Incorporating the traveller's experience value in assessing the quality of transit nodes: A Rotterdam case study

Master thesis

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Incorporating the traveller's experience value in assessing the quality of transit nodes: A Rotterdam case study

by

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Preface

This thesis report forms the concluding piece of my graduation research. With this report, I finish the Master study Transport, Infrastructure and Logistics at Delft University of Technology. With this research, I was able to combine my interest in spatial planning and transport.

This thesis is performed at the Municipality of Rotterdam. First of all, I would like to thank all my colleagues of the department, for showing great interest in me and my research. They have helped me to their best abilities and made me feel as one of them. Special thanks go to Martin Guit, who was always available to discuss my research but also to talk about other matters.

Second, I would like to thank my thesis committee. Their efforts and advices have helped me to take this research to the next level. I want to thank Gonçalo Correia for his critical reviews and valuable suggestions to further improve the thesis. Many thanks go to Jafar Rezaei for his contribution to this research by enthusing me for the great method he has developed. His explanations were very clear and helpful. I want to thank Judith Boelhouwers for the many discussions we have had and for giving me confidence during the past half year. She was always available when I had a question or a problem. Thanks to Bart van Arem for supervising the committee and for giving me valuable advice.

During the past half year people from different companies and governments were willing to help me. They were available to discuss my thesis or to provide me with data I required. Because of them I gained new insights and I was able to take a next step in my research. Therefore, thanks to everyone for the much appreciated help.

Last but definitely not least, I would like to thank my parents and brother Jasper for their everlasting support during my entire study. Extra gratitude goes to my father who took the time to make wonderful pictures that add great value to this report. Also, many thanks go to Marco for his endless confidence in me and my research. Thanks to all my friends, for distracting me when I needed it, but also listening to me when I could not stop talking about my thesis. Special thanks go to Arthur and Rik for helping me with my research.

I have enjoyed my study time in Delft because I have learned a lot and I have met great people. However, I am relieved that I am finished and I am happy to begin a new chapter of my life.

Laura Groenendijk,
Rotterdam, 2015

Summary

Due to increasing congestion and pollution a modal shift from car towards public transport is desired. Literature review has shown that by increasing the customer satisfaction, a modal shift can be obtained. Compared to the car, public transport has a bad image. In order to change this, the quality of public transport needs to be improved after which measures can be used to promote its image. The bad image of public transport is caused by the many components of a public transport journey and the unwanted interruption of a transfer. Waiting for a transfer is valued three times as low as the actual journey because travellers experience waiting time and insecurity, which means that every minute of waiting is perceived as three minutes. By improving the transfer at a transit node, the overall quality of a public transport journey increases which leads to a higher customer satisfaction. The quality of a transit node determines for 25% the customer satisfaction and is currently valued low according to travellers because they perceive stations as boring, not atmospheric and cold. Because we live in an experience economy where the emotional experience of a service has become increasingly important, it is expected that this percentage will continue to increase. A customer is satisfied when the experience matches his expectations. The pyramid of customer needs shows that after satisfying the basic needs, attention must be paid to speed, convenience, comfort and experience. Therefore, value needs to be added to the transfer at a transit node by focusing on satisfying the customers' needs.

Three strategies are proposed to add value: accelerate, condense and enhance. The first two influence the objective waiting time and satisfy customer needs such as speed and convenience. Enhancement influences the subjective waiting time and satisfies comfort and experience. Because the last one cannot be measured, policy makers pay more attention to acceleration and condensation, whereas enhancement has a big influence on the customer satisfaction. However, only applying all three strategies simultaneously leads to a significant growth of performance indicators. All three strategies should be applied in different areas of the transit node: the transfer area, the transit node area and the transit node environment.

In order to determine where the strategies should be applied, the current quality of a transit node must be known. In the Netherlands, different applications of the node-place model are used to assess the quality of transit nodes and indicate the potential that can be realized. The node-place model determines the functionality of a transit node by analysing the relationship between the node- and place characteristics. When these two values are coherent, the transit node functions well. The thesis elaborates on the most recent application of the node-place model, the Butterfly model. By means of a Multi Criteria Analysis (MCA) the node and place value of transit nodes are calculated and the quality assessed. Subsequently, the potential is indicated by classifying the transit nodes into twelve different typologies with ideal situations for the node and place value.

The node-place model identifies the potential of the transit nodes with relation to the transfer and station area, improvements in the transit node environment are not considered. Currently, the node-place model only indicates where it is needed to accelerate and condense. Therefore, the model should be extended with a third value to illustrate the influence of enhancing the transit node environment in order to satisfy the remaining customer needs; comfort and experience. In this thesis, the node-place model will be

extended with the experience value.

Therefore, for this study the following research question was formulated:

How can the node-place model be extended with the traveller's experience in order to assess the quality of transit nodes and indicate the potential?

The experience value is a rather vague term that changes over time and is not the same in every region. Literature review has determined the criteria for the experience value; comfort, station organization, ambient elements and social elements. The weights of the main- and corresponding sub criteria are derived by means of an Multi Criteria Decision Making method, the Best Worst Method. BWM asks a decision-maker to select the best and worst option after which he has to express his preference of the best compared to the others and the others compared to the worst. The data for BWM was obtained by conducting a survey among 160 respondents. According to the respondents comfort (0.40) and station organization (0.36) are more important than ambient elements (0.13) and social elements (0.12).

Because the method should be applicable throughout the Netherlands, the experience value should be quantified. In order to quantify the experience value, it is vital that the data is practically obtainable. Therefore, it was decided to exclude the subjective sub criteria of the experience value from the method. By multiplying the data with the weights, the experience value can be calculated. In previous applications the node and place value have an equal influence on the transit node quality, but it is not known what the relative influence of the experience value should be. Based on literature and interviews, it was decided to assume that all three values have an equal share in the transit node quality. The transit node typologies were extended with an ideal situation for the experience value for each transit node type based the expectations of customers of the RET (Rotterdam Public Transport Company).

Finally, the node-place model was extended with the experience value to assess the quality of transit nodes and indicate the potential. The method can be applied by taking the following steps:

1. Make a selection of transit nodes
2. Classify the transit nodes
3. Collect the data
4. Execute the MCA and assess the quality
5. Compare with typologies

A case study was used to illustrate and apply the method. The method was applied on a selection of 32 transit nodes in the Rotterdam Urban Region. After the selection, the transit nodes were classified in the typologies and data was collected by visiting all transit nodes. Subsequently, the MCA was executed and the quality assessed. Comparing the quality with the typologies has resulted in a priority list of the transit nodes where it can be seen which transit nodes should be improved and what strategy needs to be applied. The Municipality of Rotterdam is advised to first improve Zuidplein, Rotterdam Alexander and Spijkenisse Centrum.

The method was evaluated by comparing the priority list of the node-place model with the priority of the new method. The ranking changes significantly after the experience value was added. The new priority list better reflects the current ambitions of the Municipality of Rotterdam. In addition, the situation of Rotterdam Central station in 2004 and 2014 was compared. The transit node was recently completed and much attention was paid to the traveller's experience. Before the renovation the station was home for drug addicts and tramps and avoided by most people. Nowadays, inhabitants of Rotterdam are proud of their station and tourists are taking pictures daily. Applying the method shows that the node and place value have not changed much, whereas the experience value shows a significant growth. This means that the experience value contributes to the transit node quality. Based on these findings, it can be concluded that extending the node-place model with the experience value contributes to the quality assessment of transit nodes and can be used as a tool for policymakers to determine the strategy for the improvement of transit nodes and public transport in general.

There are several main recommendations that could significantly improve the method. First, doing more research to the subjective sub criteria of the experience value and adding the criteria to the method. This way, a more comprehensive image of the experience value can be created. Second, a more representative sample for the survey will lead to more reliable weights. Third, the current method shows which strategy needs to be applied where, but does not indicate the effects of the improvements. It is recommended to monitor transit nodes where strategies have been applied in order to provide insight into the growth of the performance indicators.

Table of contents

List of figures

List of tables

1 Introduction

1.1 Problem definition

Changes in technology, society and the urban pattern have led to an increase of mobility and average travel distances (Schrijnen et al., 2011). Travel choice was always based on distance, but factors such as time and quality have become more important. Facilities are no longer located within people's neighborhoods but are situated all over the city or even region (Bertolini & Dijst, 2003). Because of this, the car has become the main mode of transportation; 39% of all movements in the Netherlands are made by car (Kennisinstituut voor Mobiliteitsbeleid, 2013). This development has resulted in congestion and pollution (Beirão & Sarsfield Cabral, 2007). For many years, fighting congestion, decreasing growth of car use and stimulating the use of public transport have been objectives of political parties in the country (Dijst et al., 2002). Despite scientific and political discussions, and much effort, these issues have not yet been solved. Reasons for this are the uncontrollability of the population behavior, the lack of quality of public transport and the persistent habit of people to travel by car.

There are different reasons why people prefer to travel by car instead of public transport. Subjective reasons contribute to the high percentage of car usage such as convenience, speed, comfort and individual freedom (Anable, 2005; Hagman, 2003; Jensen, 1999; Steg, 2003). Also, the attitude of travellers towards public transport is negative (Harms et al., 2007), even though this is an important determinant for mode choice (Beirão & Sarsfield Cabral, 2007). Another reason is the loss of time in a journey by public transport (Van der Spek, 2003). Transfers between modes and waiting at stations have a negative effect on the public transport experience of a traveller, while the experience has a large influence on the customer satisfaction (Boes, 2007).

Research has shown that by increasing the customer satisfaction, a modal shift from car to public transport can be obtained (STIMULUS, 1999). From the NS customer survey can be concluded that the customer satisfaction is for 25% determined by the station quality (Van Hagen, et al., 2009). The station quality is mostly determined by the traveller's experience (30.6%), but is valued very low according to the travellers (Van Hagen & Exel, 2012). A research to station quality commissioned by the NS and executed by Senta (2005) has shown that travellers perceive many stations as boring, not atmospheric and cold. It can be expected that this percentage will keep rising because we are currently living in an experience economy where the emotional experience of a service has become increasingly important (Pine & Gilmore, 1998). In this society the quality of goods and services is becoming more homogeneous which means that the experience value can set a service apart. Therefore, in order to increase the customer satisfaction, more attention should be paid to the experience of travellers at stations. According to Peek and van Hagen (2002), stations in the Netherlands are not the most inviting places. Travellers are rushing to their connecting trains and do not value the time they spend in a station. However, the past few years several stations have completed where more attention was paid to the traveller's experience.

In March 2014, the new Rotterdam Central Station was officially opened by king Willem-Alexander (Figure 1-1). Much attention was paid to the design of the station; the use of materials attracts the city to the station, new sight lines provide an overview for the travellers and the mix of living and working greatly improves the social climate of the railway zone (Benthem Crouwel Architects, 2014). The shape of the building expresses the internal logistics of the transport hub and points the way to the city's heart. Because of these characteristics, inhabitants of Rotterdam are proud of their station, the station has several affectionate nicknames and tourists are taking pictures daily.

Figure 1-1: Rotterdam Centraal (Rotterdam Image Bank, 2014a)

Station Amsterdam Bijlmer ArenA was completed in 2007 (Figure 1-2). The main conditions for the design were optimal comfort for travellers, a high social security and a good connection between the two districts on both sides of the station (Arcadis, 2014). Based on these conditions, a warm and light station was designed. The station was very well received and the architects have even won the BNA architecture prize 'Building of the Year 2008'.

Figure 1-2: Amsterdam Bijlmer ArenA (Grimshaw Architects, 2014)

Metro station Wilhelminaplein in Rotterdam was completed in 1997 (Figure 1-3). The aim of designing this station was a luxurious look with high quality finishing in order to upgrade the quality of the public transport network to a comprehensive alternative for car usage (Zwarts & Jansma Architects, 2014b). It has become a light and modern metro station with a metallic look. A nice touch is that every time a metro arrives, the lights switch on and when the metro departs, the lights go out again.

Figure 1-3: Wilhelminaplein, Rotterdam (Zwarts & Jansma Architects, 2014a)

The tram tunnel in The Hague, completed in 2004, is a station of a different leve (Figure 1-4). The multi-story underground tunnel connects two tram stations and houses a parking garage as well (OMA, 2014). In order to provide a good orientation for the travellers, every opportunity has been taken to connect the tunnel physically or visually with the program in the city.

Figure 1-4: Tram tunnel, The Hague (IGG, 2014)

These examples show that when designing stations, the experience of a traveller has become more important. As mentioned, the quality a station determines for 25% the customer satisfaction and, according to Dutch travellers, the quality is below average. As mentioned, by improving the customer satisfaction a modal shift can be obtained (STIMULUS, 1999). There are more ways to achieve this, but this thesis focuses on improving the quality of stations.

In order to improve the customer satisfaction the quality of stations must be assessed and possible improvements must be identified. In the Netherlands, transit node models are used for this purpose (Peek, 2006). The used transit node models are different applications of the node-place model by Bertolini (1999), which is based on the theory of the Land-use Transport Feedback Cycle by Wegener & Fürst (2004) (Figure 1-5). This theory focuses on the node- and place characteristics of a station; a station is a node in a network and a place in a city (Bertolini, 1996). The Land-use Transport Feedback Cycle is aimed at the relationship between the two by stating that by improving the transport supply (or node value) of a location will, by improving the accessibility, create conditions favorable to further location development. By its turn, the development of a location (or increase of the place value) will, because of a growing demand for transport, create conditions favorable to further development of the transport system. Hence, when there is a strong coherence between the node value and place value, the transit node functions well. Based on this theory, the node-place model assesses the quality of a station and indicates the improvements that should be made to create coherence between the node and place value and improve the functioning of the transit node.

In the Netherlands, different applications of the node-place model are used. According to Schrijnen et al. (2011) it is needed to develop a common language to obtain a better communication between different governments. Also, the theory and examples have shown that the experience has become more important for the quality of transit nodes; however this aspect is currently not part of the node-place model.

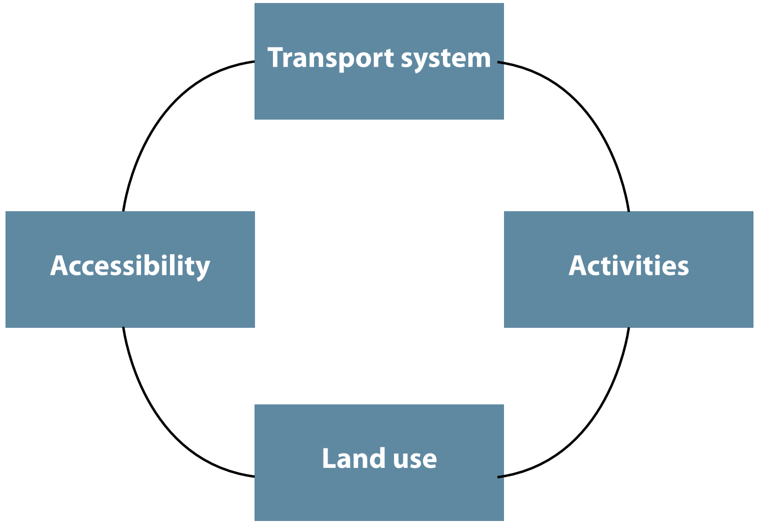

Figure 1-5: Land-use Transport Feedback Cycle (Wegener & Fürst, 2004, p.6)

1.2 Research objectives and research question

1.2.1 Research objectives

This thesis aims to address the previously mentioned issues by developing a common method for the Netherlands that can be used to assess the quality of transit nodes as well as indicate possible improvements while incorporating the experience value. This will be done by exploring the existing node-place model by Bertolini (1999) and its applications throughout the country. After this, research is conducted in order to provide more insight into the experience value. Finally, a case study is used to apply and illustrate the method. Because this thesis is conducted at the Municipality of Rotterdam, the city of Rotterdam is selected as area for the case study. This area will make an interesting case because the public transport network is comprehensive and consists of different types of transit nodes.

For this thesis, both a theoretical and a practical research objective are formulated.

- The theoretical research objective is to develop a common method for the Netherlands in order to assess the quality of transit nodes and indicate possible improvements, by extending the node-place model by Bertolini (1999) with the experience value.
- The practical research objective is to contribute to the improvement of the quality of transit nodes in the city of Rotterdam, by applying the method on a selection of transit nodes in the city and providing the Municipality of Rotterdam with a quality assessment of transit nodes and indication of possible improvements.

1.2.2 Research question

For this thesis the following main research question is formulated:

How can the node-place model be extended with the traveller's experience in order to assess the quality of transit nodes and indicate the potential?

To answer the main research question, the following sub questions are formulated:

1. What steps should be taken to obtain a modal shift from car towards public transport?
2. How can public transport be made more attractive?
3. What measures can be taken to add value to the time spent a transit node during the transfer?
4. What applications of the node-place model are available to assess the quality of transit nodes and indicate the potential?
5. What criteria contribute to the experience value of a transit node and how important are they?
6. How can the experience value be calculated and what is the influence on the transit node quality?
7. How can the potential of the experience value be indicated?

1.3 Scientific and societal relevance

Based on the formulated theoretical and practical research objectives in section 1.2.1, this research has a scientific and societal relevance.

The scientific relevance of this research is to extend the existing node-place model with the experience value in order develop a new method that can be used to assess the quality of transit nodes and indicate possible improvements. This study also provides more insight into the characteristics of the experience value.

This research provides a method that assesses the quality of transit nodes and indicates possible improvements. The outcome of the method can function as a guideline for municipalities, governments and public transport operators to discuss the quality of transit nodes. This way it will be possible to decide which and where improvements are needed. By improving transit nodes and increasing customer satisfaction, a first step is taken in obtaining a modal shift from car to public transport. Finally, this could lead to less car usage and hence, less congestion and pollution, which is of great relevance for the entire society.

1.4 Scope

1.4.1 Scope transit nodes

This thesis focuses on improving the quality of stations in order to increase customer satisfaction. This is done by extending the node-place model with the experience value. The node-place model only considers larger stations where travellers transfer from one mode to another, the so-called transit nodes. A transit node is multi-modal transfer point with a train- and/or metro connection in a public transport network where several facilities and activities are organized. Because the original model only considers transit nodes, the method that is to be developed will do likewise.

1.4.2 Scope node-place model

The aim of this thesis is to develop a common method for the Netherlands that can be used to assess the quality of transit nodes as well as indicate possible improvements while incorporating the experience value. This will be achieved by extending the existing node-place model with the experience value. Only the experience value is within the scope of this thesis. No changes are made to the node and place value.

1.4.3 Geographic scope

The method is aimed to be generic and thus suitable for application to any transit node in the Netherlands. However, in order to apply and illustrate the method, a case study will be done in Rotterdam. The current capacity of the road network around Rotterdam is not enough to compensate for the increase of mobility. Compared to other cities in the Netherlands, the share of public transport users in Rotterdam is relatively low which could indicate that there is room for improvement (Gemeente Rotterdam, 2012). Hence, the Municipality of Rotterdam has great interest in a method that can be used to improve transit nodes which contributes to a modal shift from car towards public transport. In consultation with the municipality it was decided to apply the method on a selection of transit nodes in the Rotterdam Urban Region (Figure 1-6). Besides Rotterdam, fourteen other municipalities are part of the urban region. The municipalities where transit nodes are situated are the following: Albrandswaard, Capelle aan den IJssel, Lansingerland, Maassluis, Schiedam, Spijkenisse, and Vlaardingen.

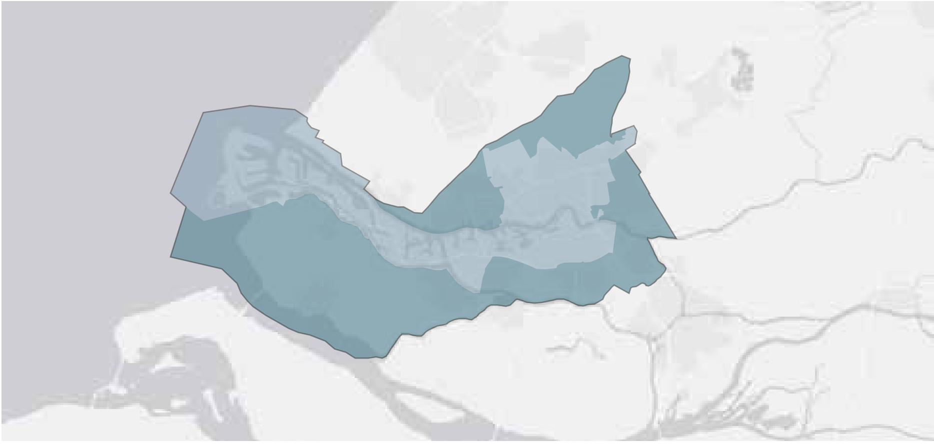

Figure 1-6: Municipality of Rotterdam (blue) and Rotterdam Urban Region (green and blue)

1.5 Thesis outline

This thesis report is structured as follows. In Chapter 2 it will be investigated what steps should be taken to obtain a modal shift from car towards public transport. By taking a closer look at a journey by public transport and the needs of public transport customers it is determined how the quality of a public transport journey can be improved. In Chapter 3, three measures are proposed that can be used to improve the quality of transit nodes. Also, a closer look is taken at the node-place model. In Chapter 4, the criteria that are part of the experience value are determined as well as their importance. Subsequently in Chapter 5, the node-place model is extended with the experience value. Finally, in Chapter 6 a case study is conducted in the Rotterdam Urban Region in order to apply and illustrate the method.


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2 Literature review

The introduction has shown that the car is the main mode of transportation in the Netherlands. Because of increasing congestion and pollution a modal shift from car towards public transport is desired. This chapter aims to provide insight into the differences between a car and public transport journey in order to clarify why people often choose to travel by car and what steps should be taken to change this. From the NS customer survey can be concluded that the customer satisfaction is for 25% determined by the station quality (Van Hagen, et al., 2009). A research to station quality commissioned by the NS and executed by Senta (2005) has shown that travellers perceive many stations as boring, not atmospheric and cold. This Chapter provides more insight into the quality of transit nodes by taking a closer look at a public transport journey. The sub questions that are answered in this chapter are the following:

1. *What steps should be taken to obtain a modal shift from car towards public transport?*
2. *How can public transport be made more attractive?*

The first section starts with providing general information about a journey. Section 2.2 focuses on the competition between car and public transport by taking a closer look at the reasons behind mode choice and how to obtain a modal shift from car towards public transport. Lessons learned from these sections are further explored in sections 2.3, 2.4 and 2.5.

2.1 A journey

A movement is not a goal in itself, but the result of an activity pattern such as work, sport and leisure (Van der Spek, 2003). These activities are situated on different locations which makes it necessary for people to move. Undertaking a journey is not only based on wanting to go somewhere, but is also dependent on whether or not it is possible for a traveller. The needs of a traveller are made possible by their travel budget. A traveller has three travel budgets: money, time and effort (Van den Heuvel, 1997). Together these components determine the travel resistance. The travel resistance is the disutility of a journey (Annema, 2002). A potential traveller compares the utility awaiting him at the destination with the disutility of the journey. The trip is worth making if the utility is higher than the disutility. The travel resistance influences the passenger's choice not only with regard to whether the trip will be made but also the choice of mode and departure time. When making a choice between traveling by car or public transport, people particularly weigh up the differences in reliability, travel time, ease, comfort, experience and costs (Van den Heuvel, 1997; Van Hagen et al., 2000). People want to travel as quickly, cheaply and effortlessly as possible (Peek & van Hagen, 2004). Of course, the traveller chooses for the way of transportation with the least total resistance or highest utility.

2.2 Competition public transport and car

2.2.1 Mode choice

In order to attract more travellers to public transport, it is necessary to understand more about the different factors that influence mode choice. Different studies have shown that mode choice is mostly determined by travel time (Van den Heuvel, 1997; Van Goeverden & Van Den Heuvel, 1993). With the level of prosperity rising time has become more important than money (Pine & Gilmore, 1998). The choice of transportation mode is determined for 60% by the travel time of both alternatives, for commuting traffic this percentage is even 80% (Van den Heuvel, 1997; Van Goeverden & Van Den Heuvel, 1993). Therefore, the choice between car and public transport can for a large part be explained by the relation between the travel times. The Travel Time Factor (TTF) was introduced in order to better explain this relation and to define the quality of public transport. The TTF is defined as the ratio between the door-to-door travel time by public transport and by car. The smaller the TTF, the larger the relative quality of public transport.

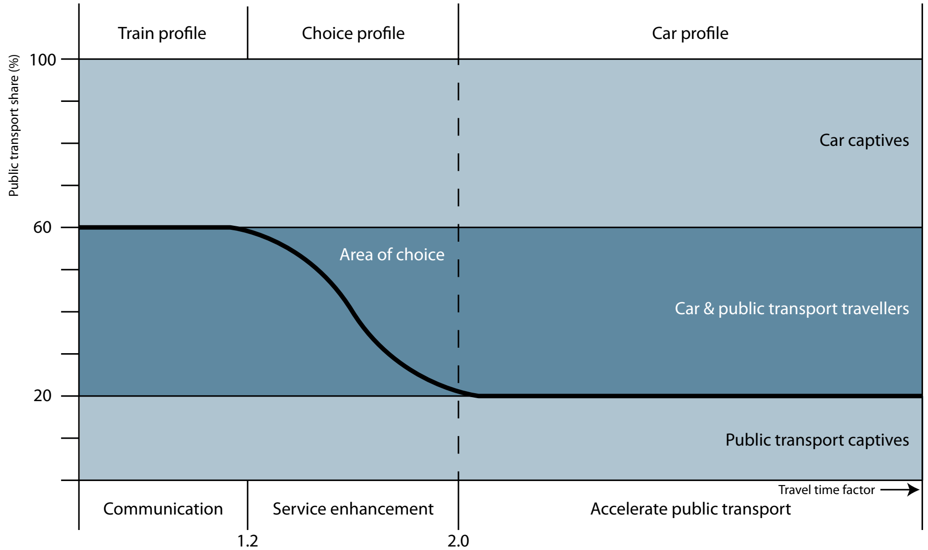


Figure 2-1: TFF-values and PT market share (Based on Van den Heuvel, 1997, p. 21; Van Hagen, 2011, p. 9)

Figure 2-1 above shows various TTF-values that have been combined with the public transport market share. When the travel time by public transport and car is the same, public transport has a 60% share, but decreases to 20% when the car is faster (Van den Heuvel, 1997). Research has shown that people have a distorted idea of the actual travel time of both public transport and car (Van Hagen, 2011). The subjective TTF-values appeared close to 1, which means that people think there is not much difference between the travel times. If this is the case, the market share of public transport should be much higher than it is now. Therefore, it can be concluded that a journey by public transport differs in more than only travel time from a journey by car.

Car is more than just a mode choice. In general, it is the most attractive mode of transport because of its convenience, speed, comfort and individual freedom (Anable, 2005; Hagman, 2003; Jensen, 1999; Steg, 2003). People do not always drive a car out of necessity, but also by choice (Handy et al., 2005). Hence, attitude towards a transport mode is an important determinant for mode choice (Beirão & Sarsfield Cabral, 2007).

Harms et al. (2007) has conducted research into how travellers experience the use of car, bicycle and public transport. Public transport was experienced quite negatively; 51% of the Dutch travellers of over 18 years old judges negatively and 26% positively. From the people who travel rarely or do not travel at all with public transport 62% judged negatively. A majority of 56% of the people that travel with public transport multiple times a week are positive. However, from the people that travel very frequently with public transport 24% is negative in comparison with car (3%) and bicycle (1%).

Over the past decennia, the opinion of people concerning mobility has hardly changed (Harms, 2007). The car is still very popular, public transport is judged very negatively and the bicycle is in the middle. However, the reasons for this opinion might have changed. There has been a strong growth of the number of households with multiple cars and of women with a driver's license. Nowadays, cars provide more comfort, are easier in use, faster and safer. Disadvantages of car use have increased as well: road crowdedness, congestion, difficulties finding a parking space and higher fuel taxes. In the media and politics, these are all significant problems whereas travellers do not consider them as problems but have accepted it. Also, public transport has changed: new equipment, more comfort, more connections, better information facilities and free public transport for specific population groups. Nevertheless, people consider public transport as an unpleasant mode of transportation.

It can be questioned whether public transport is really that unpleasant. Car users have lower perceptions of public transport than public transport users. This could indicate that public transport is actually better than thought. People judge the mode of transportation they use the most always positive and alternatives are considered negative (Harms et al., 2007). People overestimate the benefits of their behavior, whereas the disadvantages are underestimated and vice versa (Dijst et al., 2002). This means that frequent car users overestimate the disadvantages of public transport or use them as excuses for other more subjective reasons such as social status or because they enjoy to drive.

2.2.2 Modal shift

By improving the service quality of public transport to its customers' requirements a modal shift can be obtained (STIMULUS, 1999). Service quality is perceived as an important determinant of users' travel demand (Prioni & Hensher, 2000). Hensher (1998) does not expect that an improved public transport service would be able to attract large numbers of car users to public transport, but his research has shown that by improving the image and level of service the intention to switch modes by car users and potential public transport users increases. Therefore, policies which aim to influence car usage should be targeted at market segments that are most willing to reduce the frequency of their car use (Anable, 2005; Jensen, 1999; Steg, 2005; Van Hagen et al., 2012).

In order to change the negative perceptions of car users towards public transport, they should experience a journey first (Thøgersen, 2006). To induce experience among car users, several initiatives can be used, such as free trips or reduced fare. Another option can be to focus on the existing customers, because a high customer satisfaction leads to loyalty (Heskett & Schlesinger, 1994) and loyal customers are associated with repetitive use and a positive word-of-mouth (Parasuraman et al., 1988). These loyal customers can encourage other travellers to experience a public transport journey.

Hence, policies which aim at increasing public transport usage should promote its image, but at the same time, public transport needs to become more market-oriented and competitive (Beirão & Sarsfield Cabral, 2007). This means that the quality of public transport should be according to the travellers' requirements in order for the policies to have an effect. This requires an improvement of the service quality, which can only be accomplished by understanding the travellers' needs. Public transport operators and authorities need to understand how customers evaluate the service quality. Also, it becomes essential to measure the quality level in order to identify improvements aimed at enhancing customer satisfaction and increasing market share.

2.3 Public transport journey

In order to have a better understanding of why public transport has such a bad image and what should be improved, a closer look will be taken to a journey by public transport. A public transport journey consists of many more components than a journey by car (Van Witsen et al., 1987). A door-to-door movement by car consists of walking from the origin to the bike or car, moving the vehicle, parking the vehicle and walking to the destination. A journey by public transport starts with the pre-transport from the origin to the access stop, waiting for the main transport, driving, a potential transfer with an active and passive part, and post-transport to the destination. The active transfer concerns the walking from egress to access stop whereas the passive transfer concerns waiting at the access stop. The total movement is complex and requires alignment in time and space between the traveller

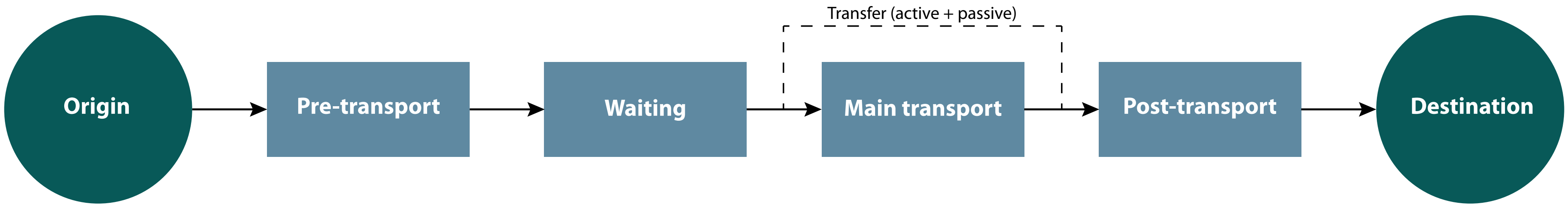


Figure 2-2: Mobility chain (Based on Van Witsen et al., 1987)

and transport providers. In Figure 2-2 the mobility chain of a public transport movement can be seen.

Research has shown that not all aspects of a public transport journey are valued the same (Van der Waard, 1989; Wardman, 2004). This value can be expressed as a clear and simple measurement: time (Peek & van Hagen, 2002). Every activity can be assigned a time value because unpleasant experiences seem to last longer than pleasant ones. Extra travel time means that an individual has less time to do the things that he or she would rather do. The more value people attach to these additional objectives, the more they are prepared to pay for shorter journey times (Baaijens et al., 1997).

Within a journey, the value differs between the time inside a vehicle, the pre- and post-transport time, and the transfer time (Van der Waard, 1989; Wardman, 2004). The 'in-vehicle time' is valued twice as high as the pre- and post-transport time and three times as high as the transfer time. This means that every minute of waiting is perceived as three minutes. It can be concluded that the transfer time is the weakest link of a public transport journey which determines the quality of the entire trip chain. Figure 2-3 visualizes the value travellers assign to the time spent in journey. The product of the time spent (horizontal axis) and the time value (vertical axis) is the total value. It is clear that the transfer is the least valued part of a public transport journey.

The transfer is a characteristic of a public transport journey. Because public transport cannot offer direct connections between origin and destination, it is in most cases needed to transfer between various transport systems that operate on a different level (Van der Spek, 2003). According to Peek and van Hagen (2002) the transfer is an unwanted interruption in the journey because travellers can experience uncertainty, inconvenience and waiting time.

