with infotainment

$$U_{OSA\_1\_6} = ASC_{OSA\_1\_6}$$
$$U_{OSA\_7\_10} = ASC_{OSA\_7\_10} + \beta_{factor\ 1} * Factor_1 + \beta_{factor\ 2} * Factor_2 + \beta_{factor\ 3} * Factor_3 + \beta_{factor\ 4} * Factor_4 + \beta_{factor\ 5} * Factor_5 + \beta_{changed_{speed}} * Change_{speed} + \beta_{Freq\_VERA3163\_IM} * D_{Freq\_VERA3163\_IM} \quad (13)$$

In the equation above, the utility function for the *digital screens with infotainment* (RailTV) is presented. Beside the five significance of the five factors, two other explanatory variables resulted to be significant and improve the model. $\beta_{freq\_VERA3136\_IM}$ explains the change in travel frequency between 2013 (before the implementation of the comfort enhancement measure) and the moment of the survey (2016). In this case the change is related to changed living conditions (e.g. moved to a new house, living together with partner or being divorced) of the traveller. Secondly, the experienced change of the customer need *speed* (positive and negative) due to RailTV is found to be significant. However, because the value is negative it results in a lower *overall station assessment*. The values of the significant variables are presented in Table 4-9.

TABLE 4-9, ESTIMATED VALUES OF PARAMETERS FOR SCALED MNL - DIGITAL SCREENS WITH INFOTAINMENT (RP DATABASE).

Sample size	618			
Final log likelihood	-255.729			
Rho-squared	0.403			
Name	**Description**	**Value**	**t-test***	**R t-test**
ASC_OSA_7_10	Alternative specific constant	2.85	4.06	6.69*
B_CHANGED_SPEE	$\beta_{changed\_speed}$, ordinal variable indication the perceived change of the customer need *speed*.	-0.0135	-2.03	-3.37*
B_F1	$\beta_{factor\ 1}$, continues variable for factor 1 (experience)	1.16	7.18	8.67*
B_F2	$\beta_{factor\ 2}$, continues variable for factor 2 (ease)	0.925	5.89	5.34*
B_F3	$\beta_{factor\ 3}$, continues variable for factor 3 (comfort)	0.828	5.59	4.43*
B_F4	$\beta_{factor\ 4}$, continues variable for factor 4 (safety & cleanliness)	0.721	5.56	3.11*
B_F5	$\beta_{factor\ 5}$, continues variable for factor 5 (speed)	0.404	3.30	5.20*
B_FREQ_VERA3163_IM	$\beta_{FREQ\_VERA3163\_IM}$, dummy variable for changed ridership due to changed living conditions (includes “agree” and “completely agree”)	1.91	1.99	1.44**
SCALE_RAILTV	θ_{RailTV}, scale factor for the measure of *RailTV*	0.639	5.47	6.78*

** = significant at 95%, ** = significant at 85%.*

For *digital screens with infotainment* (RailTV) a scaled MNL model is estimated for *ridership* (see equation (14)). As for the measure of *green and planters*, only the trip purposes *from / to work* and *from / to school* are found to be significant (both are likely to be frequent travellers). Furthermore, the personal characterises of *age* and *gender* are found to be significant. Male travellers are most likely to have a higher ridership, but as age increases the ridership will decrease. Finally, one of the reasons explaining the change in ridership is found to be significant: travel more due to study (VERA2163).

$$\begin{aligned} U_{FREQ\_3\_5} &= ASC_{FREQ\_3\_5} \\ U_{FREQ\_1\_2} &= ASC_{FREQ\_1\_2} + \beta_{TM=1} * D_{TM=1} + \beta_{TM=3} * D_{TM=3} + \beta_{age} \\ &\quad * age + \beta_{male} * gender + \beta_{Freq\_VERA2163\_IM} \\ &\quad * D_{Freq\_VERA2163\_IM} \end{aligned} \tag{14}$$

In Table 4-10 the estimated values and (Robust) t-tests are presented. As can be noticed, the *alternative specific constant* resulted to be insignificant (p=1.08).

TABLE 4-10, ESTIMATED VALUES OF PARAMETERS FOR SCALED MNL - DIGITAL SCREENS WITH INFOTAINMENT (RP DATABASE).

Sample size	618			
Final log likelihood	-203.940			
Rho-squared	0.692			
Name	**Description**	**Value**	**t-test**	**R t-test**
ASC_FREQ_1_2	Alternative specific constant	0.580	1.50**	0.79**
B_AGE	β_{age}, continues variable for the respondents age	-0.0278	-2.95*	-2.39*
B_FREQ_VERA2163_IM	$\beta_{FREQ\_VERA2163\_IM}$, dummy variable for changed ridership due to study (includes “agree” and “completely agree”)	2.35	2.08*	2.16*
B_MALE	β_{male}, dummy variable for gender (takes value 1 if male)	0.640	2.36*	2.22*
B_TM_1	$\beta_{travel\ motive\ =\ 1}$, ordinal variable for trip purpose (from / to work)	3.41	8.98*	4.82*

B_TM_3	$\beta_{\text{travel motive = 3}}$, ordinal variable for trip purpose (from / to school)	3.14	8.28*	5.13*
SCALE_RAILTV	θ_{RailTV}, scale factor for the measure of *digital screens with infotainment*	1.09	7.35*	2.92*

* = significant at 95%, ** = insignificant.

Lightning

The utility function to estimate *overall station assessment* related to the measure of *lighting* are presented in equation (15).

$$\begin{aligned} U_{OSA\_1\_6} &= ASC_{OSA\_1\_6} \\ U_{OSA\_7\_10} &= ASC_{OSA\_7\_10} + \beta_{factor\ 1} * Factor_1 + \beta_{factor\ 2} * Factor_2 \\ &\quad + \beta_{factor\ 3} * Factor_3 + \beta_{factor\ 4} * Factor_4 \\ &\quad + \beta_{factor\ 5} * Factor_5 + \beta_{age_6} * D_{age_6} \\ &\quad + \beta_{Freq\_VERA6163\_IM} * D_{Freq\_VERA6163\_IM} \end{aligned} \tag{15}$$

As for the previous two scaled MNL models (see equations (13) and (11)), all factors are found to be significant. As for the variable of age, only the age category for travellers between the age of 51 and 60 years old are found to be significant. These traveller have a lower *overall station assessment* compared to their fellow travellers, see Table 4-11. Furthermore, when travellers travel relatively little (6 to 11 days per year) they are expected to have a high overall station assessment. Finally, if the travellers travel frequency has changed between 2013 and 2016 due to an improved accessibility of the railway station, an high overall station assessment is expected by the model.

TABLE 4-11, ESTIMATED VALUES OF PARAMETERS FOR SCALED MNL – LIGHTNING (RP DATABASE).

Sample size	618			
Final log likelihood	-248.527			
Rho-squared	0.420			
Name	**Description**	**Value**	**t-test***	**R t-test***
ASC_OSA_7_10	Alternative specific constant	1.29	9.12	10.43
B_AGE_6	$\beta_{\text{age\_category\_51-60}}$, dummy variable for respondents between the age of 51 and 60 years old.	-0.80	-2.09	-2.08
B_F1	$\beta_{\text{factor 1}}$, continues variable for factor 1 (experience)	0.938	6.82	6.07
B_F2	$\beta_{\text{factor 2}}$, continues variable for factor 2 (ease)	0.719	6.02	4.83
B_F3	$\beta_{\text{factor 3}}$, continues variable for factor 3 (comfort)	0.689	6.22	5.63
B_F4	$\beta_{\text{factor 4}}$, continues variable for factor 4 (safety & cleanliness)	0.685	5.47	3.59
B_F5	$\beta_{\text{factor 5}}$, continues variable for factor 5 (speed)	0.328	3.32	3.61
B_FREQ_4	$\beta_{\text{travel frequency = 4}}$, ordinal variable for travel frequency (6 to 11 days per year)	2.56	3.04	2.48
B_FREQ_VERA6163_IM	$\beta_{\text{FREQ\_VERA6163\_IM}}$, dummy variable for changed ridership due to a better accessible railway station (includes “agree” and “completely agree”)	2.44	2.19	6.73
SCALE_LIGHTNING	$\theta_{\text{lightning}}$, scale factor for the measure of *lighting*	1.15	5.56	5.80

** = significant at 95%.*

To test which independent parameters contribute to the model for estimating *ridership* in relation to the comfort enhancement measure of *lighting*, a scaled MNL model is estimated, see equation (16).

$$U_{FREQ\_3\_5} = ASC_{FREQ\_3\_5} \tag{16}$$

$$U_{FREQ\_1\_2} = ASC_{FREQ\_1\_2} + \beta_{TM=1} * D_{TM=1} + \beta_{TM=3} * D_{TM=3} + \beta_{age} * age + \beta_{Freq\_VERA6163\_IM} * D_{Freq\_VERA6163\_IM} + \beta_{Freq\_VERA7163\_IM} * D_{Freq\_VERA7163\_IM}$$

As in previous scaled MNL models relating to *ridership*, the trip purposes of *from / to school* and *from / to work* are estimated to improve the model. However, where in previous models *gender* did contribute to the model, for the measure of *lighting* it did not improve the model. The most interesting independent variables to improve the estimation of *ridership* are the dummy variables that explain the change in ridership: VERA6163 and VERA7163. The former reason explains the changed ridership to related to a better accessibility of the railway station. The latter reason states that the respondent changed their ridership due to the increased attractiveness of the railway station. In Table 4-12 the values and corresponding (Robust) t-test are presented.

TABLE 4-12, ESTIMATED VALUES OF PARAMETERS FOR SCALED MNL - LIGHTNING (MODEL_RP_SCALE_FREQ_0544).

Sample size	618			
Final log likelihood	-204.744			
Rho-squared	0.691			
Name	**Description**	**Value**	**t-test***	**R t-test**
ASC_FREQ_1_2	Alternative specific constant	0.779	1.99	1.07**
B_AGE	β_{age}, continues variable for the respondents age	-0.0258	-2.65	-1.99*
B_FREQ_VERA6163_IM	$\beta_{FREQ\_VERA6163\_IM}$, dummy variable for changed ridership due to a better accessible railway station (includes “agree” and “completely agree”)	4.20	2.47	3.48*
B_FREQ_VERA7163_IM	$\beta_{FREQ\_VERA7163\_IM}$, dummy variable for changed ridership due to a more attractive railway station (includes “agree” and “completely agree”)	-2.84	-2.13	-3.19*
B_TM_1	$\beta_{travel\ motive\ =\ 1}$, ordinal variable for trip purpose (from / to work)	3.60	9.39	4.90*
B_TM_3	$\beta_{travel\ motive\ =\ 3}$, ordinal variable for trip purpose (from / to school)	3.38	9.02	6.16*
SCALE_LIGHTNING	$\theta_{Lighting}$, scale factor for the measure of *lighting*	0.934	6.86	2.74*

** = significant at 95%, ** = insignificant.*

Summary

In the tables presented for each comfort enhancement measures, the scale parameter (θ_x) is the most interesting parameter. For all estimated scale MNL model two user groups are tested: (1) high *overall station assessment* or *high ridership* and (2) *low overall station assessment* or *low ridership*. With high defined as an *overall station assessment* of 7 or higher, or a trip frequency of at least once per week.

Green and planters is estimate to have 1.12 (p= 5.42) more variance compared to the other two comfort enhancement measures. For the measure of *lighting* the scale parameter has been estimated to be 1.15 (p= 5.56) more compared to *green and planters*, and *digital screens with infotainment*. Finally, the comfort enhancement measure of *digital screens with infotainment* (a.k.a. RailTV), has a explains less variation compared to the two measures of *green and planters* and *lighting*.

Where *green and planters* and *lighting* are positively contributing to the variance in *overall station assessment*, the impact on *ridership* is negative. For either two measures (*green and planters* and *lighting*) the estimated values are respectively 0.957 (p=6.37) and 0.934 (p=6.86). However, the measure of RailTV does explain more variance (1.09) compared to the measures *green and planters* and *lighting* in the models estimating *ridership*. Nevertheless, in all instances a dispersion is present among each of the six estimated MNL models, indicating that each tested comfort enhancement measure is different compared to the other measures.

TABLE 4-13, OVERVIEW SCALE PARAMETERS FINAL SCALED MNL MODELS (RP DATABASE).

Overall station assessment	**Value**	**t-test***	**Robust t-test***
Green and planters	1.12	5.42	5.60
RailTV	0.644	5.45	7.17
Lighting	1.15	5.56	5.80
Ridership	**Value**	**t-test***	**Robust t-test***
Green and planters	0.957	6.37	2.87
RailTV	1.09	7.35	2.92
Lighting	0.934	6.86	2.74

** = significant at 95%.*

4.2.2.3. Nested logit

The pervious estimated models provided evidence of a weak link between *overall station assessment* and *ridership*. To test the correlation between these two explanatory variables, a nested logit (NL) is estimated using the nest structure presented in Figure 4-2. *Normalized from the top down*, tests the μ_{nests} (μ is fixed). *Normalized from the bottom up*, tests the μ (μ_{nests} is fixed). However, both NL models resulted in unusable models, confirming the weak link presented in previous models and resulting from the empirical evidence. The estimated (initial) models resulted in μ and μ_{nest} being unidentifiable (n=612) and insignificant (n=612) respectively (with x equal to '7' and y equal to 'at least once per week').