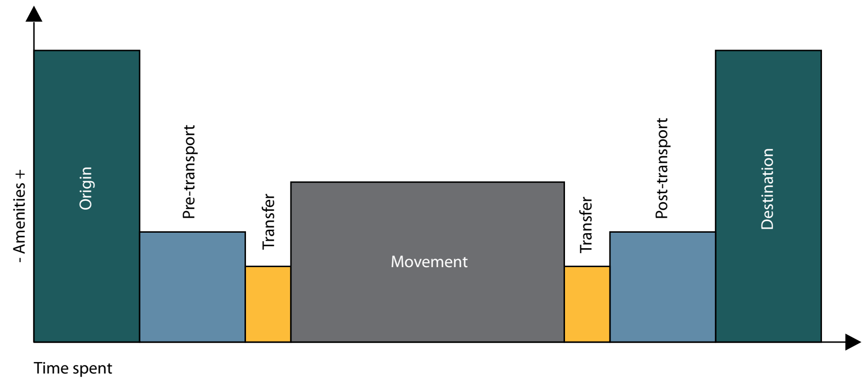


Figure 2-3: Time valuation of a public transport journey (Peek & Van Hagen, 2002, p. 4)

2.4 Waiting experience

Waiting time during a transfer is the main obstacle in a journey for travellers. During their wait, travellers feel that they are wasting valuable time (Van Hagen & Heiligers, 2011). Hence, waiting is the biggest annoyance of a traveller

(Peek, 2006) and generally overestimated (Baaijens et al., 1997). Very little is still known about the experience of the wait and how it can be influenced. This section will give some background information about the waiting experience.

2.4.1 What is time?

Before explaining what is understood by the waiting experience, the concept of time needs to be addressed. Even though we are living in an age where time controls our life it is very difficult to define time (Van Hagen, 2011). All our activities occur in time and space and where space is reasonably tangible, time is not. Our senses can observe colours, smells, sound, taste, and temperature, but we cannot sense time. Because of our daily activities we are able to guess the current time and for how long we have been doing something, but as soon as our routine changes the estimation deviates from reality.

We are constantly aware of time, but how aware we are differs significantly (Van Hagen, 2011). When we are having an interesting conversation or are caught up in a challenging activity, we seem to forget the time. During unpleasant moments, when we have to do something we do not like or when we are bored, time seems to drag on.

Time can be perceived both objectively and subjectively (Hornik, 1984; Pruyn & Smidts, 1998). This differentiation is relevant because it offers the possibility to influence both perceptions by shortening the waiting time on the one hand and by making the wait more pleasant on the other.

Objective time perception

Objective time perception is the same for everyone and can be measured with clocks and stopwatches (Van Hagen, 2011). Diaries and calendars are based on objective time; they structure our lives and help us keep our appointments. Until 1909 each town in the Netherlands had its own clock time, but the introduction of the train with a timetable made it imperative that the clock times of various towns were synchronized (Knippenberg & De Pater, 2000).

Subjective time perception

People whose waits are equally long can experience the length of their wait completely different. Subjective time can be distinguished in a cognitive and affective component (Pruyn & Smidts, 1998). The cognitive component reflects the perception of time span in terms and the affective component consists of emotional responses such as irritation, boredom, stress, etc. The longer the perceived waiting time, the more negative the appraisal of the wait. The cognitive component will be affected more strongly than the affective component.

More attention should be paid to subjective waiting time because it is a strong determinant for customer satisfaction (Pruyn & Smidts, 1998). Customers' reaction to waiting are more strongly affected by perceived than by objective waiting time (Hornik, 1984). Pruyn and Smidts (1998) have shown that the waiting environment has a big influence on the time perception. People think the wait passes more quickly in a pleasant environment than in an unpleasant one. An attractive environment directly influences customers' moods and thus the affective appraisal of the wait (Baker & Cameron, 1996; Bitner, 1992).

2.4.2 Waiting environment

The waiting environment of a traveller during a transfer is the transit node. Transit nodes are special environments because time plays a central role (Van Hagen, 2011). Speed is of the essence so a wait is considered lost time. Also, transportation departs at a predetermined time so travellers have to keep an eye on the clock. In the Netherlands, travellers spend on average seven minutes at a transit node but the traveller perceives the time as much longer (Van Hagen et al., 2007).

2.5 Customer satisfaction

As mentioned, by improving the customer satisfaction a modal shift can be obtained from car towards public transport. This requires an improvement of the service quality, which can only be accomplished by understanding the travellers' needs. Public transport operators and authorities need to understand how customers evaluate the service quality.

A customer tries to satisfy a need or searches for certain benefits that can be gained by buying a product or service (Kotler & Armstrong, 2013). Whether the customer is satisfied is determined by the difference between the expected quality and the actual experience (Grönroos, 1982; Parasuraman et al., 1988). Personal characteristics and environmental factors can lead to differences in the quality experience. Hence, in order to satisfy a customer's needs the experience of the customer must be similar to his expectations.

The different needs of a traveller are ranked in a pyramid according to their importance similar to the hierarchy of Maslow (1954). The pyramid of customer needs is based on the perception of quality by the NS (Dutch Railways) but is also used by various transport scientists (Van Hagen, 2011) (Figure 2-4).

The basic needs security and reliability form the base of the pyramid (Peek & van Hagen, 2002; Van Hagen et al., 2000). Safety indicates that travellers should feel a sense of social safety at the station. An unsafe station is likely to be avoided. Reliability means that travellers receive that they expected in advance. Speed is the principal customer need because travellers base their journey on the travel time between origin and destination. Travel information and signposting contribute to a traveller's convenience during a journey. Sheltered waiting, seating areas and facilities are part of the comfort a traveller experiences. A pleasant experience can be accomplished by visual aspects such as the presence of architecture, cleanliness and light.

Boes (2007) has a remark on the pyramid in her thesis; the experience need is in the top of the pyramid but is actually present in all other aspects. For example, security includes not only the number of crimes but also the sense of security a traveller experiences. This contributes to the already stated importance of the experience value.

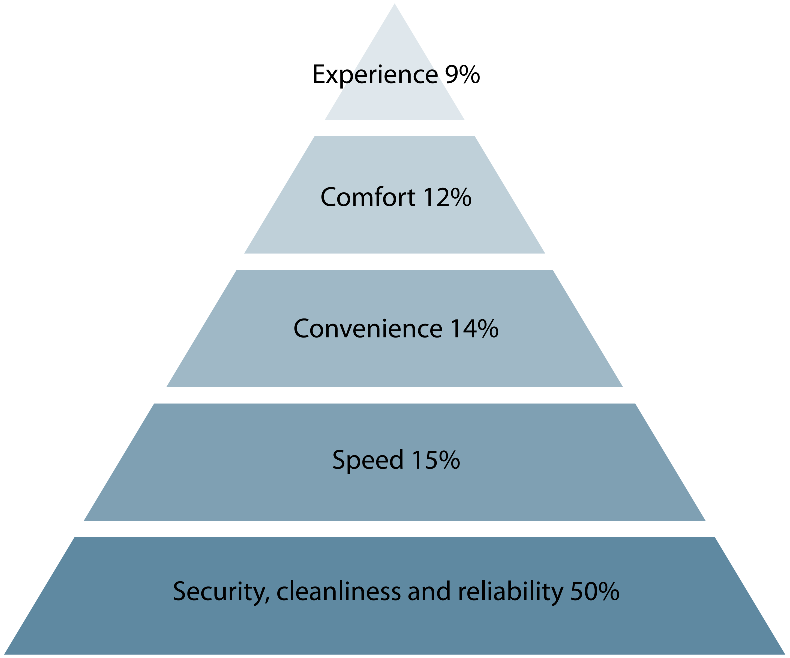


Figure 2-4: The pyramid of customer needs (Van Hagen et al., 2000)

As explained, the transfer is valued the lowest in a public transport journey. A transfer is built up from four different components (Van der Spek, 2003). The first is a physical component which includes distance and time: the route. An informative component which consists of overview and information systems: the orientation. A third component exists of comfort and the fourth component the experience. These components can be brought back to the pyramid of customer needs (Van Hagen et al., 2000) as speed, convenience, comfort and experience.

During a transfer, activities of travellers can be distinguished in two movements; moving and staying (Peek & Van Hagen, 2006). It has been shown that these travellers value different things during their journey. When travellers move through a transit node, speed and convenience are of high importance because all travellers are satisfied with a safe, reliable, easy and fast journey (Wakefield & Blodgett, 1994). Therefore, these quality aspects are dissatisfiers which means that they can disappoint travellers when the expectations are not met (Mausner & Snyderman, 1993). Comfort and experience are satisfiers, which means they are noticed when they are better than expected in advance.

However, when staying at a transit node while waiting for a connection, comfort and experience are vital (Wakefield & Blodgett, 1994). The pyramid can be seen upside-down when considering a staying traveller (Peek & Van Hagen, 2006). Security and reliability are still the basic needs but the ranking of the other needs will turn around. This means that for this group of travellers experience and comfort are now dissatisfiers and influence the customer satisfaction.

Because some needs are satisfiers for moving travellers and some for staying travellers, it is important to focus on all needs of the pyramid. First, the basic needs from the pyramid – security, cleanliness and reliability – must be satisfied, after which quality can be added by focusing on the other needs.

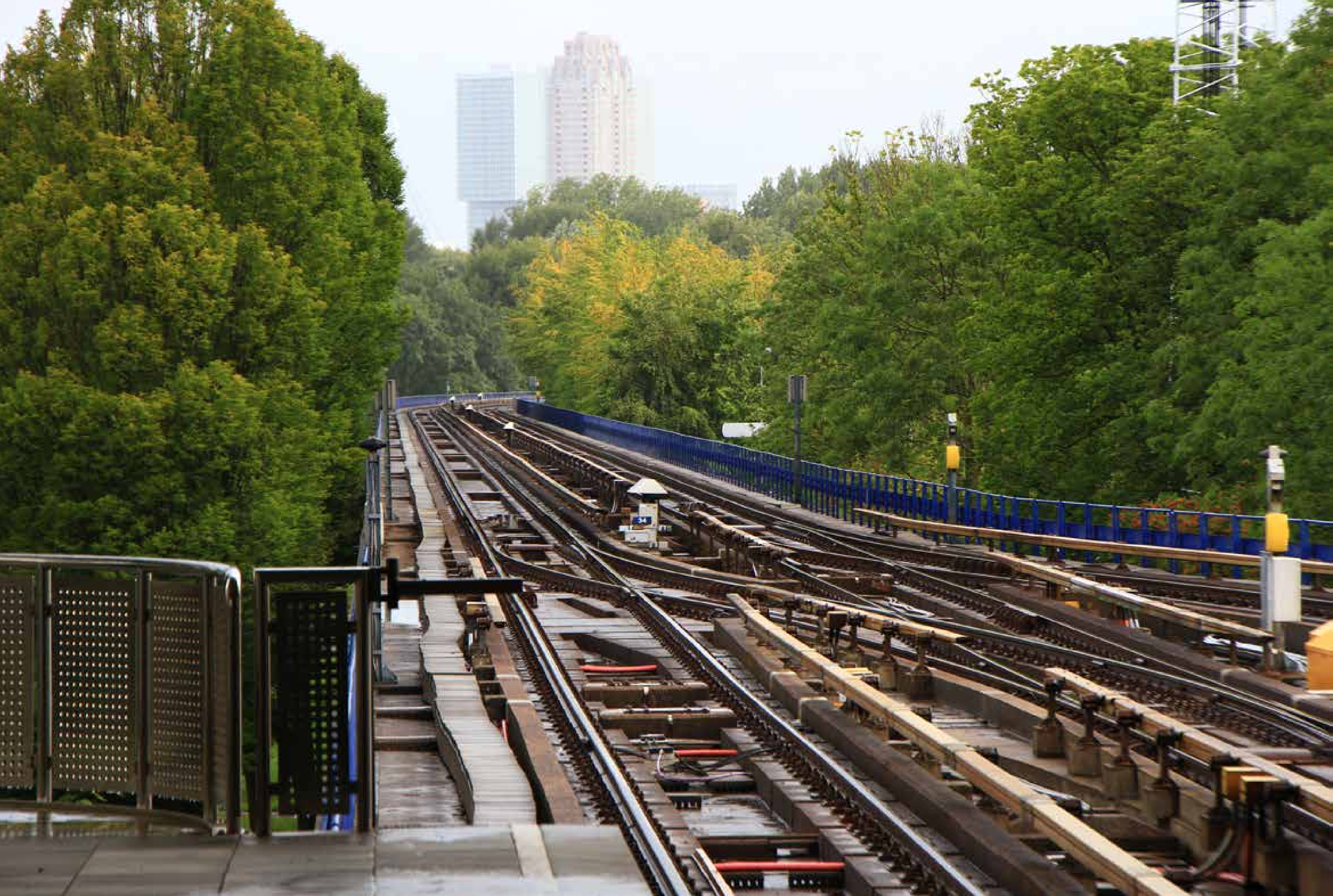
2.6 Conclusions

This chapter has aimed to provide insight into the competition between a car and public transport journey in order to clarify why people generally prefer to travel by car. As the level of prosperity has risen, a traveller's mode choice is mostly determined by trip duration. However, there are more reasons that contribute to this choice. Driving a car is more attractive because of its convenience, speed, comfort and individual freedom. At the same time, the attitude of travellers towards public transport is bad, especially according to car travellers. Research has shown that by improving the customer satisfaction a modal shift can be obtained. Public transport services can do this by improving their quality, but only if this is accompanied by policies to promote the image of public transport such as free trips, reduced fare and a positive word-of-mouth of existing customers. This research focuses on improving the quality of the public transport service.

A closer look was taken to the public transport journey in order to have a better understanding of why public transport has such a bad image. First of all, a public transport journey has many more components than a journey by car. Second, the transfer is an unwanted interruption in a journey and valued the lowest because travellers have to wait. Waiting time can be perceived both objectively and subjectively. More attention should be paid to subjective waiting time because it is a strong determinant for customer satisfaction.

An improvement of the public transport services leads to a higher customer satisfaction. A customer's needs are satisfied when the experience is similar to his expectations. During a transfer, travellers are moving during the active part of the transfer and staying during the passive part of the transfer. For active travellers speed, convenience, comfort and experience are important in that order. For passive travellers, the order is reversed. This means that all aspects of the customer pyramid are important during a transfer.

Hence, the transfer is the least valued part of a public transport journey. By adding value to this part of the journey, the transport service quality will increase which will lead to a higher customer satisfaction. During the transfer travellers are at transit nodes, where time plays a central role. Therefore, in the next chapter measures should be identified to add value to the time people spent at a transit node during the transfer by focusing on satisfying the customers' needs when moving and staying.



3 Measures and models

This chapter uses the findings from the previous chapter to investigate what measures can be taken to add value to the time spent a transit node during the transfer. Then, in order to determine what kind of measures should be taken, the current quality of a transit node has to be determined. As explained before, in the Netherlands transit node models are used for this purpose. This chapter provides information about measures to add value to the transfer and the different applications of transit node models. The sub questions that are answered in this chapter are:

3. *What measures can be taken to add value to the time spent at a transit node during the transfer?*
4. *What applications of the node-place model are available to assess the quality of transit nodes and indicate the potential that can be realized?*

Section 3.1 explains what measures can be taken to add value to the time spent at a transit node. Section 3.2 elaborates on the node-place model and its several applications throughout the Netherlands. Subsequently, a link is made between the measures and the transit node model in Section 3.3.

3.1 From strategy to synergy

Peek and van Hagen (2002) propose that the negative experience of travellers transferring can be turned into a more positive experience by making use of the ambivalent character of a transit node; a node in a network and a place in a city (Bertolini, 1996). As explained before, a transfer has an active and passive part. (Van der Spek, 2003). Activities of travellers during a transfer can be distinguished in two states; moving and staying (Peek & Van Hagen, 2006). The transfer is a threshold for travellers which should be decreased to a minimum (Van der Bijl, 2010). Synergy should be created between moving and staying in order to create an integral design (Peek & Van Hagen, 2006). Synergy in a transit node exists when the composite elements, such as facilities and spatial elements, together create more value than the sum of the individual parts (Peek, 2006). Synergy can be translated in performance indicators such as travel demand, customer opinions, retail turnover and real estate profits. The exact definition of synergy is:

"Synergy is the individually perceived contribution of added value arising from coherence oriented collaboration (Peek, 2006, p. 84)."

As explained earlier, the transfer is the part of a public transport journey that is valued the lowest. When value is added to the transfer process, a public transport journey can compete with a journey by car. Adding value to the time spent in a station leads to synergy between moving and staying, and an improved waiting experience. This means that the transit node becomes more than just a transfer machine and that attention must be paid to the relationship between transporting people and having them enjoying the time spent at the transit node.

Peek and van Hagen (2002) have proposed three strategies that can be used to add this value and can lead to synergy: accelerate, condense and enhance. The next few sub sections shortly explain the strategies.

Accelerate

The first strategy that can be applied to add value to the time spent at a transit node is to shorten travel times. This can be done by increasing the average speed of transport modes and by reducing waiting times (Figure 3-1). In practice, accelerating public transport is costly and generates relatively little new transport (Peek & van Hagen, 2002).

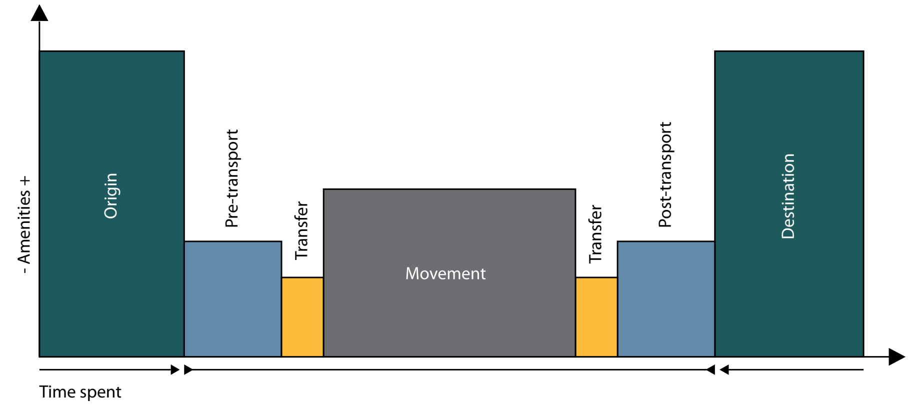


Figure 3-1: Accelerate (Peek & Van Hagen, 2002, p. 5)

Condense

By situating urban facilities such as housing, workplaces and leisure centers closer and/or in greater densities to the station. Because activities are now at walking distance from the station the need for access and egress modes can be eliminated and the traveller does not experience the low valued transfer time (Figure 3-2). In practice, investments in spatial planning are costly but generate a lot of extra transport (Peek & van Hagen, 2002).

Densifying the area around transit nodes is a part of Transit-oriented development (TOD). TOD is the integration of urban development and the development of public transport networks (Bertolini, 2013; Rietveld, 2013). Concentrating urbanization projects around transit nodes leads to, by mixing functions and sufficient urban density, a higher quality of the urban environment and more efficient use of urban areas (Tan, 2013). Over the past years, TOD has gained popularity as a tool to address urban problems such as traffic congestion, air pollution and urban sprawl (Cervero et al., 2002).

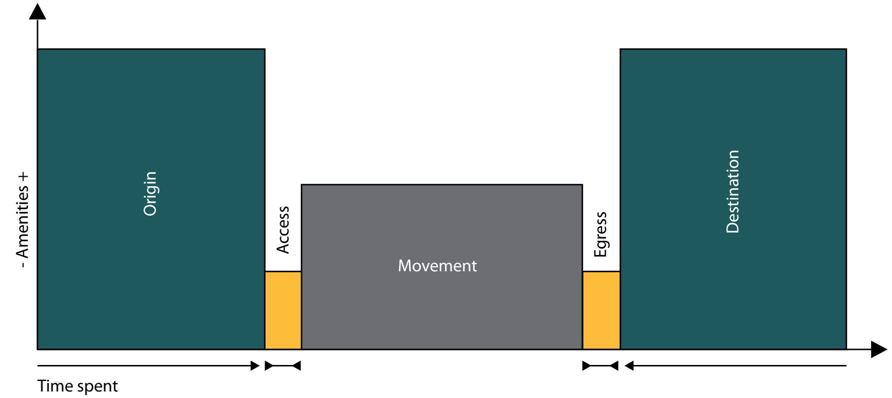


Figure 3-2: Condense (Peek & Van Hagen, 2002, p. 5)

Enhance

The third strategy is to enhance the time value of the least-valued elements. By making waiting and transferring pleasant or useful experiences, the value of the passenger's journey goes up (Figure 3-3). In practice, investments in

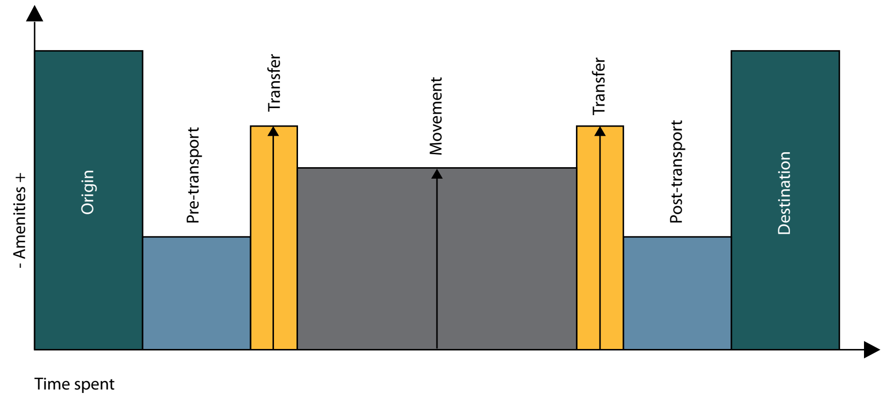


Figure 3-3: Enhance (Peek & Van Hagen, 2002, p. 6)

this area are relatively modest but immediately show an effect for the traveller. This can be concluded from customer opinions, retail turnover and real estate profits (Peek & van Hagen, 2002).

Even though there are three strategies to add value to the journey of a traveller the focus is always on accelerating and condensing (Peek & Van Hagen, 2006). It is assumed that investments in the enhancement area are not taken seriously because they cannot be measured. This thesis focuses on the third strategy: enhancement. The first two strategies clearly shorten the objective time, whereas enhancing shortens the perceived time.

The strategies satisfy different needs of the customer wish pyramid (Figure 2-3). Acceleration aims on satisfying speed, condensation focuses on satisfying speed and convenience, and enhancement satisfies comfort and experience. The importance of applying all three strategies simultaneously is emphasized by the research of Vaessens (2005). In his research, he evaluated the effects of the strategies on the synergy of ten stations by means of performance indicators such as travel demand, customer opinions, retail turnover and real estate profits. The research has demonstrated that only stations that underwent changes in all three areas have shown a significant growth of all performance indicators. A unilateral approach of only two of the three strategies leads to a varying growth. Therefore, it is clear that only when all three strategies are applied simultaneously a better synergy can be accomplished.

In order to create synergy in a transit node, a new station layout is required (Peek & van Hagen, 2002). The station area should be divided in three spatial areas: the transfer area, the station area and the station environment.

The transfer area is the core of the transit node. The main priority of this area is the interchange, access and egress between different transport modes. A logical interchange with short walking distances, minimum waiting times, logical and simple signposting and minimal congestion is needed. Acceleration is a strategy that can be applied in this area to add value to a journey.

The station environment is situated around the transfer area and offers facilities to make transfer time useful and pleasant. Facilities for commerce and meeting are situated in this area. Enhancement of comfort and experience is a strategy that can be applied in this area.

The station area contains less travel related activities such as housing, workplaces and leisure areas. The choice of location of these urban facilities is related to the proximity of the station. Condensation is a strategy that can be applied in this area.

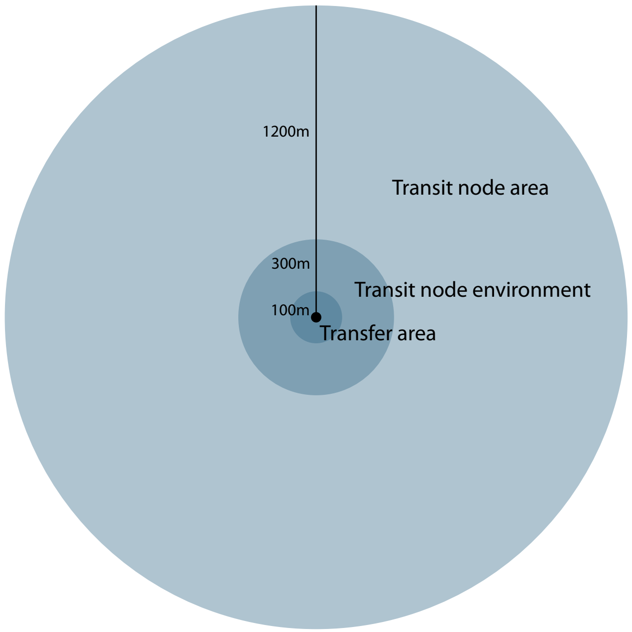


Figure 3-4: Station layout with strategies (Peek & Van Hagen, 2002, p. 7)

3.2 Theory of the node-place model

It is clear that the three strategies should be applied simultaneously in order to reach station synergy. However, it is unknown how the current quality of the transit nodes can be assessed and how their potential can be indicated. For this purpose, node-place models are used in the Netherlands.

The main thought behind the node-place model by Bertolini (1999) was to determine the functionality of a transit node by analysing the relation between node- and place properties. Bertolini's node-place model is based on the reasoning of the land use feedback cycle that was explained before (Wegener & Fürst, 2004). The basic idea is that improving the transport supply (or node value) of a location will, by improving accessibility, create conditions favourable to the further development of the location. In turn, the development of a location (or increase its place value) will, because of a growing demand for transport, create conditions favourable to the further development of the transport system. Therefore, when there is a strong coherence between the node value and place value, the transit node functions well. The node-place model indicates the potential that can be realized to improve the coherence between the node and place value and therefore the functioning of the transit node. The node value includes the supply of infrastructure and transport systems and the place value is determined by the spatial range of functions and activities.

The node-place model illustrates the optimal coherence between the node- and place value by an xy diagram (Figure 3-5). The x-axis represents the place value and the y-axis the node value. Every transit node is positioned in the diagram according to the coherence between the two values. The node-place model distinguishes five ideal-typical situations a transit node can find itself in. Within the shape there are transit nodes that are equally balanced. Along the diagonal there are balanced nodes where the node and place are roughly equal; the transport system and the land use support each other. At the top of the line there are stressed nodes where the node and the place have been used to the fullest. Further development in these transit nodes can become problematic due to the limited amount of space. At the bottom of the line are dependent transit nodes where the values are so weak that other factors must intervene in order for the area to sustain itself. Outside of the shape, two imbalanced transit nodes can be identified. Above the middle line are the imbalanced nodes where the transport systems are more developed than the urban activities. The opposite is true below the middle line where there are imbalanced places. An imbalanced transit node has a relatively stronger position in either the node or place scale.

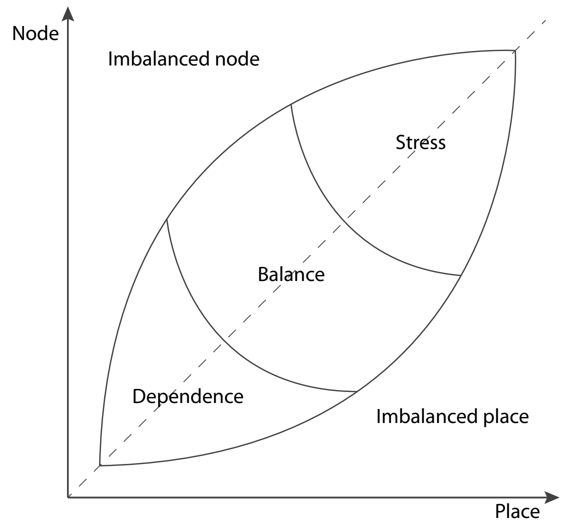


Figure 3-5: Node-place model (Bertolini, 1999, p. 202)

According to the land use feedback cycle (Figure 1-5), the imbalanced situations will eventually move towards a more balanced state. However, the application of the node-place model to Tokyo has compared the predicted developments of imbalanced nodes that resulted from the node-place model with the actual investments taking place in and around the transit nodes (Chorus & Bertolini, 2011). The development pattern only partly matches the investments taking place. It can be concluded that the node-place model cannot predict developments but can, however, help to identify where there is room for further improvement.

3.2.1 Applications of the node-place model

In scientific literature several applications of the node-place model can be found. Zweedijk (1997), Zweedijk and Serlie (1998) and Serlie (1998) have operationalized the model shortly after it was published by Bertolini. They compare different characteristics of the node- and place value by using a multi criteria analysis. After that, Van Kerkhof (2000) applied the model on the southern wing of the Randstad whereas Van Bakel (2001) applied the model on the entire Randstad.

For more practical purposes, the node-place model is applied throughout the country in order to determine what is best for the area around transit nodes (Schrijnen et al., 2011). However, when making use of the node-place model the way the node- and place value is measured differs significantly. The characteristics of the values are different and also the weights that are assigned to the characteristics. The used method and the calculations are unclear and it is hard to trace back the assumptions that were made. Although considerable data has been collected for different locations, the lack of a common method ensures that it is hard to compare these locations with each other. Therefore, it is necessary to develop a common method and language that can describe and analyse transport and urban characteristics of a location.

The development of a more common method started with the application of the model on the southern wing of the Randstad by Atelier Zuidvleugel (2006). The node value is characterized by the position of the transit node in the public transport network and the position in the road network. The place value is characterized by the density of inhabitants and employees, and the mixture. By visualizing these four characteristics it can be clearly seen whether the values are balanced. Transit nodes can be categorized in nine types with different characteristics and potentials.

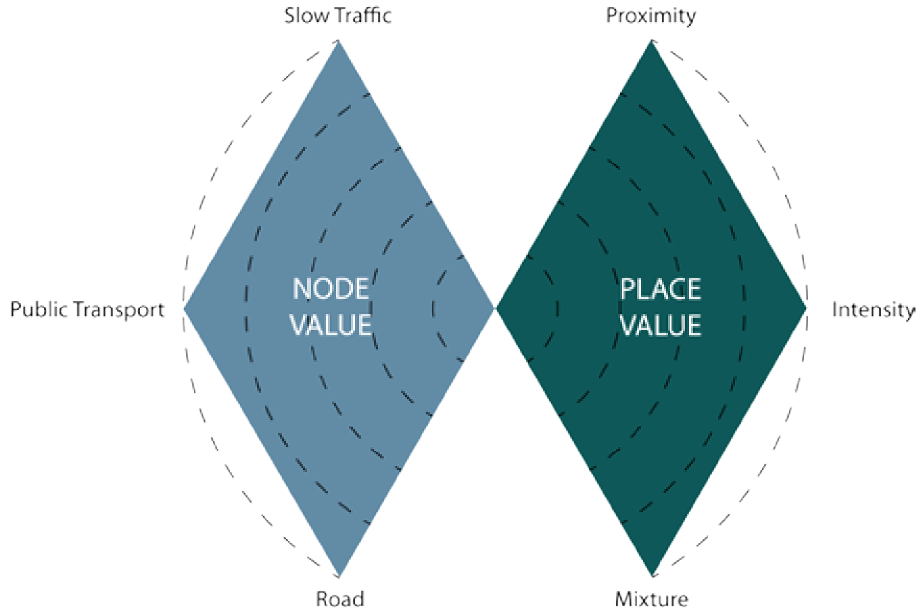


Figure 3-6: The Butterfly model (Vereniging Deltametropool, 2013b, p. 2)

In 2013, Vereniging Deltametropool (2013b) created the Butterfly model (Figure 3-6), based on the application of the node-place model by Atelier Zuidvleugel. The Butterfly model added two characteristics; the position in the slow traffic network to the node value and the proximity to the place value. The main idea behind the Butterfly model is that the two wings need to have the same size for the transit node to function well. Especially the intensity and public transport value need to be equally big. In 2013, the Butterfly model was already applied to transit nodes in the province Noord-Holland, the city region of Rotterdam (Vereniging Deltametropool, 2013a, 2013c), the train corridor 'Oude Lijn', and the southern wing of the Randstad (Zuidvleugel Stedenbaanplus, 2013a, 2013b). In order to classify and compare the transit nodes with each other and indicate their possible potential, twelve types of transit nodes are distinguished (Appendix A). This thesis will further elaborate on the latest application of the node-place model by Bertolini (1999), the Butterfly model (Vereniging Deltametropool, 2013b).

3.2.2 The node value

As was already mentioned, the node value includes the supply of infrastructure and transport systems. The node value (NV) is calculated by equally weighing the indicators that represent the position in the slow traffic network (ST), the public transport network (PT) and road network (RD) (Vereniging Deltametropool, 2013c).

$$\mathrm{NV} = \frac{ST + PT + RD}{3} \tag{3.1}$$

In the original method, the indicators have an equal weight in the node value (Vereniging Deltametropool, 2013c). Because the node and place value are out of the scope of this research, it is assumed that this is correct.