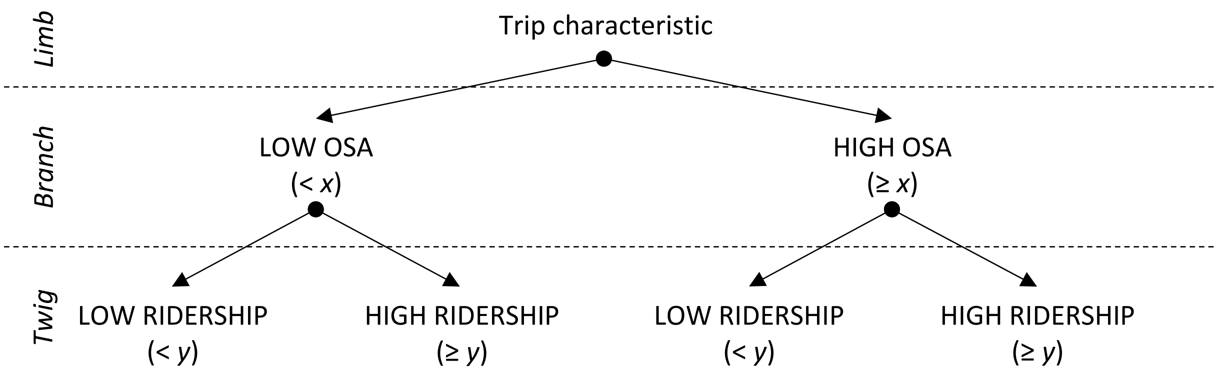


FIGURE 4-2, NEST STRUCTURES FOR NL MODEL.

4.2.3. General MNL model

The two databases are used in different model, however these estimated models cannot be compared. To see how each database (SBM vs. RP) compares to the other, the most basic choice model, the multinomial logistic regression model, is estimated for each database. Choice models are estimated for both depended variables: (1) *overall station assessment* and (2) *ridership* and only include variables that are present in both databases.

For the *Stationsbelevingmonitor* only the data related to the railway stations of *Almelo*, *Eindhoven*, and *Helmond* are used in the MNL model. All other data has been excluded from the estimation. Only those independent variables are used that are available for both databases. Important to consider is the difference in sample size. For estimation *overall station assessment*, the SBM sample size consists of 5126 respondents. The sample size of the RP database contains 618 respondents.

In the table below, the values (and related (robust) t-tests) of each variable is presented for each database (SBM and RP). For every database all shared independent variables are tested, however not all contributed to an improvement of the model. Both *age* and *assessment of the weather* are found to improve the MNL model using the SBM data, however these variables are found to be insignificant in the MNL model using the RP data. The opposite is true for *gender*, it is estimated to improve the RP MNL model, while *gender* is insignificant in the MNL model using the SBM data. The last deviation between the models is the *travel motive*. For the SBM database, commuting respondents (TM = 1) do improve the model, however have a lower *overall station assessment*. In both MNL models, all factors are significant, and improve the estimated model (F1 = *experience*, F2 = *ease*, F3 = *comfort*, F4 = *safety & cleanliness*, and F5 = *speed*). For both models, the presence of *comfort enhancement measures* are contributing to each estimated model. In both cases the measure of *green and planters* (Almelo station) is fixed, the measures of *digital screens with infotainment* (Eindhoven station) and *lighting* (Helmond) are estimated. For both models the *comfort enhancement measures* are estimated to improve the models. The *comfort enhancement measures* are used as dummy variables based on their station ID. For example, if the respondent is associated with station ID “391” (Helmond station) the dummy variable for *lighting* is true and takes the value of “1”.

The goodness-of-fit for both models are expressed in the r^2 value. For both models the r^2-value is above 0.8, and therefore the models fit the data relatively well. The r^2-values are 0.812 and 0.815 for respectively the SBM and RP database.

TABLE 4-14, ESTIMATED PARAMETERS FOR MNL MODELS ESTIMATING *OVERALL STATION ASSESSMENT*.

Database	**SBM**			**RP**		
Sample size	5126			618		
Final log likelihood	-5933.876			-733.051		
Rho-squared	0.812			0.815		
Name	**Value**	**t-test***	**R t-test***	**Value**	**t-test**	**R t-test**
ASC_OSA	10.2	29.18	28.97	8.69	8.40*	8.33*
B_AGE	-0.0131	-6.95	-6.92			
B_F1	1.52	40.48	36.39	0.888	9.92*	9.09*
B_F2	1.35	36.20	28.70	0.782	9.44*	8.04*
B_F3	0.745	23.20	19.81	0.504	5.97*	5.54*
B_F4	1.03	30.59	26.43	0.637	7.59*	6.28*
B_F5	0.157	5.19	4.58	0.384	4.95*	4.34*
B_LIGHTNING	0.537	3.21	3.05	0.854	3.66*	3.78*
B_MALE				-0.356	-2.27*	-2.21*
B_RAILTV	0.168	2.57	2.53	0.640	3.03*	3.00*
B_TM_1	-0.230	-3.49	-3.57			
B_WEATHER	0.0344	2.37	2.20			
delta1	1.59	5.48	5.68	1.12	1.35**	1.38**
delta2	1.36	8.79	8.66	1.33	2.59*	2.47*
delta3	1.30	13.04	12.88	0.889	3.27*	3.17*

delta4	1.66	21.67	21.24	1.31	5.75*	5.88*
delta5	2.43	38.98	38.18	1.99	11.27*	11.19*
delta6	2.87	50.05	49.28	2.77	18.25*	18.42*
delta7	2.88	32.98	33.43	2.74	12.71*	12.88*
delta8	1.91	12.95	13.52	2.36	4.24*	4.25*

** = significant at 95%, ** = insignificant*

Next, is the estimation of *ridership*. The sample sizes are 5273 respondents and 619 respondents for respectively the *Stationsbelevingsmonitor* and *RP survey*. In earlier sections of this thesis, the estimation of *ridership* with the two available databases is resulted in few variables relating to customer experience. The final MNL models resulted in a r^2 of 0.213 and 0.288 for respectively the SBM and RP databases. Compared to the high goodness-of-fit of the *overall station assessment*, the goodness-of-fit of these *ridership* models can be considered very low, and not suited for any estimation.

In Table 4-15, the estimated parameters are presented for both models. Interestingly, the effects of all factors (= Customer needs) are marginal at most. For the SBM MNL model, factors 1, 3, and 5 are improving the model. Factor 1 is related to *experience*, factor 3 relates to *comfort*, and factor 5 can be associated with *speed*. However, the MNL model with the RP data shows only one factor (factor 5, *speed*) estimated to improve the model. All other factors resulted to be insignificant.

For both databases, the trip purposes *from / to work* (TM_1) and *from / to school* (TM_3) are estimated to improve the MNL models. For both trip purposes the values are estimated to be negative. Hence, the lower the utility, the higher the ridership. In the SBM database, the trip purpose related to recreational use of the train e.g. for a day trip, outing, holiday. However, the value is positive, indication a low ridership for recreational train use. As for personal characteristics, both *age* and *gender* contribute to the improvement of the MNL model. Lastly, only one comfort enhancement measure, *lighting*, resulted in the improvement of the general MNL model (using the RP database). However, this measure has been combined with the reconstruction of the station building and station environment. Therefore the experienced changed might be biased by the complete reconstruction. As for the measures *green and planters* and *RailTV*. Both measures resulted in an incremental, and thus insignificant, improvement of the MNL model.

TABLE 4-15, ESTIMATED PARAMETERS FOR MNL MODELS ESTIMATING *RIDERSHIP*.

Database	**SBM**			**RP**		
Sample size	5273			619		
Final log likelihood	-5592.886			-691.195		
Rho-squared	0.213			0.288		
Name	**Value**	**t-test***	**R t-test***	**Value**	**t-test***	**R t-test***
ASC_FREQ	1.40	14.09	13.35	2.76	8.60	8.37
B_AGE	0.0336	16.00	16.30	0.0343	5.56	5.79
B_F1	0.0799	2.51	2.48			
B_F3	-0.0718	-2.40	-2.31			
B_F5	0.224	7.38	7.34	0.342	4.03	3.87
B_LIGHTNING				-0.425	-2.28	-2.25
B_MALE	-0.280	-4.79	-4.83	-0.503	-3.02	-3.03
B_TM_1	-2.08	-23.92	-23.55	-3.20	-12.40	-12.21
B_TM_3	-2.05	-24.49	-23.49	-2.86	-11.00	-10.67

B_TM_6	0.516	5.01	4.95			
delta1	1.53	35.25	36.29	1.83	12.72	12.64
delta2	0.948	22.77	22.15	0.988	7.80	7.47
delta3	0.899	18.70	17.99	0.713	6.02	5.96
delta4	1.11	14.65	14.73	0.708	5.14	5.31
delta5	1.08	8.86	8.87	1.15	4.97	4.82

** = significant at 95%.*

4.3. Summary

In this section, various models have been presented which estimate the travellers *overall station assessment* and *ridership* on railway stations. To estimate the various models two databases have been used; (1) the *Stationsbelevingsmonitor* and (2) *revealed preference survey* which are conducted on three railway stations. The large number of variables related to *overall station assessment* present in the SBM are reduced to a total of five factors. These factors, clearly define the link between reality (the *Stationsbelevingsmonitor*) and literature. For both databases the factor analysis has been conducted, and in both instances the factors could be related to the same Customer Needs, as presented in Figure 2-1. Factor 1 includes all variables (SBM questions) related to *attractivity* and *waiting time experience*; themes associated with *experience*. Factor 2 has been labelled *ease*. The variables are related to *station environment* and *orientation*. Both themes contribute to the *ease* by which the traveller moves in and around the railway station. *Comfort* is the label for the third factor. Comfort is directly related to the NS theme *inviting*, which includes statements about the physical comfort of travellers. Factor 4, can be considered to be the basics; *safety & cleanliness*. As the label states, this factor includes the NS themes *safety* and *cleanliness*. The final factor resulting from the factor analysis has been labelled *speed*. As found in Table 4-1 and Table 4-2, factor 5 included the statements related to *busy* and *pedestrian flow*. However, the factor analyses between the two databases are reported. The FA conducted using the RP data found that the variables *OMGE2134*, *OMGE3134*, *OMGE1134, and OMGE2134* could not be associated with any of the factors, and are therefore excluded from future usage of the factors.

The available explanatory variables are reduced from 26 (SBM) or 24 (RP) to a total of 5 variables using a factor analysis. Together with the personal and trip related characteristics, *overall station assessment* and *ridership* are estimated using a MNL model. In the models estimating *overall station assessment*, the factors are the most prominent explanatory variables. However, in most models estimating *ridership* these factors have a limited impact. The goodness-of-fit for both models (overall station assessment and ridership) show large differences. In general, models estimating *overall station assessment* have a high goodness-of-fit, while models estimating ridership are low. The general MNL models presented in Table 4-14 and Table 4-15 indicate the large difference between estimating *overall station assessment* and *ridership*. Both models estimating *overall station assessment* resulted in r^2 at least 0.812, whereas the estimating *ridership* with both databases results in r^2 values of 0.288 at most.

To test each surveyed measure against the other two comfort enhancement measures, several scaled MNL model are estimated. For *overall station assessment* the scale parameters varies between each tested comfort enhancement measure. The estimated scaled MNL models for *green and planters* and *lighting* explained respectively 1.12 and 1.15 more variance compared to the other two comfort enhancement measures. While the scale parameter of *RailTV* is estimated to explain 0.644 less variance compared to the other two measures. When estimating *ridership*, the difference between scale parameters are less. Nevertheless, the goodness-of-fit for each of these three models, can be considered low. The measure of *green and planters* is estimated to explain 0.957 less, for the measure of *lighting* the scale parameter resulted in explain 0.934 less compared to the other two models. Interestingly, the model for *RailTV* is estimated to explain 1.09 more compared to *lighting* and *green and planters* (in the case of *ridership*).

Included in the RP questionnaire, are statements related to why traveller have changed their *ridership* between the moment of implementation (of the comfort enhancement measure) and the moment or questioning (2016). Some of these statements, or reasons for change, resulted in an improvement of the scaled MNL models. Of the seven statements, the following three statements are estimated to improve at least one of estimated scaled MNL models; (1) "I need to travel more due to my study", (2) "The railway station is better accessible", and (3) "The railway station has become more attractive". These statements could indicate that the travellers assess the station quality higher when one of these statements is true. Nevertheless, the relation between *overall station assessment* and travellers *ridership* is very weak in all estimated scaled MNL models.

To test the correlation between *overall station assessment* and *ridership* a nested logit model has been created. For both top-down normalization and bottom-up normalization the models resulted in unusable results i.e. the model is either unidentifiable or insignificant. Both cases support the statement that there is no correlation between *overall station assessment* and *ridership*.

5. Application

The province of North-Brabant has created a development program to improve its nodes, high quality public transport, and rail related transport. This program, also known as *Ontwikkelagenda spoor, HOV en knooppunten*, defines five strategies to improve the accessibility of the whole province. The strategies focusses on (1) diversity, (2) accelerate, (3) transfer, (4) comfort enhancement, and (5) freight. In short, *diversity* focusses on programs that improve the mixed land use function of places and nodes. *Accelerate* is a program to decrease the travel time of (high quality) PT between all transport nodes within the province. The third program, *transfer*, will focus on improving transfers between all available modalities (e.g. walking, biking, car, PT) and thereby improving the efficiency of the whole transport network. The fourth program, and the focus of this research, should improve the comfort, experience and overall (spatial) quality of transport nodes. The last program, *freight*, does not directly focus at the transportation of people. However this program aims to disentangle freight transport with public transport (rail only). To disentangle both ways of rail transport policies should increase the available 'space' on the tracks for freight transport (without increasing travel time of public transport). Of all the five strategies, the forth strategy is of importance in this thesis.

FIGURE 5-1, GRAPHIC REPRESENTATION OF THE FIVE DEVELOPMENT PROGRAMS.

Goudappel Coffeng created the development agenda for every transport node in the province of North-Brabant using the five strategies. To create realistic ambitions for every node, the transport nodes are categorized in five typologies. Ranging from *international nodes* (e.g. Breda) to *local nodes* (e.g. Maarheeze). Here, international nodes are compared with station typologies 1 or 2, and local nodes are station typologies 5 or 6.

FIGURE 5-2, NODE TYPOLOGIES USED BY THE PROVINCE OF NORTH-BRABANT.

For every node, the current valuation of each strategy is defined and visualised in a radar chart. In this radar chart the four strategies focussing on passenger transport are presented. Every quadrant relates to the three main topics relating to the strategy. Goudappel Coffeng defined the strategy of *comfort enhancement* to include three topics: facilities ( ), assessment of station environment ( ), and assessment of the station ( ). As example, the evaluation of Tilburg station is presented in Figure 5-3. In the development agenda of the province, Tilburg Station is defined as *national node*. For this typology, the ambition is set

FIGURE 5-3, EVALUATION OF TILBURG STATION AS NATIONAL NODE.

to achieve a 100% score for the assessment of the station itself as for the station environment. To create an attractive and inviting node, a total of 28 facilities are desired at a *national node*.

To estimate the effects of comfort enhancement measures on public transport nodes in the Province of North-Brabant, five railway stations are selected. The *Ontwikkelagenda spoor, HOV en knooppunten* used customer satisfaction data collected in 2014 to measure overall station assessment, defined as the share of travellers with an assessment of 7 or higher (on a scale of 1 to 10, 1 = very unsatisfied, 10 = excellent). Five of the lowest ranking railway stations of the province are selected for the simulation, resulting in the recruitment of the railway stations: Oss (<50%, typology 4), Tilburg (50-60%, typology 2), Breda (<50%, typology 2), Roosendaal (50-60%, typology 2), and Bergen op Zoom (<50%, typology 4). In Figure 5-4 the average *overall station assessment* for each of the five railway stations is presented over time. As can be seen, since the completing of the development program, an increase in the average overall station assessment is visible for most of the recruited railway stations. However, for the station of Breda, a relative large increase in assessment can be noticed. This is most likely caused by the fact that the complete station building is reconstructed (construction started in 2012). As construction progressed, travellers started using new sections of the station building, which could have caused the increase in customer satisfaction. Opposite to the changes at Breda is the station of Bergen op Zoom. Here, the average overall station assessment slightly declines over time, no explanation has been found to support this decline.

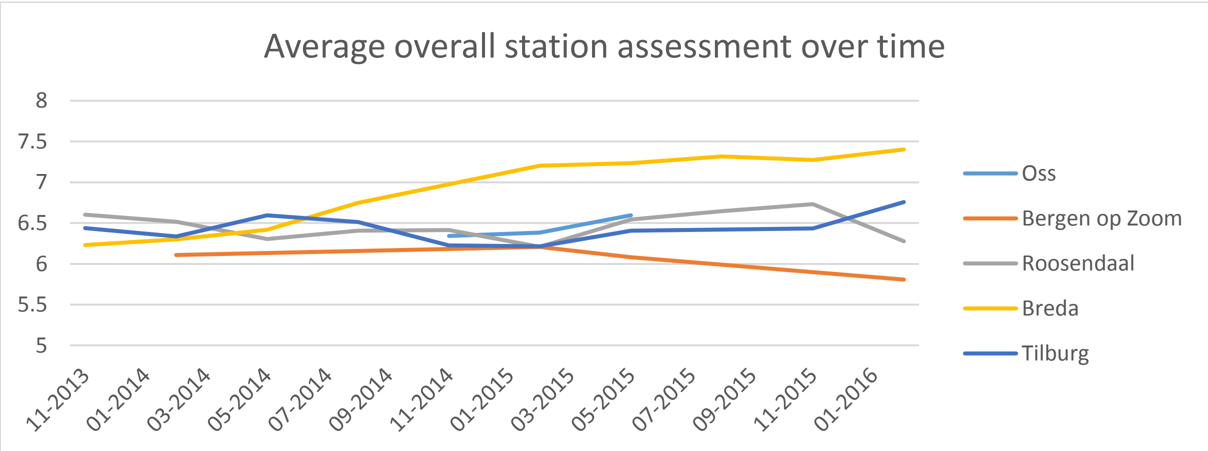


FIGURE 5-4, AVERAGE OVERALL STATION ASSESSMENT OF FIVE RAILWAY STATIONS IN THE PROVINCE OF NORTH-BRABANT.

In chapter 4, multiple choice models are developed to estimate *overall station assessment*. To forecast the *overall station assessment* in each of these five railway stations data from the Stationsbelevingsmonitor will be used, as this database contains customer satisfaction data needed for the forecasting. Whereas the RP database only includes data of the stations Almelo, Eindhoven, and Helmond. For each of the five railway stations the *overall station assessment* will be forecasted based on three scenarios. These scenarios will be based on the statistical data found using the RP questionnaire and is presented in Table 3-6. The changes reported in Table 3-6 will be added (as weights) to the factors (see Table 4-1) of each individual respondent of the SBM. The weights are not added to the values reported for each statement in the SBM, at these statements could only be answered with integers on a 1 to 10 scale (1 = completely disagree, 10 = completely agree). For example an increase of e.g. 1.27% (in the case of the measure of *digital screens with infotainment*) would be incremental and have no effect of the factor analysis, the raw data consists only of integers. In the enumeration below, the three scenarios will are presented.

Scenario 1. This scenario will be used as baseline measure, where only the unweighted data will be used to forecast the average overall station assessment.

Scenario 2. To forecast the effects of *lighting*, as this measure resulted in the highest change in *overall station assessment* measured using the RP questionnaire.

Scenario 3. The final scenario will forecast the overall station assessment based on the total change of the three surveyed comfort enhancement measures.

The scenarios will be forecasted using simulation function of Pythonbiogeme (Bierlaire, 2016b). To forecast the change in *overall station assessment* based on the three scenarios, the equation presented in equation (7) is used. This generic MNL model is developed using the SBM database. This model has been selected because the customer satisfaction data used is part of the SBM database. Furthermore, none of the variables related to the perceived change related to a comfort enhancement measure is found to be significant. Therefore, making the estimated choice models using the RP data less valuable. In Figure 5-5 the forecasted average *overall station assessment* for each scenario is presented. As reference, the actual reported average *overall station assessment* (as found in the SBM database) of the railway station is presented (see label "Actual (SBM)").

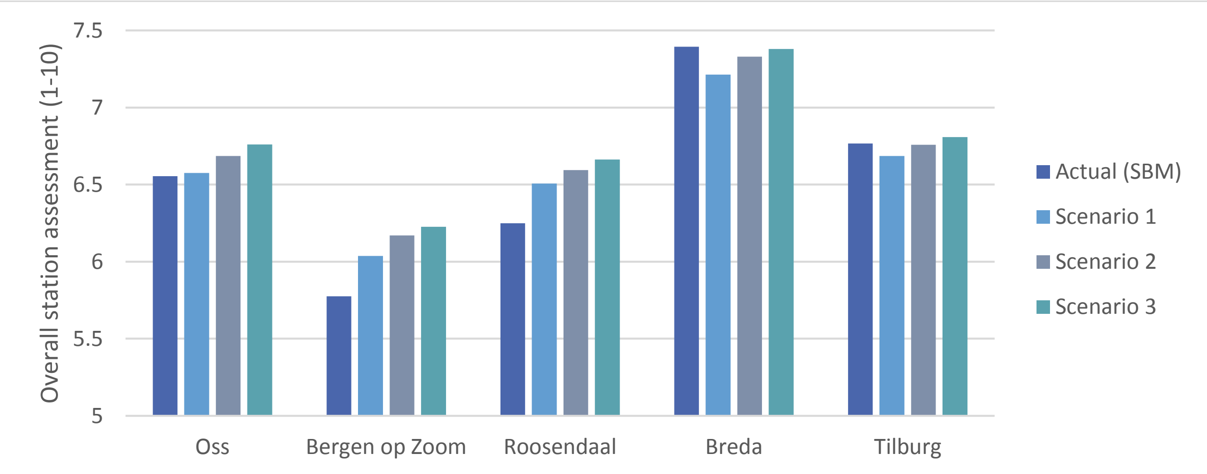


FIGURE 5-5, FORECASTED AVERAGE OVERALL STATION ASSESSMENT PER SCENARIO AND RAILWAY STATION.

Not included in the model application is the measure of *green and planters*, the measure reported to affect *overall station assessment* the least. As can be seen in equation (7), the value estimated for the variable $D_{\text{Green and planters}}$ is negative. Forecasting *overall station assessment* with is data would result in a negative change in assessment. Which would imply that doing nothing is better compared implementing the measure of *green and planters*. The negative value could be the result of the estimation process of the utility function (see equation (7)). Here, the railway stations of Almelo and Amsterdam Muiderpoort are used to estimate the value for $\beta_{\text{CEM Green and planters}}$ for the measure of *green and planters*. These railway stations have a low *overall station assessment* compared to all other railway stations in The Netherlands, and could therefore have a negative effect on the estimation of this value.

When the actual change (Δ) of *overall station assessment* is calculated, scenario 1 (no measure) will be used as reference scenario and is set at 100%. Presented in Figure 5-6 are the forecasted changes in *overall station assessment* for scenarios 2 and 3 per railway station.

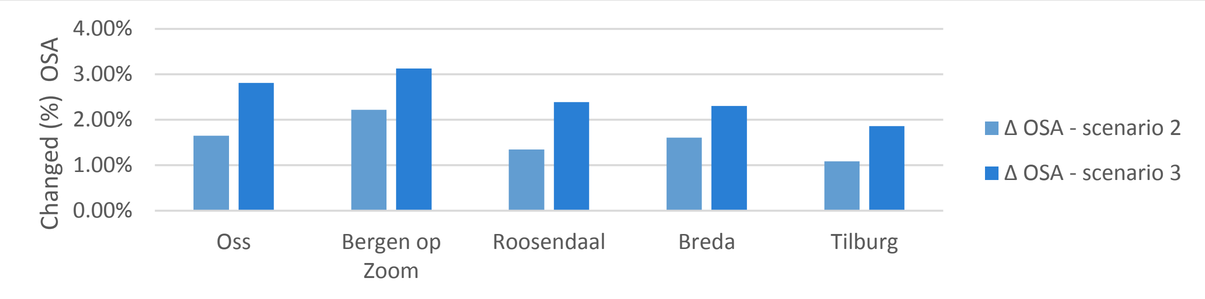


FIGURE 5-6, FORECASTED CHANGE (Δ) IN AVERAGE OVERALL STATION ASSESSMENT FOR EACH SCENARIO AND RAILWAY STATION.

Resulting from the simulation, scenario 2 (measure of *lighting*) forecasts a positive impact on the *overall station assessment* of travellers. For all railway stations, a positive change (1.09% Tilburg to 2.22% for Bergen op Zoom) is forecasted when the measure of *lighting* is implemented. The large difference between scenarios 1 and 2 is most likely caused by the dummy variables for *green and planters* and *lighting*. The utility function of scenario 2 uses the dummy variable $D_{Lightning}$ (see equation (9)), which takes the value of '1' if the measure of *lighting* is presented (which is the case for scenario 2). The third, and final, scenario assumed that all three comfort enhancement measures are implemented at every tested railway stations. Resulting an in improvement by 4.2% of all five customer needs (factors 1 to 5). Scenario 3 resulted in an improvement of (average) *overall station assessment* from 1.86% (Tilburg) to 3.13% (Bergen op Zoom). However, despite the fact that *overall station assessment* will change related to the implementation of one (or multiple) comfort enhancement measures. Only the change at Breda station between the reference scenario 1 (7.21 ± 0.871) and scenario 3 (7.38 ± 0.841) resulted in a significant difference in *overall station assessment* ($t(672)=-2.521$, and $p=0.012$). As for this final scenario, it has to be noted that the sum of the effects of each induvial comfort enhancement measure are used. It could just be the case that the combination of these three comfort enhancement measures result in a synergy, or just the opposite. Future research should focus on the impact of two or more comfort enhancement measures on *overall station assessment* and *ridership*. Ideally several combinations of the same measures must be tested across various railway stations or station typologies.

When the changes of each scenario are compared to their corresponding station typology, difference in changed *overall station assessment* can be noticed. As mentioned earlier, the railway stations of Oss and Bergen op Zoom are categorized as typology 4. The stations of Roosendaal, Breda, and Tilburg are of typology 2. In Table 5-1 the change in average *overall station assessment* between the different station typologies (type 2 and type 4) are presented.