Slow traffic

The position in the slow traffic network is determined by several indicators. Nowadays, 40% of the traveller uses the bicycle to go to the transit node and 15% to cycle from arrival to their destination (Berenschot Groep B.V., 2010). Also, the use of the public transport bicycle has quadrupled from 2007-2012 (Goudappel Coffeng, 2012). Therefore, it is important to have enough bicycle parking and the possibility to rent a public transport bicycle. The presence of a railway crossing near the transit node is needed for the internal connection within a transit node. A denser network has more possibilities for a traveller to go to the transit node by foot or bicycle. Therefore, the number of local roads around the transit node plays a role as well.

$$\mathrm{ST} = SCORE(PTB + RC + BPR) + (\mathrm{LR} * 1.5) \tag{3.2}$$

With parameters:

PTB	=	Presence of PT-bicycle (Score: 25)
RC	=	Presence of railway crossing (Score: 50)
BPR	=	(BP/BA) * 100 > 30 (Score: 50)
BPR	=	(BP/BA) * 100 > 30 (Score: 25)
BP	=	Number of bicycle parking places
BA	=	Number of people boarding and alighting
LR	=	Number of local roads within 300 meters

Public transport

The position in the public transport network indicates how well the location is accessible by public transport. Every connection to the public transport system is valued separately. Faster connections with more travellers are valued higher than slow connections with fewer travellers. The frequencies and number of directions are taken into account as well.

$$\begin{aligned} \mathrm{PT} = {} & SCORE(HSL + IC + SPRMT + RB + LB + TR) \\ & + \textstyle\sum_i (F * D * 0.2 * SCORE_i) \end{aligned} \tag{3.3}$$

With parameters:

HSL	=	Presence of high speed line (Score: 125)
IC	=	Presence of intercity (Score: 100)
SPRMT	=	Presence of sprinter/metro (Score: 75)
RB	=	Presence of regional bus (Score: 50)
LB	=	Presence of local bus (Score: 25)
TR	=	Presence of tram (Score: 25)
F	=	Frequency per hour
D	=	Number of directions

Road

The position in the road network describes the accessibility of the transit node by car. The presence of highways, regional roads and highway exits within a certain range are valued. Similar to the public transport network, the directions are taken into account as well. Another indicator is the number of parking places compared to the travel demand.

$$\mathrm{RD} = SCORE(HE + H + RR1 + RR2 + CPR) + \textstyle\sum_i (D * 0.5 * SCORE_i) \tag{3.4}$$

With parameters:

HE	=	Presence of highway exit 1200m (Score: 75)
H	=	Presence of highway 3200m (Score: 50)
RR1	=	Regional road within 1200m (Score: 25)
RR2	=	Regional road within 3200m (Score: 10)
CPR	=	(CP/BA)*100 > 5% (Score: 50)
CPR	=	(CP/BA)*100 > 2.5% (Score: 25)
CP	=	Number of car parking places
BA	=	Number of people boarding and alighting
D	=	Number of directions

3.2.3 The place value

The place value is determined by the spatial range of functions and activities. The place value (PV) is calculated by equally weighing the indicators that represent the proximity (PR), the intensity (IT) and the mixture (MT) (Vereniging Deltametropool, 2013c).

$$\mathrm{PV} = \frac{PR + IT + MT}{3} \tag{3.5}$$

Proximity

The proximity represents the transit node as center in its environment. When more functions are situated around a transit node, inhabitants, employees and visitors will be more likely to travel by public transport (Lee & Cervero, 2007). When offices are situated within a range of 500m from the transit node, the real estate value increases (De Graaff et al., 2007). The ratio between the number of functions close to the transit nodes and the number of functions in the entire area indicates whether the transit node functions as a center in its environment.

$$\mathrm{PR} = \frac{(IH_{300m} + EP_{300m} + VT_{300m})}{(IH_{1200m} + EP_{1200m} + VT_{1200m})} * 100 \tag{3.6}$$

With parameters:

IH	Inhabitants
EP	Employees
VT	Visitors

Intensity

Intensity indicates the number of people that make use of the influence area. The higher the density of people, the higher the potential travel demand. At the same time, spatial developments with a high density generate fewer movements than developments with a low density because the distance between home, work and facilities decreases (Lee & Cervero, 2007). Not only inhabitants and employees make use of the influence area, visitors are taken into account as well. The higher the number of users in relation to the influence area, the higher the density of functions around the transit node.

$$\mathrm{IT} = \frac{(IH + EP + VT)}{IA} \tag{3.7}$$

With parameters:	IH	Inhabitants
	EP	Employees
	VT	Visitors

Mixture

Mixture illustrates the ratio between inhabitants and employees. A high mix of functions contributes to a diverse use of the transit node. Jobs attract travellers in the morning peak and housing attracts travellers in the evening peak when people return home from work. Different functions generate different types of travellers at different times. Similar to a higher intensity, more mixture generates fewer movements because the distance between different destinations decreases. Furthermore, mixture contributes to a pleasant atmosphere in the area around the transit node.

$$\mathrm{MT} = \frac{1}{N}\sum\frac{MIN(IH, EP)}{MAX(IH, EP)} \quad (3.8)$$

With parameters:	IH	Inhabitants
	EP	Employees
	N	Number of squares 100mx100m

3.2.4 Transit node typologies

In order to compare transit nodes with each other, the scores for the different indicators of the node and place value are normalised. This means that each transit node receives a score from 0 to 1 for each indicator. Subsequently, the transit nodes can be compared with their corresponding transit node typologies. Twelve transit node typologies are distinguished based on ideal situations. The coherence between node and place offers different opportunities for new developments (Vereniging Deltametropool, 2013b). A metro station in the city center offers other possibilities than an intercity station at the outskirts of a city. A diversity of locations where the node and place value are reasonably balanced, combined with desired living and working environments results in different types of transit nodes. Every type represents a specific environment where living, working and facilities come together. A variety of transit nodes in a network means that the nodes can complement each other and increase each other's functioning. By classifying existing transit nodes according to the typologies, it can be seen where improvements are necessary. The classification table can be found in Appendix A.

3.3 Relationship strategies and node-place model

In Section 2.3 was explained that the transfer is the lowest valued part of a public transport journey because travellers experience waiting time. Value needs to be added to the transfer in order to improve the customer satisfaction. Three strategies are proposed to add this value: accelerate, condense and enhance. The first two influence the objective waiting time and enhancement influences the subjective waiting time. Because the last one cannot be measured, policy makers pay more attention to the accelerating and condensing, whereas the latter has a big influence on the customer satisfaction. Only when all three strategies are applied simultaneously, the performance of the transit node significantly increases. All three strategies should be applied in different areas of the transit node: the transfer area, the transit area and the transit node environment.

In order to determine where the strategies should be applied, the current quality of the transit nodes needs to be assessed. For this purpose, node-place models are used in the Netherlands. The node-place model provides insight into the relation between the node- and place value. If these values are coherent, the transit node functions well. If not, the model helps to identify where there is room for further improvement. However, Van der Spek (2003) questions the outcome of the node-place model because a high node and high place value do not always lead to a good transit node. According to

Bertolini (1999) the train station Amsterdam South has a high node and place value and is in balance, but Van der Spek (2003) demonstrated that the design of this station has been reviewed negatively, especially in relation with the high node- and place value. He states that the traveller's experience should be added to the node-place model.

Even though the node-place model helps to identify the potential of the transit node, the model only considers possible improvements in the transfer- and station area. Acceleration influences the node value, condensation influences the place value, but enhancement is not part of the node-place model. Figure 3-7 shows clearly that, based on the conclusions from literature, the node-place model is currently not suitable in order to determine where the strategies should be applied. Another value should be added to the model that helps to identify transit nodes where enhancement is needed to improve the waiting experience.

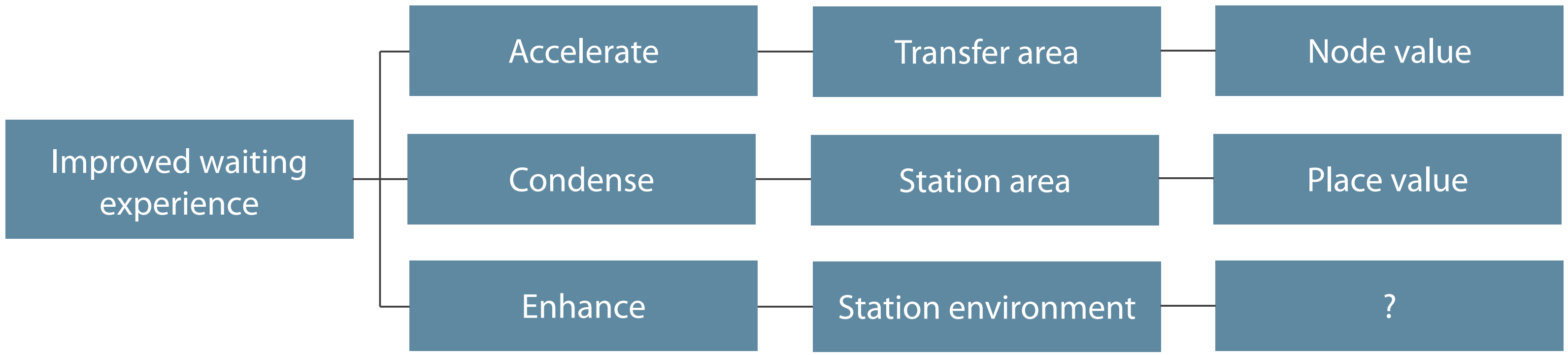


Figure 3-7: Relationship strategy and node-place model

The introduction has explained that the experience of traveller's is becoming more important (Section 1.1). By paying more attention to the experience the customer satisfaction will increase. Hence, in order to indicate where the experience at transit nodes needs to be improved, or enhanced, the node-place model needs to be extended with the experience value.

3.4 Conclusions

This chapter has aimed to provide measures that add value to the lowest part of the public transport journey, the transfer, and give insight into transit node models that can be used to assess the quality and possible improvements of a transit node. The ambivalent character of a transit node creates opportunities for creating synergy between moving and staying. Synergy in a transit node exists when the composite elements, such as facilities and spatial elements, together create more value than the sum of the individual parts. Synergy can be translated in performance indicators such as travel demand, customer opinions, retail turnover and real estate profits. Three strategies are proposed to add this value: accelerate, condense and enhance. The first two influence the objective waiting time and satisfy customer needs such as speed and convenience. Enhancement influence the subjective waiting time and satisfies comfort and experience. Because the last one cannot be measured, policy makers pay more attention to the accelerating and enhancement, whereas the latter has a big influence on the customer satisfaction. However, only applying all three strategies simultaneously leads to a significant growth. All three strategies should be applied in different areas of the transit node: the transfer area, the transit area and the transit node environment. In the Netherlands, transit node models are used to assess the quality of transit nodes and indicate room for possible improvements. The used transit node models in the Netherlands are all based on the node-place model. This model determines the functionality of a transit node by analysing the relationship between the node- and place characteristics. The theory behind the model implies that a transit node functions well when these two values are coherent. The model indicates the potential that can be realized in order to increase the coherence. Several applications of the model were described, but this thesis will elaborate on the most recent one, The Butterfly model. In order to indicate possible improvements, the transit nodes are classified in transit node typologies.

Even though the model identifies the potential of the transit node with relation to the transfer and transit node area, improvements in the transit node environment are not considered. Only two of the three strategies have an influence on the node-place model. Therefore, the model should be extended with a third value to illustrate the influence of enhancing the transit node environment in order to satisfy the remaining customer needs; comfort and experience. The node-place model will be extended with the experience value. Because it is unclear what this value entails, in the next chapter research will be done to investigate what criteria contribute to the experience value and how important the criteria are.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4 The experience value

The previous chapter has concluded that the node-place model should be extended with the experience value. This chapter aims to provide insight into what this value entails. Further literature study should reveal what travellers value at a transit node in order to determine criteria that contribute to the experience value. Then, in order to determine weights, research is done to find out how important the criteria are for the experience value. Hence, the sub question that is answered in this chapter is:

5. *What criteria contribute to the experience value and how important are they?*

Before taking a closer look at the criteria that contribute to the experience value, the first section will shortly explain what can be understood by the experience value. After that, section 4.2 focuses on the waiting environment. Based on these conclusions and literature findings, section 4.3 determines the criteria for the experience value. In order to determine the weights for the criteria a method should be used. Sections 4.3 and 4.4 explain the choice and application of the method and determine the weights.

4.1 What is the experience value?

Over the past ten years, governments are increasingly investing in station areas (Dammers et al., 2005). These investments are not only focused on the utilization value but also on the value of experience. Investing in the experience value in larger projects has become a topical issue. Examples of these projects are integrated projects around stations such as Amsterdam South Station, Rotterdam Central Station and Utrecht Central Station. It is expected that the increased value of experience in the station areas reinforce the positive image of the city which should lead to an increased settlement of residents and companies and a higher visitor's rate (Florida, 2002).

Currently, the value of experience is a rather vague term that changes over the years. Also, the experience value is not the same in every region. On top of that, different types of people differently value the experience of certain places. Dammers et al. (2005) define the experience value as the design characteristics that are experienced by people that use a station and its direct environment. Because the value of experience is becoming more and more important, it is vital to determine what this value exactly entails. This is done by taking a closer look at the waiting environment, as this environment has a big influence on the perception of time of a traveller.

4.2 Waiting environment

Because the waiting environment appears to be an influential factor in customers' reaction to waiting, research into relevant factors which contribute to an attractive waiting environment is required (Pruyn & Smidts, 1998). This section will provide insight into what their ideal waiting environment is. The waiting experience determines if someone thinks to have been waiting for a long or a short time, if someone finds the wait to be acceptable and how the service is assessed (Van Hagen, 2011). The context in which the wait occurs is relevant to the way it is experienced. Waiting can be positively influenced by making the waiting environment more pleasant. The waiting environment is where the public transport service takes place.

4.2.1 Service environment

The quality of a service can be assessed by looking at the service process, the interaction between customers and personnel, and the service environment

(Bitner, 1992; Rust & Oliver, 1993). The service process at a transit node is time-bound and has to be as efficient as possible. A higher customer satisfaction will be achieved when the service process runs efficiently and smoothly (Van Hagen, 2011). The presence of sufficient and competent personnel has a positive influence on the customer satisfaction. Too many or too few customers can result in negative emotions and avoidance behaviour because a deserted or very busy station is not preferred by travellers. Finally the service environment can strongly influence the service satisfaction (Bitner, 1992; Pruyn & Smidts, 1998). As a service is intangible, customers often unconsciously seek things in the service environment that indicate the expected quality (Brady & Cronin Jr, 2001). Factors in the service environment act as stimuli (S), which evoke a customer judgment (O) and lead to a specific response (R) (Mehrabian & Russell, 1974) (Figure 4-1). This way, a service environment can be designed in such a way that the experience and the behaviour of customers can be affected (Bitner, 1992). To define what factors can act as stimuli to affect the behaviour of customers, a closer look must be taken to the service environment.

Figure 4-1: Stimulus-Organism-Response model (Mehrabian & Russell, 1974)

However, it is important to keep in mind that travellers are only receptive to these stimuli when they feel in control. An example of this is that when people are waiting for their departure, they tend to wait on the platform where they have the mode of transportation in direct sight. Therefore, when adding value to the time spent during a transfer it is important that travellers must be able to feel comfortable without forgetting the time.

Bitner (1992) distinguishes three criteria that contribute to the quality of the service environment: ambient elements, spatial layout and functionality, and signs, symbols and artefacts. According to Baker and Cameron (1996) and Brady and Cronin Jr (2001) the quality consists of ambient-, design- and social elements. Ambient elements are intangible background conditions that affect the non visual senses and in some cases have a subconscious effect. The elements are a factor that affects the perception of human responses to the environment. Sub criteria are temperature, lighting, noise, music and scent. Spatial layout refers to the way in which an area is organized and functionality refers to the ability of an area to facilitate performance. Design elements represent components of the environment that tend to be visual and more tangible in nature. Sub criteria are colour, furnishings and spatial layout. Signs, symbols and artefacts are important when giving an impression of the area and for communicating with users about the meaning of the place and the expected behaviour. Sub criteria of social elements are people, customers and employees, in service setting. The effects of these elements can be recognized in employee visibility and customer interaction.

4.2.2 Transit node environment

The characteristics of the service environment mostly correspond to the environment of a transit node. However, this section focuses on criteria found in literature that are specifically for the transit node environment. A literature study is carried out to collect different types of criteria and sub criteria. Below, an elaboration can be found of literature that has determined criteria for the experience value at train stations. Only main criteria are mentioned in this section.

Galetzka and Vries (2012) distinguish four criteria which are derived from the literature above: social elements, ambient elements, spatial layout and facilitating design. The Customer Satisfaction Survey of the NS investigates the quality of their service (Brons & Rietveld, 2007). Ten different criteria were distinguished, but only criteria and sub criteria with regard to the transit node area are considered because the experience value influences this area. These criteria are information and organization station, updated information, ticket service, social security and personnel. Boes (2007) has conducted research to the needs of travellers on a train station. First qualitative data was collected by interviewing nine travellers. After this, the needs that followed from the interviews were incorporated in a survey that was distributed among train passengers of the NS (N=1781). The outcome of the research was the needs of the passengers ranked in order of importance: safety, uncertainty reduction, cleanliness, personal control, organization of station, comfort facilities, aesthetics, social contact, relaxation, privacy, spending time usefully and distraction. In a paper of Van Hagen et al. (2009) sub criteria are classified in satisfiers and dissatisfiers. However, in other papers from the same author six criteria are distinguished: attractive, inviting, functional, environment, safe and cleanliness (Van Hagen & Exel, 2012; Van Hagen & Heiligers, 2011).

4.3 Criteria experience value

4.3.1 Determination of criteria

All main criteria and sub criteria that were derived from the literature in the previous sub section are merged in a table. This way, overlap can be found between many of the sub criteria. Sub criteria that appear only once in the table are left out as well as sub criteria that concern the ticket service because since the introduction of the public transport card in the Netherlands this service is no longer necessary. The remaining sub criteria were clustered, duplicates were removed and once again classified into different main criteria. This process has resulted in Figure 4-2.

4.3.2 Comfort

Sub criteria that are part of comfort are comfortable waiting, entertainment, spending time usefully and facilities. Doornenbal (1982) states that comfort facilities influence the waiting experience of a traveller. The value of time spent

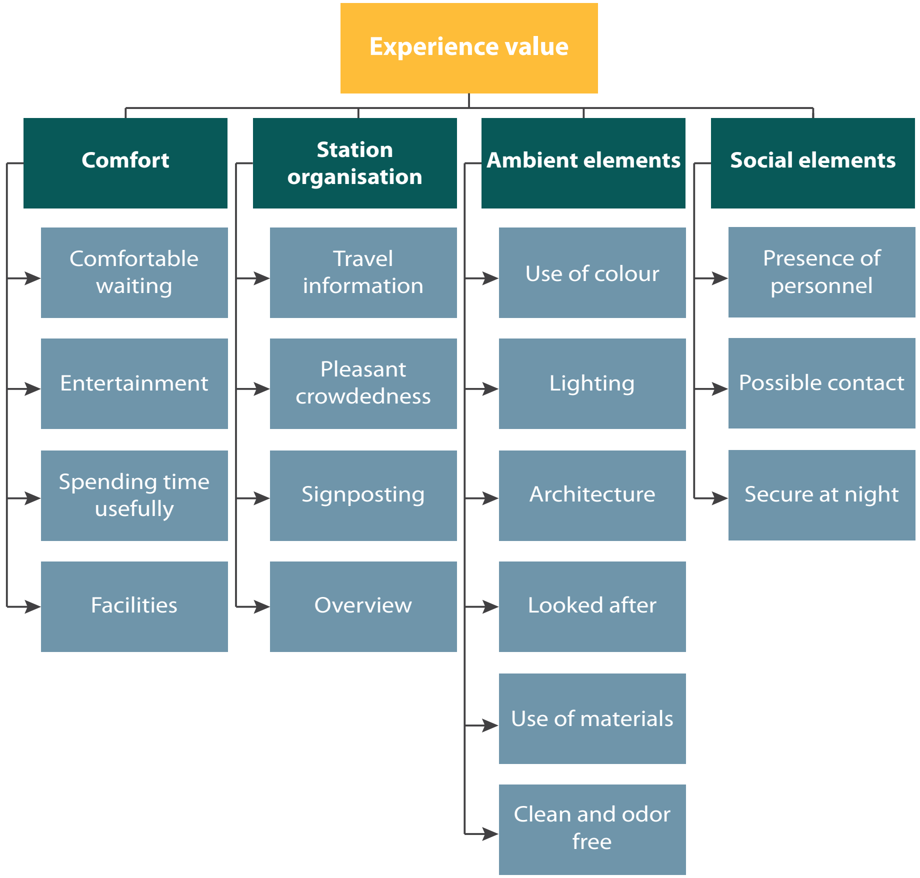


Figure 4-2: Criteria experience value

at a transit node increases when the traveller experiences more comfort. From interviews with travellers it can be concluded that a frequently mentioned aspect is comfortable waiting (Boes, 2007). People prefer to wait at transit nodes with a sheltered and heated waiting area.

Infotainment, an informative way of entertainment can be used in order to increase the comfort of travellers (Galetzka & Vries, 2012). Moving images draw more attention than static images, because they offer both an informative element as well as an atmospheric element. Boes (2007) has concluded that travellers appreciate the presence of for example a free newspaper (Figure 4-3) and television screens with news.

Figure 4-3: Reading a newspaper

Figure 4-4: Facilities

When travellers are able to spend their time usefully, the waiting time is experienced shorter than reality. Spending time usefully at a transit node can be accomplished by doing groceries and making use of Wi-Fi (Boes, 2007; Van Hagen et al., 2009).

The presence of facilities at a transit node also contributes to the comfort of the traveller (Figure 4-4). Facilities at a transit node are restaurants, toilets and shops (Boes, 2007).

4.3.3 Transit node organization

Sub criteria that are part of the transit node organization are travel information, signposting, overview and pleasurable crowdedness. According to (Van Hagen & Exel, 2012), a well-functioning transit node must have an optimized overview, clear signposting and up-to-date travel information. Up-to-date travel information has a positive influence on the value of time of the waiting traveller (Doornenbal, 1982). Especially in case of a delay, it is important to communicate reliable information as soon as possible to increase the customers' acceptance of the extra wait (Van Hagen, 2011).

Feeling self-confident is one of the most mentioned aspects in the interviews held by Boes (2007). Clear signposting at the transit node contributes to the self-confidence of travellers (Figure 4-5). It is also a quality aspect in the customer satisfaction survey by the NS (Brons & Rietveld, 2007) and the experience survey created by Van Hagen et al. (2009). Overview of the transit node also contributes to feeling self-confident, because it does not only mean that travellers can easily find their way, it also gives a sense of security when a traveller has overview. This aspect was mentioned several times during the interviews held by Boes (2007). It also part of the experience survey by Van Hagen et al. (2009). Overview, signposting and travel information are also part of the list of quality aspects of the Customer Satisfaction Survey (Brons & Rietveld, 2007).

Galetzka and Vries (2012) state that the station organization plays a significant role in advancing the pedestrian flow. Research has shown that congestion leads to discomfort, frustration and safety concerns. When the crowdedness at a transit node is pleasant, it can be assumed that the dimensions are suitable for the number of travellers to allow an efficient pedestrian flow.

Figure 4-5: Signposting

Also, crowded environments have a negative effect on the sense of control of travellers which makes then unreceptive for environmental stimuli. When the human density is too high, travellers seek for ways to find personal control of the situation. This can be done by going to less dense places, or by avoiding the situation by choosing to travel by car instead of public transport.

4.3.4 Ambient elements

Van Hagen and Exel (2012) describe ambient elements such as colours, materials, architecture, and cleanliness influence the experience value. Since the 50's, more research has been done to the effects of colour use in different environments. Galetzka and Vries (2012) discuss several studies to colour. Warm colours, such as red and orange, lead to a perceived delay of time, whereas colder colours, such as blue and green, accelerate the time. The colours are experienced as more pleasantly when the brightness and saturation increases. Bright colours are associated with happiness and hope. On the other hand, dark colours evoke negative feelings such as boredom or sadness. Other researchers state that colours have no emotional influence, but that the effect is determined by culture and personal experiences. However, the service environment and mood of people influence the effect of the colours. Warm colours attract more people than cold colours, but warm colours can lead more easily to unpleasant feelings and stress. Van Hagen (2011) explains that during the peak hours, colder colours must be used to avoid avoidance responses. According to Boes (2007), travellers prefer warm, dull and light colours.

Looked after is also part of the experience tool of Van Hagen et al. (2009) (Figure 4-6). It does not mean that the transit node is clean, but that it has been taken care of. Van Hagen and Exel (2012) distinguish looked after as an indicator for atmosphere, which they use to classify different types of stations.

Figure 4-6: Outdated

Galetzka and Vries (2012) discuss several researches on the effect of lighting on people. Time seems to go by faster when the light in waiting environment has a lower intensity compared to a higher intensity. The preferred intensity is dependent of the number of stimuli, the complexity of the environment and the goal people have in the environment. More stimuli and a higher complexity require more light which increases the visibility and overview. Van Hagen (2011) advises for larger stations to have a low light intensity in the off-peak hours combined with warm colours. In the peak hours, a higher light intensity with cold colours is advised. This leads to pleasure, excitement and control, as well as more overview and orientation. Lighting was mentioned several times in the interviews held by Boes (2007). Lighting is also part of the experience survey by Van Hagen et al. (2009).

Clean and odor free was an important factor for the travellers interviewed by Boes (2007). A regression analysis has shown that cleanliness is an important determinant for among others security, overview and comfort. Cleanliness is also part of the customer survey by Van Hagen et al. (2009). Van Hagen and Exel (2012) state that everyone benefits from a clean transit node which gives a secure feeling at the same time. Cleanliness of the station is also part of the Customer Satisfaction Survey (Brons & Rietveld, 2007).

Figure 4-7: Stainless steel

Figure 4-8: Wood

Not much research has been done to the preference of travellers on material use. Boes (2007) has determined that travellers prefer natural, transparent materials and stainless steel (Figure 4-7 and Figure 4-8).

In the interviews held by Boes (2007), aesthetics was a frequently mentioned aspect. Travellers appreciate the presence of beautiful architecture at transit nodes. She has classified six different types of architecture and interior design and asked travellers (N=1781) to give their preference. Based on the survey, classic and modern-classic are the most attractive types of architecture (Figure 4-9).

4.3.5 Social elements

According to Boes (2007), the presence of personnel is for the respondents one of the most important aspects at a station. Also, the presence of personnel is an important determinant for security. The presence of personnel also contributes to a pleasant stay (Van Hagen & Exel, 2012). They use it as an indicator for atmosphere to distinguish several transit node types. The Customer Satisfaction Survey distinguishes aspects such as the approachability and friendliness of personnel (Brons & Rietveld, 2007).

During the interviews of Boes (2007), several respondents mentioned the aspect of social contact. A feeling of social security is also part of the Customer Satisfaction Survey (Brons & Rietveld, 2007).

Security is the most important factor according to the respondents of the survey held by Boes (2007). Security after 19.00 is part of the experience survey by (Van Hagen et al., 2009). Security after 19.00 is an indicator for the general aspect security in Van Hagen & Exel (2012).

Figure 4-9: Architecture

4.4 Weights experience value

Section 4.3 has determined which criteria are part of the experience value. Now the criteria are known, it is time to determine the importance of the criteria for the experience value.

4.4.1 Introduction to Best Worst Method

A Multi Criteria Decision Making (MCDM) method is needed to obtain the weights for the criteria. Pairwise comparisons are used to show the relative preferences of a number of stimuli in situations where it is unfeasible to provide score estimates for the stimuli with respect to the criteria (Rezaei, 2015a). A significant challenge of a pairwise comparison method is the lack of consistency which usually occurs in practice. A new MCDM method was recently developed to solve decision-making problems regarding the shortcomings of existing MCDM methods. The Best-Worst Method (BWM), requires less comparison data and remedies the inconsistency that characterizes pairwise comparisons (Rezaei, 2015a). Rezaei (2015a) demonstrates the performance of BWM by comparing with AHP (Analytic Hierarchy Process), which is one of the most popular MCDM methods and also a pairwise comparison-based method. Statistical results show that BWM performs significantly better than AHP.

When executing a pairwise comparison, each criterion is compared with another criterion and the relative preference is determined. In a pairwise comparison of n criteria by using a 1/9 to 9 scale, a matrix is obtained. In this matrix, a_{ij} shows the relative preference of criterion i to criterion j. When i and j are equally important $a_{ij} = 1$, whereas an extremely larger importance is shown by $a_{ij} = 9$. The matrix must be reciprocal, which means that for all i and j, $a_{ij} = 1 / a_{ji}$ and $a_{ii} = 1$. In order to obtain a completed matrix, it is necessary to have $n(n-1)/2$ pairwise comparisons. The matrix is consistent for each i and j, $a_{ik} \times a_{kj} = a_{ij}$.

When executing a pairwise comparison a_{ij}, the decision-maker expresses both the direction and the strength of the preference. In most situations, there is no problem expressing the direction, but expressing the strength is a difficult task that is almost the main source of inconsistency. BWM has a new approach for pairwise comparisons in order to provide more consistent answers. First, the best and worst criteria are selected, which are then compared with the remaining criteria. As a result, fewer comparisons are needed and the chance of inconsistency is reduced. Hence, the required number of comparisons to complete the matrix is $2n-3$. Figure 4-10 hows the pairwise comparisons between the best criterion to the other criteria and the other criteria to the worst criterion j.

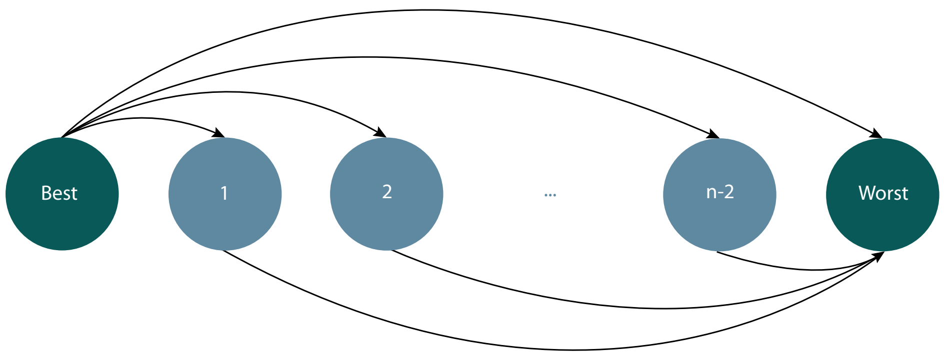


Figure 4-10: Best-Worst Method

4.4.2 Steps of BWM

Below, five steps of BWM are described that are used to derive the weights of the criteria.

Step 1: Determine a set of decision criteria

First, a set of decision criteria $\{c_1, c_2, ..., c_n\}$ is formed that should be used to reach a decision.

Step 2: Determine the best and worst

In the second step, the decision-maker is asked to determine the best and the worst criteria. No comparison is made in this step.

Step 3: Determine the preference best to others

In this step, the decision-maker is asked to indicate the preference of the best criterion over all the other criteria using a number between 1 and 9. The resulting vector is $A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn})$.

Step 4: Determine the preference others to worst

Here, the decision-maker is asked to indicate the preference of the other criteria over the worst criterion using a number between 1 and 9. The resulting vector is $A_W = (a_{1W}, a_{2W}, \ldots, a_{nW})$.

Step 5: Find the optimal weights

The final step is to calculate the optimal weights for the criteria $(w_1^*, w_2^*, \cdots, w_n^*)$. The optimal weight for the criteria is where, for each pair of w_B / w_j and w_j / w_W, we have $w_B / w_j = a_{Bj}$ and $w_j / w_W = a_{jW}$. To satisfy these conditions, a solution must be found where the maximum absolute differences for $\left|\frac{w_B}{w_j} - a_{Bj}\right|$ and $\left|\frac{w_j}{w_W} - a_{jW}\right|$ for all j is minimized. Considering the non-negativity and sum condition for the weights, this result in the following problem:

$$\min_x \max \left\{ \left|\frac{w_B}{w_j} - a_{Bj}\right|, \left|\frac{w_j}{w_W} - a_{jW}\right| \right\}$$
$$\text{s.t.}$$
$$\sum_j w_j = 1 \tag{4.1}$$
$$w_j \geq 0, \text{ for all } j$$

In order to solve this problem it is transferred to the following mathematical programming problem:

$$\min \xi$$
$$\text{s.t.}$$
$$\left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \xi, \text{for all } j$$
$$\left|\frac{w_j}{w_W} - a_{jW}\right| \leq \xi, \text{for all } j \tag{4.2}$$
$$\sum_j w_j = 1$$
$$w_j \geq 0, \text{ for all } j$$

After solving the mathematical programming problem, the exact value of ξ^* is obtained.

4.4.3 Consistency ratio

A pairwise comparison is fully consistent if $a_{Bj} \times a_{jW} = a_{BW}$, for all j. However, it is possible that for some j the comparison is not fully consistent. Therefore, it is necessary to check the results for consistency. According to Rezaei (2015a) the values in Table 4-1 can be used to calculate the consistency ratio.

Table 4-1: Consistency Index (Rezaei, 2015a)

a_{BW}	1	2	3	4	5	6	7	8	9
Consistency Index (max ξ)	0.00	0.44	1.00	1.63	2.30	3,00	3.73	4.47	5.23

Then, the Consistency Ratio can be calculated using the following equation:

$$\text{Consistency Ratio} = \frac{\xi^*}{\text{Consistency Index}} \tag{4.3}$$

In case of collecting data from more than one respondent, it is important to calculate the final value of the consistency ratio by averaging the ratios for each respondent.