TABLE 5-1, CHANGE IN AVERAGE OVERALL STATION ASSESSMENT BETWEEN STATION TYPOLOGIES.

	Typology 2	Typology 4
Δ OSA - scenario 0-2	1.35%	2.02%
Δ OSA - scenario 0-3	2.14%	3.02%

It can be noticed that the implementation of a comfort enhancement measure is forecasted to have a larger impact on the changed *overall station assessment* when implemented on a smaller railway station (e.g. typology 4) compared to larger railway stations (typology 2). This might indicate that when comfort enhancement measures are used, their effect is larger on smaller railway stations, however the measure affects less travellers. With the information presented in Figure 3-16 (smaller typology railway have a worse assessment compared to larger typology stations), it can be suggested to implement comfort enhance measures at smaller stations. These stations would benefit the most, but affect less travellers. Policymakers should define a clear target on what they want to achieve with comfort enhancement measures. When the target is set on increasing the average customer satisfaction on all railway stations (e.g. nationwide), data suggest implementing comfort enhancement measures on large railway stations i.e. the change in *overall station assessment* will be small but it affects many travellers. If the target is set to improve the worst scoring railway stations, the data suggest implementing comfort enhancement measures on the worst railway stations. This will most likely result in a relative large improvement, but affects less travellers.

In the case of Bergen op Zoom, customer satisfaction is experienced relatively low compared to the other four railway stations (see Figure 5-6, label "Actual (SBM)"). The province of North-Brabant has stated in their development program that comfort enhancement is one of the main targets with regards to this transport node. The municipality of Bergen op Zoom has developed a plan to improve the quality of the station environment. This plan aims to improve not only the node function but also the place function of the public transport node. To achieve these goals, the plan uses comfort enhancement measures like *green and planters* and *design* (by using of old, historic materials) to connect the station (bus and railways) with the old historic city centre of Bergen op Zoom. Bergen op Zoom will take the lead in the realisation of this project. Therefore the municipality is also tasked with involving stakeholder in the project. Important is not only to involve the direct stakeholders (like NS, ProRail, Arriva, Connection, taxi companies) but also the neighbouring entrepreneurs and businesses. The final stakeholders are the users of the public transport node. From this latter stakeholder it is suggested to included them in a panel survey. This longitudinal survey must be used for three different reasons: (1) a baseline measurement of the perceived customer satisfaction, (2) highlight aspects that are found to be important (e.g. NS themes or customer needs), and (3) report the experienced change related to the implemented comfort enhancement measure(s). This panel data is crucial in determining the effects of implemented comfort enhancement measure(s) in relation to the customer satisfaction. Furthermore the panel data can be used to determine key performance indicators for future projects involving comfort enhancement measures.

With slight adjustments to the revealed preference questionnaire (see Appendix C), this questionnaire can be used to determine the impact of the implemented comfort enhancement measures at the station environment. However, where this research focusses at only a single comfort enhancement measure, should the RP questionnaire be used to all implemented comfort enhancements measures. The reported change in overall station assessment will be related to all measures, the effects of individual measures cannot be determined. To get a sense of which travellers valued the most, participants of the panel survey should be asked to distribute, for example, 100 points among the implemented comfort enhancement measures. More points means a higher value for the respondent.

Besides involving the users (in most cases the traveller) in a panel survey, it is suggested that the municipality must work together with all stakeholders. NS and ProRail have the authority over the rail infrastructure, the Province of North-Brabant for their involvement in the bus concessions, the bus companies, and municipality with their local businesses and entrepreneurs) all have to agree to achieve the same goal. If executed properly, this collaboration might result in a synergy between comfort enhancement, densification (more amenities in and around the public transport node), and acceleration (reducing transfer time). As explained by Vaessens (2005) in his research into the synergy of railway stations. An excellent case of cooperation is the station of Deurne. Here, citizen participation resulted in the improvement of customer satisfaction (*overall station assessment*) of the railway station and the station environment. Not only did the comfort and experience increase, but also the experienced safety and cleanliness. In the case of Deurne, the citizen participation was rewarded with the *Pluk van de Pettefletprijs*, an award for initiative that result in an improvement of the sustainability and liveability of an environment.

To conclude, depending on which and how many measures are implemented an improvement of *overall station assessment* is feasible. Furthermore, the impact might also dependent on which typology of station the measure is implemented. Data suggests a larger improvement among smaller railway stations, compared to larger railway stations. If policymakers (e.g. local governments or national governments) decide to improve the station quality by implementing comfort enhancement measures, it is recommended to start by creating a panel survey among travellers to define a baseline measurement. Next the policy makes should actively involve all stakeholders, as each stakeholder has their own expertise which they are willing to put to use. Using transit oriented development (density, diversity, design) a synergy might occur, where the total result is greater than the sum of the individual strategies. The panel created during the early phases of the project, is asked to report their (changed) customer satisfaction after the realisation of the project. Using both panel measurements, a longitudinal dataset of the same respondents is created. This data will contain valuable information on how traveller perceived the comfort enhancement measure(s) in relation to their *overall station assessment* and *ridership*.

6. Conclusion and discussion

6.1. Conclusion

The main research question formulated for this thesis report is:

What are the effects of comfort enhancement measures on overall station assessment and travel frequency at railway stations in the Netherlands, and how can these results help the province of North-Brabant in increasing customer satisfaction at public transport nodes?

To answer the main research question, eight sub research questions were defined, which were answered throughout this thesis report. In the next section, each sub question will be answered and then the conclusion will answer the main research question.

6.1.1. Conclusion sub research questions

1. What are the important customer needs that influence overall station assessment?

A lot of the available literature about *customer satisfaction* and *waiting experience* at public transport nodes, originates from the Netherlands. Peek and Van Hagen (2003) have developed a theory linking the basic human needs, as proposed by Maslow (1943), with *customer satisfaction* in public transport. The theory proposed by Peek and Van Hagen (2003) defines five *customer needs*, that can be fulfilled when travelling by public transport. As with the hierarchy of needs, each *customer need* must be fulfilled, after which the next *customer need* can be fulfilled. The five customer needs are (in order of basic needs): (1) *safety, cleanliness & reliability*, (2) *speed*, (3) *ease*, (4) *comfort*, and (5) *experience* (see Figure 2-2). Each need refers to a particular part of the overall customer satisfaction. *Safety, cleanliness & reliability* are responsible for 50% of all customer satisfaction. The dissatisfiers *speed* and *ease* affect the customer satisfaction by 29%. The remaining share (21%) is accounted for by the needs of *comfort* and *experience* (satisfiers). When applying this theory in practice, policymakers should not focus on the individual needs, but use the three main layers of the hierarchy (basic needs, dissatisfiers, and satisfiers) as guidelines.

2. What is the relationship between customer satisfaction and waiting experience?

To improve the *waiting experience* on Dutch railway stations, the majority of *comfort enhancement measures* are aimed to improve the travellers' *comfort* and *experience* (satisfiers). The term *comfort* refers to the sensual aspects of travellers, e.g. comfortable seating, presence of shops, etc.. While *experience*, refers to the mental comfort of travellers, e.g. the ambiance, colours, architecture, etc.. However, many comfort enhancement measures do not only affect the *comfort* and/or *experience* but, also one or multiple other customer needs.

3. How does time valuation of a public transport trip relate to ridership and customer satisfaction?

With the improvement of the *customer satisfaction* and *waiting experience* on railway stations, the attractiveness of travelling by public transport became more attractive. Harms et al. (2007) found that 67% of the Dutch population values the car as being the most attractive transport mode in the Netherlands. Only 4% of the population stated *public transport* as being most attractive mode of transport. This implies that the Dutch population perceives the quality of public transport as being low. The amenity of *transfer* during a public transport trip is found to be low. During this phase of the trip, the time valuation is perceived as being relatively low (Peek & Van Hagen, 2002) by travellers, compared to other trip activities (e.g. the access mode). To improve the amenity during the PT trip, NS Stations have developed a synergy-policy consisting of three strategies: (1) *accelerate*: reduce travel time from origin to destination, (2) *densification*: increase the diversity of activities in and around a railway station (mixed land use / TOD), and (3) *comfort enhancement*: to improve the amenity of all stages of a trip (see Figure 1-3). The last strategy initiates the implementation of various comfort enhancement measures, which are aimed at increasing the amenity of the transfer (at the railway station) and for the (main) trip. The synergy-policy might result in increased ridership if the correct stakeholders are involved and also, if the quality of public transport is perceived as being sufficient by the Dutch population and the amenities of all stages of a public transport trip are as expected by the users.

4. Do social-economic characteristics (age/gender/trip purpose) have an effect on the overall station assessment of a railway station?

The Station Experience Monitor (*Stationsbelevingsmonitor*, SBM for short) is a survey tool developed by NS Stations to capture the travellers' level of satisfaction for a railway station by focusing on the satisfiers of the hierarchy of customer needs. By answering multiple statements and questions, the perceived station quality of the respondent is captured. NS Stations use eight categories, which are also referred to as NS themes, to categorize these questions and statements. The SBM data is used to estimate multiple choice models (MNL). To reduce the available variables present in the SBM and RP databases, a factor analysis has been applied resulting in five factors. These five factors have been labelled as follows: (1) *experience*, (2) *ease*, (3) *comfort*, (4) *safety & cleanliness*, and (5) *speed*. The labelling is a result of the variables (which are associated with NS themes), relating to the hierarchy of customer needs. The MNL model estimates *overall station assessment* (see Table 4-3). Three personal characteristics are all estimated to improve the MNL model: (1) age, (2) gender, and (3) assessment of the weather condition. Of the trip characteristics, only (1) *travel frequency '3 or more days per week'* and (2) travelling *from / to work* were found to be significant.

5. Which comfort enhancement measures affect the change in overall station assessment of a railway station and how big is this change?

Of the three surveyed comfort enhancement measures, the measure of *lighting* (Helmond station) is reported to (largely) improve the *overall station assessment* the most(90.2% of respondents). Secondly is the measure of *green and planters* (Almelo station), for which 52.6% of respondents stated an improvement of their *overall station assessment*. For the measure of *digital screens with infotainment* (RailTV at Eindhoven station), 49.8% of respondents reported to have experienced an improvement of their *overall station assessment*. For all measures, the majority of respondents reported no change in their travel frequency (respectively 79.1%, 88.1%, 82.6%). The experienced change for each individual *customer need* is less prominent. The measure of *lighting* aimed to improve the *experience*, *comfort* and *safety & cleanliness* at Helmond station. The RP survey found that the majority of respondents experienced positive improvements of the relevant customer needs (*experience:* 78.0%, *comfort:* 58.9%, *safety & cleanliness:* 77.5%). However, as the measure was part of the reconstruction of the station building, a bias could be interpreted from the respondents' answers which might have caused an overvaluation of the perceived change. Nevertheless, changes in *overall station assessment* are perceived differently by travellers who are familiar with the before and after situation. New travellers who use the railway station for the first time include the measures as their baseline experience. In the cases of Eindhoven and Helmond, the average *overall station assessment* between *existing* and *new* travellers differs from 6.92 (new) to 7.15 (existing) for Eindhoven and from 7.05 (new) to 7.42 (existing). This difference in assessment indicates one of the effects of implementing comfort enhancement measures, i.e. comfort enhancement measures increases the customer loyalty of existing travellers, whereas incremental benefits might be noticed by new travellers.

Respondents of the RP questionnaire, stated that the top 3 most important categories (NS themes) are: (#1) *safety* (17.5%), (#2) *waiting time experience* (14.5%), and (#3) *cleanliness* (13.9%) (see Figure 3-28). When referring to the hierarchy of customer needs by Peek and Van Hagen (2003), the two basic needs (bottom level of the hierarchy) are still perceived to be important. This indicates a desire from travellers to still improve the *safety* and *cleanliness* at railway stations.

6. Which explanatory variables account for the change in overall station assessment and ridership using the *Stationsbelevingsmonitor* and a *revealed preference survey*?

To compare the SBM and RP database, a MNL model is estimated for both dependent variables (*overall station assessment* and *ridership*) using explanatory variables which are present in both databases. For *overall station assessment*, all factors (hierarchy of customer needs) are found to be significant. As are the (dummy) variables for measures of *digital screens with infotainment* (t_{SBM}=2.57, t_{RP}=3,03) and *lighting* (t_{SBM}=3.21, t_{RP}=3.66). The personal characteristics *age* (t_{SBM}=-6.95), *gender* (t_{RP}=-2.27), and *assessment of the weather* (t_{SBM}=-2.37) are estimated to be significant in only one of the two databases. Both estimated choice models have a high goodness-of-fit i.e. both have a value above 0.8 ($r^2_{SBM\_OSA}$=0.812, $r^2_{RP\_OSA}$=0.815). For both models estimating *ridership*, the goodness-of-fit is low: $r^2_{SBM\_FREQ}$=0.812, $r^2_{RP\_FREQ}$=0.815. As the descriptive statistics indicated, the factors are less significant in the *ridership* models compared to models estimating *overall station assessment*. Furthermore, the personal characteristic *age* (t_{SBM}=16.00, t_{RP}=5.56), *gender* (t_{SBM}=-4.79, t_{RP}=-3.02) are able to account for *ridership*. The significant trip characteristic are *from / to work* (t_{SBM}=-23.92, t_{RP}=12.40) and *from / to school* (t_{SBM}=-24.49, t_{RP}=-11.00). In the SBM model, the trip purpose of travelling for *holiday / day out / outing* (t_{SBM}=5.01) is significant as well.

To test the effects of each *comfort enhancement measure*, a scaled MNL model is predicet for each of the three measures. The scale parameter explains the amount of variance of a single measure, in relation to the other two surveyed measures. To estimate the scaled MNL models, only the RP database is used, as this database contains more relevant explanatory variables relating to the comfort enhancement measures. For *overall station assessment*, the measures of *green and planters*, and *lighting* are found to have scale parameters higher than 1: $\Theta_{\text{green and planters\_OSA}}$=1.12 (p=5.42), and $\Theta_{\text{lightning\_OSA}}$=1.15 (p=5.56). For the measure of *digital screens with infotainment*, the scale parameter has been estimated to equal $\Theta_{\text{digital screens with infotainment\_OSA}}$=0.664 (p=5.45). Both *green and planters* and *lighting* explain more variance in *overall station assessment*, in relation to the other two measures. As for *ridership*, the scaled MNL resulted in a different outcome. Here, *digital screens with infotainment* ($\Theta_{\text{digital screens with infotainment\_FREQ}}$=1.09, p=7.35) is the only measure which can account for more variance compared to the other two comfort enhancement measures ($\Theta_{\text{green and planters\_FREQ}}$=0.957, p=6.37 and $\Theta_{\text{lightning \_FREQ}}$=0.934, p=6.86).

7. What is the explanatory power of overall station assessment, in relation to ridership based on the available databases?

The estimated nested logit (NL) models indicate that there is no correlation between high *overall station assessment* and *high* ridership. With *high* overall station assessment being defined as ≥7 and *high* ridership as *at least once per week* (TM = 1 or 2). For the estimated NL model, the μ and μ_{nests} are respectively unidentifiable (normalized bottom up) or insignificant with p=0.99 (normalized top down). This implies that there is no correlation between *overall station assessment* and *ridership*, as expected by the empirical evidence.

8. Which comfort enhancement measures should be implemented to improve public transport nodes in the province of North-Brabant, based on the available data and estimated models?

The estimated choice models are applied to simulate the change in *overall station assessment*. Four scenarios have been created and have been used to forecast the overall station stations at five low-assessed railway stations in the province of North-Brabant. The scenarios include a (1) no measure scenario (used as the baseline), a (2) scenario where *lighting* is used as comfort enhancement measure (as highest scoring measure), and (3) the last scenario combines the effects of all three surveyed comfort enhancement measures. According to the simulation, both scenarios (the measure of *lighting* and the combination of all three measures) resulted in a positive change of *overall station assessment* (in relation to scenario 1). Policymakers should be aware of what they want to achieve when implementing comfort enhancement measures i.e. do they want improve the national average, or improve the worst assessed public transport nodes? The simulation suggests that comfort enhancement measures have less effect on the change of *overall station assessment* at larger railway stations, however they do affect more travellers compared to smaller railway stations, if policymakers decide to implement one or multiple comfort enhancement measure(s). It is recommended to use a longitudinal survey to measure the impact of the measure(s). Furthermore, it is recommended to use a panel to conduct this longitudinal survey (e.g. as presented in Appendix C). The panel will set a baseline assessment for the perceived customer satisfaction, and highlight the themes (as presented in Figure 2-1) that need the most attention. After the implementation of the comfort enhancement measure(s), the panel is used again to determine the changed experience at the public transport node.

6.1.2. Conclusion of main research question

Sub questions 1 to 3 provided insights in the relationship between *customer satisfaction*, *waiting experience*, and *time valuation* and the dependent variables *overall station assessment* and *ridership*. Sub question 4 answers which personal and trip characteristics affect *overall station assessment* and *ridership*. These, and more, explanatory variables are used to estimate multiple ordinal and scaled logit models to estimate *overall station assessment* and *ridership* (sub questions 5 to 7). The final sub question (8) is used to simulate the effects of comfort enhancement measures on five low-assessed railway stations in the province of North-Brabant. The answers of these sub questions provide the conclusion for the main research question.

What are the effects of comfort enhancement measures on overall station assessment and travel frequency at railway stations in the Netherlands, and how can these results help the province of North-Brabant in increasing customer satisfaction at public transport nodes?

A wide variety of comfort enhancement measures are available to be implemented at public transport nodes throughout the Netherlands. Important stakeholders in the development of comfort enhancement measures are the Dutch Railways (NS). These measures are used by NS to improve the customer satisfaction and reduce the perceived waiting time at railway. In order to capture the customers' satisfaction, the *Stationsbelevingsmonitor* is used. This questionnaire asks waiting travellers to state their *overall station assessment* and their experience of various statements and questions. To capture the changed experience related to comfort enhancement measures, a *revealed preference survey* has been distributed for three comfort enhancement measures: (1) *green and planters* (Almelo station), (2) *digital screens with infotainment* (Eindhoven station), and (3) *lighting* (Helmond station). The data of both databases were used to define the change of *overall station assessment* and *ridership* related to one of the comfort enhancement measures. A slight majority of travellers stated that their *overall station assessment* did increase by the measure of *green and planters*. For RailTV similar results were found. The most promising measure is *lighting*. Almost all respondents reported a positive change for their *overall station assessment*. Furthermore, on average existing travellers (travellers that have used the railway station without the comfort enhancement measure) reported a higher *overall station assessment* compared to new travellers (travellers using the railway station for the first time with the comfort enhancement measure present). This suggests that comfort enhancement measures are mostly improving customer loyalty. Because the data and estimated models suggest that an improvement of *overall station assessment* does not affect *ridership*. The nested logit models found no correlation between (high) *overall station assessment* and (high) *ridership*. Travellers that did change their ridership between 2013 (before the implementation) and 2016 (the moment of the survey) reported that the change is most likely caused by the fact that they can *spend their time more usefully* when travelling by train. The results of the estimated choice models and descriptive statistics are used to forecast the change in *overall station assessment* at five low-assessed, railway stations in the province of North-Brabant. The two scenarios that included one or multiple comfort enhancement measures resulted in an improvement of *overall station assessment*. Furthermore, the forecast suggest that the station size (typology) is dependent on the change in *overall station assessment*. Bigger changes are reported for smaller railway stations, when compared to larger railway stations.

6.2. Discussion

Customer satisfaction is becoming more important for customers and businesses. Apart from functionality, the experience of the product and/or service is becoming increasingly important. Measuring the *functionality* of a product or service is commonly defined as something that can be measured (objectively) i.e. cost, travel speed, travel time. However, the *experience* of a product or service is most likely measured in a subjective way. The user expects a level of customer service based on previous unique and personal experiences. When the experience of using a product or service equals or exceeds the customers' expectations, the user will (in most cases) be satisfied. To capture the travellers' experience at a railway station, NS Stations uses the longitudinal survey *Stationsbelevingsmonitor*. This monitor includes a combination of questions and statements to capture the respondent assessment (defined as a integer between 1 and 10, where a higher mark is better). However, the problem with this assessment is the level of subjectivity. As mentioned earlier, travellers have predefined expectations and use this as a guide to base their assessment on. Furthermore, the method of assessing the station quality, a 10 level ordinal scale, is open for interpretation by respondents. The difference between an assessment with, for example, a '7' and a '8' largely depends on the respondents' personal experiences. It might just be the case that one person uses a '7' as *average* assessment, while another person has an *average assessment* equal to a '6' or '8'. In other words, only the rank can be considered relevant, when the distance between each rank is not of great value. As the *Stationsbelevingsmonitor* uses different respondents for every survey, a bias might be introduced. To reduce this bias, it is recommended to use a panel. This panel should be a representation of the different travellers based on gender, age, travel frequency and trip purpose. The SBM randomly asks waiting travellers to participate in the survey, while users of the panel have to be committed to participate over a longer period of time, which might be perceived as being difficult for users and thus do not participate. The longitudinal panel survey can also be used for future comfort enhancement measures. Before implementation, the panel will establish a baseline measurement, which must be compared with the results of the panel survey conducted after the measure has been implemented.

Important for all commercial business, including the Dutch Railways, is profit. In the case of NS, profit is generated by passenger transport and the operation of shops (at railway stations). However, as the RP questionnaire results indicated, *overall station assessment* does positively improve when comfort enhancement measures are implemented. Whereas the majority of respondents stated that their *ridership* remained unaffected. The estimated choice models, showed similar results i.e. low goodness-of-fit, and no correlation between (high) *overall station assessment* and (high) *ridership*. The findings suggest that other attributes, which are beyond the scope of this thesis, are relevant in estimating *ridership*. The estimated choice models regarding *ridership* all have a relatively low goodness-of-fit. It might be the case that the variables included in the *Stationsbelevingsmonitor* are not relevant to estimate *ridership*. The data used in this research focusses only on customer satisfaction at railway stations. Whereas predicting *ridership* needs different explanatory variables, which are beyond the scope of this research. For example, NS Reizigers collects door-to-door travel information about travellers, which is expected to be more useful in explaining *ridership*, when compared to the *Stationsbelevingsmonitor*.

Nevertheless, comfort enhancements measures also affect the most basic needs. However, the amount of change experienced by travellers (related to one (or multiple) comfort enhancement measure) might also depend on the scale for which the comfort enhancement measure is implemented. When the measure at Almelo is compared with the measure at Helmond, a difference in scale can be noticed i.e. one wall versus a station building. A small scale measure might only have an incremental impact on customer satisfaction, and it might not even affect all travellers at the railway station. However, when a measure is implemented throughout the station building (and station environment), all passengers will most likely benefit from this measure. Apart the scale of a measures, the size of the railway station might be important as well. The choice model applied in chapter 6 resulted in bigger changes in *overall station assessment* for smaller railway stations compared to larger railway stations. This might imply that the effects of comfort enhancement measures are larger when implemented on smaller railway stations. The descriptive data reported that travellers assess the station quality lower (see Figure 3-16), compared to larger railway stations (typologies 1 and 2). Therefore it might be more beneficial to implement comfort enhancement measures on smaller stations, as the effects would be the greater. However, over three quarters of train travellers use a station of typology 1 or 2, which accounts for less than 20% of all railway stations in the Netherlands. Should policymakers improve the quality of larger railway stations, with a relative high assessment and affect more travellers? Or implement measures on small railway stations, with a low *overall station assessment*, where the impact is larger but affecting less travellers?

Future research should focus on: (1) the effects of multiple comfort enhancement measures on *overall station assessment* (as suggested by one of the forecasted scenarios) and (2) the effects of a complete reconstruction/renovation of a station building on *overall station assessment*, and (3) the effects of *temporarily* comfort enhancement measures (e.g. during construction at a railway station).

7. Literature

Bertolini, L. (1999). Spatial development patterns and public transport: The application of an analytical model in the Netherlands. *Planning Practice and Research, 14*(2), 199-210.

Bierlaire, M. (2016a). Estimating choice models with latent variables with PythonBiogeme. *Report TRANSP-OR 160628*.

Bierlaire, M. (2016b). PythonBiogeme: a short introduction. *Report TRANSP-OR 160706*.

Boes, J. (2007). Stations? Daar zit muziek in!: een onderzoek naar de effecten van muziektempo op stationsbeleving.

Brons, M., Givoni, M., & Rietveld, P. (2009). Access to railway stations and its potential in increasing rail use. *Transportation Research Part A: Policy and Practice, 43*(2), 136-149. doi: http://dx.doi.org/10.1016/j.tra.2008.08.002

Cameron, M. A., Baker, J., Peterson, M., & Braunsberger, K. (2003). The effects of music, wait-length evaluation, and mood on a low-cost wait experience. *Journal of Business Research, 56*(6), 421-430. doi: http://dx.doi.org/10.1016/S0148-2963(01)00244-2

Cascetta, E., & Cartenì, A. (2014). The hedonic value of railways terminals. A quantitative analysis of the impact of stations quality on travellers behaviour. *Transportation Research Part A: Policy and Practice, 61*, 41-52. doi: 10.1016/j.tra.2013.12.008

Cervero, R. (1993). Ridership impacts of transit-focused development in California. *University of California Transportation Center*.

Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation Research Part D: Transport and Environment, 2*(3), 199-219. doi: http://dx.doi.org/10.1016/S1361-9209(97)00009-6

Cottle, T. J. (1976). Perceiving time. *A Psychological Investigation with Men and Women. NY.*

CROW. (2014). De klantwenspiramide; het instrument om klantgericht te werken. Retrieved from http://www.crow.nl/mobiliteit-en-gedrag/weblog/december-2014-(1)/de-klantwenspiramide;-het-instrument-om-klantgeric

dell'Olio, L., Ibeas, A., & Cecín, P. (2010). Modelling user perception of bus transit quality. *Transport Policy, 17*(6), 388-397. doi: http://dx.doi.org/10.1016/j.tranpol.2010.04.006

Eboli, L., & Mazzulla, G. (2015). Relationships between rail passengers' satisfaction and service quality: a framework for identifying key service factors. *Public Transport, 7*(2), 185-201. doi: 10.1007/s12469-014-0096-x

Fietsberaad, C. (2016). 'Welvaartswinst van fietssnelwegen beperkt'.