4.4.4 Interval weights

When pairwise comparisons are not fully consistent, the optimal weights are intervals (Rezaei, 2015b). Hence, the next step is to find the minimum and maximum weights of each criterion by solving the following mathematical programming problems:

$$\begin{aligned} & \min w_j \\ & \text{s.t.} \\ & \left| \frac{w_B}{w_j} - a_{Bj} \right| \leq \xi^*, \text{for all } j \\ & \left| \frac{w_j}{w_W} - a_{jW} \right| \leq \xi^*, \text{for all } j \\ & \sum_j w_j = 1 \\ & w_j \geq 0, \text{ for all } j \end{aligned} \tag{4.4}$$

$$\begin{aligned} & \max w_j \\ & \text{s.t.} \\ & \left| \frac{w_B}{w_j} - a_{Bj} \right| \leq \xi^*, \text{for all } j \\ & \left| \frac{w_j}{w_W} - a_{jW} \right| \leq \xi^*, \text{for all } j \\ & \sum_j w_j = 1 \\ & w_j \geq 0, \text{ for all } j \end{aligned} \tag{4.5}$$

By solving the mathematical programming problems above, the optimal interval weights of the criteria are obtained. The interval weights must be analysed in order to compare and rank them because it is possible to have some overlap between the different intervals.

A closed interval A can be defined as follows:

$$A = [a_L, a_U] = \{x : a_L \leq x \leq a_U, x \in R\} \tag{4.6}$$

The following two operations can be used in order to sum or multiply two interval weights:

$$A + B = [a_L + b_L, a_U + b_U] \tag{4.7}$$

$$A \times B = [a_L \times b_L, a_U \times b_U] \tag{4.8}$$

In order to compare two interval numbers of $A = [a_L, a_U]$ and $B = [b_L, b_U]$, the degree of preference of A over $B (A > B)$ and B over $A (B > A)$ can be calculated as follows:

$$P(A > B) = \frac{\max(0, a_U - b_L) - \max(0, a_L - b_U)}{(a_U - a_L) + (b_U - b_L)} \tag{4.9}$$

$$P(B > A) = \frac{\max(0, b_U - a_L) - \max(0, b_L - a_U)}{(a_U - a_L) + (b_U - b_L)} \tag{4.10}$$

In order to compare and rank the two interval numbers, a matrix of degree of preference and a matrix of preference must be formed.

$$DP_{ij} = \begin{bmatrix} P(A > A) & P(A > B) & \cdots & P(A > N) \\ P(B > A) & P(B > B) & \cdots & P(B > N) \\ \vdots & \vdots & \ddots & \vdots \\ P(N > A) & P(N > B) & \cdots & P(N > N) \end{bmatrix} \quad (4.11)$$

$$P_{ij} = \begin{bmatrix} P_{AA} & P_{AB} & \cdots & P_{AN} \\ P_{BA} & P_{BB} & \cdots & P_{BN} \\ \vdots & \vdots & \ddots & \vdots \\ P_{NA} & P_{NB} & \cdots & P_{NN} \end{bmatrix} \quad (4.12)$$

Where

$$P_{ij} = \begin{cases} 1, \text{if } P(i > j) > 0.5 \\ 0, \text{if } P(i > j) \leq 0.5, \quad i, j = A, \ldots, N \end{cases}$$

After calculating the matrix of preference, the ranking of interval numbers is obtained by the sum of each row of the matrix shown in equation 4.7. By using this method, only the local weights of each criterion within a set of criteria and its ranking are derived. In order to calculate the global weight of each criterion, first the interval weight of each sub-criterion must be multiplied with interval weight of the corresponding main criterion. This can be done by using equation 4.8. After this, equations 4.9 to 4.12 should be calculated do obtain the global interval weights and corresponding ranking. In case of more than one respondent, it is important to first calculate the interval weights of the criteria for every respondent followed by averaging the interval weights for each criterion. This is the same for calculating the final value of ξ .

4.5 Survey

In order to obtain the weights for the criteria, a decision-maker is asked to determine the best and worst criteria. Subsequently, the decision-maker is asked to indicate the preference of the best criterion over all other criteria and the preference of all other criteira over the worst criterion. The goal of BWM is to derive the weights for the criteria according to the Dutch population. Because the purpose of improving transit nodes is to obtain a modal shift from car towards public transport, it is also needed to provide insight into the preferences of people who do not travel by public transport.

In order to do this, a survey was conducted among different types of respondents. This way, the weights can be obtained based on the preferences of public transport travellers, car users but also people who hardly travel. The survey was distributed via internet and it was possible to complete the survey on the computer, tablet or mobile phone. This was done in order to avoid a possible bias of the circumstances of the respondents while filling in the survey.

First, the respondents were asked to fill in some personal information. This was needed to gain insight in the socio-demographic characteristics of the respondents. Second, the respondents were asked to answer three types of questions:

1. What criterion is valued the most and which criterion the least?
2. What is the preference of the most valued criterion over the others?
3. What is the preference of the other criteria over the least valued criterion?

In order to determine the preference ratio, a scale from 1 to 9 was used. 1 represents equal importance and 9 means extremely more important. This was repeated for five different sets of decision criteria. The exact survey questions can be found in Appendix B.

Table 4-2: Socio-demographic characteristics (N=160)

Variables	n	(%)
Gender		
Male	66	41%
Female	94	59%
Age		
18 - 35	112	70%
35 - 50	31	19%
50 - 65	14	9%
65 >	3	2%
Place of residence		
Gelderland	2	1%
Groningen	1	1%
Noord-Brabant	12	8%
Noord-Holland	2	1%
Overijssel	1	1%
Utrecht	3	2%
Zeeland	1	1%
Zuid-Holland	138	86%
Level of education		
VMBO	9	6%
HAVO	8	5%
VWO/Gymnasium	18	11%
MBO	20	13%
HBO	38	24%
WO	65	41%
Other	2	1%

Variables	n	(%)
Frequency of travelling by public transport		
Daily	24	15%
More than 3 times a week	31	19%
Less than 3 times a week	32	20%
Several times a month	37	23%
Rarely	30	19%
Never	6	4%
Travel purpose		
Work/education	87	56%
Leisure	66	43%
Other	1	1%
Travel hours		
Peak hours	66	43%
Off-peak	48	31%
Both	40	26%

4.5.1 Survey respondents

The survey was filled in by 160 respondents. Table 4-2 shows the socio-demographic characteristics of the respondents. The characteristics of the group of respondents differ from when a random sample was taken of the Dutch population. It can be seen that mostly people between 18 and 35 have filled in the survey (70%), whereas the share of this group in the Netherlands is 48% (CBS, 2015). Also, no people below 18 are part of the respondents group, while this share is normally 14%. Most respondents are HBO (24%) and WO (41%) educated. Data from CBS (2015) shows that only 36% of the population is educated at a university. Finally, the place of residence of most respondents is Zuid-Holland (86%). However, only 21% of the population lives in this province. The respondents travel frequently by public transport, whereas only 7% of the Dutch population makes use of public transport (CBS, 2015). Therefore, it cannot be concluded that the sample represents the Dutch population which means that there is a possible bias.

In addition, the respondents have filled in an online survey, which means that it is possible that there is also a bias due to misunderstandings or the circumstances of the respondent. A common method bias can occur because of the way the questions were constructed, the way they were asked and the audience to which they were asked (Podsakoff et al., 2003). Hence, it can be concluded that there might be some bias in the outcome of the survey. Due to the available resources during the research, it was decided to assume that the data is correct.

4.5.2 Survey results

By solving the programming problems (Equations 4.2, 4.4 and 4.5) in Matlab, the weight intervals for the different decision criteria sets were obtained. Figure 4-11 shows the weight intervals of the main criteria based on the survey. Comfort and station organisation are almost equally important to the respondents, whereas ambient elements and social elements are both less important. It can be seen that the respondents were unanimous about the social elements, the weights for the other criteria differed more per respondent. Because there is overlap between the different weight intervals, a rank calculation was needed to determine this which can be seen in Table 4-3. Comfort is the most important criteria followed by station organization, ambient elements and social elements.

The detailed description of the local weight intervals of the sub criteria can be found in the appendix. By multiplying the local weight intervals (Appendix C) with the weight intervals of the main criteria (Table 4-3), the global weight intervals were obtained (Figure 4-12). Because there is some overlap between the intervals of different criteria, the ranking of the criteria is calculated (Equations 4.11 and 4.12).

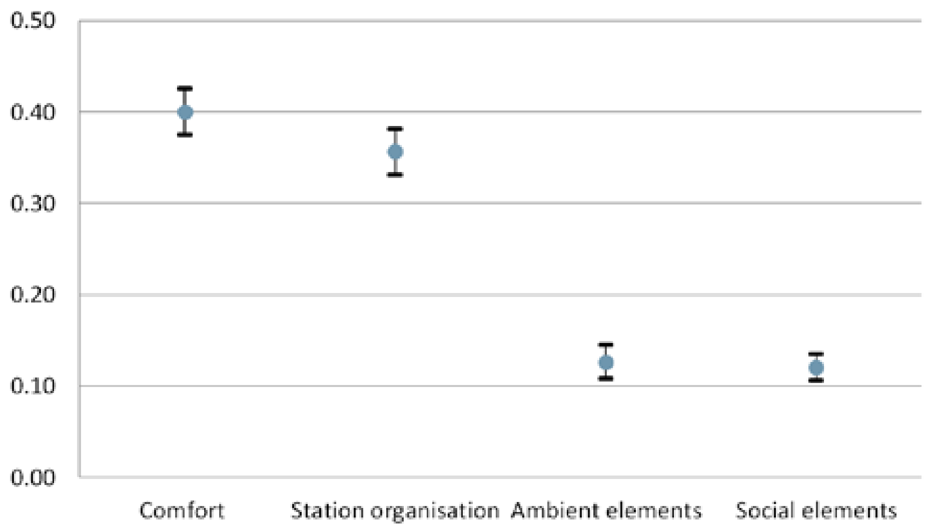


Figure 4-11: Weight intervals main criteria

Table 4-3: Weight intervals main criteria

	Comfort	Station organisation	Ambient elements	Social elements	ξ^*	CR
Center	0.400	0.356	0.126	0.120	2.496	0.633
Width	0.026	0.025	0.019	0.014		
Interval rank	1	2	3	4		

As mentioned, comfort and station organisation are valued the highest according to the survey respondents. Figure 4-12 and Table 4-4 show that comfortable waiting is valued the highest, closely followed by travel information. It can be seen that the intervals are quite large, which means that the opinions differed between the respondents. Facilities, signposting, spending time usefully, overview and secure at night are all on approximately

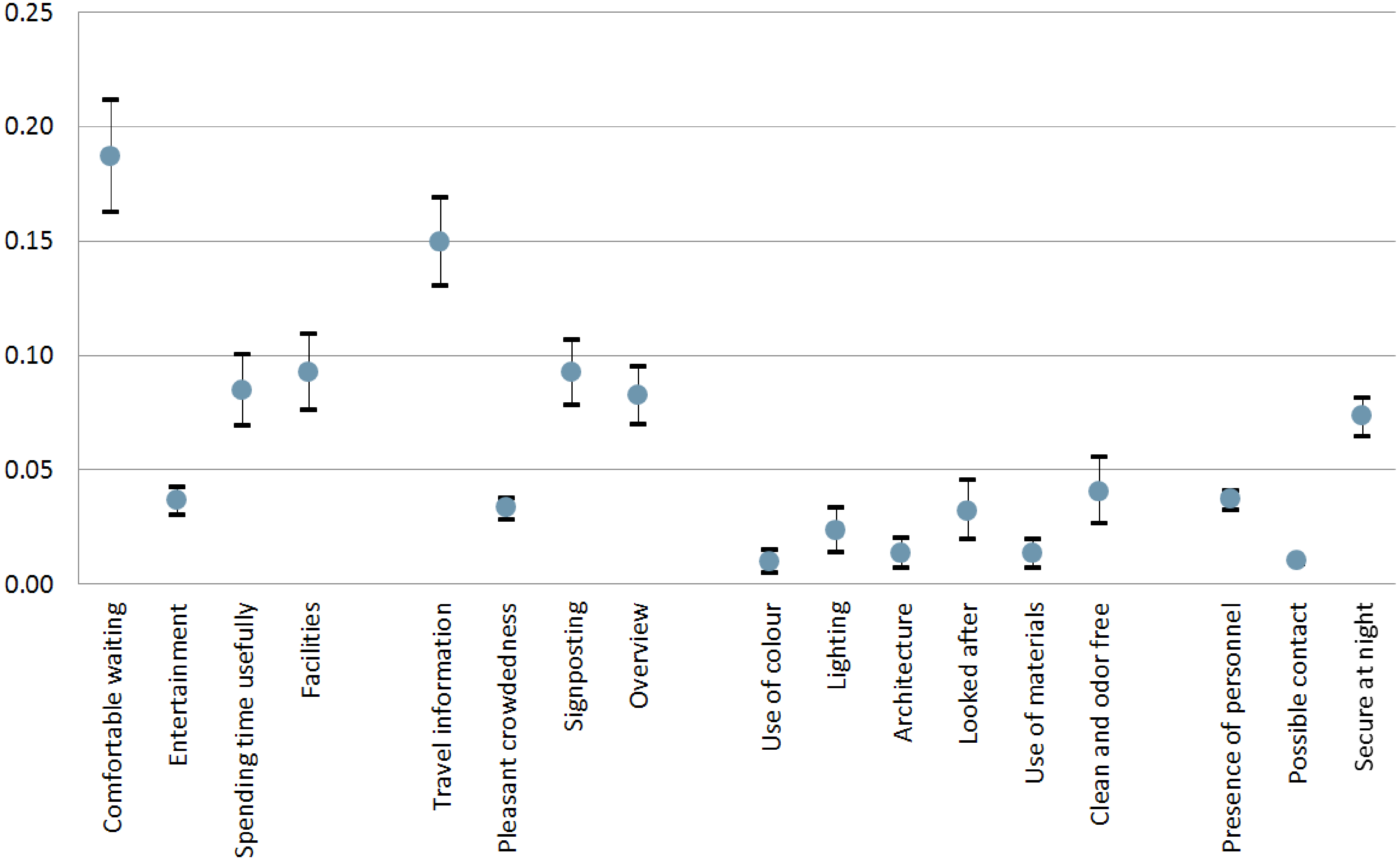


Figure 4-12: Global weight intervals

the same level. The other criteria are all quite low, with as lowest possible contact. The interval for this criterion is very small which means that all respondents agreed that this one is not important. By multiplying the weight intervals of the criteria with data, the experience value of transit nodes can be calculated.

Table 4-4: Global weight intervals

Rank	Criteria	Minimum weight	Maximum weight
1	Comfortable waiting	0,16	0,21
2	Travel information	0,13	0,17
3	Facilities	0,08	0,11
4	Signposting	0,08	0,11
5	Spending time usefully	0,07	0,10
6	Overview	0,07	0,10
7	Secure at night	0,06	0,08
8	Clean and odor free	0,03	0,06
9	Presence of personnel	0,03	0,04
10	Entertainment	0,03	0,04
11	Pleasant crowdedness	0,03	0,04
12	Looked after	0,02	0,05
13	Lighting	0,01	0,03
14	Architecture	0,01	0,02
15	Use of materials	0,01	0,02
16	Use of colour	0,01	0,02
17	Possible contact	0,01	0,01

4.6 Relation characteristics respondents and weights

A literature study has determined which criteria are part of the experience value. Applying BWM has resulted in weight intervals for the different criteria. A regression analysis can reveal whether there are significant relations between the socio-demographic characteristics of the respondents and the weights that have been determined. By conducting a backward regression analysis, multiple significant results were found. Some independent variables are significant, which means that conclusions can be drawn and that there is a relation between the independent variable and the dependent variable. Only the linear regression analyses where significant results were found are shown. Also, only the first and final model is reported.

Main criteria

Table 4-5: Multiple linear regression analysis of main criterion comfort (N=159)

Model	Independent variables	B	SE	Beta	t
1	(Constant)	.472	.109		4.323
	Gender	-.017	.031	-.046	-.564
	Age	-.021	.022	-.085	-.963
	Place of residence	-.001	.000	-.116	-1.461
	Level of education	.016	.010	.128	1.536
	Travel frequency	.000	.013	.003	.030
	Travel purpose	.082	.043	.217*	1.923
	Travel moment	-.112	.049	-.224**	-2.273
	Adj. R^2 = .030 F = 1.700				

Model	Independent variables	B	SE	Beta	t
5	(Constant)	.363	.079		4.597
	Level of education	**.019**	**.010**	**.156****	**1.995**
	Travel purpose	.069	.037	.182*	1.888
	Travel moment	**-.099**	**.048**	**-.199****	**-2.069**
	Adj. R^2 = .034 F = 2.850**				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

The regression analysis in Table 4-5 indicates that weight of the criterion comfort increases with the level of education. In general, higher educated have a higher standard of living (OECD, 2014), which explains why the value people attach to comfort increases with the level of education. People who mostly travel during the peak seem to think comfort is more important than people who travel in off-peak hours. It could be argued that higher educated people usually travel in peak hours, but because there is no significant relation between the people who travel for work purposes and the criterion comfort, this cannot be stated.

Comfort

Table 4-6: Multiple linear regression analysis of sub criterion comfortable waiting (N=159)

Model	Independent variables	B	SE	Beta	t
1	(Constant)	.447	.092		4.865
	Gender	.024	.026	.076	.929
	Age	.030	.019	.139	1.576
	Place of residence	-.001	.000	-.132*	-1.669
	Level of education	.011	.009	.106	1.275
	Travel frequency	.012	.011	.109	1.106
	Travel purpose	.005	.036	.016	.146
	Travel moment	-.080	.041	-.190*	-1.931
	Adj. R^2 = .036 F = 1.850*				
5	(Constant)	.567	.058		9.735
	Place of residence	-.001	.000	-.134*	-1.717
	Travel frequency	**.018**	**.009**	**.168****	**2.033**
	Travel moment	**-.081**	**.035**	**-.192****	**-2.309**
	Adj. R^2 = .037 F = 3.051**				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

Table 4-6 indicates that less frequent public transport travellers attach more value to comfortable waiting than people who travel regularly (Beta = 0.168**). This might be because people who travel by public transport regularly know when their mode of transportation departs. They are also familiar with the transit node and know where they need to be. It is possible that they arrive at the transit nodes minutes before departure, whereas people who travel rarely prefer coming earlier to the transit node to make sure they are in time. In that case, comfortable waiting could be more appreciated.

It seems that travellers who mostly travel during the peak hours think that, similar to the main criterion comfort, comfortable waiting is more important than off-peak travellers.

Table 4-7: Multiple linear regression analysis of sub criterion spending time usefully (N=159)

Model	Independent variables	B	SE	Beta	t
1	(Constant)	.217	.079		2.763
	Gender	.011	.022	.040	.480
	Age	-.011	.016	-.061	-.687
	Place of residence	.000	.000	.071	.892
	Level of education	-.003	.007	-.032	-.382
	Travel frequency	-.004	.009	-.039	-.394
	Travel purpose	-.066	.031	-.243**	-2.141
	Travel moment	.063	.036	.177*	1.775
	Adj. R^2 = .015 F = 1.344				
6	(Constant)	.227	.045		5.091
	Travel purpose	**-.074**	**.026**	**-.270****	**-2.815**
	Travel moment	.058	.034	.163*	1.694
	Adj. R^2 = .036 F = 3.963**				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

It seems that people who travel for work or educational purposes attach more value to spending time usefully than people who travel for leisure purposes (Table 4-7). This might be because their time is valuable and by being able to do some work during their wait at the transit node or doing groceries on the way home they save time.

Table 4-8: Multiple linear regression analysis of sub criterion facilities (N=159)

Model	Independent variables	B	SE	Beta	t
1	(Constant)	.136	.078		1.749
	Gender	-.005	.022	-.020	-.234
	Age	-.006	.016	-.033	-.372
	Place of residence	.001	.000	.140	1.740
	Level of education	-.003	.007	-.033	-.391
	Travel frequency	-.003	.009	-.035	-.354
	Travel purpose	.019	.031	.071	.622
	Travel moment	.051	.035	.146	1.456
	Adj. R^2 = .005 F = 1.106				
6	(Constant)	.108	.048		2.254
	Place of residence	.001	.000	.138*	1.758
	Travel moment	**.061**	**.028**	**.174****	**2.214**
	Adj. R^2 = .032 F = 3.662**				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

Table 4-8 indicates that people who travel in off-peak hours think facilities are more important than people who travel during the peak hours. This could be because off-peak travellers might have more time to make use of the facilities compared to peak travellers. However, there is no significant relation between travel purpose and the criterion facilities, so it cannot be said that off-peak travellers travel for leisure purposes and have more time available.

Station organisation

Table 4-9: Multiple linear regression analysis of sub criterion travel information (N=159)

Model	Independent variables	B	SE	Beta	t
1	(Constant)	.542	.097		5.603
	Gender	-.038	.027	-.112	-1.398
	Age	.017	.020	.075	.875
	Place of residence	.000	.000	-.020	-.255
	Level of education	.016	.009	.141*	1.748
	Travel frequency	-.032	.011	-.278**	-2.878
	Travel purpose	.065	.038	.189*	1.724
	Travel moment	-.093	.044	-.206**	-2.137
	Adj. R^2 = .079 F = 2.936**				
7	(Constant)	.513	.032		16.184
	Travel frequency	**-.029**	**.009**	**-.248*** **	**-3.219**
	Adj. R^2 = .056 F = 10.362**				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

People who often travel seem to think travel information is more important than people who travel less often (Table 4-9). This could be because they have experienced more delays and want to be kept informed. During a delay, it is important to communicate reliable information as soon as possible to increase the customers' acceptance of the extra wait (Van Hagen, 2011).

Table 4-10: Multiple linear regression analysis of sub criterion pleasant crowdedness (N=159)

Model	Independent variables	B	SE	Beta	t
1	(Constant)	.164	.059		2.797
	Gender	1.923E-5	.017	.000	.001
	Age	.001	.012	.007	.078
	Place of residence	.000	.000	-.098	-1.220
	Level of education	-.004	.005	-.064	-.762
	Travel frequency	-.012	.007	-.173*	-1.729
	Travel purpose	-.010	.023	-.049	-.426
	Travel moment	.010	.026	.037	.372
	Adj. R^2 = .005 F = 1.115 (p = .356)				
7	(Constant)	.133	.019		7.115
	Travel frequency	**-.012**	**.005**	**-.183****	**-2.344**
	Adj. R^2 = .027 F = 5.494** (p = .020**)				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

Table 4-10 indicates that people who travel more often attach more value to pleasant crowdedness. This could be because they have experienced different types of crowdedness before whereas less frequent travellers have not.

Table 4-11: Multiple linear regression analysis of sub criterion signposting (N=159)

Model	Independent variables	B	SE	Beta	t
1	(Constant)	.165	.071		2.308
	Gender	.031	.020	.126	1.527
	Age	.007	.015	.039	.447
	Place of residence	7.804E-5	.000	.020	.252
	Level of education	-.006	.007	-.078	-.940
	Travel frequency	.016	.008	.195*	1.967
	Travel purpose	-.023	.028	-.092	-.817
	Travel moment	.027	.032	.084	.851
	Adj. R^2 = .030 F = 1.691				
7	(Constant)	.202	.023		8.760
	Travel frequency	**.018**	**.007**	**.214*****	**2.757**
	Adj. R^2 = .040 F = 7.602**				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

Table 4-11 indicates that people who travel less frequently attach more value to the presence of clear signposting than frequent travellers. This makes sense, because the less frequent traveller does not know the station very well and needs signposting in order to find his way, whereas the frequent traveller exactly knows where to go.

Table 4-12: Multiple linear regression analysis of sub criterion overview (N=159)

Model	Independent variables	B	SE	Beta	t
1	(Constant)	.109	.070		1.553
	Gender	.014	.020	.056	.696
	Age	-.017	.014	-.101	-1.162
	Place of residence	.000	.000	.082	1.054
	Level of education	-.003	.007	-.042	-.516
	Travel frequency	.025	.008	.298**	3.065
	Travel purpose	-.038	.027	-.153	-1.386
	Travel moment	.064	.032	.195**	2.015
	Adj. R^2 = .066 F = 2.607**				
7	(Constant)	.161	.023		7.091
	Travel frequency	**.022**	**.006**	**.259*****	**3.368**
	Adj. R^2 = .061 F = 11.340***				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

It seems that less frequent travellers attach more value to overview than frequent travellers (Table 4-12). This can be explained in the same way as signposting. Less frequent travellers do not know the station very well, so they would like to have overview for orientation and a confident feeling.

Ambient elements

Table 4-13: Multiple linear regression analysis of sub criterion colour (N=158)

Model	Independent variables	B	SE	Beta	t
1	(Constant)	.109	.030		3.602
	Gender	.013	.009	.119	1.472
	Age	-.005	.006	-.072	-.826
	Place of residence	6.389E-5	.000	.038	.484
	Level of education	-.011	.003	-.309***	-3.790
	Travel frequency	.001	.004	.029	.299
	Travel purpose	-.002	.012	-.022	-.202
	Travel moment	.001	.014	.004	.042
	Adj. R^2 = .066 F = 2.607**				
7	(Constant)	.124	.013		9.277
	Level of education	**-.011**	**.003**	**-.296*** **	**-3.876**
	Adj. R^2 = .082 F = 15.024**				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

The results indicate that there is a tendency for lower educated people to attach more value to the presence of colour at transit nodes than higher educated people (Table 4-13).

Table 4-14: Multiple linear regression analysis of sub criterion lighting (N=158)

Model	Independent variables	B	SE	Beta	t
1	(Constant)	.095	.059		1.613
	Gender	.020	.017	.093	1.175
	Age	.023	.012	.166*	1.949
	Place of residence	.000	.000	-.084	-1.094
	Level of education	.001	.006	.012	.147
	Travel frequency	.025	.007	.343***	3.603
	Travel purpose	-.064	.023	-.298***	-2.752
	Travel moment	.023	.027	.082	.860
	Adj. R^2 = .101 F = 3.541*** (p = .001***)				
5	(Constant)	.124	.013		9.277
	Age	.021	.011	.146*	1.821
	Travel frequency	**.025**	**.007**	**.354*** **	**3.781**
	Travel purpose	**-.050**	**.020**	**-.237** **	**-2.566**
	Adj. R^2 = .105 F = 7.147*** (p = .000***)				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

Less frequent travellers seem to think lighting is more important than frequent travellers (Table 4-14). This can be explained the same way as signposting and overview. People who travel less frequent do not know the station very well. Lighting helps them to have a good orientation and might give them a sense of security as well.

It can be also seen that people who mostly travel for work or education seem to attach more value to lighting than leisure travellers.

Table 4-15: Multiple linear regression analysis of sub criterion architecture (N=158)

Model	Independent variables	B	SE	Beta	t
1	(Constant)	.235	.043		5.447
	Gender	-.060	.012	-.376***	-4.964
	Age	-.015	.009	-.138*	-1.705
	Place of residence	.000	.000	-.094	-1.293
	Level of education	-.002	.004	-.030	-.393
	Travel frequency	-.013	.005	-.229**	-2.518
	Travel purpose	.030	.017	.186*	1.800
	Travel moment	-.003	.019	-.012	-.135
	Adj. R^2 = .182 F = 6.016***				
4	(Constant)	.208	.025		8.244
	Gender	**-.058**	**.012**	**-.362*** **	**-4.951**
	Age	-.014	.008	-.132*	-1.727
	Travel frequency	**-.013**	**.005**	**-.239** **	**-2.652**
	Travel purpose	**.031**	**.014**	**.188** **	**2.143**
	Adj. R^2 = .188 F = 10.147***				

* $p \leq 0.1$ ** $p \leq 0.05$ *** $p \leq 0.01$

Table 4-15 indicates that men think architecture is more important than women. Also, frequent travellers attach more value to architecture than less frequent travellers. People who travel for leisure purposes seem to think architecture is more important than people that travel for work or education. This might be because these people have more time to appreciate the presence of nice architecture, whereas people who have to go to work or school are in a rush.

Table 4-16: Multiple linear regression analysis of sub criterion cleanliness (N=158)

Model	Independent variables	B	SE	Beta	t
1	(Constant)	.198	.082		2.418
	Gender	.050	.023	.177**	2.154
	Age	-.029	.017	-.154*	-1.747
	Place of residence	.001	.000	.140*	1.763
	Level of education	.005	.008	.058	.694
	Travel frequency	-.003	.010	-.027	-.278
	Travel purpose	.023	.032	.080	.713
	Travel moment	.001	.037	.002	.016
	Adj. R^2 = .034 F = 1.805*				
5	(Constant)	.251	.047		5.406
	Gender	**.050**	**.022**	**.177** **	**2.281**
	Age	**-.030**	**.015**	**-.159** **	**-2.047**
	Place of residence	.001	.000	.135	1.734
	Adj. R^2 = .052 F = 3.866**				

* $p \leq 0.1$ ** $p \leq 0.05$ *** $p \leq 0.01$

It seems that women attach more value to cleanliness than men (Table 4-16). This is a common difference between men and women and explains this difference. The results also indicate that younger people value cleanliness more than older people.

Social elements

Table 4-17: Multiple linear regression analysis of sub criterion presence of personnel (N=157)

Model	Independent variables	β	SE	Beta	t
1	(Constant)	.267	.091		2.944
	Gender	-.026	.026	-.080	-.992
	Age	.076	.019	.354***	4.098
	Place of residence	-4.753E-5	.000	-.009	-.120
	Level of education	.010	.009	.091	1.119
	Travel frequency	-.005	.011	-.047	-.484
	Travel purpose	.012	.036	.035	.321
	Travel moment	-.046	.041	-.108	-1.119
	Adj. R^2 = .079 F = 2.918***				
7	(Constant)	.213	.026		8.142
	Age	**.066**	**.016**	**.308*** **	**4.037**
	Adj. R^2 = .089 F = 16.294***				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

Table 4-17 indicates that older people attach more value to the presence of personnel than younger people. This might be because older people appreciate the service in order to ask something whereas younger people rather find the answer by themselves or on their smart phone. Another reason could be that the presence of personnel gives them a feeling of security.

Table 4-18: Multiple linear regression analysis of sub criterion possible contact (N=157)

Model	Independent variables	β	SE	Beta	t
1	(Constant)	.210	.045		4.627
	Gender	-.025	.013	-.158	-1.933
	Age	-.016	.009	-.147*	-1.686
	Place of residence	1.428E-5	.000	.006	.072
	Level of education	-.009	.004	-.174**	-2.120
	Travel frequency	-.006	.005	-.111	-1.133
	Travel purpose	-.013	.018	-.080	-.716
	Travel moment	.011	.021	.051	.526
	Adj. R^2 = .058 F = 2.373 (p = .025**)				
5	(Constant)	.208	.035		5.953
	Gender	**-.031**	**.012**	**-.194** **	**-2.506**
	Age	**-.021**	**.009**	**-.201** **	**-2.465**
	Level of education	**-.009**	**.004**	**-.179** **	**-2.193**
	Adj. R^2 = .063 F = 4.509 (p = .005***)				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

Men seem to think possible contact with other travellers is more important than women (Table 4-18). Younger travellers and lower educated people seem to think the same.

Table 4-19: Multiple linear regression analysis of sub criterion secure at night (N=157)

Model	Independent variables	β	SE	Beta	t
1	(Constant)	.525	.088		5.957
	Gender	.050	.025	.161	1.998
	Age	-.061	.018	-.293***	-3.381
	Place of residence	3.666E-5	.000	.007	.096
	Level of education	.000	.008	-.003	-.034
	Travel frequency	.011	.010	.104	1.075
	Travel purpose	.002	.035	.006	.050
	Travel moment	.034	.040	.082	.855
	Adj. R^2 = .074 F = 2.791 (p = .009***)				
5	(Constant)	.574	.047		12.134
	Gender	.046	.024	.150*	1.931
	Age	**-.060**	**.017**	**-.290*****	**-3.592**
	Travel frequency	.014	.009	.136*	1.659
	Adj. R^2 = .092 F = 6.280 (p = .000***)				

* p ≤ 0.1 ** p ≤ 0.05 *** p ≤ 0.01

Table 4-19 indicates that younger people attach more value to security at night than older people.

4.7 Conclusions

This chapter has aimed to determine the criteria that contribute to the experience value. The experience value is becoming increasingly important, but it is still a rather vague term that differs with time, places and people. The waiting environment is an influential determinant for the time perception of a traveller. Because the goal is to add value to the time spent at a transit node where the public transport service takes place, a closer look was taken to the service environment which can strongly influence the customer satisfaction. Factors in the service environment act as stimuli, which evoke a customer judgment which leads to a specific response. Hence, a high quality of the service environment leads to a positive customer judgment which results in a positive word-of-mouth. Criteria that contribute to a high quality service environment differ per research, but the most mentioned aspects are ambient elements, spatial layout and functionality, social elements, and design elements. In order to find more specific criteria, a closer look was taken to the transit node environment.

Based on different scientific sources, criteria for the experience value were collected and classified into the following main criteria: comfort, station organization, ambient elements and social elements. In order to find the weights for the different criteria and sub criteria, the Best Worst Method was applied. This method is a Multi Criteria Decision Making method and is based on the pairwise comparison of criteria. In BWM, for each set of criteria, decision-makers were asked for the best and worst criterion and are asked to give a preference between the other criteria and the best and worst. As a result, less comparisons are needed which leads to a higher consistency. The data for BWM was collected by conducting a survey among 160 respondents. Finally, weight intervals were calculated for each sub criterion. According to the respondents, the main criteria comfort and station organisation are valued the most. From the global weights of all sub criteria can be concluded that comfortable waiting and travel information are valued the most. The use of colour, type of architecture, use of materials and possible contact are valued the least by the respondents. The results were analysed by means of a regression analysis to reveal whether there is a relation between the characteristics of the respondents and the weights. Multiple significant results were found which means that there is a relation between the independent variables and several dependent variables.

In order to calculate the experience value, the weights must be multiplied with the data. The next chapter will provide more insight into the data that has to be collected and will determine how the node-place model can be extended with the experience value.

Lift

5 Developing the method

The previous chapter has provided insight into the experience value. Corresponding criteria and their importance were determined by doing a literature study and using the Best-Worst Method (BWM) based on survey results. After obtaining the criteria and weights, the node-place model can be extended with the experience value. However, before doing this there are several issues that need to be addressed. It is still not known what data needs to be collected and how it should be scored in order to calculate the experience value. Also, the influence of the experience value on the quality of a transit node is not yet determined. Moreover, the potential of the node and place value can be indicated by applying the node-place model and using the transit node typologies, but the potential of the experience value is not yet part of the typologies. Hence, this chapter aims to answer the following sub questions:

6. *How can the experience value be calculated and what is the influence on the transit node quality?*
7. *How can the potential of the experience value be indicated?*

The first section addresses the final issues in order to calculate the experience value. Section 5.2 and 5.3 explain how the experience value becomes part of the final method. Finally, the steps of the method are listed in Section 5.4.

5.1 The experience value

5.1.1 Selection of criteria

The literature study from the previous chapter has resulted in criteria and sub criteria for the experience value. In order to develop a common method, it is important to quantify the experience value. In order to quantify the value of experience it is vital that the number of criteria is limited, the overlap is minimal, and the need of data is practically obtainable (Dammers et al., 2005). Because of this, the data should be collected and scored objectively. Currently, there is not enough information available about the intangible aspects of the experience value to collect this objectively. The literature study in section 4.3 has started with describing the preferences of travellers concerning the intangible sub criteria, but more research should be done. Due to time limitations of this thesis, it was decided to leave these sub criteria out of the scope of this research. Figure 5-1 shows that when the subjective sub criteria are left out of the method, the main criterion station organization is omitted. The objective sub criteria represent almost half of the experience value (49%).

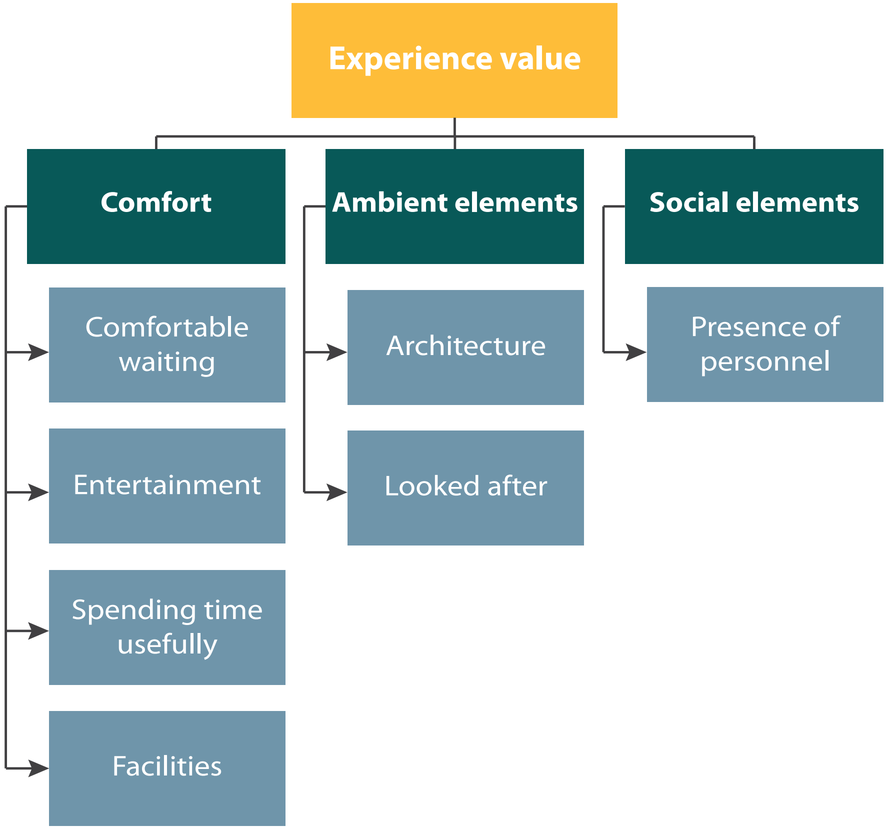


Figure 5-1: Objective sub criteria

5.1.2 Data collection

Data for the criteria needs to be collected in order to calculate the experience value. Different aspects contribute to the sub criteria for which data has to be collected. Based on the literature study in section 4.3 it was decided which data to collect and how they are scored. Before the scores are used to calculate the experience value, they are normalized first. This is similar to the original method and done to be able to compare the transit nodes with each other. For each criterion, there is a transit node that has a maximum (1.0) and minimum score (0.0). Below a short explanation and scoring table for each main criterion can be found.

Comfort

Table 5-1: Scoring table comfort

Comfort			
Comfortable waiting			
Heated waiting	Yes = 1	Partially = 0.5	No = 0
Sheltered waiting	Yes = 1	Partially = 0.5	No = 0
Entertainment			
Television screens	Yes = 1	No = 0	
Free newspaper	Yes = 1	No = 0	
Spending time usefully			
Wi-Fi	Yes = 1	No = 0	
Supermarket	>1 = 1	1 = 0.5	0 = 0
Facilities			
Stores	>3 = 1	1-3 = 0.5	0 = 0
Restaurants	>3 = 1	1-3 = 0.5	0 = 0
Toilets	Yes = 1	No = 0	

Comfortable waiting can be sub divided in heated and sheltered waiting. When a transit node offers heated waiting, it receives a 1, partially a 0.5 and if there is no heated waiting a 0. The same applies to sheltered waiting. For example, an underground transit node receives a 0.5 for sheltered waiting because it is warmer than outside, but there is no specified heated waiting area. For sheltered waiting, the transit node receives a 1 because travellers are not hindered by weather circumstances. Entertainment is based on the presence of television screens and free newspapers. Both aspects receive a 1 if present and a 0 if not. Spending time usefully is sub divided in Wi-Fi and supermarket. Wi-Fi is scored a 1 if present and a 0 if not. The input for main criterion facilities is based on the presence of shops, restaurants and toilets. If there are more than three shops at the station, the transit node receives a 1, between one and three, the transit node receives a 0.5, and no shops a 0.

Ambient elements

Table 5-2: Scoring table ambient elements

Ambient elements			
Architecture	Classic = 1	Modern classic = 0.8	Homely = 0.6
	Modern/futuristic = 0.4	Artistic = 0.2	Trendy = 0
Looked after	Most recent year of renovation		

The score for main criterion architecture is based on the classification made by Boes (2007). A survey was held among NS passengers (N=1781) where people were asked to give a preference to different types of architecture. The outcome of this survey was that a classic architecture style is most preferred and a trendy architecture style the least. Whether a transit node is looked after is based on the most recent year of renovation. When it has been a long time since the station was lastly renovated, a refurbishment could help to improve the ambiance of the transit node.

Social elements

Table 5-3: Scoring table social elements

Social elements		
Presence of personnel	Yes = 1	No = 0

If there is personnel present at the transit node, the score is a 1 and if not a 0.

5.1.3 Weights experience value

The experience value can be calculated by multiplying the scored data with the weights that have resulted from section 4.4. Because the subjective criteria are omitted, the weight intervals need to be recalculated in order for the sum of the criteria to be 1. Figure 5.1 and Table 5 4 show the weight intervals for the objective sub criteria.

Table 5-4: Ranking of objective sub criteria

Rank	Criteria	Minimum weight	Maximum weight	Center
1	Comfortable waiting	0.34	0.44	0.39
2	Facilities	0.16	0.23	0.19
3	Spending time usefully	0.14	0.21	0.18
4	Presence of personnel	0.07	0.09	0.08
5	Entertainment	0.06	0.09	0.08
6	Looked after	0.04	0.09	0.06
7	Architecture	0.02	0.04	0.03

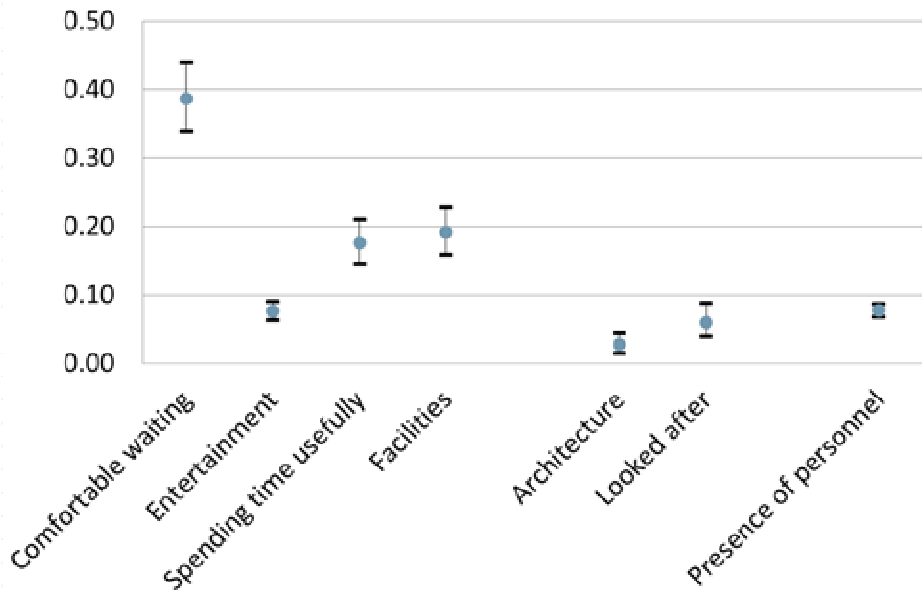


Figure 5-2: Weight intervals objective sub criteria

Figure 5-3 shows that comfort is the most important main criterion of the experience value with 83%. Ambient elements (9%) and social elements (8%) are less important.

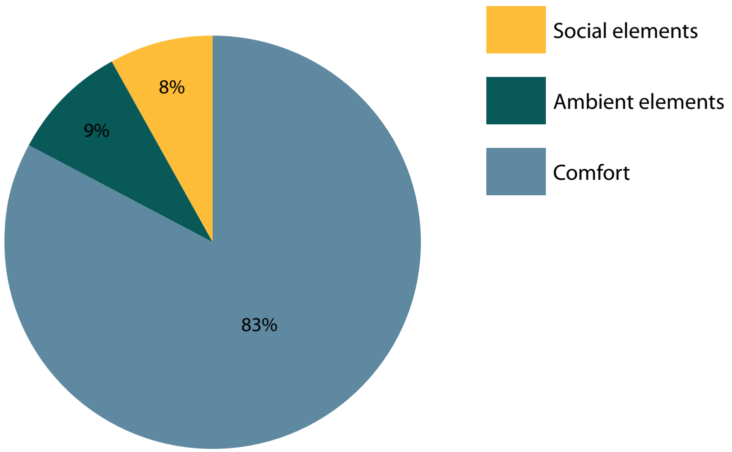


Figure 5-3: Weights of the main criteria

5.1.4 Calculating the experience value

It is already known how the node and place value can be calculated (3.2.2 and 3.2.2). Based on the criteria that were determined by the literature study and the weights that were derived from the survey, the experience value can be calculated as well. The experience value (EV) is calculated by adding the indicators that represent comfort (CM), ambient elements (AE) and social elements (SE). Because the sum of the weights of the sub criteria is 1, there is no need to average the outcome.

$$\mathrm{EV} = CM + AE + SE \tag{5.1}$$

With the collected data, the different variables of the experience value can be calculated. The data can be scored according to the scoring tables in 5.1.2 and multiplied with the corresponding weights (Section 5.1.3).

$$\mathrm{CM} = \frac{(HW + SW)}{2} * 0.39 + \frac{(TS + FN)}{2} * 0.08 + \frac{(WF + SM)}{2} * 0.18 + \frac{(ST + RT + TL)}{3} * 0.19 \tag{5.2}$$

With parameters:	HW	= Heated waiting
	SW	= Sheltered waiting
	TS	= Television screens
	FN	= Free newspaper
	WF	= Wi-Fi
	SM	= Supermarket
	ST	= Stores
	RT	= Restaurants
	TL	= Toilets

$$\mathrm{AE} = AR * 0.03 + LA * 0.06 \tag{5.3}$$

With parameters:	AR	= Architecture
	LA	= Looked after

$$\mathrm{SE} = PP * 0.08 \tag{5.4}$$

With parameter:	PP	= Presence of personnel

5.2 Share of the experience value

It is now known how the three different values that contribute to the quality of a transit node are calculated. However, it is still unclear what the influence of the experience value on the transit node quality is. The main reason for extending the node-place model with the experience value is the theory of the three strategies: accelerate, condense and enhance (Peek & van Hagen, 2002). Only when these three strategies are applied simultaneously an increased performance can be observed (Vaessens, 2005). The node-place model indicates possible improvements such as acceleration and condensation, but enhancement could not be indicated. By adding the experience value this third strategy becomes part of the model.

In order to determine the share of the experience value, several interviews with experts from different departments of the Municipality of Rotterdam and the public transport operator in Rotterdam (RET) have taken place (Gemeente Rotterdam, 2014d; RET, 2014a). The experts were asked to give their opinion on the share of the experience value in the transit node quality. During the interviews it became clear that there is no unanimous answer to this question. Most experts have stated that the three values support each other, but to what extent could not be answered.

As mentioned, the strategies - accelerating, condensing and enhancing - need to be applied simultaneously in order to obtain in an increased performance, but what was not said was to what extent the strategies have to be applied and if the strategies are equally important. However, based on the theory and expert interviews, it was decided to assume that all three values have an equal share in the transit node quality (Figure 5-4).

5.3 Potential of the experience value

In order to provide insight in the possible improvements of a transit node, transit node typologies are used. By comparing the current quality of the transit node with his corresponding typology, it can be seen where improvements can be made. Hence, in order to clarify where the strategies must be applied, one needs to make use of transit node typologies. Though the existing typologies have to be extended with a standard for the experience value.

From the literature review, it could be concluded that when the experience of a traveller matches its expectations, the subjective quality of a transit node is high (Section 1.1). This means that the standard for the experience value should be based on the expectations of travellers. An interview with the RET was held to determine the standard for the experience value based on the expectations of its customers (RET, 2014). It can be assumed that the expectation of a traveller varies for different transit nodes. Also, it was stated during the interview that, similar to the balance between the node and place value, there should be coherence with the experience value as well. Based on these assumptions, a standard was determined for each transit node type (Table 5-5). The exact values can be found in Appendix G. For most types the three values are equal, expect for the type *city centre*. Hence, it cannot be concluded that the transit node quality is a result of the coherence between the values, but needs to be compared with the corresponding typology.

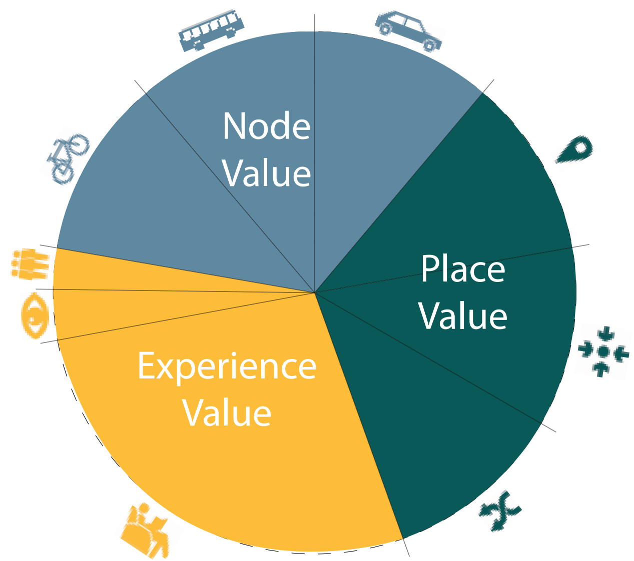
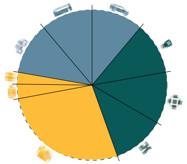
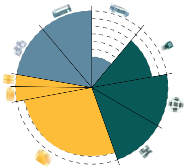
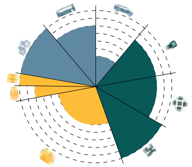
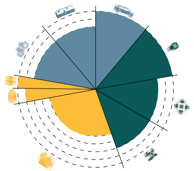
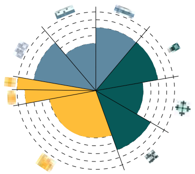
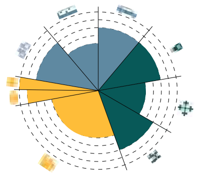
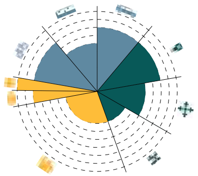
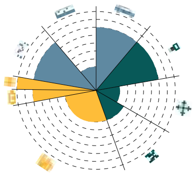
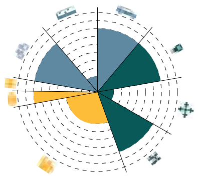
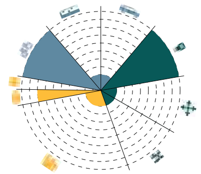
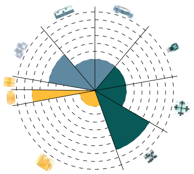
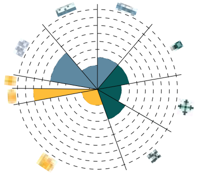
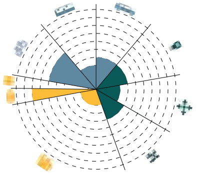
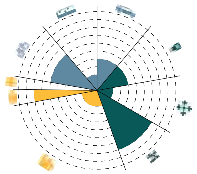
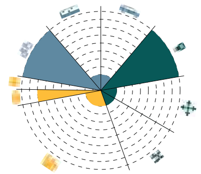


Figure 5-4: Model extended with the experience value

Table 5-5: Typologies transit nodes

Working and facilities	Living: Urban centre plus	Urban centre	Small urban centre	Urban prewar/post-war compact	Postwar urban/small urban/green urban	Centre village	* Landscape
Metropolitan top location	World city 						
Urban centre location	Big city 	City centre 					
Transit node location Randstad		Metropolitan centre 					
Regional transit node location/ regional facilities		Regional centre 	Regional centre 	Modern city 	Gate quarter 	Hub village 	Outside gate 
Small-scale businesses			Suburb 	Public transport quarter 	Public transport quarter 	Centre village 	Outside gate 

5.4 Steps of the method

After addressing the issues mentioned in the introduction of this chapter, it is now possible to apply the method on transit nodes. In this section, a stepwise explanation will show how to apply the method and how a strategy can be determined based on the results.

Step 1: Make a selection of transit nodes

The method needs to be applied on a set of transit nodes. It is advised to apply the method on a comprehensive selection of transit nodes. Because the quality of a transit node is based on best and worst transit node in the selection, it is vital to select multiple transit node with different strengths and weaknesses. Only this way, conclusions can be drawn from the results.

Step 2: Classify the transit nodes

The selection of transit nodes needs to be classified according the typologies in Table 5-5. After the current transit node quality is calculated, the typology indicates what can be improved in the transit nodes. The classification is based on the current situation and/or ambitions of policy makers.

Step 3: Collect the data

In order to calculate the node, place and experience value, data needs to be collected and scored. What data needs to be collected and how to score can be found in Sections 3.2.2, 3.2.3 and 5.1.2.

Step 4: Execute the MCA and assess the quality

When the data has been collected and the scores are given, it is possible to execute the MCA. First, the scores for the experience value have to be multiplied with the corresponding weights that were derived from the survey. The weights for the experience value can be found in Section 5.1.3. Now, the quality can be assessed.

Step 5: Compare with typologies

Even though the quality of the transit nodes is now known, not every transit node needs to have the same quality. Transit nodes in a network should complement each other, instead of compete with each other. That is why the transit nodes were classified in typologies. Every typology has set a target for the transit node to meet which represents a situation where the transit node performs the best. By comparing the outcome of the MCA with the targets set by the typologies, the potential that can be realized for each transit node is indicated. Based on the potential, strategies can be determined in order to improve the transit nodes and increase customer satisfaction.

5.5 Conclusions

This chapter has aimed to address the final issues before the node-place model can be extended with the experience value. It was still not clear what data had to be collected and how the data should be scored before calculating the experience value. Also, the influence of the experience value on the transit node quality was not yet determined as well as the potential that can be realized for each transit node typology.

In order to calculate the experience value, data needs to be collected. Similar to the node and place value, the data must be collected objectively and easily. Currently, there is not enough information about the intangible aspects of the experience value to measure them objectively, which is why it was decided to exclude the subjective sub criteria from the method and only collect data for the other sub criteria. As a result of this decision, the weights were recalculated in order for the sum of the criteria to be 1. It can be clearly seen that comfort is more important for the respondents of the survey (0.83) than ambient elements (0.09) and social elements (0.08). By multiplying the scores of the collected data with the corresponding weights the experience value can be calculated.

Before, the quality of a transit node was calculated by the node and place value with equal importance. Now that the experience value becomes part of the method, it has to be determined what the share of the experience value is. Based on interviews with experts from the municipality and the public transport operator and conclusions from theory, it was decided to assume that the three values have an equal share in the transit node quality.

The potential of a transit node can be indicated by comparing its quality with the typology. However, the potential of the experience value was not part of the typologies yet. From the literature review it can be concluded that the quality of a transit node is high when the experience matches with a traveller's expectations. That is why the potential of the experience value is based on the expectations of the travellers. It can be assumed that the expectation of a traveller differs for different transit nodes. An interview with the public transport operator was held to determine the standard of the experience value for the transit node typologies. Finally, after addressing these final issues a stepwise explanation has shown how to apply the method and how a strategy can be determined based on the results. In the next chapter, a case study is used to apply and illustrate the developed method.

6 Case study: Rotterdam

In this chapter, the method that was developed in the previous chapter will be applied to the city region of Rotterdam. First, section 6.1 gives some background information on Rotterdam. Second, section 6.2 explains the interests of the Municipality of Rotterdam concerning the application of the method to the city. After this, in the subsequent sections the method is applied according to the steps described in chapter 5. Finally, this chapter ends with an analysis of the outcome of the method.

6.1 Background study Rotterdam

In 1340, city rights were granted to Rotterdam, which then had approximately 2000 inhabitants (Rotterdam, 2014). Ten years later a shipping canal was completed, which provided Rotterdam access to the larger towns in the north, allowing it to become a local trans-shipment centre between Holland, England and Germany. Also, the completion led to urbanization of Rotterdam. The port of Rotterdam grew slowly, but the completion of the Nieuwe Waterweg in 1872, a shipping canal from the port to the sea, contributed greatly to the growth of the port.

During World War II, on May 14th of 1940, the heart of Rotterdam was almost completely destroyed by an aerial bombardment of the German air force (Rotterdam, 2014) (Figure 6-1). Rotterdam was gradually rebuilt from the 1950's through the 1970's. Because of the urge for modernization many buildings were not restored but demolished. In the 1950's Europe's first car-free shopping street and the new Rotterdam central station were opened. In 1960, the Euromast was completed as symbol for the post-war Rotterdam. Because of housing shortage, several new neighbourhoods were built. The city remained quite windy and open until in the 1980's an active architectural policy was developed by the city councils. Apartments, office buildings and recreation facilities were built in a daring and new type of architecture (Figure 6-2). This policy has resulted in a livable city centre with a new skyline. In 2015, Rotterdam was voted European City of the Year by the Academy of Urbanism (The Academy of Urbanism, 2015).

Figure 6-1: Rotterdam in 1940 (Gemeentearchief, Rotterdam, 2015)

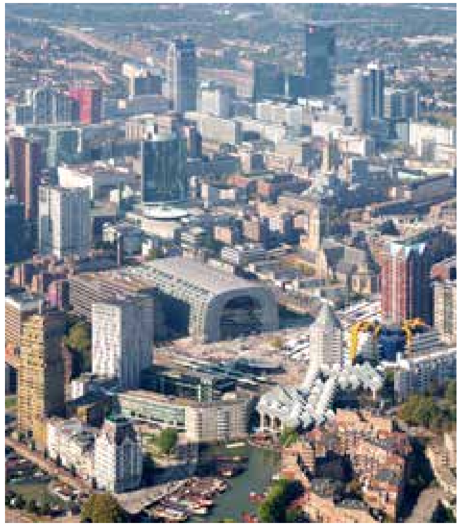


Figure 6-2: Centre of Rotterdam in 2014 (Rotterdam Image Bank, 2014b)

Not only the city was rebuilt, the port of Rotterdam was recovered and further expanded by disconnecting the city and the port by developing new port areas at the south side of the Nieuwe Waterweg. The port grew so rapidly that in 1962 the port of Rotterdam became the greatest port of the world and remained the greatest until 2004.

Currently, Rotterdam is the second-largest city in the Netherlands with approximately 600.00 inhabitants. The population of the Rotterdam Urban Region is 1.6 million inhabitants (Rotterdam in Cijfers, 2015). Rotterdam is situated in the south-west part of the Netherlands and part of the Randstad, which is a conurbation of the four largest cities in the country (Figure 6-3). The Randstad has a population of 7.1 million people and is one of the largest conurbations of Europe (CBS,2014).

Figure 6-3: The Randstad and the Rotterdam Urban Region

Rotterdam is divided into a northern and southern part by the river Nieuwe Maas and connected by several tunnels and bridges. The city centre is located on the northern bank of the river, although recent urban developments have extended the center to the northern part of the south of Rotterdam.

The city of Rotterdam is enclosed by a diamond-shaped ring road, consisting of highways A20 (north), A16 (east), A15 (south), and A4 (west). Seven main routes through the city connect the city with the different highways.

Figure 6-4: Rotterdam

The public transport network of Rotterdam has multiple levels. Several train tracks run through Rotterdam among which the high speed line from Amsterdam to Antwerp. The city of Rotterdam has a central station in the city centre and five other train stations. The train tracks run to different directions and connect Rotterdam with train stations throughout the Rotterdam Urban Region.

At a lower level, Rotterdam is disclosed by a metro network (Figure 6-5). There are five lines with more than 50 metro stations (RET, 2014b). At a few stations a transfer can be made to train and at most stations travellers can transfer to bus or tram. Rotterdam has an extensive bus- and tram network with over 50 bus lines and nine tram lines. Most of the metro-, tram- and bus lines are operated by the RET.

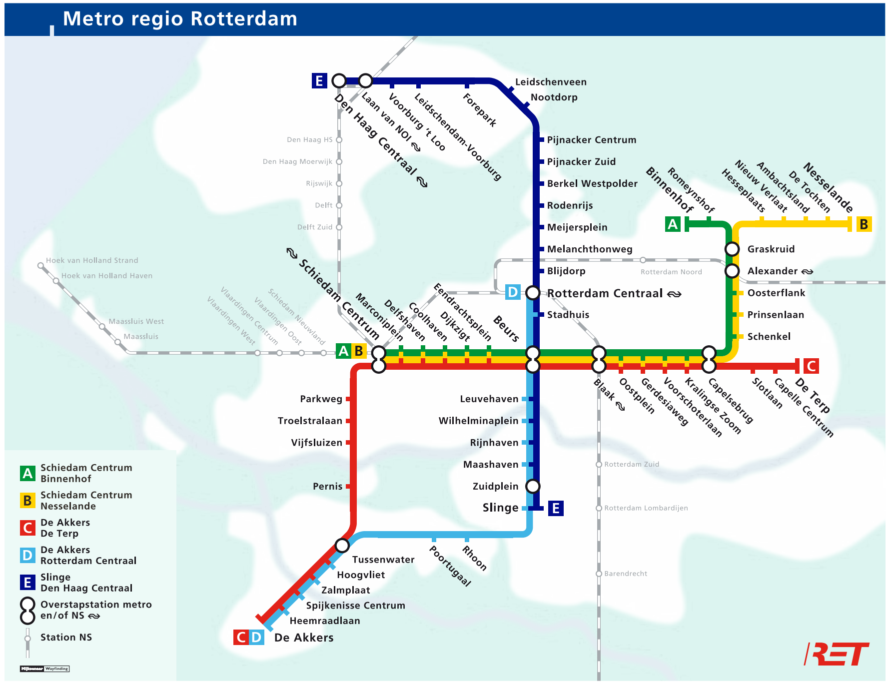


Figure 6-5: Rotterdam metro map (RET, 2014c)

The transport network of Rotterdam has increasingly expanded since 1960 (Rotterdam, 2014). In 1968 the first metro line of the Netherlands was completed in Rotterdam in order to connect the northern and southern part. In 1974 the line was extended to De Akkers in Spijkenisse and in 2007 to The Hague Central Station. In 1982 a new metro line from west to east was opened and in the years after branched to several neighbourhoods in the east of the city. The road network was expanded as well; several bridges and tunnels were built to connect the northern and southern part of the city. In 1993 the Willemsspoortunnel was completed which allowed the trains to cross the river through the tunnel.

6.2 Interests of the Municipality of Rotterdam

As explained in the introduction, the increase of car mobility has resulted in congestion and pollution (Beirão & Sarsfield Cabral, 2007). For many years, fighting congestion, decreasing growth of car use and stimulating the use of public transport have been objectives of political parties in the country (Dijst et al., 2002). These issues are also on the agenda of the Municipality of Rotterdam where this research was conducted. The municipality is cooperating with the Rotterdam Urban Region, the Port of Rotterdam and the Ministry of Infrastructure to guarantee high accessibility of the Rotterdam region (De Verkeersonderneming, 2012; Gemeente Rotterdam, 2014a; Stadsregio Rotterdam, 2013). The throughput rate of the port keeps increasing and also the road transportation keeps on growing. The current capacity of the road network around Rotterdam is not enough to compensate for the increase of mobility. Figure 6-6 shows that the share of public transport users in Rotterdam is relatively low compared to other cities which could indicate that there is room for improvement (Gemeente Rotterdam, 2012). By obtaining a modal shift from car towards public transport problems such as congestion and pollution will decrease. Hence, the Municipality of Rotterdam has great interest in a method that can be used to improve transit nodes which will finally result in a modal shift from car towards public transport.

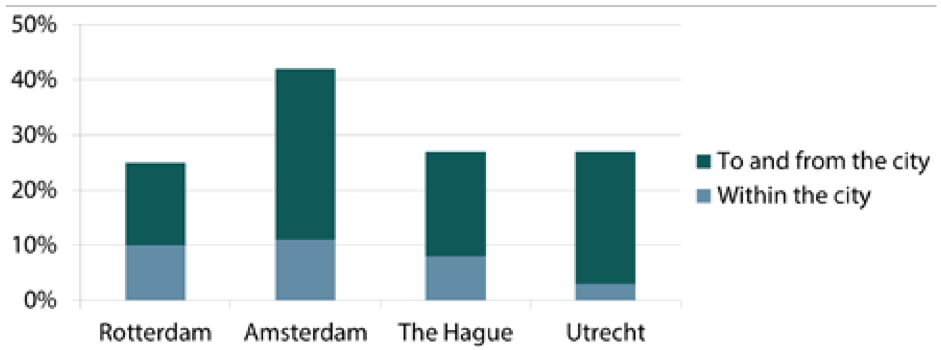


Figure 6-6: Public transport modal split share 2012 (Gemeente Rotterdam, 2012)

6.3 Selection and classification of transit nodes

6.3.1 Selection

The first step is to make a selection of transit nodes to further analyse. Following the previously stated definition of a transit node (Section 1.4), a selection was made of only train- and metro stations with at least two connecting modalities. In consultation with the Municipality of Rotterdam, it was decided that the selection of transit nodes would be based on the accessibility by public transport because the municipality wanted to take a closer look at transit nodes with a high public transport value. Hence, in order to make the selection, data concerning the public transport accessibility was collected for all transit nodes in the city region. Based on the data, it was decided that transit nodes with a public transport accessibility of higher than 400 were selected. This selection was based according to the public transport network in 2014. Finally, a selection of 32 transit nodes was made (Figure 6-7).

6.3.2 Classification

Based on conversations with the Municipality of Rotterdam (Gemeente Rotterdam, 2014d) and the RET (2014a), the transit nodes were classified in the typologies. The classification was based on the current situation and ambitions for the nearby future. The classifications can be seen in Table 6-1.