Friman, M. (2004). Implementing quality improvements in public transport. *Journal of Public Transportation, 7*(4), 3.

Givoni, M., & Rietveld, P. (2007). The access journey to the railway station and its role in passengers' satisfaction with rail travel. *Transport Policy, 14*(5), 357-365. doi: 10.1016/j.tranpol.2007.04.004

Goeverden, C. v., & Van Den Heuvel, M. (1993). De verplaatsingstijdfactor in relatie tot de vervoerwijzekeuze. *Delft University of Technology under the authority of PB IVVS/Ministry of Transport, Public Works and Watermanagement, Delft*.

Groenendijk, L. (2015). *Incorporating the traveller's experience value in assessing the quality of transit nodes: A Rotterdam case study.* (Master), Delft University of Technology, Delft.

Hagen, M. v., & Bron, P. (2013). De emotionele reis van onze klant. Waarom een 56 minder is dan 45. *Colloquium Vervoersplanologisch Speurwerk*.

Hagen, M. v., & Exel, M. (2012). De reiziger centraal: Bureau Spoorbouwmeester.

Harms, L., Jorritsma, P., & Kalfs, N. (2007). *Beleving en beeldvorming van mobiliteit*: Kennisinstituut voor Mobiliteitsbeleid.

Hine, J., & Scott, J. (2000). Seamless, accessible travel: users' views of the public transport journey and interchange. *Transport Policy, 7*(3), 217-226. doi: http://dx.doi.org/10.1016/S0967-070X(00)00022-6

Hornik, J. (1984). Subjective vs. Objective Time Measures: A Note on the Perception of Time in Consumer Behavior. *Journal of Consumer Research, 11*(1), 615-618.
IBM Support. (2010). What does a significance or p-value of .000 mean? Retrieved 14-07-2016, 2016, from http://www-01.ibm.com/support/docview.wss?uid=swg21479571
Kramer, J. (2009). Wachten wordt leuk! : onderzoek naar de invloed van reclame en infotainment, in een stationsomgeving, op wachttijdbeleving.
Kruit, C. (2015). Prettig Wachten. from http://www.spoorbeeld.nl/sites/default/files/issuu/Prettig%20Wachten_0.pdf
Larsen, L., Adams, J., Deal, B., Kweon, B. S., & Tyler, E. (1998). Plants in the workplace the effects of plant density on productivity, attitudes, and perceptions. *Environment and Behavior, 30*(3), 261-281.
LimeSurvey Project Team, & Schmitz, C. (2015). LimeSurvey: An Open Source survey tool. from http://www.limesurvey.org
Maslow, A. H. (1943). A theory of human motivation. *Psychological Review, 50*(4), 370.
Mouwen, A. (2015). Drivers of customer satisfaction with public transport services. *Transportation Research Part A: Policy and Practice, 78*, 1-20. doi: http://dx.doi.org/10.1016/j.tra.2015.05.005
Nederlandse Spoorwegen. (2014). Bedrijfsopbrengsten Jaarverslag 2014. Retrieved November 16, 2015, from http://nsjaarverslag.nl/jaarverslag-2014/s1316_verslagvanactiviteiten/onzefinancin/bedrijfsopbrengsten/a1425_default
Nederlandse Spoorwegen. (2016). NS Jaarverslag 2016. 246. http://www.nsjaarverslag.nl/FbContent.ashx/pub_1000/Downloads/NS-jaarverslag-2016.pdf
Nie, W. (2000). Waiting: integrating social and psychological perspectives in operations management. *Omega, 28*(6), 611-629. doi: http://dx.doi.org/10.1016/S0305-0483(00)00019-0
Peek, G., & Van Hagen, M. (2002). Creating synergy in and around stations: Three strategies for adding value. *Transportation Research Record*(1793), 1-6. doi: http://dx.doi.org/10.3141/1793-01
Peek, G., & Van Hagen, M. (2003). What you want is what you should get: customer's whishes in relation to the redevelopment of inner-city railway stations areas. *European Transport Congerence*, 4-7.
ProRail. (2013). Belettering en bewegwijzering Nederlandse treinstations.
Stedenbaan. (2015). Monitor Stedenbaan 2015.
Train, K. E. (2009). *Discrete choice methods with simulation, second edition*.
Vaessens, B. (2005). Synergie op stationslocaties. *Doctoraal scriptie Sociale Geografie, Faculteit Geowetenschappen, Afstudeerrichting Economische Geografie, Universiteit Utrecht, Utrecht*.
Van Den Heuvel, M., & Schoemaker, T. (1989). Visie Systeemopbouw openbaar vervoer Randstad. *Faculteit Civiele Techniek, Vakgroep Verkeer, Technische Universiteit Delft*.
van Hagen, M. (2011). *Waiting experience at train stations*: Eburon Uitgeverij BV.
Zeithaml, V., Berry, L., & Parasuraman, A. (1990). Delivering Quality Service, Balancing Customer Perception and Expectations. *The Free Press*.

Appendices

Appendix A SBM variables

Variable	Value label	Values	Type
OMGE1134	Ik kan makkelijk bij het station komen *I can easily get to the railway station*	1 – 10, 98 nvt, 99 missing	NUM
OMGE2134	Ik ervaar de directe omgeving van dit station als prettig *I experience the station environment as pleasant.*	1 – 10, 98 nvt, 99 missing	NUM
ORIE1134	Ik heb een goed overzicht op dit station *I have a good overview at this station*	1 – 10, 98 nvt, 99 missing	NUM
ORIE2134	Ik vind de borden die de weg aangeven (bewegwijzering) op dit station duidelijk *I find the signing at this station clear*	1 – 10, 98 nvt, 99 missing	NUM
ORIE3134	Ik vind de reisinformatie op dit station duidelijk *I find the travel information at this station clear*	1 – 10, 98 nvt, 99 missing	NUM
UITN1134	Ik weet op dit station waar ik informatie kan inwinnen *I know where to find travel information at this station*	1 – 10, 98 nvt, 99 missing	NUM
UITN2134	Ik vind het personeel op dit station klantvriendelijk *I think the personnel at this station is friendly.*	1 – 10, 98 nvt, 99 missing	NUM
VEIL1134	Ik voel me veilig op dit station s' avonds na 19.00 uur *I feel safe at this station after 19:00*	1 – 10, 98 nvt, 99 missing	NUM
VEIL2134	Ik ervaar de verlichting op dit station als prettig *I experience the lighting at this station as pleasant*	1 – 10, 98 nvt, 99 missing	NUM
SCHO1134	Ik ervaar dit station als schoon *I experience this station as clean*	1 – 10, 98 nvt, 99 missing	NUM
SCHO2134	Ik vind het station fris ruiken *I think this station smells fresh*	1 – 10, 98 nvt, 99 missing	NUM
UITN3134	Ik vind dat er op dit station voldoende winkels open zijn *I think that enough shops are open right now at this station*	1 – 10, 98 nvt, 99 missing	NUM
UITN4134	Ik voel me uitgenodigd om op dit station iets te kopen *I feel invited to buy something at this station*	1 – 10, 98 nvt, 99 missing	NUM
WACH1134	Ik kan mijn tijd op dit station aangenaam besteden *I can pleasantly spend my time at this station*	1 – 10, 98 nvt, 99 missing	NUM

WACH2134	Ik ervaar het wachten op dit station als comfortabel *I experience waiting as comfortable at this station*	1 – 10, 98 nvt, 99 missing	NUM
WACH3134	Ik ervaar voldoende beschutting tegen wind, regen en kou op het perron *I experience enough protection against the elements at this station*	1 – 10, 98 nvt, 99 missing	NUM
DOOR1134	Ik ervaar dat er genoeg ruimte is op dit perron *I experience the station platform as spacious*	1 – 10, 98 nvt, 99 missing	NUM
DOOR2134	Ik kan op dit station ongehinderd de trein bereiken *I can access the train without any hindrance at this station*	1 – 10, 98 nvt, 99 missing	NUM
SFEE1134	Ik ervaar dit station als sfeervol *I experience this station as attractive*	1 – 10, 98 nvt, 99 missing	NUM
SFEE2134	Ik vind dat dit station een warme uitstraling heeft *I think this station has a warm appearance*	1 – 10, 98 nvt, 99 missing	NUM
SFEE3134	Ik vind dat het station er verzorgd uitziet *I think the station is taken care of*	1 – 10, 98 nvt, 99 missing	NUM
SFEE4134	Ik vind het station kleurrijk *I think the station is colourful*	1 – 10, 98 nvt, 99 missing	NUM
OMGE3134	Ik vind de stationsomgeving overzichtelijk *I think there is a clear overview of the station environment*	1 – 10, 98 nvt, 99 missing	NUM
BOUW1134	Ik vind dat NS/ProRail haar best doet om eventuele overlast op dit station zoveel mogelijk te beperken *I think NS/ProRail tries to limit the any inconvenience as much as possible at this station*	1 – 10, 98 nvt, 99 missing	NUM
BOUW2134	Ik word voldoende geinformeerd over de bouwwerkzaamheden op dit station *I'm sufficiently informed about the construction works on this station*	1 – 10, 98 nvt, 99 missing	NUM
ALGO1134	Uw algemeen oordeel over het perron waar u wacht *What is your overall assessment for this station platform*	1 – 10, 98 nvt, 99 missing	NUM
ALGO2134	Uw algemeen oordeel over dit station *What is your overall station assessment*	1 – 10, 98 nvt, 99 missing	NUM
DRUK1334	Ik ervaar dit station als druk *I experience this station as busy*	1 – 10, 98 nvt, 99 missing	NUM
XFIETS1134	Maakt u wel eens gebruik van de fietsenstallingen op dit station? *Do you use any of the bicycle parking facilities on this station?*	1 – 5, 99 missing	NUM
XFIETS2134	Van welke fietsenstalling op dit station maakt u het meest gebruik?	1 – 4, 98 nvt, 99 missing	NUM

	Which of the bicycle parking facilities on this station do you use most often?		
NUMXFIETS3134	Wat is uw algemeen oordeel over de fietsenstalling waar u het meest gebruik van maakt op dit station? *What is your overall assessment of the bicycle parking facility which you use most often on this station?*	1 – 10, 98 nvt, 99 missing	NUM
-	Wat bevalt u het meest op dit station *What do you like most at this station*	Tekst	STRING
-	Wat bevalt u het minst of moet volgens u dringend aan dit station verbeterd worden *What do you dislike most at this station, or needs urgent improvements*	Tekst	STRING
VERP1134	Met welk vervoermiddel bent u zojuist naar dit station gekomen *Which access mode did you use to arrive at this station*	1 – 8, 99 missing	NUM
VERP2134	Maakt u een overstap op dit station *Do you make a transfer at this station*	1 – 3, 99 missing	NUM
MOTI1134	Wat is voor u de belangrijkste reden om vandaag deze treinreis te maken *What is you most important purpose of travelling by train today*	1 – 9, 99 missing	NUM
FREQ1134	Hoe vaak reist u met de trein *How often do you travel by train*	1 – 7, 99 missing	NUM
TOEG1134	Heeft u een lichamelijke beperking, waardoor u minder mobiel bent *Do you have a physical condition, which reduced your mobility*	1 – 2, 99 missing	NUM
WEER1134	Hoe ervaart u het weer op dit moment *How do you experience the weather today*	1 – 10, 98 nvt, 99 missing	NUM
LEEF1134	Wat is uw leeftijd *What is your age*	1 – 98, 99 missing	NUM
GESL1134	Wat is uw geslacht *What is your gender*	1 – 2, 99 missing	NUM
DATU1134	Datum (ddmmyy) *Date*	ddmmyy	NUM
TIJD1134	Tijd (uumm) *Time*	uumm	NUM
PERR1134	Perronnummer (nn) *Station platform number (nn)*	nn	NUM
PERR2134	Perronletter (aa) *Station platform letter (aa)*	aa	STRING
weeg	Weegfactor *Weight factor*	-	NUM
TH_ORIENTATIE	Thema Orïentatie *Theme orientation*	-	NUM
TH_UITNODIGEND	Thema Uitnodigend *Theme inviting*	-	NUM

TH_VEILIG	Thema Veilig *Theme safety*	-	NUM
TH_SCHOON	Thema Schoon *Theme cleanliness*	-	NUM
TH_WACHTTIJDBEL	Thema Wachttijdbeleving *Theme waiting time experience*	-	NUM
TH_DOORSTROMING	Thema Doorstroming *Theme pedestrian flow*	-	NUM
TH_SFEERVOL	Thema Sfeervol *Theme attractively*	-	NUM
TH_FUNCTIONEEL	Thema Functioneel *Theme functionality*	-	NUM
meting	Meting (yyqq) *Measurement (yyqq)*	yyqq	NUM
vragenlijst	Type vragenlijst (nn) *Type of questionnaire (nn)*	1-99	NUM
stationscode	Stationscode veldwerk (nnn) *Station code field work (nnn)*	1-999	NUM
enqueteur	Code enqueteur (nnnn) *Code pollster (nnnn)*	9999	NUM
-	Verkorting *Abbreviation*	Tekst	STRING
-	Stationsnaam *Station name*	Tekst	STRING
-	Provincie *Province*	Tekst	STRING
-	Vervoersautoriteitgeograpisch *Transportation authority geographical*	Tekst	STRING
-	Vervoersconcessiehouder *Transportation concessionaire*	Tekst	STRING
-	Netwerk *Network*	Tekst	STRING
-	Regio *Region*	Tekst	STRING
-	Typenr *Type number*	9	NUM
-	Type *Type*	Tekst	STRING
-	Geocode *Geo code*	Tekst	STRING
-	TypestationProRail *Type of station ProRail*	Tekst	STRING
-	ProRailRegio *ProRail Region*	Tekst	STRING
-	InUitstappers *Ridership*	-	NUM
-	InUitstrappers_Typenr *Ridership Type number*	-	NUM
-	Typenr_orgineel *Type number original*	-	NUM