Table 6-1: Classification of transit nodes

Transit node	Typology
Beurs	Big city
Capelsebrug	Gate quarter
De Akkers	Suburb
Delfshaven	Centre village
Dijkzigt	Modern city
Eendrachtsplein	City centre
Graskruid	Public transport quarter
Heemraadlaan	Suburb
Hoogvliet	Centre village
Kralingse Zoom	Gate quarter
Leuvehaven	City centre
Maashaven	Public transport quarter
Marconiplein	Public transport quarter
Oosterflank	Centre village
Oostplein	Modern city
Poortugaal	Centre village
Rotterdam Alexander	Metropolitan centre
Rotterdam Blaak	Big city
Rotterdam Centraal	World city
Rotterdam Lombardijen	Modern city
Rotterdam Noord	Public transport quarter
Schenkel	Centre village
Schiedam Centrum	Regional centre
Schiedam Nieuwland	Public transport quarter
Slinge	Centre village
Spijkenisse Centrum	Regional centre
Stadhuis	City centre
Vijfsluizen	Gate quarter
Vlaardingen Oost	Public transport quarter
Voorschoterlaan	Centre village
Wilhelminaplein	Modern city
Zuidplein	Metropolitan centre

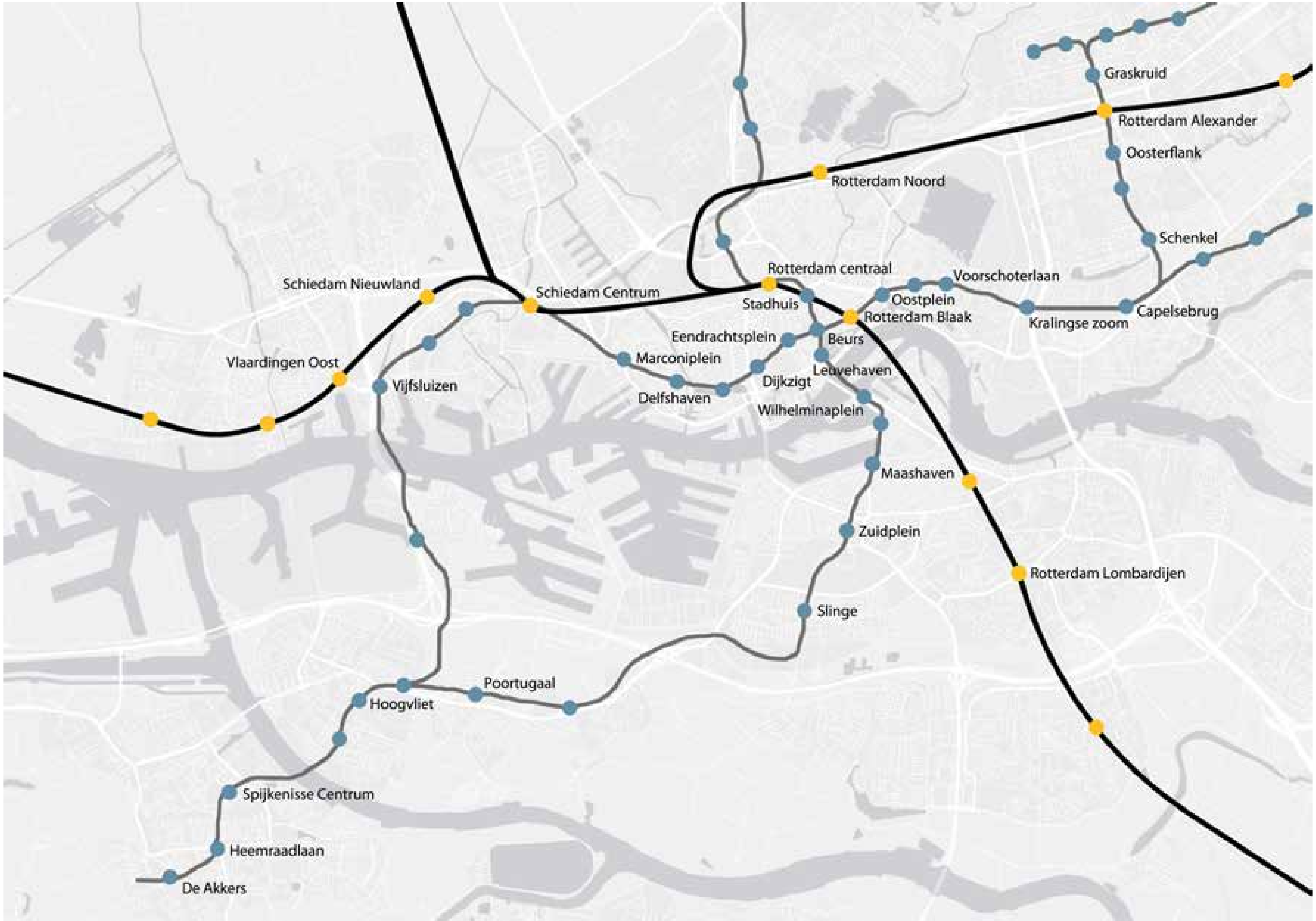


Figure 6-7: Selection of transit nodes

6.4 Data collection

6.4.1 Node value

Data for the sub criterion slow traffic was collected by checking whether a public transport bicycle could be rented (OV-fiets, 2014) and whether it is possible to cross the railway/metro line. The number of bicycle parking places was collected (Gemeente Rotterdam, 2014e), as well as the number of travellers boarding and alighting per day at each transit node (Arriva, 2014; Connexxion, 2014; RET, 2013; Zuidvleugel Stedenbaanplus, 2013b). In order to collect data for the sub criterion public transport, the timetable of OV in Nederland (2014) was consulted. The data for the sub criterion roads was collected by using a map of the Rotterdam Urban Region.

6.4.2 Place value

The sub criterion proximity is calculated by using data such as the number of inhabitants, employees and visitors. The number of inhabitants and employees per transit node was calculated by making use of ArcGIS (Gemeente Rotterdam, 2014a; Gemeente Rotterdam, 2014b). Because the municipality does not have access to data concerning visitor numbers, this data was collected manually by making use of a map and the estimation calculation that was used in the application of the model on transit nodes in Noord-Holland (Vereniging Deltametropool, 2013c). Similar to the previously mentioned source only facilities with a visitor rate of over 30.000 per year were considered. The sub criterion intensity is based on the same data. For the sub criterion mixture, the calculation should be made per square of 100x100m. Unfortunately, this data was not available. Because of this, the calculation was made with the available data of inhabitants and employees.

6.4.3 Experience value

In order to collect the necessary data for the experience value, all 32 transit nodes were visited. During the visits, different aspects of the experience value were checked and aspects such as stores, restaurants and supermarkets were counted. Photographs were taken at each transit node for later reference.

6.5 Multi Criteria Analysis

6.5.1 Calculation

In order to calculate the public transport criterion of the node value, several data needs to be collected concerning the different types of transportation that connect the transit node with the network (Equation 3.3). When there is a tram connection a score of 25 is given. However, in Rotterdam there is a TramPlus connection, which means that there are several tram lines that have priority at intersections and have a higher average speed. To make a difference between these two types of trams, it was decided in consultation with the municipality to give a score of 30 to a TramPlus connection.

In order to calculate the intensity criterion of the place value, the number of inhabitants, employees and visitors must be divided by the influence area (Equation 3.7). The influence area is interpreted differently by the applications of the node-place model. Zuidvleugel Stedenbaanplus (2013a, 2013b) have set the influence area to 1200 meters. Overlapping influence areas were cut in half and divided. The application of the Vereniging Deltametropool (2013) on the Rotterdam Urban Region have set the influence area at 800 meters for both train and metro stations. Also here, overlapping influence areas were divided. Several solutions were considered, but because the intensity criterion describes the density of the area, the difference would not be big. Also, because the equations of the other criteria of the place value use 1200 meters as area, this is assumed for the intensity criterion as well. Finally, because the selected transit nodes are relatively close to each other it was decided to ignore overlap of the influence areas.

6.5.2 Quality of transit nodes

By applying the method to the selection of transit nodes, the current quality can be measured. The results of the MCA can be seen in Table 6-2. In order to gain more knowledge about the quality of the transit nodes and the different characteristics that contribute to this, the results of the MCA will be analysed.

Node value

From the selection of 32 transit nodes, Schiedam Centrum has the highest node value (Figure 6-8). This is notable, because perhaps it could be expected that Rotterdam Centraal would be the highest. However, the node value is based on the accessibility by slow traffic and roads as well. Rotterdam Centraal has a higher score on the criterion public transport, but a lower score on slow traffic and roads. The location of Schiedam Centrum near the highway and the city centre has led to a high score on these two criteria and to the high node value.

Figure 6-8: Schiedam Centrum

Maashaven and Wilhelminaplein have the lowest node value. The transit nodes have a low score on all criteria, but Maashaven scores specifically low on roads and Wilhelminaplein on slow traffic. The low node value can be explained by the situation of the transit nodes near the river Nieuwe Maas. Because the transit nodes are surrounded by water there are fewer possibilities for cars and/or bicycles to access.

The transit node that has the highest accessibility for slow traffic is Slinge. This can be explained because Slinge is situated in a residential neighbourhood. Because of this, it is easy for cyclists and pedestrians to access the transit node.

Multiple transit nodes have a high score on the criterion slow traffic. As mentioned, Wilhelminaplein scores very low on this aspect because of its location near the river. Vijfsluizen, Dijkzigt and Kralingse Zoom also have a low accessibility for slow traffic which can be explained because they are situated in industrial areas with large buildings and few roads.

As mentioned, Rotterdam Centraal has the highest score on the criterion public transport. This does not come as a surprise, as it is the largest transit node in the selection and the station is connected by all possible modes of public transportation.

There are many transit nodes in the selection that have a low public transport value. The transit nodes that have the worst accessibility by public transport are Vijfsluizen, Rotterdam Noord and Schenkel. Even though Rotterdam Noord is connected by sprinter, tram and bus, the frequency of the sprinters and buses are quite low. Vijfsluizen and Schenkel are connected by metro and buses but also with a low frequency.

Transit nodes that are the best accessible by road are Schiedam Centrum and Kralingse Zoom. Both are situated next to the highway, have highway exits nearby and are connected by multiple regional roads. Also, the transit nodes are facilitated with a park+ride which contribute to the car accessibility.

Maashaven has the lowest score on the criterion roads. This is caused by the location of the transit node in the city and next to the river. On top of that,

Table 6-2: Quality of transit nodes

Transit node	Node value				Place value				Experience value			
	Slow traffic	Public transport	Roads	Average	Proximity	Intensity	Mixture	Average	Comfort	Ambient elements	Social elements	Average
Beurs	0.6	0.7	0.2	0.5	0.2	0.7	1.0	0.6	0.7	0.7	1.0	0.8
Capelsebrug	0.1	0.4	0.3	0.3	0.1	0.1	0.3	0.1	0.3	0.4	1.0	0.4
De Akkers	0.5	0.0	0.2	0.3	0.5	0.1	0.0	0.2	0.2	0.7	1.0	0.3
Delfshaven	0.4	0.2	0.3	0.3	0.2	0.3	0.2	0.2	0.4	0.7	1.0	0.5
Dijkzigt	0.0	0.2	0.5	0.2	0.3	0.6	0.6	0.5	0.5	0.4	1.0	0.6
Eendrachtsplein	0.2	0.3	0.5	0.3	0.0	1.0	1.0	0.7	0.4	0.4	1.0	0.5
Graskruid	0.3	0.0	0.3	0.2	0.0	0.2	0.8	0.3	0.0	0.4	0.0	0.0
Heemraadlaan	0.4	0.2	0.3	0.3	0.1	0.2	0.1	0.1	0.2	0.5	1.0	0.3
Hoogvliet	0.8	0.1	0.5	0.5	0.1	0.1	0.2	0.1	0.2	0.6	1.0	0.3
Kralingse Zoom	0.0	0.3	1.0	0.4	0.1	0.1	0.8	0.3	0.3	0.5	1.0	0.4
Leuvehaven	0.3	0.3	0.2	0.3	0.0	0.9	0.7	0.5	0.5	0.6	1.0	0.5
Maashaven	0.2	0.2	0.0	0.1	0.4	0.4	0.2	0.3	0.2	0.9	1.0	0.4
Marconiplein	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.5	0.5	1.0	0.6
Oosterflank	0.5	0.1	0.2	0.3	0.2	0.2	0.6	0.3	0.0	0.7	0.0	0.1
Oostplein	0.4	0.2	0.3	0.3	0.0	0.8	0.3	0.4	0.4	0.4	1.0	0.5
Poortugaal	0.5	0.0	0.6	0.4	0.1	0.1	0.4	0.2	0.2	0.6	1.0	0.3
Rotterdam Alexander	0.2	0.4	0.5	0.4	1.0	0.1	0.6	0.6	0.3	0.4	1.0	0.3
Rotterdam Blaak	0.7	0.5	0.3	0.5	0.2	0.9	0.8	0.6	0.5	0.3	1.0	0.5
Rotterdam Centraal	0.3	1.0	0.5	0.6	0.1	0.9	0.6	0.5	1.0	1.0	1.0	1.0
Rotterdam Lombardijen	0.6	0.3	0.5	0.5	0.7	0.1	0.4	0.4	0.6	0.6	1.0	0.6
Rotterdam Noord	0.1	0.0	0.7	0.3	0.2	0.2	0.1	0.2	0.0	0.0	0.0	0.0
Schenkel	0.3	0.0	0.5	0.3	0.1	0.1	0.2	0.1	0.0	0.6	0.0	0.1
Schiedam Centrum	0.5	0.5	1.0	0.7	0.2	0.2	0.4	0.3	0.4	0.8	1.0	0.5
Schiedam Nieuwland	0.2	0.0	0.6	0.3	0.5	0.1	0.2	0.3	0.0	0.3	0.0	0.0
Slinge	1.0	0.2	0.4	0.5	0.5	0.0	0.1	0.2	0.2	0.8	1.0	0.3
Spijkenisse Centrum	0.6	0.4	0.4	0.4	0.4	0.1	0.3	0.3	0.2	0.7	1.0	0.3
Stadhuis	0.5	0.2	0.3	0.3	0.1	0.8	0.7	0.5	0.4	0.7	1.0	0.5
Vijfsluizen	0.0	0.0	0.5	0.2	0.4	0.0	0.6	0.3	0.3	0.8	1.0	0.4
Vlaardingen Oost	0.5	0.0	0.5	0.3	0.1	0.0	0.4	0.2	0.4	0.0	1.0	0.4
Voorschoterlaan	0.3	0.2	0.2	0.2	0.3	0.2	0.3	0.2	0.4	0.6	1.0	0.5
Wilhelminaplein	0.0	0.3	0.1	0.1	0.2	0.3	0.5	0.4	0.4	0.7	1.0	0.5
Zuidplein	0.4	0.6	0.3	0.4	0.4	0.3	0.2	0.3	0.3	0.4	1.0	0.4

there are no parking places at the transit node.

Place value

Eendrachtsplein has the highest place value of the selection of transit nodes. The transit node has the highest score on criteria intensity and mixture, but scores very low on proximity. This means that the density of inhabitants and employees is high, but also the mixture between inhabitants, employees and visitors. The proximity is low which indicates that the transit node is not the centre of the area, which is correct because housing, companies and facilities are widely spread.

Figure 6-9: Eendrachtsplein

Heemraadlaan has the lowest place value, closely followed by Hoogvliet, Capelsebrug and Schenkel. Heemraadlaan, Hoogvliet and Schenkel are situated in residential areas with a low density. This results in a low place value because there is very little mixture, low intensity and low proximity. Capelsebrug has a low intensity and low proximity as well, but because it is situated in an industrial area close to a residential neighbourhood the mixture is slightly higher.

The transit node with the highest proximity is Rotterdam Alexander which is caused by the presence of a shopping mall, schools and companies within 300 meters of the node. At a further distance from the node, there are residential areas. Rotterdam Alexander is the centre of the area and has a high proximity. Graskruid has the lowest proximity of all selected transit nodes. This can be explained because Graskruid is situated in a residential area with several companies nearby. As soon as travellers arrive at Graskruid they spread across the area to their destination.

As mentioned, Eendrachtsplein has the highest intensity. Eendrachtsplein is situated in the city centre with high density. Besides houses and companies, there is a range of facilities such as schools, museums, shopping, etc. Because of this, there is a high intensity in the area.

Several transit nodes have a low score on the criterion intensity such as Vijfsluizen, Vlaardingen Oost and Slinge. The area around Vijfsluizen houses a lot of companies, few houses facilities. Vlaardingen Oost and Slinge are situated in residential areas with few companies and no facilities. The density in these areas is low which leads to a low intensity.

The mixture at Eendrachtsplein is the highest, closely followed by Beurs. Both transit nodes are situated in the city centre with many houses and companies. Because there is a high number of both inhabitants and employees, the mixture is high.

De Akkers has the lowest mixture, which can be explained because it is situated in a residential area. Although there is a small shopping centre, there are mostly inhabitants in the area.

Experience value

Rotterdam Centraal has the highest experience value of the 32 transit nodes (Figure 6-10). The station was completed in 2014 and as mentioned in the introduction (Section 1.1), a lot of attention has been paid to the experience of

Figure 6-10: Rotterdam centraal

Rotterdam Noord had the lowest experience value (Figure 6-11), closely followed by Schiedam Nieuwland and Graskruid (Figure 6-12 and Figure 6-13). All three transit nodes have a low score on comfort and social elements. Rotterdam Noord scores low on ambient elements as well, whereas the other two stations score slightly higher.

Figure 6-11: Rotterdam Noord

Figure 6-12:SchiedamNieuwland

Figure 6-13: Graskruid

Based on the survey, comfort is the most important according to the respondents (0.85) (Section 5.1). As mentioned, Rotterdam Centraal has the highest score on this criterion. There is heated and sheltered waiting, travellers can read a free newspaper, make use of the Wi-Fi or look at one of the television screens. Also, there are restaurants, stores and toilets at the station. The presence of these aspects have resulted in a high score on the criterion comfort.

The transit node with the lowest score on comfort is Rotterdam Noord. Other transit nodes that scored low on this criterion are Schiedam Nieuwland, Graskruid, Schenkel (Figure 6-14) and Oosterflank (Figure 6-15). Rotterdam Noord and Schiedam Nieuwland are train stations with few facilities. Travellers have to wait outside and there it is hardly possible to be distracted during the wait. Graskruid, Schenkel and Oosterflank are metro stations with no facilities.

Figure 6-14: Schenkel

Figure 6-15: Oosterflank

As mentioned, Rotterdam Centraal has the highest score on the criterion ambient elements. This is because it has the one of the most preferred types of architecture - modern-classic - and is most recently renovated. Rotterdam Noord and Vlaardingen Oost have the lowest score, mainly because the stations are very old and in need of a renovation.

The criterion social elements is only based on one aspect; the presence of personnel. This means that the transit nodes could either score a 1 or a 0 on this criterion. There are many stations where personnel is present, mostly on the bigger stations and underground metro stations. Stations where there is no personnel are smaller and mostly outside.

6.5.3 Potential of transit nodes

There is a lot of variation in the current quality of the transit nodes. However, not every transit node needs to meet the same demands. By classifying the nodes into different typologies, it can be indicated for which criteria the transit nodes can be improved. The classification is based on the current situation and ambitions for the near future (Table 6-1).

The results of the MCA for each transit node are compared with the corresponding typologies (Table 6-3). This way, it can be seen on which criteria the transit nodes meets the target level set by the typology, and on which criteria improvements are needed. In order to determine how to prioritize the transit nodes are ranked by means of the possible improvements. In Part B an overview of all transit nodes can be found.

All transit nodes need improvements in order to meet the target set by the typologies. Below, several of the worst and best scoring transit nodes according to the typologies are discussed as well as some notable aspects.

Zuidplein - Metropolitan centre

The transit node where most improvements are needed to meet the targets set by the typology is Zuidplein. Figure 6-17 and Figure 6-18 give an impression of the transit node Zuidplein. Zuidplein was classified in the typology *metropolitan centre*, which means that it is a transit node that is connected with other parts of the Randstad and is located in the city. Several buses connect Zuidplein with Zeeland and there is a metro line that runs to the Hague. However, it can be seen that Zuidplein does not meet the targets set by the typology at all (Figure 6-16). In order to become a *metropolitan centre* all strategies need to be applied.

Most attention should be paid to condensing because the potential for place value is the highest. Improvements should be made on all criteria; proximity,

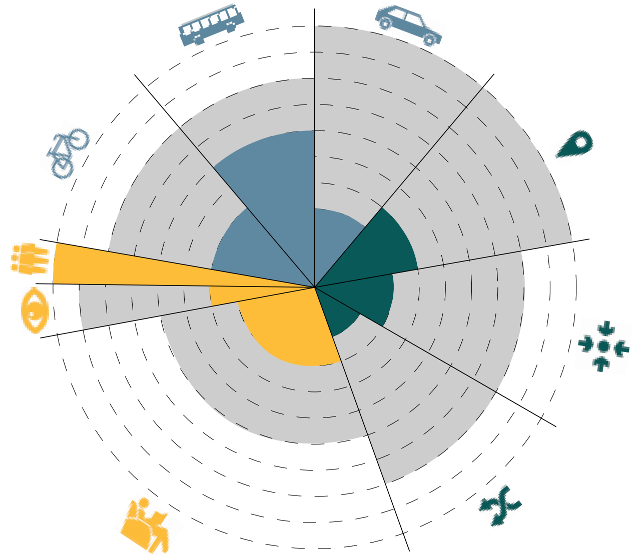


Figure 6-16: Zuidplein

intensity and mixture. The low proximity indicates that Zuidplein can become more the centre of the area. This can be done by creating more facilities closer to the transit node. The low intensity indicates that there is room for more housing, companies and facilities in the area. The collected data shows that there are many more residents than employees, which leads to the low mixture. This can be improved by creating more jobs in the area.

Acceleration can be accomplished when there is a smoother transfer between different modes. The accessibility by slow traffic can be improved by creating more bicycle parking facilities. There are very few local roads for the cyclist or pedestrian to access the transit node, but it is hard to change this. Only small improvements have to be made to public transport, but according to the typology there is enough demand for extensions of the network provided that the intensity improves as well. Also, the accessibility by road should be improved significantly. The score is mainly low because there is no highway exit within 1200m, but this is cannot be easily changed. What can be changed

Table 6-3: Potential of transit nodes

Transit node	Node value: Slow traffic	Node value: Public transport	Node value: Roads	Node value: Average	Place value: Proximity	Place value: Intensity	Place value: Mixture	Place value: Average	Experience value: Comfort	Experience value: Ambient elements	Experience value: Social elements	Experience value: Average	Total averages
Zuidplein	-0.4	-0.2	-0.7	-0.4	-0.6	-0.5	-0.6	-0.6	-0.3	-0.5	0.0	-0.3	**-1.3**
Rotterdam Alexander	-0.6	-0.4	-0.5	-0.5	0.0	-0.7	-0.2	-0.3	-0.4	-0.5	0.0	-0.3	**-1.1**
Spijkenisse Centrum	-0.2	-0.2	-0.4	-0.3	-0.4	-0.5	-0.5	-0.5	-0.4	-0.2	0.0	-0.3	**-1.1**
Rotterdam Blaak	-0.3	-0.5	-0.1	-0.3	-0.6	-0.1	-0.2	-0.3	-0.3	-0.7	0.0	-0.3	**-0.9**
Wilhelminaplein	-0.8	-0.3	-0.7	-0.6	-0.6	-0.3	0.1	-0.3	0.0	-0.1	0.0	0.0	**-0.9**
Rotterdam Centraal	-0.7	0.0	-0.5	-0.4	-0.9	-0.1	-0.4	-0.5	0.0	0.0	0.0	0.0	**-0.9**
Leuvehaven	-0.7	-0.5	-0.2	-0.5	-0.8	0.1	-0.3	-0.4	0.0	-0.1	0.0	0.0	**-0.8**
Capelsebrug	-0.7	0.1	-0.5	-0.4	-0.7	-0.2	-0.1	-0.4	0.0	-0.4	0.0	0.0	**-0.8**
Stadhuis	-0.5	-0.6	-0.1	-0.4	-0.7	0.0	-0.3	-0.3	0.0	-0.1	0.0	0.0	**-0.8**
Schiedam Centrum	-0.3	-0.1	0.2	-0.1	-0.6	-0.4	-0.4	-0.5	-0.2	-0.1	0.0	-0.2	**-0.8**
Oostplein	-0.4	-0.4	-0.5	-0.5	-0.8	0.2	-0.1	-0.3	0.0	-0.4	0.0	0.0	**-0.8**
Eendrachtsplein	-0.8	-0.5	0.1	-0.4	-0.8	0.2	0.0	-0.3	0.0	-0.4	0.0	-0.1	**-0.8**
Beurs	-0.4	-0.3	-0.2	-0.3	-0.6	-0.3	0.0	-0.3	-0.1	-0.3	0.0	-0.1	**-0.7**
Rotterdam Noord	-0.5	-0.3	0.3	-0.2	-0.2	-0.1	-0.3	-0.2	-0.2	-0.8	0.0	-0.3	**-0.7**
Vijfsluizen	-0.8	-0.3	-0.3	-0.5	-0.4	-0.3	0.2	-0.2	0.0	0.0	0.0	0.0	**-0.7**
Dijkzigt	-0.8	-0.4	-0.3	-0.5	-0.5	0.0	0.2	-0.2	0.1	-0.4	0.0	0.0	**-0.7**

Transit node	Node value: Slow traffic	Node value: Public transport	Node value: Roads	Node value: Average	Place value: Proximity	Place value: Intensity	Place value: Mixture	Place value: Average	Experience value: Comfort	Experience value: Ambient elements	Experience value: Social elements	Experience value: Average	Total averages
Schenkel	-0.3	-0.2	0.1	-0.2	-0.3	-0.1	-0.6	-0.3	-0.2	-0.2	0.0	-0.2	**-0.7**
Heemraadlaan	-0.2	-0.2	-0.1	-0.2	-0.3	-0.2	-0.7	-0.4	0.0	-0.3	1.0	-0.1	**-0.7**
Graskruid	-0.3	-0.3	-0.1	-0.2	-0.4	-0.1	0.4	-0.2	-0.2	-0.4	0.0	-0.2	**-0.6**
De Akkers	-0.1	-0.4	-0.2	-0.2	0.1	-0.3	-0.8	-0.4	0.0	-0.1	1.0	0.0	**-0.6**
Schiedam Nieuwland	-0.4	-0.3	0.2	-0.2	0.1	-0.2	-0.2	-0.1	-0.2	-0.5	0.0	-0.2	**-0.6**
Kralingse Zoom	-0.8	0.0	0.2	-0.3	-0.7	-0.2	0.4	-0.3	0.0	-0.3	0.0	0.0	**-0.6**
Rotterdam Lombardijen	-0.2	-0.3	-0.3	-0.3	-0.1	-0.5	0.0	-0.2	0.2	-0.2	0.0	0.0	**-0.5**
Oosterflank	-0.1	-0.1	-0.2	-0.1	-0.2	0.0	-0.2	-0.1	-0.2	-0.1	0.0	-0.2	**-0.5**
Hoogvliet	0.2	-0.1	0.1	0.0	-0.3	-0.1	-0.6	-0.3	0.0	-0.1	1.0	0.0	**-0.4**
Voorschoterlaan	-0.3	0.0	-0.2	-0.2	-0.1	0.0	-0.5	-0.2	0.2	-0.2	1.0	0.0	**-0.4**
Vlaardingen Oost	-0.1	-0.3	0.1	-0.1	-0.3	-0.3	0.0	-0.2	0.2	-0.7	1.0	-0.1	**-0.4**
Delfshaven	-0.2	0.0	-0.1	-0.1	-0.2	0.1	-0.6	-0.3	0.2	-0.1	1.0	0.0	**-0.4**
Maashaven	-0.4	-0.1	-0.4	-0.3	0.0	0.1	-0.2	-0.1	0.0	0.1	1.0	0.0	**-0.4**
Poortugaal	-0.1	-0.2	0.2	-0.1	-0.3	-0.1	-0.4	-0.3	0.0	-0.2	1.0	0.0	**-0.4**
Slinge	0.4	0.0	0.0	0.0	0.1	-0.2	-0.7	-0.3	0.0	0.0	1.0	0.0	**-0.3**
Marconiplein	-0.3	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	0.3	-0.3	1.0	0.0	**-0.3**

is the number of car parking places. There is a parking garage at Zuidplein, but it is not intended for public transport travellers. However, it can be questioned whether this is needed because Slinge, one metro stop from Zuidplein, has a P+R.

Figure 6-17: Zuidplein bus station

Figure 6-18: Zuidplein metro station

The experience value can be increased by improving comfort and ambient elements. Because comfort is more important than ambient elements (Section 5.1), it would be advised to first focus on heated waiting. Other aspects that improve the comfort at Zuidplein are television screens, Wi-Fi and a supermarket. The type of architecture at Zuidplein is homely which is above average, but the station has not been renovated since 1983. Therefore, it is advised to renovate the transit node and to use a classic type of architecture for the station (Section 5.1.2).

It can be concluded that many things have to be improved before Zuidplein becomes a well-functioning *metropolitan centre*. It is advised to first focus on meeting the targets for *regional centre.*

Rotterdam Alexander - Metropolitan centre

Rotterdam Alexander has the second highest priority of the selection of transit nodes. Figure 6-20 and Figure 6-21 give an impression of the transit node Rotterdam Alexander. Similar to Zuidplein, Rotterdam Alexander was classified in the typology *metropolitan centre* which means that it is a transit node that it that is connected with other parts of the Randstad and is located in the city. The transit node is situated in the east part of the city and is connected by train with other parts of the Randstad. The model in Figure 6-19 shows that Rotterdam Alexander does not meet the targets set by the typology. In order to become a *metropolitan centre*, all strategies need to be applied.

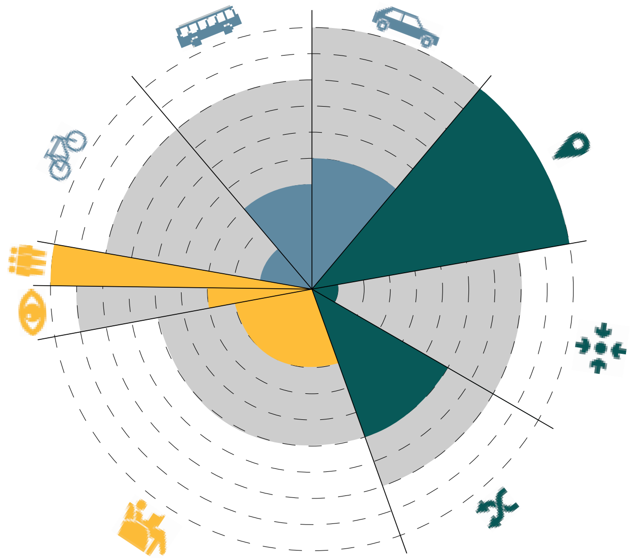


Figure 6-19: Rotterdam Alexander

Most attention needs to be paid to accelerating, because the potential for the node value is the highest. The accessibility by slow traffic needs to be improved because there are not enough local roads and there are not enough bicycle parking places. Creating more bicycle facilities is a measure that could be easily taken. The public transport value should increase as well as long it is in balance with the intensity. Finally, the road value is mainly low because there is no highway exit nearby, but also because there are not enough parking places.

The place value can be increased as well. The model shows that there is no need to further condense the area around the transit node, as the proximity is already quite high (Figure 6-19). This is a result of the shopping mall next to Rotterdam Alexander. The intensity should improve a lot before meeting the target of the typology. This can be done by attracting more visitors and creating more employment opportunities. These measures will also result in a higher mixture between inhabitants and employees.

Enhancing will lead to an increased experience value. It can be seen that comfort and ambient elements need to be improved in order to meet the targets of the typology. Aspects that could be improved are heated waiting, television screens, Wi-Fi, stores and restaurants. Ambient elements could be improved by renovating the station because it has not been renovated since 1983. While renovating the station should get a classic type of architecture because that type is most preferred.

Figure 6-20: Rotterdam Alexander train platform

Figure 6-21: Rotterdam Alexander station hall

Spijkenisse Centrum - Regional centre

The transit node that was ranked third on the list is Spijkenisse Centrum. Figure 6-23 and Figure 6-24 give an impression of transit node Spijkenisse Centrum. Spijkenisse Centrum is classified as a *regional centre*, which means that it is a transit node with regional facilities, situated in a city and connected with the region. Spijkenisse Centrum is situated in the centre of Spijkenisse and there is a metro connection with Rotterdam and several bus connections with other places in the region. Also, a hospital is situated nearby. The model in Figure 6-22 shows that improvements are needed in all areas in order for Spijkenisse Centrum to become a *regional centre*.

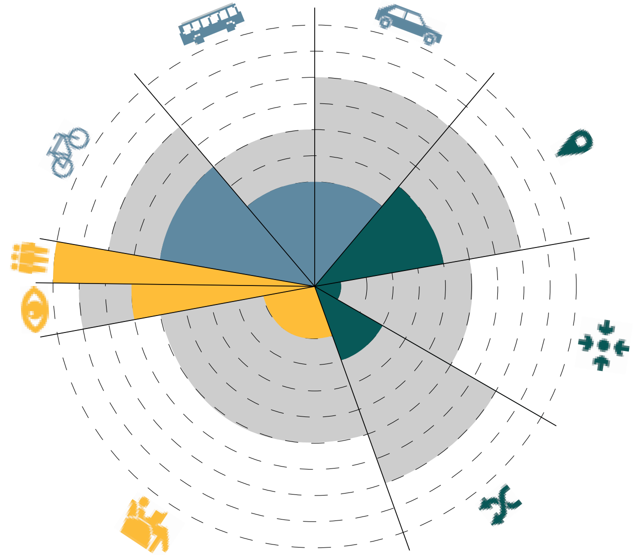


Figure 6-22: Spijkenisse Centrum

Most attention needs to be paid to condensing the transit node in order to increase the place value. Spijkenisse Centrum could become more condensed by increasing the intensity of the area. The model indicates that the intensity should become much higher by creating more housing, jobs and facilities in the area and preferably close to the transit node to further increase the proximity as well. The increase of employment possibilities would also contribute to a higher mixture in the area, because the number of residents is higher than the number of employees.