Appendix B Overview comfort enhancement measures

Date	Measure	Description	Attractiveness	Inviting	Waiting time experience	Orientation		Pedestrian flow	Cleanliness	Safety	Environment	Construction	Station
2011-2013	Signing station and entrances	By placing additional signing and lighting (during construction) the aim to maintain the appearance of the station hall and pathways. This should increase the orientation of the station as well.				x		x					Amsterdam
Q1 2013	Infrared heating columns	Infrared heating columns provide heat with one push on a button. The columns are situated in the outside waiting areas (on a station platform). During winter these heating columns increase the comfort and waiting time experience of a traveller.	x	x	x								Utrecht
Q4 2010	Nice waiting area / reading kiosk	Empty rooms/shops can be repurposed as a new (or temporarily) waiting area. For example a 'reading kiosk' can be built with benches, real-time travel information, plants, tables, chairs. There might even be a coffee/vending machine	x	x	x								
2011-2013	Digital screens with infotainment	With large digital screes, information, Twitter streams, news can be shared with passengers. Furthermore, specific messages (e.g. during construction) can be presented to the waiting travellers. These digital information screens ease the waiting, and depending on the information displayed increase the attractiveness and orientation of a railway station.		x	x								
2011-2013	Planters and green	Large vandal-proof planters with plants create a warm and welcome feeling. There are even signs of travellers feeling safer. Using green in general creates the sense of human attention.	x		x					x			All construction stations
Q2 2013	Lightning	Lighting is an essential part of the experience when staying at a railway station. Unfortunately most of the time lightning meets the minimum requirements. The use of good/decent lightning many aspects of the overall station assessment can be improved: attractiveness, invitingness, safety, and cleanliness.	x	x					x	x			The Hague
Q2 2013	Foil/Film	A (temporally) tunnel or wall might create an uninviting view for travellers. Furthermore it can evolve in a negative perception of the station quality. By applying a foil or film with e.g. a landscape, the unattractive wall can be turned into an aesthetic part of the railway station.	x	x	x					x			
	Information centre	A central location where passengers can ask for (background) information. The information centre can be used during construction. The presence of personnel has positive effect to safety and invitingness.		x		x					x	x	
	Rail TV	Rail TV ("Spoor TV") is situated on the largest railway stations in the Netherlands. Rail TV presents films/movies/fragments which apply to all railway stations in the Netherlands. This measure is focused to reduce waiting time experience.	x	x	x								
	Escalator stickers	Livery of an escalator will result in a high reach of passengers. Because many travellers stand still on an escalator the message printed on the sticker(s) will be seen/read by many.	x	x	x				x				
	Meeting for ideas and wishes	Inviting stakeholders to come up with innovative ideas and to define their wishes might lower the resistance of upcoming/planned construction/improvements.		x							x	x	
	Pop-up terrace	The use of so-called pop-up terraces will attract passengers who arrived early at the railway station or have a business meeting. By spending time, drink, relaxing at these terraces the waiting time experience of travellers might improve.	x	x	x								Leiden
	Lift shaft lightning	The use of glass lift shafts is ideal for experimenting with light.	x	x									Amsterdam South

Date	Measure	Description	Attractiveness	Inviting	Waiting time experience	Orientation		Pedestrian flow	Cleanliness	Safety	Environment	Construction	Station
	Safety awareness	Network Rail launched a campaign to increase the awareness among travellers of the many accidents that occur on and around railway tracks. By using word artists (e.g. rappers) the waiting travellers listen and 'learn' how to prevent (deadly) accidents.								x			
	Poems increasing awareness for littering	Poems and smart advertising might increase the awareness of travellers about the negative impact of littering. The poems and posters are located in central areas. By reading the traveller gets informed and these interesting advertisement/poems increase the waiting time experience.							X	X			

Appendix C Printout revealed preference questionnaire

Onderzoek naar de wachtbeleving op NS stations

Welkom bij dit onderzoek naar slimme manieren om uw verblijf op het treinstation te veraangenamen. De Nederlandse Spoorwegen en ProRail zijn bezig om uw verblijf op treinstations aangenamer maken.

Het invullen van deze enquête duurt ca. 7 tot 10 minuten en bestaat uit 2 delen:

- uw huidige stationsbeleving;
- uw veranderde stationsbeleving.

Door het invullen van deze vragenlijst maakt u kans op een VVV waardebon t.w.v. €25,-!

Bij voorbaat hartelijk dank voor uw tijd.
Enzo Bronzwaer
Student Civil Engineering and Management (Universiteit Twente)

Er zijn 39 vragen in deze enquête

Stationskeuze

Selecteer één van de drie stations en klik op "volgende" om met de vragenlijst te beginnen.

Op welk station bent u gevraagd om deel te nemen aan dit onderzoek? *

Kies één van de volgende mogelijkheden:

○ Almelo
○ Eindhoven
○ Helmond

Op welke datum heeft u op station Almelo de uitnodiging tot deelname aan deze enquête ontvangen? *

Kies één van de volgende mogelijkheden:

○ 24-10-2016
○ 25-10-2016

Op welke datum heeft u op station Eindhoven de uitnodiging tot deelname aan deze enquête ontvangen? *

Kies één van de volgende mogelijkheden:

○ 06-10-2016
○ 07-10-2016
○ 26-10-2016
○ 27-10-2016

Op welke datum heeft u op station Helmond de uitnodiging tot deelname aan deze enquête ontvangen? *

Kies één van de volgende mogelijkheden:

◯ 03-10-2016
◯ 04-10-2016

Huidige beleving

Uw huidige beleving bestaat uit twee delen:

- Uw reiseigenschappen;
- Uw huidige stationsbeleving.

Alle vragen op deze pagina zijn van toepassing op uw reis op **[datum]** vanaf station **[station].**

Hoe vaak reist u gemiddeld met de trein vanaf station [station]? *

Kies één van de volgende mogelijkheden:

◯ 4 of meer dagen per week
◯ 1 tot 3 dagen per week
◯ 1 tot 3 dagen per maand
◯ 6 tot 11 dagen per jaar
◯ 3 tot 5 dagen per jaar
◯ 1 of 2 dagen per jaar
◯ Minder dan 1 dag per jaar

Wat was de voornaamste reden van uw treinreis op **[datum]** vanaf station [station]? *

Kies één van de volgende mogelijkheden:

◯ Van / naar werk
◯ Zakenreis
◯ Van / naar school / studie / opleiding
◯ Bezoeken van familie / vrienden / ziekenhuis
◯ Winkelen
◯ Vakantie / excursie / dagje erop uit
◯ Sport / hobby
◯ Ik heb niet met de trein gereisd
◯ Anders

Met welk vervoermiddel bent u op **[datum]** naar station [station] gereisd? *

Kies één van de volgende mogelijkheden:

◯ Te voet
◯ Met de fiets / brommer / scooter
◯ Met de auto als bestuurder
◯ Met de auto als bijrijder
◯ Met de bus / tram / metro
◯ Met de trein
◯ Met de taxi
◯ Anders

Welk type treinkaart heeft u op **[datum]** gebruikt? *

Kies één van de volgende mogelijkheden:

- OV Chipkaart (vol tarief)
- OV Chipkaart (korting)
- NS-Business card
- Los kaartje (enkel of retour)
- Anders

Had u voor deze treinreis de beschikking over een auto? *

Kies één van de volgende mogelijkheden:

- Nee, ik heb geen rijbewijs en/of auto
- Nee, de auto was op dat moment in gebruik door mijn partner, kind of anderen
- Ja, ik heb een auto / heb toegang tot een auto

Heeft u overwogen om de auto te gebruiken als alternatief voor de trein? *

Kies één van de volgende mogelijkheden:

- Nee, de auto was geen alternatief voor deze reis
- Ja, de auto was een geschikt alternatief voor deze reis

Stationsbelevingsmonitor

De Stationsbelevingsmonitor is een onderzoeksmethodiek van NS Stations. Aan de hand van diverse vragen en stellingen is het mogelijk om de wensen van de reiziger te identificeren en te begrijpen.

Algemeen stationsoordeel

Welk cijfer geeft u station [station] gebaseerd op uw reis op [datum]?

Kies het toepasselijke antwoord voor elk onderdeel:

	1	2	3	4	5	6	7	8	9	10
Uw algemeen oordeel over station [station] 1 = zeer slecht, 10 = uitmuntend.	○	○	○	○	○	○	○	○	○	○

Nu volgen 24 stellingen verdeeld over 8 thema's. Alle stellingen zijn van toepassing op uw reis van **[datum]**. Geef per stelling aan in hoeverre u het eens of oneens bent met de stelling.

Thema: Omgeving

In hoeverre bent u het eens met de volgende stellingen?

Kies het toepasselijke antwoord voor elk onderdeel:

	1	2	3	4	5	6	7	8	9	10
Ik kan makkelijk bij het station komen	○	○	○	○	○	○	○	○	○	○
Ik ervaar de directe omgeving van dit station als prettig	○	○	○	○	○	○	○	○	○	○
Ik vind de stationsomgeving overzichtelijk	○	○	○	○	○	○	○	○	○	○

1 = helemaal mee oneens, 10 = helemaal mee eens.

Thema: Oriëntatie

In hoeverre bent u het eens met de volgende stellingen?

Kies het toepasselijke antwoord voor elk onderdeel:

	1	2	3	4	5	6	7	8	9	10
Ik heb een goed overzicht op dit station	○	○	○	○	○	○	○	○	○	○
Ik vind de borden die de weg aangeven (bewegwijzering) op dit station duidelijk	○	○	○	○	○	○	○	○	○	○
Ik vind de reisinformatie op dit station duidelijk	○	○	○	○	○	○	○	○	○	○

1 = helemaal mee oneens, 10 = helemaal mee eens.

Thema: Uitnodigend

In hoeverre bent u het eens met de volgende stellingen?

Kies het toepasselijke antwoord voor elk onderdeel:

	1	2	3	4	5	6	7	8	9	10
Ik weet op dit station waar ik informatie kan inwinnen	○	○	○	○	○	○	○	○	○	○
Ik vind het personeel op dit station klantvriendelijk	○	○	○	○	○	○	○	○	○	○
Ik vind dat er op dit station voldoende winkels open zijn	○	○	○	○	○	○	○	○	○	○
Ik voel me genodigd om op dit station iets te kopen	○	○	○	○	○	○	○	○	○	○

1 = helemaal mee oneens, 10 = helemaal mee eens.

Thema: Schoon en Veilig

In hoeverre bent u het eens met de volgende stellingen?

Kies het toepasselijke antwoord voor elk onderdeel:

	1	2	3	4	5	6	7	8	9	10
Ik voel me veilig op dit station s 'avonds na 19:00 uur	○	○	○	○	○	○	○	○	○	○
Ik ervaar de verlichting op dit station als prettig	○	○	○	○	○	○	○	○	○	○
Ik ervaar dit station als schoon	○	○	○	○	○	○	○	○	○	○
Ik vind het station fris ruiken	○	○	○	○	○	○	○	○	○	○

1 = helemaal mee oneens, 10 = helemaal mee eens.

Thema: Wachttijdbeleving

In hoeverre bent u het eens met de volgende stellingen?

Kies het toepasselijke antwoord voor elk onderdeel:

	1	2	3	4	5	6	7	8	9	10
Ik kan mijn tijd op dit station aangenaam besteden	○	○	○	○	○	○	○	○	○	○
Ik ervaar het wachten op dit station als comfortabel	○	○	○	○	○	○	○	○	○	○
Ik ervaar voldoende beschutting tegen wind, regen en kou op het perron	○	○	○	○	○	○	○	○	○	○

1 = helemaal mee oneens, 10 = helemaal mee eens.

Thema: Doorstroming

In hoeverre bent u het eens met de volgende stellingen?

Kies het toepasselijke antwoord voor elk onderdeel:

	1	2	3	4	5	6	7	8	9	10
Ik ervaar dat er genoeg ruimte is op dit station	○	○	○	○	○	○	○	○	○	○
Ik kan op dit station ongehinderd de trein bereiken	○	○	○	○	○	○	○	○	○	○
Ik ervaar dit station als druk	○	○	○	○	○	○	○	○	○	○

1 = helemaal mee oneens, 10 = helemaal mee eens.

Thema: Sfeervol

In hoeverre bent u het eens met de volgende stellingen?