Figure 6-23: Spijkenisse Centrum metro platform

Figure 6-24: Spijkenisse Centrum station hall

The node value of Spijkenisse Centrum should increase in order to meet the target set by the typology. The accessibility of Spijkenisse Centrum by slow traffic is slightly below the target. The low value can be increased by creating more bicycle parking facilities. According to the model, the connection by public transport can be improved as well, as long as there is coherence with the intensity. The accessibility by road needs much improvement. The low value is caused by the absence of a freeway exit nearby and the low number of parking places. The latter could be increased more easily.

The experience value of Wilhelminaplein needs enhancement. The model shows especially comfort needs to be increased. Aspects that contribute to the enhancement are heated waiting, television screens, Wi-Fi, supermarket, stores and restaurants. The score for ambient elements almost meets target, therefore it is advised to focus on increasing the comfort before paying attention to the ambiance.

6.6 Evaluation method

6.6.1 Comparison with node-place model

In Table 6-3, the selection of transit nodes is ranked according to the potential that can be realized at each transit node compared to the corresponding transit node typologies. By comparing the priority list of the extended model with the priority list of the node-place model, the list changes significantly (Table 6-4).

Table 6-4: Comparison ranking of priorities

Model with experience value		Node-place model	
Transit node	**Potential**	**Transit node**	**Potential**
Zuidplein	-0.4	Zuidplein	-0.5
Rotterdam Alexander	-0.4	Wilhelminaplein	-0.4
Spijkenisse Centrum	-0.4	Rotterdam Centraal	-0.4
Rotterdam Blaak	-0.3	Leuvehaven	-0.4
Wilhelminaplein	-0.3	Rotterdam Alexander	-0.4
Rotterdam Centraal	-0.3	Capelsebrug	-0.4
Leuvehaven	-0.3	Oostplein	-0.4
Capelsebrug	-0.3	Spijkenisse Centrum	-0.4
Stadhuis	-0.3	Stadhuis	-0.4
Schiedam Centrum	-0.3	Vijfsluizen	-0.4
Oostplein	-0.3	Eendrachtsplein	-0.3
Eendrachtsplein	-0.3	Dijkzigt	-0.3
Beurs	-0.2	Heemraadlaan	-0.3
Rotterdam Noord	-0.2	Beurs	-0.3
Vijfsluizen	-0.2	Rotterdam Blaak	-0.3
Dijkzigt	-0.2	Schiedam Centrum	-0.3

Model with experience value		Node-place model	
Transit node	**Potential**	**Transit node**	**Potential**
Schenkel	-0.2	De Akkers	-0.3
Heemraadlaan	-0.2	Kralingse Zoom	-0.3
Graskruid	-0.2	Rotterdam Lombardijen	-0.2
De Akkers	-0.2	Schenkel	-0.2
Schiedam Nieuwland	-0.2	Rotterdam Noord	-0.2
Kralingse Zoom	-0.2	Graskruid	-0.2
Rotterdam Lombardijen	-0.2	Voorschoterlaan	-0.2
Oosterflank	-0.2	Maashaven	-0.2
Hoogvliet	-0.1	Schiedam Nieuwland	-0.2
Voorschoterlaan	-0.1	Delfshaven	-0.2
Vlaardingen Oost	-0.1	Hoogvliet	-0.2
Delfshaven	-0.1	Poortugaal	-0.2
Maashaven	-0.1	Vlaardingen Oost	-0.2
Poortugaal	-0.1	Marconiplein	-0.2
Slinge	-0.1	Slinge	-0.2
Marconiplein	-0.1	Oosterflank	-0.1

As discussed in the previous section, the priority list with the experience value included shows that Zuidplein is ranked first and Rotterdam Alexander and Spijkenisse Centrum second and third. The priority list of the node-place model without the experience value shows that Zuidplein is still ranked first, but Wilhelminaplein and Rotterdam Centraal second and third. It can be concluded that the node and place value of Zuidplein are very low compared to the typology, because even without the experience value the transit node has the highest potential for improvement. The Municipality of Rotterdam has stated that there are already plans to redevelop Zuidplein and Rotterdam Alexander which are high on the priority list of the new method. There are also plans to redevelop Rotterdam Blaak which is ranked fourth on the priority list of the new method, whereas the transit node is positioned fifteenth on the list of the node-place model. From these results can be concluded that the priority list of the new method is more accurate.

6.6.2 Rotterdam Centraal

Because Rotterdam Centraal is one of the transit nodes that was recently renovated and where more attention was paid to the experience value, the current quality is compared with the quality of the transit node before the renovation. By making a comparison between the two situations, the influence of the experience value can be demonstrated.

Figure 6-25: Rotterdam Centraal in 1957 (Feijenoordse Meesters, 2015)

Figure 6-26: Rotterdam Centraal in 2014

In 1957, the old Rotterdam Central station was completed. Before the renovation started in 2004, the old station was home for tramps, addicts and drug dealers. The old station was a place travellers avoided being at night. Since the renovation inhabitants of Rotterdam are proud of their station and tourists can be seen taking pictures of the station daily.

Because the station was recently completed, a growth of performance indicators could not yet be detected. However, by comparing the models it can be seen that most changes have been made to the experience value. The node and place value are more or less the same, but the experience value has grown enormously. The station as well as the area around the station have gone through a major change. Hence, it can be concluded that the experience value has a significant influence on the way customers perceive a transit node.

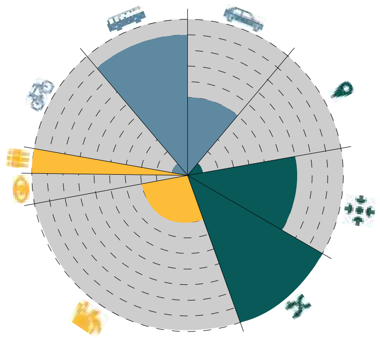


Figure 6-27: Rotterdam Centraal 2004

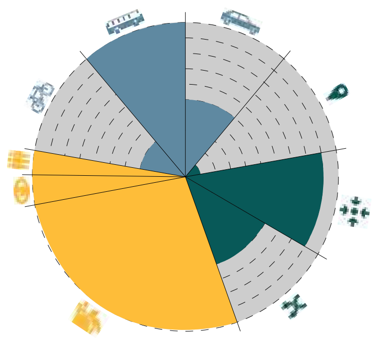


Figure 6-28: Rotterdam Centraal 2014

6.6.3 Remarkable aspects

Several aspects that emerged from the analysis are remarkable and will be discussed in this section. First of all, it can be seen that not one of the transit nodes meets the targets of its corresponding typology. This could either mean that the selected transit nodes all function below standard or that a closer look must be taken to the typologies. The typologies initiated by Vereniging Deltametropool (2013b) were originally intended for train stations. In this case study, the typologies are also used for metro stations. Although the score for a sprinter and metro is equal (Section 3.2.2), the characteristics of both types of stations could differ. It might be that the typologies need to be changed in order to be applicable for both train- and metro stations.

Besides Hoogvliet and Slinge, the accessibility by slow traffic should be improved for all transit nodes. The slow traffic variable consists of the number of local roads in a circle of 300 meters around the transit node and the number of bicycle parking places. From the collected data it can be concluded that the number of bicycle parking places is too low for all transit nodes. Hence, it is advised to pay more attention to the bicycle facilities at transit nodes.

It can be seen that the model indicates that the public transport value can be increased for most transit nodes. As explained, there should be balance between the node and place value for the transit node to function well, especially between intensity and public transport (Vereniging Deltametropool, 2013b). Therefore, when the method indicates that there is room for an increase of the public transport value, the intensity should be at the same level. There should be enough public transport demand for the public transport operator to exploit. Therefore, it is advised to take the intensity into account when increasing the public transport value and the other way around.

Wilhelminaplein is ranked fifth of the 32 transit nodes on the priority list (Table 6-3), which is unexpected because according to the municipality it is a well-functioning transit node. One of the main reasons Wilhelminaplein is ranked so high is the low score on the node value. Especially the road and slow traffic accessibility should be improved. However, because of the unfavorable location of Wilhelminaplein next to the Nieuwe Maas, it is almost impossible to improve this. It is advised to take a closer look at the situation and try to find a solution.

6.7 Conclusions

In this chapter, the developed method is applied on a selection of transit nodes in the Rotterdam Urban Region. After giving some background information about Rotterdam and elaborating on the interests of the Municipality of Rotterdam, the method is applied according to the steps explained in Section 5.4. First, in consultation with the municipality a selection of 32 transit nodes was made and classified in typologies. Second, data was collected for the node, place and experience value and scored. After this, the MCA was executed and the quality of the transit nodes was assessed. Before comparing the results with the typologies, the results were analysed in order to provide insight into the different characteristics of the transit nodes that contribute to the transit node quality. Finally, the results were compared with the typologies to indicate the potential that can be realized at each transit node. The outcome was prioritized according to the improvements that have to be made for the transit node to function to its full potential. The three transit nodes with the highest priority are Zuidplein, Rotterdam Alexander and Spijkensise Centrum.

The method was evaluated by looking at several aspects. The priority list of the new method was compared with the priority list of the the node-place model which shows signifant differences. The transit nodes that are already on the priority list of the Municipality of Rotterdam are ranked higher in the list of the new method than the list of the node-place model. It can be concluded that the priority list of the new method is more accurate. In order to demonstrate the contribution of the experience value, the method is applied on Rotterdam Centraal in 2004 and 2014. Before the renovation, the station was home for tramps, addicts and drug dealers, whereas after the renovation the station attracts tourists and the inhabitans of the city are proud of their station. The application of the method shows a similar node and place value, but the experience value has grown enormously. The experience value has a significant influence on the way customers perceive a transit node. Based on these findings, it can be concluded that the new method performs better than the node-place model and that the experience value contributes to the transit node quality.

7 Conclusions and recommendations

In this research, the existing node-place model was extended with the experience value to assess the quality of transit nodes and indicate the potential. The original model only took the node and place value into account to measure the quality (Bertolini, 1999; Vereniging Deltametropool, 2013b). However, it is hypothesized that the experience value has an impact on the transit node quality as well. Therefore, the experience value is included in the method.

In order to be able to add the experience value to the method, first it was investigated what the experience value entails. Based on literature, criteria for the experience value were set. Second, weights were determined for the criteria by means of an MCDM, the Best-Worst Method (Rezaei, 2015a). The data for BWM was obtained by conducting a survey. Finally, the node-place model was extended with the experience value and applied to a selection of transit nodes in the Rotterdam Urban Region. The method was evaluated by comparing results of the new method with results of the node-place model.

In this chapter, the conclusions of the research will be presented in section 7.1. Subsequently, the recommendations are discussed in section 7.2.

7.1 Conclusions

For this study, the following main research question is formulated:

How can the node-place model be extended with the traveller's experience in order to assess the quality of transit nodes and indicate the potential?

The main question was divided in multiple sub questions that were answered throughout the research. Below, the sub questions will be shortly discussed after which the main research question is answered.

7.1.1 Conclusions sub questions

1. What steps should be taken to obtain a modal shift from car towards public transport?

Because in the Netherlands congestion and pollution are increasing, a modal shift from car towards public transport is desired. By increasing the satisfaction of public transport customers a modal shift can be obtained. Public transport services can increase customer satisfaction by improving their quality, but only if this is accompanied by policies to persuade people to make use of public transport. This research focuses on improving the quality of a public transport journey.

2. How can public transport be made more attractive?

A public transport journey has a bad image because it has more components than a journey by car. Also, the transfer is an unwanted interruption in a public transport journey and valued the least because people have to wait. The transport service quality increases when the customers' needs are satisfied. During a transfer, moving travellers prefer speed, convenience, comfort and experience, whereas waiting travellers prefer the needs in opposite order. This means that during a transfer all customer needs should be satisfied. Hence, value must be added to the least valued part of the public transport journey, the transfer, by focusing on satisfying the customers' needs.

3. What measures can be taken to add value to the time spent at transit node during the transfer?

Three strategies are proposed to add value to the transfer: accelerating, condensing and enhancing. Each strategy satisfies different customer needs and must be applied in different areas of a transit node: the transfer area, the transit area and the transit node environment. Only when all strategies are applied simultaneously a significant growth of the performance indicators can be detected. In order to know which strategy must be applied where, it must be known what the current quality of a transit node is.

4. What applications of the node-place model are available to assess the quality of transit nodes and indicate the potential that can be realized?

In order to determine the quality of transit nodes, transit node models are used. In the Netherlands, different applications of the node-place model are in use. By analysing the node and place characteristics of a transit node, the quality is determined. The theory behind the model implies that when the node and place value are coherent the transit node functions well. A Multi Criteria Analysis (MCA) is used to calculate the node and place value in order to assess the quality. Transit nodes are classified in twelve different types to provide insight into the potential that can be realized at each node. The node-place model only identifies the potential of the transfer area and transit node area, but not in the transit node environment. Hence, it cannot be determined where enhancement is needed, which has a big influence on the customer satisfaction. Also, accelerating satisfies customer need speed and condensing satisfies customer need convenience. Therefore, the model should be extended with a third value to illustrate the influence of enhancing the transit node environment and to satisfy the customer needs comfort and experience: the experience value.

5. What criteria contribute to the experience value and how important are they?

A literature study was conducted to determine the criteria that are part of the experience value (Section 4.3). The Best-Worst Method (BWM) was used to determine the weights of the criteria by comparing the best and worst criterion with the other criteria. Data for BWM was collected by conducting a survey and asking 160 respondents to determine the best, worst and their preferences compared to the others. This was done for each set of main criteria. By multiplying the local weights of the sub criteria with the weights of the main criteria, the global weights were derived (Section 4.4).

6. How can the experience value be calculated and what is the influence on the transit node quality?

Similar to the calculation of the node and place value, data needs to be collected in order to calculate the experience value. The data must be collected objectively and easily. Because there is currently not enough information about the intangible aspects of the experience value to measure them objectively, it was decided to exclude the subjective criteria from the method. By multiplying the scores of the objective criteria with the corresponding weights, the experience value can be calculated. Before, the node and place value had an equal share in the transit node quality. Based on interviews and conclusions from theory, it was decided to assume that the experience value has an equal share as well.

7. How can the potential of the experience value be indicated?

The potential of the node and place value can be indicated by comparing the current quality of transit nodes with the corresponding transit node typologies. From literature can be concluded that the transit node quality is high when the traveller's experience matches his expectations. Hence, the potential of the experience value was based on the expectations of travellers.

7.1.2 Conclusions on the main research question

Answering sub questions 1 to 4 has provided more insight into why the node-place model has to be extended with the experience value. Sub questions 4 to 7 represent the stepwise extension of the node-place model with the experience value. Here, the main research question will be answered.

The node-place model was extended with the experience value by first taking a closer look at the node-place model which is based on the theory that the node and place value should be coherent for the transit node to function well. The node and place value are calculated by means of an MCA. The collected data for the criteria are scored and after that multiplied with the weights. Because the weights of the sub criteria are equal and the share of the node and place value as well, there is no need to multiply. Because different transit nodes have different characteristics, transit node typologies are used to indicate the potential that can be realized at each type of transit node.

A literature study was used to determine what criteria are part of the experience value. The main criteria are comfort, station organisation, ambient elements and social elements. The weights of the main- and sub criteria were obtained by using a Multi Criteria Decision Making (MCDM) method, the Best-Worst Method (BWM). The data for BWM was obtained by conducting a survey among 160 respondents. In order to quantify the experience value, data needs to be collected objectively and easily. Therefore, it was decided to only include the objective sub criteria of the experience value. Because of this only comfort, ambient elements and social elements were included in the method. Figure 7-1 shows the sub criteria with corresponding weights.

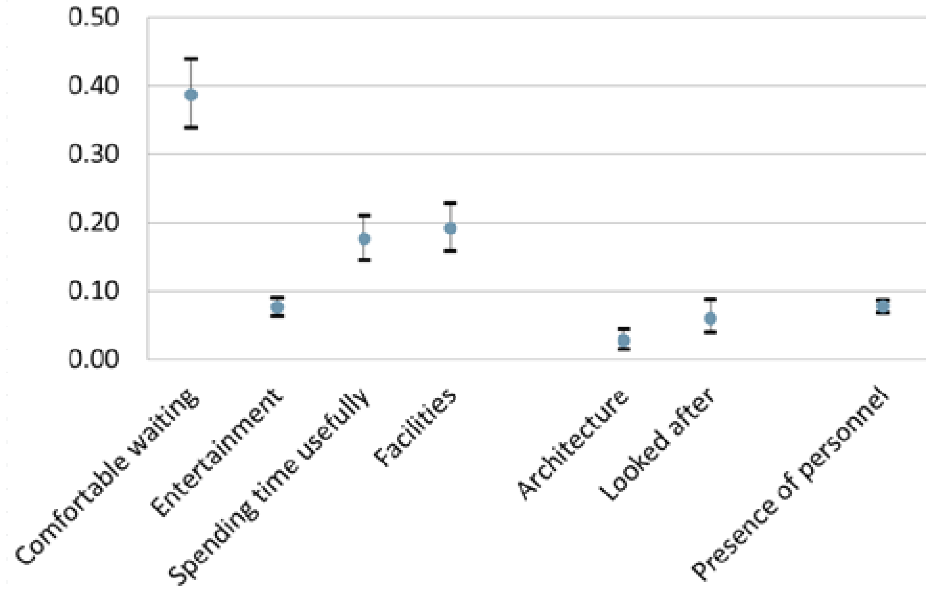


Figure 7-1: Weight intervals objective sub criteria

In order to extend the node-place model with the experience value, it had to be determined what the share of the experience value on the transit node quality is. Based on interviews and literature, it was decided to assume that the three values have an equal share. As a result, the quality of transit nodes could be assessed. Figure 7-2 shows the result of the extension of the node-place model with the experience value.

However, the potential of the transit nodes could not be indicated because the transit node typologies were only applicable for the node and place value. Together with the public transport operator RET and the Municipality of Rotterdam, the potential of the experience value was determined based on the expectations of customers. Table 5-5 shows the transit node typologies for the new method.

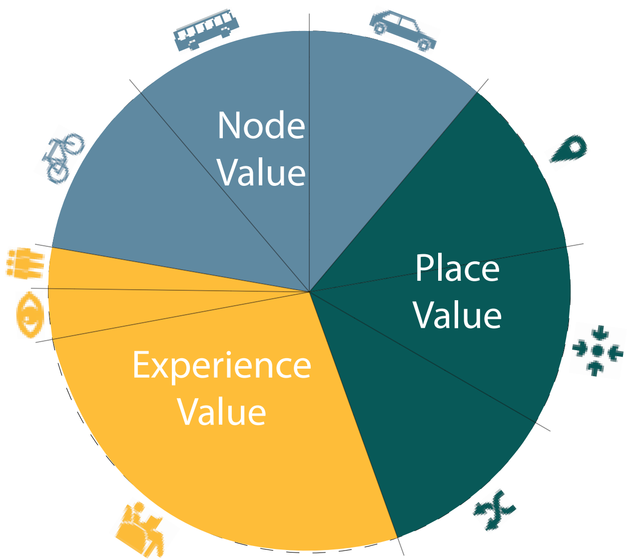


Figure 7-2: Model extended with the experience value

Finally, the method can be applied to transit nodes in the Netherlands. Below, the different steps of the method are shown.

Step 1: Make a selection of transit nodes

The method needs to be applied on a set of transit nodes. It is advised to apply the method on a comprehensive selection of transit nodes. Because the quality of a transit node is based on best and worst transit node in the selection, it is vital to select multiple transit node with different strengths and weaknesses. Only this way, conclusions can be drawn from the results.

Step 2: Classify the transit nodes

The selection of transit nodes needs to be classified according the typologies in Table 5-5. After the current transit node quality is calculated, the typology indicates what can be improved to the transit nodes. The classification is based on the current situation and/or ambitions of policy makers.

Step 3: Collect the data

In order to calculate the node, place and experience value, data needs to be collected and scored. What data needs to be collected and how to score can be found in Sections 3.2.2, 3.2.3 and 5.1.2.

Step 4: Execute the MCA and assess the quality

When the data has been collected and the scores are given, it is possible to execute the MCA. First, the scores for the experience value have to be multiplied with the corresponding weights that were derived from the survey. The weights for the experience value can be found in Section 5.1.3. Now, the quality can be assessed.

Step 5: Compare with typologies

Even though the quality of the transit nodes is now known, not every transit node needs to have the same quality. Transit nodes in a network should complement each other, instead of compete with each other. That is why the transit nodes were classified in typologies (Table 5-5). Every typology has a target for the transit node to meet which represents a situation when the transit node performs the best. By comparing the outcome of the MCA with the targets set by the typologies, the potential that can be realized for each transit node is indicated. Based on the potential strategies can be determined in order to improve the transit nodes and increase customer satisfaction.

In this research, the model was applied to 32 transit nodes in the Rotterdam Urban Region. The method was evaluated by comparing results of the new method with results of the node-place model which will be further discussed in Section 7.1.3.

7.1.3 Contribution of the method

The research has resulted in a method that can be used to assess the quality of transit nodes and provide insight into what improvements are needed.

The node-place model only indicates where it is needed to accelerate and condense. By extending the node-place model with the experience value, it can also be determined where enhancement is needed. According to Vaessens (2005), only a growth of the performance indicators can be detected when all three strategies are applied. This means that when applying the new method and applying the strategies, the performance of transit nodes will increase in terms of travel demand, customer opinions, retail turnover and real estate profits.

Applying the three strategies adds value to the time travellers spend at a transit node (Peek & van Hagen, 2002). Accelerating makes the transfer time shorter, condensing decreases the need to transfer and enhancing improves the waiting time in order to make it feel shorter. By adding value to the transfer, the least valued part of a public transport journey is improved. This means that the overall quality of a public transport journey increases. By improving the public transport journey the customer satisfaction increases (STIMULUS, 1999). This is the first step in the right direction into obtaining a modal shift from car towards public transport.

In this research, more knowledge was gained about the experience value. The experience value was a rather vague term that changes through time and is not the same in each region (Dammers et al., 2005). Now more insight is provided into the experience value. Because the knowledge is based on Dutch literature, the method is most suitable for transit nodes in the Netherlands.

The method was applied on the Rotterdam Urban Region where it could be clearly detected that the experience value contributes to the node-place model. The comparison of the priority ranking of the node-place model and the new method shows that the ranking has changed, which implies that adding the experience value has made a difference. The ranking of the new method is more similar to the priorities from the Municipality of Rotterdam than the ranking of the node-place model. This means that the new method is more accurate than the node-place model.

Also, a closer look was taken to Rotterdam Central station, because it was recently completed and much attention was paid to the experience of travellers. There is a significant difference in the way the old station was perceived compared to the new station. The application of the method on the station in 2004 and 2014 shows that the node and place value has not changed much. On the other hand, the experience value has changed significantly. It can be concluded that the experience value changes the way travellers perceive the station and contributes to the transit node quality.

Based on these findings, it can be concluded that the extension of the node-place model with the experience value contributes to the existing knowledge about the experience value as well as to the quality of public transport. Applying the method will increase the quality of public transport because it indicates where the three strategies need to be applied in order to improve the least valued part of a public transport journey, the transfer.

7.2 Recommendations

7.2.1 Recommendations for application of the method

It is recommended to use the developed method in order to gain insight in the current quality of transit nodes and the potential that can be realized. The main purpose of the model is that it can function as a tool for policy makers to discuss about possible improvements of transit nodes and public transport in general. Hence, it is recommended to policy makers to use the method as a guideline.

The case study has shown that the results of the method are highly dependent on the selection of transit nodes that is made by the user of the method. Because the scores of the transit nodes are normalized, the value for each transit node depends on the best and worst transit node in the selection. Therefore, it is recommended to select a diverse and large group of transit nodes.

The potential that can be realized at each transit node is based on the comparison between the current quality and the transit node typology. The case study has shown that it is quite hard to classify the transit nodes. It is recommended to classify the transit nodes with a diverse group of people. Because the classification is based on the current situation and the ambitions of the policy maker, the classification is influenced by the ambitions. Therefore, it is recommended to classify the transit nodes with a diverse group to have the most suitable outcome.

The transit node typologies are designed in such a way that the different types complement each other. Therefore, it is recommended to make a selection of transit nodes that are situated in the same network. That way, the transit nodes can complement each other instead of compete.

7.2.2 Limitations and recommendations for further improvement of the method

Experience value

In order to quantify the experience value it had to be possible to collect the data objectively and easily. Due to a lack of literature on the subjective sub criteria, it was not possible to collect data for these sub criteria objectively and easily. Therefore, it was decided to exclude the subjective sub criteria from the method. More research should be done to the subjective sub criteria before being able to collect the data objectively and easily. After that, the subjective sub criteria can be added to the method in order to give a better representation of the experience value.

Node and place value

In the original method to calculate the node and place value, the criteria all have equal weights (Vereniging Deltametropool, 2013c). Because the node and place value are out of the scope of this research, it was assumed that this is correct. However, it is recommended to research this because it cannot be concluded from literature how these weights were determined.

In the case study, the method was applied on a selection of 32 transit nodes in the Rotterdam Urban Region. Among the selected transit nodes were both train- and metro stations. However, in order to calculate the intensity criterion of the place value, the number of inhabitants, employees and visitors must be divided by the influence area (Equation 3.7). Different applications of the node-place model use a different size for the influence area. Several solutions were considered, but because the intensity criterion describes the density of the area, the difference would not be big. Also, because the equations of the other criteria of the place value use 1200 meters as area, this is assumed for the intensity criterion as well. Finally, because the selected transit nodes are relatively close to each other it was decided to ignore overlap of the influence areas. Because the influence areas of train- and metro stations differ, a closer look must be taken to the calculation of the intensity criterion. Also, it must be further researched what influence the overlap of more influence areas has on the final outcome of the place value.

In the node-place model, the node and place value have an equal share in the transit node quality (Bertolini, 1999). Only when the node and place value are balanced, the transit node functions well. This is based on the theory of the Land-Use Feedback Cycle (Wegener & Fürst, 2004). This thesis has focused on the experience value and has left the node and place value out of the scope. However, in order to further improve the method, a closer look should be taken to the node and place value. It was assumed that they have to be balanced, but this is only based on a theory.

Extending the node-place model

In order to determine the share of the experience value on the transit node quality, it was assumed that the share of this value is one third. This assumptions was based conclusions from literature and interviews. The experience value represents the third strategy, enhancement. According to Vaessens (2005) only a growth of the performance indicators can be detected when all strategies are applied simultaneously. From interviews with the RET and the Municipality of Rotterdam, no univocal answer was given when the experts were asked to the share of the experience value. Therefore, it was assumed that the experience has an equal share as well. Because this is only an assumption, a closer look should be taken at the shares of the experience value on the transit node quality.

Transit node typologies

It was hard to classify the transit nodes because the selection of transit nodes did not fit well in the typologies. Also, the case study has shown that not one of the transit nodes meets the targets set by its corresponding typology. The typologies were originally intended for train stations, but there are many more types of metro stations. It is recommended to take a closer look at the typologies and revise them to better fit with metro stations in the city.

The transit node typologies have also been extended with the experience value in order to be able to also indicate the potential that can be realized by enhancing. The target for the experience value for the different types was based on the expectations of the customers. Together with the RET and Municipality and Rotterdam assumptions were made about what customers in Rotterdam expect. However, more research should be done to this in order to set a more reliable target the experience value of the transit nodes should meet.

As mentioned, the node and place value need to be in balance for the transit node to function well (Bertolini, 1999). The transit node typologies are based on ideal situations where the transit node functions to its full potential (Vereniging Deltametropool, 2013b). However, when looking at the transit node typologies, it can be seen that for some typologies, the node and place value are not perfectly balanced. More research should be done to the transit node typologies in order to clarify this.

Survey

A survey among 160 respondents was used to obtain the data for the Best-Worst method. A larger group of respondents will lead to more reliable results and more reliable weights. Also, the characteristics of the respondents are not similar to when a random sample from the Dutch population was taken. It cannot be concluded that the sample is biased, but when the sample is proportionally taken from a random group of respondents, the outcome will be more reliable. It was decided not to make a proportional selection from the group of respondents because this would lead to a smaller sample. With more reliable results, the regression analysis will show also more reliable relations between the weights and the characteristics of the respondents.

Influence strategies on performance indicators

As mentioned, only when all three strategies are applied simultaneously a growth of the performance indicators can be detected in terms of travel demand, customer opinions, retail turnover and real estate profits (Vaessens, 2005). More research should be done to what extent applying the strategies leads to increased performance indicators. Currently, the method only shows what strategy needs to be applied where, but does not indicate the effects of the improvements. Similar to the research by Vaessens (2005) transit nodes where strategies are applied should be monitored for several years in order to determine the influence of the strategies. That way, it can concluded what the influence of the different values is on the performance indicators. Also, it can be concluded if improving the transit node quality leads to a modal shift.

Evaluation of the proposed method

It can be concluded that adding the experience value results in a different outcome, but even though the Municipality of Rotterdam has stated that it better fits their own priorities, it cannot be concluded that the new method performs better. More research must be done to the performance of the method.

7.2.3 General recommendations

The weights for the criteria were obtained by making use of a MCDM method. There are expert-based methods and data-based methods that can be used to make a decision (Rezaei et al., 2012). The Best-Worst Method is an expert-based method, which means that the decision is based on the opinion of experts. However, in this research the determination of the weights was not based on the opinion of experts. Instead, a sample of 160 people was used as input for the method in order to find out what people value in a transit node. This means that BWM does not only have to be used as an expert-based method. The method is user-friendly and can be used when dealing with large numbers of respondents. Therefore, it is recommended to make use of this method in order to make decisions or obtain weights with experts or a group of respondents as decision-makers.

7.2.4 Future research directions

This research has provided more insight into the experience value. It can be seen that the experience value is playing an increasingly large role in public transport. Therefore, it is recommended to do more research to this area because it is still unclear what the psychological effect of the experience value is on a traveller. The outcome of that research can be used to further improve the public transport.

This research has proposed a method that can be used to improve transit nodes, which is the least valued part of the public transport journey. By improving the quality of public transport, the customer satisfaction increases which could lead to a modal shift. In order for this to happen, more people should experience a public transport journey to change its bad image. It is recommended to research policies that can be used in order to persuade the group of car users that could go by public transport to make use of public transport. That way, a modal shift can be obtained from car towards public transport.