Kies het toepasselijke antwoord voor elk onderdeel:

	1	2	3	4	5	6	7	8	9	10
Ik ervaar dit station als sfeervol	○	○	○	○	○	○	○	○	○	○
Ik vind dat dit station een warme uitstraling heeft	○	○	○	○	○	○	○	○	○	○
Ik vind dat het station er verzorgd uitziet	○	○	○	○	○	○	○	○	○	○
Ik vind het station kleurrijk	○	○	○	○	○	○	○	○	○	○

1 = helemaal mee oneens, 10 = helemaal mee eens.

Veranderde beleving

Met behulp van de volgende vragen worden uw voorkeuren voor *veraangenaming* en (indien van toepassing) uw *veranderde stationsbeleving* op [station] vastgesteld.

Welke maatregel heeft u opgemerkt die uw reis via station [station] prettiger heeft gemaakt? Indien u meerdere maatregelen herkent, kies de maatregel die u als meest prettig heeft ervaren.

Kies één van de volgende mogelijkheden:

○ Groen en planten
○ Verlichting (gekleurd licht, gevelverlichting etc.)
○ Comfortabele zitbanken / zitplekken
○ Wanddecoratie (afbeeldingen/kleuren etc.)
○ Digitale schermen met infotainment
○ Anders:

U heeft aangegeven dat **[maatregel]** uw reis via [station] prettiger heeft gemaakt. Kunt u aangeven in hoeverre deze maatregel uw oordeel over de volgende factoren heeft veranderd?

Kies het toepasselijke antwoord voor elk onderdeel:

	Zeer verslechterd / zeer verminderd	Verslechterd / verminderd	Geen invloed	Verbeterd / toegenomen	Zeer verbeterd / zeer toegenomen
Uw algemeen stationsoordeel van station [station]	○	○	○	○	○
Uw gemiddelde reisfrequentie vanaf station [station]	○	○	○	○	○

	Zeer verslechterd / zeer verminderd	Verslechterd / verminderd	Geen invloed	Verbeterd / toegenomen	Zeer verbeterd / zeer toegenomen
Uw beleving op station [station]	○	○	○	○	○
Uw comfort op station [station]	○	○	○	○	○
Het gemak waarmee u zich op en rond station [station]verplaatst	○	○	○	○	○
De snelheid waarmee u zich op en rond station [station] verplaatst	○	○	○	○	○
De veiligheid en reinheid op station [station]	○	○	○	○	○

Geef per thema aan hoe belangrijk u het betreffende thema vindt. Het belangrijkste thema zet u bovenaan, het minst belangrijkste thema onderaan. *

De antwoorden moeten verschillend zijn en moeten worden gerangschikt.

Bepaal voor elke optie het volgnummer van 1 tot 8

- Een sfeervol station
- Een uitnodigend station
- Een station waar je prettig kunt wachten
- Een station waar je je goed kunt oriënteren
- Een station waar je goed kunt doorlopen
- Een veilig station
- Een schoon station
- Een prettige stationsomgeving

Sinds welk jaar maakt u gebruikt van station [station]? *

Vul een datum in:

Gebruik het jjjj-formaat (bijv. 2015)

Hoe vaak reisde u met de trein in **2013** vanaf station [station]? *

Kies één van de volgende mogelijkheden:

- ○ 4 of meer dagen per week
- ○ 1 tot 3 dagen per week
- ○ 1 tot 3 dagen per maand
- ○ 6 tot 11 dagen per jaar
- ○ 3 tot 5 dagen per jaar
- ○ 1 of 2 dagen per jaar
- ○ Minder dan 1 dag per jaar

Uw reisfrequentie met de trein is de afgelopen jaren veranderd. In hoeverre verklaren onderstaande redenen uw verandering in reisfrequentie?

Kies het toepasselijke antwoord voor elk onderdeel:

	Helemaal mee oneens	Mee oneens	Neutraal	Mee eens	Helemaal mee eens
Mijn nieuwe baan is beter bereikbaar met het openbaar vervoer	○	○	○	○	○
Ik moet meer reizen door mijn studie	○	○	○	○	○
Ik ben verhuisd / gaan samenwonen / gescheiden	○	○	○	○	○
Het gebruik van de auto is moeilijker geworden (meer files, auto niet beschikbaar, beperkte kilometervergoeding)	○	○	○	○	○
Ik kan mijn reistijd productief besteden	○	○	○	○	○
Het station is beter bereikbaar (verbeterde voet-fietspaden / busverbinding)	○	○	○	○	○
Het station is aantrekkelijker geworden (meer faciliteiten, verbeterde beleving, meer comfort)	○	○	○	○	○

Wat was de belangrijkste reden om in **2013** met de trein te reizen? *

Kies één van de volgende mogelijkheden:

○ Van / naar werk
○ Zakenreis
○ Van / naar school / studie / opleiding
○ Bezoeken van familie / vrienden / ziekenbezoek
○ Winkelen
○ Vakantie / excursie / dagje erop uit
○ Sport / hobby
○ Ik heb niet met de trein gereisd
○ Anders

Uw heeft aangegeven dat uw belangrijkste reden voor het reizen met de trein is veranderd. In hoeverre zijn onderstaande redenen van invloed op deze verandering.

Kies het toepasselijke antwoord voor elk onderdeel:

	Helemaal mee oneens	Mee oneens	Neutraal	Mee eens	Helemaal mee eens
Mijn nieuwe baan is beter bereikbaar met het openbaar vervoer	○	○	○	○	○
Ik moet meer reizen door mijn studie	○	○	○	○	○
Ik ben verhuisd / gaan samenwonen / gescheiden	○	○	○	○	○
Het gebruik van de auto is moeilijker geworden (meer files, auto niet beschikbaar, beperkte kilometervergoeding)	○	○	○	○	○
Ik kan mijn reistijd productief besteden	○	○	○	○	○
Het station is beter bereikbaar (verbeterde voet-fietspaden / busverbinding)	○	○	○	○	○
Het station is aantrekkelijker geworden (meer faciliteiten, verbeterde beleving, meer comfort)	○	○	○	○	○

Met welk vervoermiddel bent u in **2013** het vaakst naar station [station] gekomen? *

Kies één van de volgende mogelijkheden:

- ◯ Te voet
- ◯ Met de fiets / brommer / scooter
- ◯ Met de auto als bestuurder
- ◯ Met de auto als bijrijder
- ◯ Met de bus / tram / metro
- ◯ Met de trein
- ◯ Met de taxi
- ◯ Anders

Eind 2013 zijn in het stationsgebouw van Almelo **groen en planten** toegepast (zie afbeelding, oude en nieuwe situatie). Hoe heeft de aanwezigheid van deze veraangenamingmaatregel invloed op de volgende factoren?

Kies het toepasselijke antwoord voor elk onderdeel:

	Zeer verslechterd / zeer verminderd	Verslechterd / verminderd	Geen invloed	Verbeterd / toegenomen	Zeer verbeterd / zeer toegenomen
Uw algemeen stationsoordeel van station Almelo	◯	◯	◯	◯	◯
Uw gemiddelde reisfrequentie vanaf station Almelo	◯	◯	◯	◯	◯
Uw beleving op station Almelo	◯	◯	◯	◯	◯
Uw comfort op station Almelo	◯	◯	◯	◯	◯
Het gemak waarmee u zich	◯	◯	◯	◯	◯

	Zeer verslechterd / zeer verminderd	Verslechterd / verminderd	Geen invloed	Verbeterd / toegenomen	Zeer verbeterd / zeer toegenomen
op en rond station Almelo verplaatst					
De snelheid waarmee u zich op en rond station Almelo verplaatst	○	○	○	○	○
De veiligheid en reinheid op station Almelo	○	○	○	○	○

In **april 2013** heeft NS Stations samen met ProRail alle perrons in Eindhoven voorzien met **RailTV** (zie afbeelding). Hoe heeft de aanwezigheid van deze veraangenamingmaatregel invloed op de volgende factoren?

Kies het toepasselijke antwoord voor elk onderdeel:

	Zeer verslechterd / zeer verminderd	Verslechterd / verminderd	Geen invloed	Verbeterd / toegenomen	Zeer verbeterd / zeer toegenomen
Uw algemeen stationsoordeel van station Eindhoven	○	○	○	○	○
Uw gemiddelde reisfrequentie vanaf station Eindhoven	○	○	○	○	○
Uw beleving op station Eindhoven	○	○	○	○	○

	Zeer verslechterd / zeer verminderd	Verslechterd / verminderd	Geen invloed	Verbeterd / toegenomen	Zeer verbeterd / zeer toegenomen
Uw comfort op station Eindhoven	○	○	○	○	○
Het gemak waarmee u zich op en rond station Eindhoven verplaatst	○	○	○	○	○
De snelheid waarmee u zich op en rond station Eindhoven verplaatst	○	○	○	○	○
De veiligheid en reinheid op station Eindhoven	○	○	○	○	○

In het **eerste kwartaal van 2014** is station Helmond, na een intensieve verbouwing, opnieuw geopend. Onderdeel van het nieuwe station is de **gevelverlichting** (zie afbeelding, oude en nieuwe stationsgebouw). Hoe heeft de aanwezigheid van deze veraangenamingmaatregel invloed op de volgende factoren?


Kies het toepasselijke antwoord voor elk onderdeel:

	Zeer verslechterd / zeer verminderd	Verslechterd / verminderd	Geen invloed	Verbeterd / toegenomen	Zeer verbeterd / zeer toegenomen
Uw algemeen stationsoordeel	○	○	○	○	○

	Zeer verslechterd / zeer verminderd	Verslechterd / verminderd	Geen invloed	Verbeterd / toegenomen	Zeer verbeterd / zeer toegenomen
van station Helmond					
Uw gemiddelde reisfrequentie vanaf station Helmond	○	○	○	○	○
Uw beleving op station Helmond	○	○	○	○	○
Uw comfort op station Helmond	○	○	○	○	○
Het gemak waarmee u zich op en rond station Helmond verplaatst	○	○	○	○	○
De snelheid waarmee u zich op en rond station Helmond verplaatst	○	○	○	○	○
De veiligheid en reinheid op station Helmond	○	○	○	○	○

De volgende stellingen hebben betrekking op de stationsomgeving van Helmond. Met de reconstructie van het stationsgebouw is ook de stationsomgeving aangepakt. In hoeverre bent u het eens met de volgende stellingen?

Kies het toepasselijke antwoord voor elk onderdeel:

	1	2	3	4	5	6	7	8	9	10
Als ik het station verlaat is de route naar het centrum duidelijk zichtbaar	○	○	○	○	○	○	○	○	○	○
Het busstation en / of fietsenstalling zijn voor mij goed	○	○	○	○	○	○	○	○	○	○

	1	2	3	4	5	6	7	8	9	10
bereikbaar vanaf het stationsplein										
Het stationsplein vormt een barrière tussen noord en zuid Helmond	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

1 = helemaal mee oneens, 10 = helemaal mee eens.

Persoonlijke eigenschappen

Tot slot vraag ik u om een aantal persoonlijke kenmerken in te vullen.

Wat is uw leeftijd? *

Kies één van de volgende mogelijkheden:

_____ Jaar (waarde tussen 1 en 100).

Wat is uw geslacht? *

Kies één van de volgende mogelijkheden:

◯ Man
◯ Vrouw

Welk cijfer geeft u het weer op **[datum]**? *

Kies één van de volgende mogelijkheden:

◯ 1
◯ 2
◯ 3
◯ 4
◯ 5
◯ 6
◯ 7
◯ 8
◯ 9
◯ 10
1 = zeer slecht (storm / zware regenval), 10 = uitstekend (aangename temperatuur, veel zon)

Wat is uw hoogst genoten opleiding? *

Kies één van de volgende mogelijkheden:
◯ Lagere school
◯ lbo, mavo, vmbo, mbo-1
◯ havo, vwo, mbo-2-4
◯ hbo, wo

Wat is uw **huidige** arbeidssituatie? *

Kies één van de volgende mogelijkheden:

- ◯ Betaalde baan (fulltime / parttime)
- ◯ Werkeloos / uitkering
- ◯ Huisman / huisvrouw
- ◯ Student
- ◯ Gepensioneerd
- ◯ Anders

Bedankt

Bedankt voor uw deelname aan dit onderzoek! Uw gegevens zullen gebruikt worden om het effect van veraangenaming op [station] in kaart te brengen.

Klik rechtsonder op "Verzenden" om uw deelname af te ronden.

Wilt u kans maken op 1 van de 3 VVV waardebonnen van €25,-? Van dan hieronder uw e-mailadres in.

Vul uw antwoord hier in:

Uw e-mailadres zal nooit met derde partijen worden gedeeld!

Wilt u de resultaten van dit onderzoek ontvangen? *

Kies één van de volgende mogelijkheden:

- ◯ Ja
- ◯ Nee

Bedankt voor uw deelname aan dit onderzoek.

Indien u uw e-mailadres heeft achtergelaten maakt u kans op 1 van de 3 VVV waardebonnen t.w.v. €25,-. Alleen de winnaars zullen via e-mail worden benaderd.

Heeft u aangegeven de onderzoeksresultaten te willen ontvangen, dan ontvangt u ca. 3 weken na deelname een e-mail met alle resultaten (gegevens zijn volledig anoniem).

Met vriendelijke groet,

Enzo Bronzwaer (Student Civil Engineering and Management, Universiteit Twente)

29-10-2016 – 17:39

Verzend uw enquête.
Bedankt voor uw deelname aan deze enquête.