References

Interviews

Alex Bruijn - NS
André de Wit - Gemeente Rotterdam, Verkeer & Vervoer
Bart Brenninkmeijer - NS
Bertus Postma - Gemeente Rotterdam, Verkeer & Vervoer
Cees Stoppelenburg - Stadsregio Rotterdam
Erik de Romph - TU Delft/DAT.Mobility
Floor van Ditzhuyzen - De Ontwerpwerkplaats
Hans Baggerman - Gemeente Rotterdam, Verkeer & Vervoer
Hans van der Boor - Gemeente Rotterdam, Ruimte & Wonen
Harko Stolte - Gemeente Rotterdam, Verkeer & Vervoer
Jan Murk - Gemeente Rotterdam, Verkeer & Vervoer
Jeroen Rijsdijk - Gemeente Rotterdam, Verkeer & Vervoer
José Besselink - Gemeente Rotterdam, Ruimte & Wonen
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Kristiaan Leurs - Gemeente Rotterdam, Verkeer & Vervoer
Luca Bertolini - Universiteit van Amsterdam
Lysander van der Sluis - RET
Maarten Balk - Gemeente Rotterdam, Verkeer & Vervoer
Marc Verheijen - Gemeentewerken Rotterdam
Marcus Edelenbosch - Gemeente Rotterdam, Verkeer & Vervoer
Mark van Hagen - NS Commercie
Martin Guit - Gemeente Rotterdam, Verkeer & Vervoer
Roeland van der Gugten - Gemeente Rotterdam, Ruimte & Wonen
Will Clerx - Gemeente Rotterdam, Verkeer & Vervoer
Wouter van Minderhout - ProRail

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Appendices

A Typologies node-place model

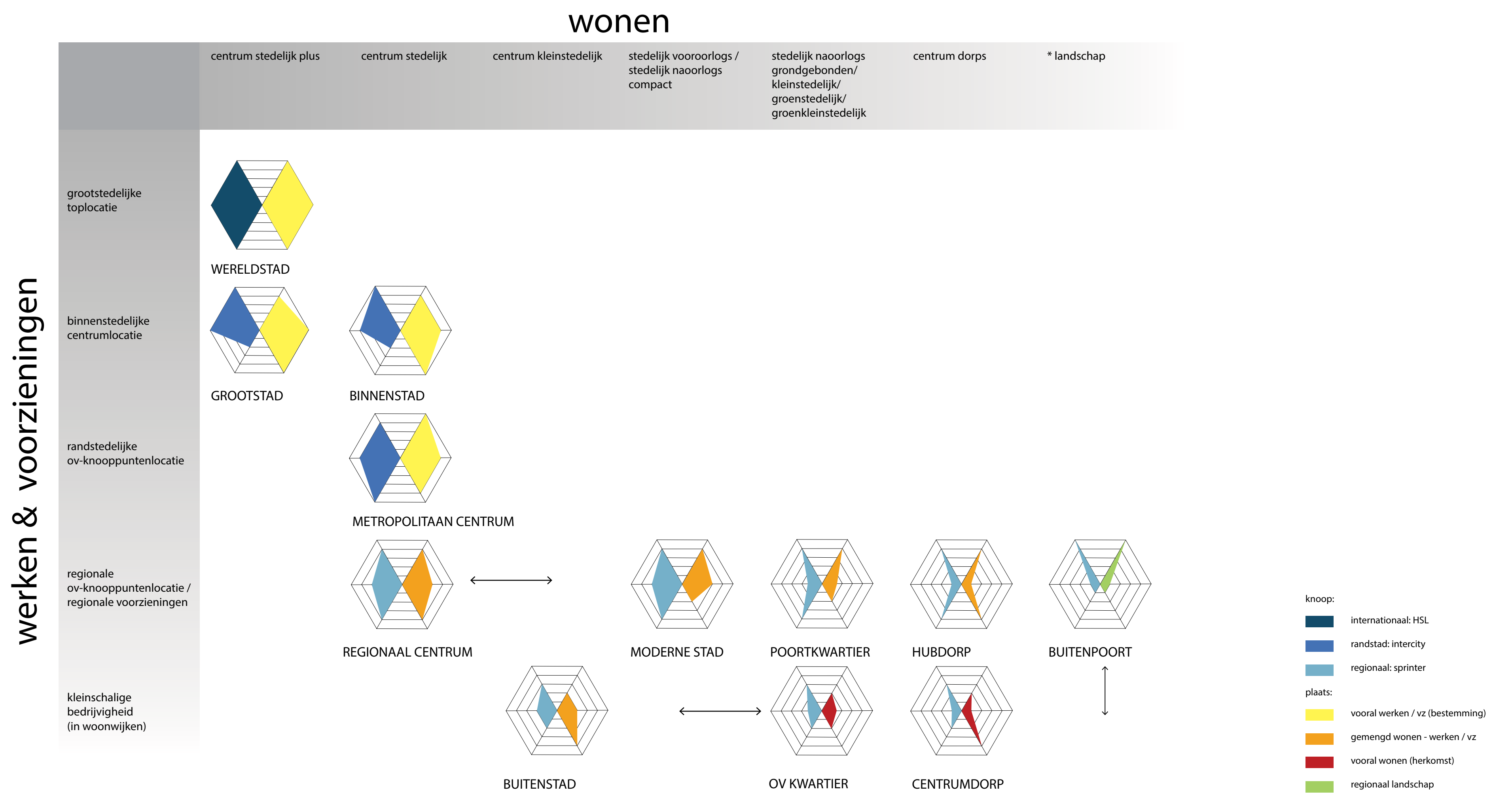

Figure A-1: Transit node typologies node-place model (Vereniging Deltametropool, 2013b)

B Survey

Dear sir/madam,

This survey is part of a research project commissioned by the Municipality of Rotterdam and Delft University of Technology. The questionnaire will take approximately 10 minutes. Thank you for participating in this survey!

1 First some personal information...

a What is your gender?

- Male
- Female

b What is your age?

- < 18
- 18 - 35
- 35 - 50
- 50 - 65
- 65 >

c In which province do you live?

- Drenthe
- Flevoland
- Friesland
- Gelderland
- Groningen
- Limburg
- Noord-Brabant
- Noord-Holland
- Overijssel
- Utrecht
- Zeeland
- Zuid-Holland

d What is your highest completed education?

- VMBO
- HAVO
- VWO/Gymnaisum
- MBO
- HBO
- WO
- PhD
- Other

e How often do you travel by public transport

- Daily
- More than 3 times a week
- Less than 3 times a week
- Several times a month
- Rarely
- Never

f With what purpose do you usually travel by public transport?

- Work/education
- Leisure
- Other

g If you travel by public transport, when do you usually do this?

- Peak hours
- Off-peak
- Both

The following questions concern aspects that influence your experience of a train- or metro station.

2 These questions concern the aspect **comfort**

a Which aspect do you value the **most** at a station?

Comfortable waiting = sheltered, heated

Entertainment = televisionscreens, newspaper

Spending time usefully = Wi-Fi, supermarket

Facilities = stores, restaurants, toilets

- Comfortable waiting
- Entertainment
- Spending time usefully
- Facilities

b Which aspect do you value the **least**?

- Comfortable waiting
- Entertainment
- Spending time usefully
- Facilities

c How much more do you value best compared to worst?

1 = equal value 5 = reasonably more value 9 = much more value

1 2 3 4 5 6 7 8 9

Now, you will see a number of comparisons with your most valued aspect best.

d-e How much more do you value best compared to others?

1 2 3 4 5 6 7 8 9

Now, you will see a number of comparisons with your most valued aspect worst.

f-g How much more do you value others compared to worst?

1 2 3 4 5 6 7 8 9

3 These questions concern the aspect **station organisation**

a Which aspect do you value the **most** at a station?

- Up-to-date travel information
- Pleasant crowdedness
- Clear signposting
- Overview

b Which aspect do you value the **least**?

- Up-to-date travel information
- Pleasant crowdedness
- Clear signposting
- Overview

c How much more do you value best compared to worst?

1 2 3 4 5 6 7 8 9

Now, you will see a number of comparisons with your most valued aspect best.

d-e How much more do you value best compared to others?

1 2 3 4 5 6 7 8 9

Now, you will see a number of comparisons with your most valued aspect worst.

f-g How much more do you value others compared to worst?

1 2 3 4 5 6 7 8 9

4 These questions concern the aspect **ambient elements**

a Which aspect do you value the **most** at a station?

- Nice use of colours
- Pleasant lighting
- Architectural design
- Station in good condition
- Nice use of materials
- Clean and odor free

b Which aspect do you value the **least**?

- Nice use of colours
- Pleasant lighting
- Architectural design
- Station in good condition
- Nice use of materials
- Clean and odor free

c How much more do you value best compared to worst?

1 2 3 4 5 6 7 8 9

Now, you will see a number of comparisons with your most valued aspect best.

d-g How much more do you value best compared to others?

1 2 3 4 5 6 7 8 9

Now, you will see a number of comparisons with your most valued aspect worst.

h-k How much more do you value others compared to worst?

1 2 3 4 5 6 7 8 9

5 These questions concern the aspect **social elements**

a Which aspect do you value the **most** at a station?

- Presence of personnel
- Possible contact with other travellers
- Safety at night

b Which aspect do you value the **least**?

- Presence of personnel
- Possible contact with other travellers
- Safety at night

c How much more do you value best compared to worst?

1 2 3 4 5 6 7 8 9

Now, you will see a number of comparisons with your most valued aspect best.

d How much more do you value best compared to others?

1 2 3 4 5 6 7 8 9

Now, you will see a number of comparisons with your most valued aspect worst.

e How much more do you value others compared to worst?

1 2 3 4 5 6 7 8 9

6 Now you have some idea what aspects affect your perception of a train- or metro station. The last few questions concern your appreciation towards all aspects.

a Which aspect do you value the **most** at a station?

- Comfort
- Station organisation
- Ambient elements
- Social elements

b Which aspect do you value the **least**?

- Comfort
- Station organisation
- Ambient elements
- Social elements

c How much more do you value best compared to worst?

1 2 3 4 5 6 7 8 9

Now, you will see a number of comparisons with your most valued aspect best.

d-e How much more do you value best compared to others?

1 2 3 4 5 6 7 8 9

Now, you will see a number of comparisons with your most valued aspect worst.

f-g How much more do you value others compared to worst?

1 2 3 4 5 6 7 8 9

C Weight intervals sub criteria

C.1 Comfort

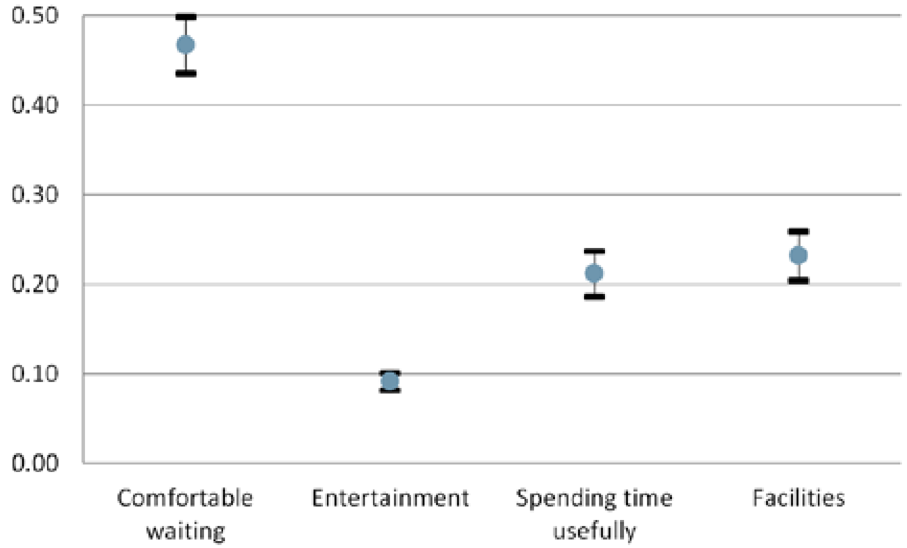

Figure C-1: Weight intervals comfort

Table C-1: Weight intervals comfort

	Comfortable waiting	Entertainment	Spending time usefully	Facilities	ξ^*	CR
Center	0.467	0.092	0.212	0.232	2.366	0.590
Width	0.031	0.009	0.026	0.027		
Interval rank	1	4	3	2		

C.2 Station organisation

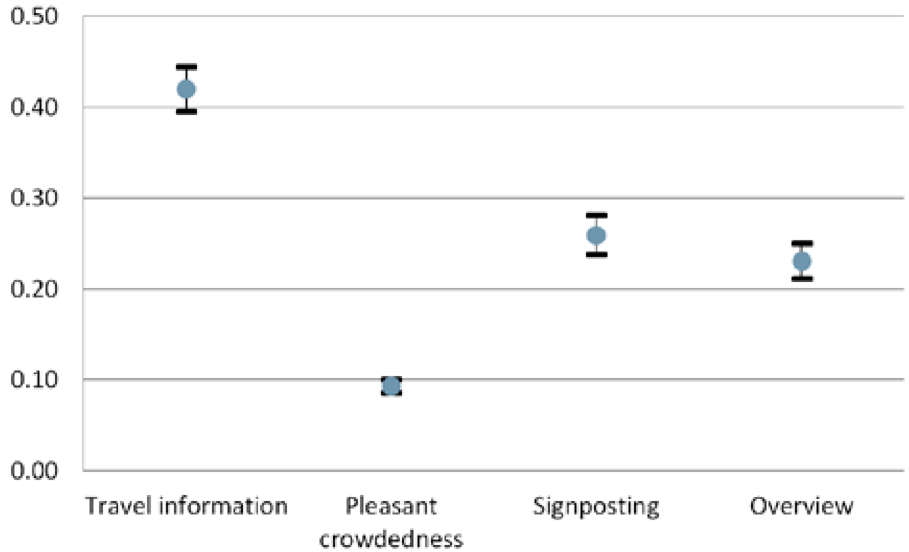

Figure C-2: Weight intervals station organisation

Table C-2: Weight intervals station organisation

	Travel information	Pleasant crowdedness	Signposting	Overview	ξ^*	CR
Center	0.420	0.093	0.259	0.231	2.191	0.559
Width	0.025	0.008	0.021	0.020		
Interval rank	1	4	2	3		

C.3 Ambient elements

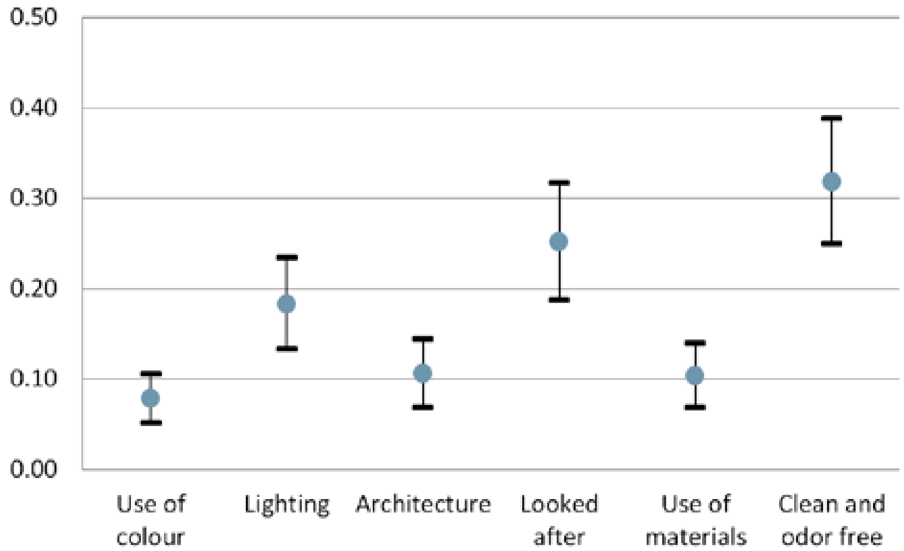

Figure C-3: Weight intervals ambient elements

Table C-3: Weight intervals ambient elements

	Use of colour	Lighting	Architecture	Looked after	Use of materials	Clean and odor free	ξ *	CR
Center	0.078	0.183	0.106	0.252	0.104	0.318	2.878	0.650
Width	0.027	0.051	0.038	0.065	0.036	0.069		
Interval rank	6	3	4	2	5	1		

C.4 Social elements

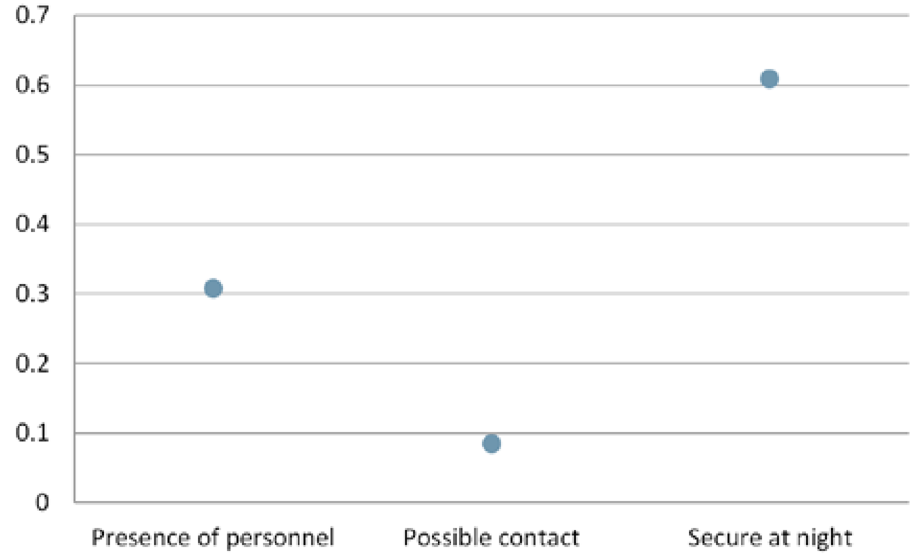

Figure C-4: Weight intervals social elements

Table C-4: Weight intervals social elements

	Presence of personnel	Possible contact	Secure at night	ξ *	CR
Center	0.307	0.085	0.608	2.077	0.503
Interval rank	2	3	1		

D Node value

D.1 Slow traffic

Table D-1: Data slow traffic

Transit node	PT-bike rental	Railway crossing 300m	Bicycle parking places	Boarding and alighting	% Ratio BP/BA	Local roads 300m	Connection value	Disclosure value	Score	Value
Beurs	No	Yes	328	111400	0%	51	50	77	127	0.6
Capelsebrug	No	Yes	871	24864	4%	22	50	33	83	0.1
De Akkers	No	Yes	364	5000	7%	46	50	69	119	0.5
Delfshaven	No	Yes	88	12600	1%	38	50	57	107	0.4
Dijkzigt	No	Yes	10	25600	0%	17	50	26	76	0.0
Eendrachtsplein	No	Yes	128	14200	1%	27	50	41	91	0.2
Graskruid	No	Yes	48	1800	3%	30	50	45	95	0.3
Heemraadlaan	No	Yes	281	4400	6%	36	50	54	104	0.4
Hoogvliet	No	Yes	348	9600	4%	66	50	99	149	0.8
Kralingse Zoom	No	Yes	294	35650	1%	17	50	26	76	0.0
Leuvehaven	No	Yes	84	12400	1%	34	50	51	101	0.3
Maashaven	No	Yes	256	17000	2%	26	50	39	89	0.2
Marconiplein	No	Yes	80	23600	0%	30	50	45	95	0.3
Oosterflank	No	Yes	239	10200	2%	48	50	72	122	0.5
Oostplein	No	Yes	98	11200	1%	36	50	54	104	0.4
Poortugaal	Yes	Yes	412	3400	12%	31	75	47	122	0.5
Rotterdam Alexander	Yes	Yes	711	36088	2%	11	75	17	92	0.2
Rotterdam Blaak	Yes	Yes	438	52279	1%	41	75	62	137	0.7
Rotterdam Centraal	Yes	Yes	5282	150649	4%	19	75	29	104	0.3
Rotterdam Lombardijen	Yes	Yes	505	14486	3%	33	75	50	125	0.6
Rotterdam Noord	No	Yes	258	4308	6%	23	50	35	85	0.1
Schenkel	No	Yes	198	5000	4%	33	50	50	100	0.3
Schiedam Centrum	Yes	Yes	1917	50426	4%	28	75	42	117	0.5
Schiedam Nieuwland	No	Yes	414	4368	9%	26	50	39	89	0.2
Slinge	No	Yes	374	17000	2%	76	50	114	164	1.0
Spijkenisse Centrum	Yes	Yes	522	17400	3%	32	75	48	123	0.6
Stadhuis	No	Yes	166	14600	1%	42	50	63	113	0.5
Vijfsluizen	No	Yes	254	9400	3%	15	50	23	73	0.0
Vlaardingen Oost	Yes	Yes	420	5147	8%	26	75	39	114	0.5
Voorschoterlaan	No	Yes	154	8600	2%	35	50	53	103	0.3
Wilhelminaplein	No	Yes	26	27400	0%	14	50	21	71	0.0
Zuidplein	Yes	Yes	598	77281	1%	20	75	30	105	0.4

D.2 Public transport

Table D-2: Data public transport

Transit node	High speed train per hour		Intercity per hour		Sprinter per hour		Metro per hour		Regional bus per hour		Local bus per hour		TramPlus per hour		Tram per hour		Connection value	Disclosure value	Score	Value
Directions	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**				
Beurs								36				6		24		6	155	1488	1643	0.7
Capelsebrug								18	37		2						150	920	1070	0.4
De Akkers							18		4	0	10						150	360	510	0.0
Delfshaven								18								12	100	660	760	0.2
Dijkzigt								18				10					100	640	740	0.2
Eendrachtsplein								18				9		8		12	155	846	1001	0.3
Graskruid								12				3					100	390	490	0.0
Heemraadlaan								18		3	6						150	630	780	0.2
Hoogvliet								18			7						100	575	675	0.1
Kralingse Zoom								18	24		4						150	800	950	0.3
Leuvehaven								18						16		6	130	792	922	0.3
Maashaven								18								6	100	600	700	0.2
Marconiplein								18			7		8	8		12	155	839	994	0.3
Oosterflank								12				14					100	500	600	0.1

Transit node	High speed train per hour		Intercity per hour		Sprinter per hour		Metro per hour		Regional bus per hour		Local bus per hour		TramPlus per hour		Tram per hour		Connection value	Disclosure value	Score	Value
Directions	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**				
Oostplein								18						8			105	636	741	0.2
Poortugaal								12				2					100	380	480	0.0
Rotterdam Alexander				4		4		12	4		17						325	765	1090	0.4
Rotterdam Blaak				4		4		18	0			12		8			305	1036	1341	0.5
Rotterdam Centraal		2	4	6	8	4	12	6	3		30		8	20		18	505	1668	2173	1.0
Rotterdam Lombardijen						4				16		15		8		6	205	746	951	0.3
Rotterdam Noord						4			2		3					12	175	275	450	0.0
Schenkel								12				1					100	370	470	0.0
Schiedam Centrum				4		8	12	6	6		15			8			355	991	1346	0.5
Schiedam Nieuwland						8						2		8			130	356	486	0.0
Slinge								12				17					100	620	720	0.2
Spijkenisse Centrum								18	17	4	3	16					150	965	1115	0.4
Stadhuis								18						16			105	732	837	0.2
Vijfsluizen								6		2		7					150	290	440	0.0
Vlaardingen Oost						8				2		7					150	350	500	0.0
Voorschoterlaan								18								6	100	600	700	0.2
Wilhelminaplein								18						24			105	828	933	0.3
Zuidplein								18	52		54						150	1330	1480	0.6

D.3 Road

Table D-3: Data road

Transit node	Nr of parking places	Highway exit	Highway 3200m	Regional road1 1200m		Regional road2 3200m	% Ratio PP/BA	Connection value	Disclosure value	Score	Value
Beurs	0	0	1	0	0	3	0%	75	63	138	0.2
Capelsebrug	407	0	1	2	25	3	2%	100	88	188	0.3
De Akkers	193	0	0	1	25	4	4%	75	63	138	0.2
Delfshaven	0	0	3	0	0	3	0%	75	113	188	0.3
Dijkzigt	0	0	3	1	25	4	0%	100	138	238	0.5
Eendrachtsplein	0	0	3	1	25	3	0%	100	125	225	0.5
Graskruid	0	0	3	0	0	1	0%	75	88	163	0.3
Heemraadlaan	400	0	0	1	25	4	9%	100	63	163	0.3
Hoogvliet	233	0	3	2	25	2	2%	100	125	225	0.5
Kralingse Zoom	1433	2	2	1	25	4	4%	200	188	388	1.0
Leuvehaven	0	0	1	0	0	3	0%	75	63	138	0.2
Maashaven	0	0	0	1	25	2	0%	50	38	88	0.0
Marconiplein	0	0	3	0	0	3	0%	75	113	188	0.3
Oosterflank	0	0	1	0	0	4	0%	75	75	150	0.2

Transit node	Nr of parking places	Highway exit	Highway 3200m	Regional road1 1200m		Regional road2 3200m	% Ratio PP/BA	Connection value	Disclosure value	Score	Value
Oostplein	0	0	2	0	0	3	0%	75	88	163	0.3
Poortugaal	171	0	3	1	25	3	5%	150	125	275	0.6
Rotterdam Alexander	480	0	3	2	25	3	1%	100	138	238	0.5
Rotterdam Blaak	0	0	2	0	0	3	0%	75	88	163	0.3
Rotterdam Centraal	0	0	3	2	25	3	0%	100	138	238	0.5
Rotterdam Lombardijen	109	0	6	0	0	1	1%	75	163	238	0.5
Rotterdam Noord	0	1	3	0	0	3	0%	150	150	300	0.7
Schenkel	102	0	3	2	25	3	2%	100	138	238	0.5
Schiedam Centrum	330	2	4	1	25	2	1%	175	213	388	1.0
Schiedam Nieuwland	66	1	3	0	0	1	2%	150	125	275	0.6
Slinge	849	0	3	0	0	3	5%	100	113	213	0.4
Spijkenisse Centrum	201	0	1	1	25	5	1%	100	100	200	0.4
Stadhuis	0	0	3	0	0	3	0%	75	113	188	0.3
Vijfsluizen	88	1	3	0	0	0	1%	125	113	238	0.5
Vlaardingen Oost	0	1	3	0	0	0	0%	125	113	238	0.5
Voorschoterlaan	0	0	2	0	0	1	0%	75	63	138	0.2
Wilhelminaplein	0	0	1	0	0	2	0%	75	125	125	0.1
Zuidplein	0	0	1	2	25	2	0%	100	175	175	0.3

E Place value

E.1 Proximity

Table E-1: Data proximity

Transit node	Residents 300m	Residents 1200m	Employees 300m	Employees 1200m	Visitors 300m	Visitors 1200m	Score	Value
Beurs	3445	61990	10318	66617	839	24124	9.6	0.2
Capelsebrug	1525	27425	620	8373	0	0	6.0	0.1
De Akkers	3780	30835	543	1771	2400	2400	19.2	0.5
Delfshaven	8250	67255	822	14090	0	115	11.1	0.2
Dijkzigt	1905	70225	10813	39070	4075	17282	13.3	0.3
Eendrachtsplein	3430	63795	4175	68013	1261	75110	4.3	0.0
Graskruid	2200	28285	71	21204	0	11622	3.7	0.0
Heemraadlaan	2580	38685	91	5415	0	5346	5.4	0.1
Hoogvliet	2440	26195	93	5377	0	0	8.0	0.1
Kralingse Zoom	305	12705	1608	16928	0	5650	5.4	0.1
Leuvehaven	3145	43000	3020	64694	1300	71341	4.2	0.0
Maashaven	6810	63085	640	16781	7820	7820	17.4	0.4
Marconiplein	2505	45975	4374	9464	0	27	12.4	0.3
Oosterflank	4195	33950	667	20720	0	2910	8.4	0.2
Oostplein	4915	81420	1753	28948	0	57942	4.0	0.0
Poortugaal	1410	10730	1753	28948	0	0	8.0	0.1
Rotterdam Alexander	935	30165	4508	18459	11591	11591	35.0	1.0
Rotterdam Blaak	3235	68160	6743	49447	9127	68089	10.3	0.2
Rotterdam Centraal	2260	83650	8472	46902	197	62902	5.6	0.1
Rotterdam Lombardijen	3410	24400	3650	9853	2133	2133	25.3	0.7
Rotterdam Noord	4010	43905	824	7855	0	0	9.3	0.2
Schenkel	2280	26395	442	6488	207	3118	8.1	0.1
Schiedam Centrum	3860	31425	1340	12781	38	11386	9.4	0.2
Schiedam Nieuwland	3610	30605	2322	6246	1564	1564	19.5	0.5
Slinge	4085	22575	851	3452	0	0	19.0	0.5
Spijkenisse Centrum	2660	27690	2420	8316	2946	11713	16.8	0.4
Stadhuis	2395	85050	8821	59049	515	21815	7.1	0.1
Vijfsluizen	120	13280	3084	7510	0	0	15.4	0.4
Vlaardingen Oost	1225	17380	462	7762	0	0	6.7	0.1
Voorschoterlaan	5700	41200	1162	12184	0	4440	11.9	0.3
Wilhelminaplein	820	47560	6941	25753	515	12376	9.7	0.2
Zuidplein	2330	45565	2717	11906	7127	11807	17.6	0.4

E.2 Intensity

Table E-2: Data intensity

Transit node	Residents	Employees	Visitors	Influence area (ha)	Score	Value
Beurs	61990	66617	24124	452	338	0.7
Capelsebrug	27425	8373	0	452	79	0.1
De Akkers	30835	1771	2400	452	77	0.1
Delfshaven	67255	14090	115	452	180	0.3
Dijkzigt	70225	39070	17282	452	280	0.6
Eendrachtsplein	63795	68013	75110	452	458	1.0
Graskruid	28285	21204	11622	452	135	0.2
Heemraadlaan	38685	5415	5346	452	109	0.2
Hoogvliet	26195	5377	0	452	70	0.1
Kralingse Zoom	12705	16928	5650	452	78	0.1
Leuvehaven	43000	64694	71341	452	396	0.9
Maashaven	63085	16781	7820	452	194	0.4
Marconiplein	45975	9464	27	452	123	0.2
Oosterflank	33950	20720	2910	452	127	0.2
Oostplein	81420	28948	57942	452	372	0.8
Poortugaal	10730	28948	0	452	88	0.1

Transit node	Residents	Employees	Visitors	Influence area (ha)	Score	Value
Rotterdam Alexander	30165	18459	0	452	108	0.1
Rotterdam Blaak	68160	49447	68089	452	411	0.9
Rotterdam Centraal	83650	46902	62902	452	428	0.9
Rotterdam Lombardijen	24400	9853	2133	452	80	0.1
Rotterdam Noord	43905	7855	0	452	114	0.2
Schenkel	26395	6488	3118	452	80	0.1
Schiedam Centrum	31425	12781	11386	452	123	0.2
Schiedam Nieuwland	30605	6246	1564	452	85	0.1
Slinge	22575	3452	0	452	58	0.0
Spijkenisse Centrum	27690	8316	11713	452	106	0.1
Stadhuis	85050	59049	21815	452	367	0.8
Vijfsluizen	13280	7510	0	452	46	0.0
Vlaardingen Oost	17380	7762	0	452	56	0.0
Voorschoterlaan	41200	12184	4440	452	128	0.2
Wilhelminaplein	47560	25753	12376	452	190	0.3
Zuidplein	45565	11906	11807	452	153	0.3

E.3 Mixture

Table E-3: Data mixture

Transit node	Inhabitants	Employees	Score	Value
Beurs	61990	66617	0,93	1,0
Capelsebrug	27425	8373	0,31	0,3
De Akkers	30835	1771	0,06	0,0
Delfshaven	67255	14090	0,21	0,2
Dijkzigt	70225	39070	0,56	0,6
Eendrachtsplein	63795	68013	0,94	1,0
Graskruid	28285	21204	0,75	0,8
Heemraadlaan	38685	5415	0,14	0,1
Hoogvliet	26195	5377	0,21	0,2
Kralingse Zoom	12705	16928	0,75	0,8
Leuvehaven	43000	64694	0,66	0,7
Maashaven	63085	16781	0,27	0,2
Marconiplein	45975	9464	0,21	0,2
Oosterflank	33950	20720	0,61	0,6
Oostplein	81420	28948	0,36	0,3
Poortugaal	10730	28948	0,37	0,4

Transit node	Inhabitants	Employees	Score	Value
Rotterdam Alexander	30165	18459	0,61	0,6
Rotterdam Blaak	68160	49447	0,73	0,8
Rotterdam Centraal	83650	46902	0,56	0,6
Rotterdam Lombardijen	24400	9853	0,40	0,4
Rotterdam Noord	43905	7855	0,18	0,1
Schenkel	26395	6488	0,25	0,2
Schiedam Centrum	31425	12781	0,41	0,4
Schiedam Nieuwland	30605	6246	0,20	0,2
Slinge	22575	3452	0,15	0,1
Spijkenisse Centrum	27690	8316	0,30	0,3
Stadhuis	85050	59049	0,69	0,7
Vijfsluizen	13280	7510	0,57	0,6
Vlaardingen Oost	17380	7762	0,45	0,4
Voorschoterlaan	41200	12184	0,30	0,3
Wilhelminaplein	47560	25753	0,54	0,5
Zuidplein	45565	11906	0,26	0,2

F Experience value

F.1 Comfort

Table F-1: Data comfort

Transit node	Heated waiting	Sheltered waiting	Television screens	Free newspaper	Wi-Fi	Supermarket	Stores	Restaurants	Toilets	Score	Value
Beurs	Partially	Yes	Yes	Yes	Yes	1	1	6	Yes	0.6	0.7
Capelsebrug	No	Partially	No	Yes	No	0	1	1	Yes	0.3	0.3
De Akkers	No	Partially	No	Yes	No	0	0	0	Yes	0.2	0.2
Delfshaven	Partially	Yes	No	Yes	No	1	0	0	Yes	0.4	0.4
Dijkzigt	Partially	Yes	Yes	Yes	No	0	0	1	Yes	0.5	0.5
Eendrachtsplein	Partially	Yes	No	Yes	No	0	0	0	Yes	0.4	0.4
Graskruid	No	No	No	Yes	No	0	0	0	No	0.0	0.0
Heemraadlaan	No	Partially	No	Yes	No	0	0	0	Yes	0.2	0.2
Hoogvliet	No	Partially	No	Yes	No	0	0	0	Yes	0.2	0.2
Kralingse Zoom	No	Partially	No	Yes	No	0	1	2	Yes	0.3	0.3
Leuvehaven	Partially	Yes	No	Yes	No	0	1	0	Yes	0.4	0.5
Maashaven	No	Partially	No	Yes	No	0	1	0	Yes	0.2	0.2
Marconiplein	Partially	Yes	No	Yes	No	0	1	1	Yes	0.5	0.5
Oosterflank	No	No	No	Yes	No	0	0	0	No	0.0	0.0
Oostplein	Partially	Yes	No	Yes	No	0	0	0	Yes	0.4	0.4
Poortugaal	No	Partially	No	Yes	No	0	0	0	Yes	0.2	0.2

Transit node	Heated waiting	Sheltered waiting	Television screens	Free newspaper	Wi-Fi	Supermarket	Stores	Restaurants	Toilets	Score	Value
Rotterdam Alexander	No	Partially	No	Yes	No	0	0	0	Yes	0.2	0.3
Rotterdam Blaak	Partially	Yes	Yes	Yes	No	0	0	1	Yes	0.5	0.5
Rotterdam Centraal	Yes	Yes	Yes	Yes	Yes	0	14	14	Yes	0.8	1.0
Rotterdam Lombardijen	Yes	Yes	No	Yes	No	1	0	0	Yes	0.5	0.6
Rotterdam Noord	No	No	No	Yes	No	0	0	0	No	0.0	0.0
Schenkel	No	No	No	Yes	No	2	0	0	No	0.0	0.0
Schiedam Centrum	Partially	Partially	No	Yes	No	0	0	2	Yes	0.3	0.4
Schiedam Nieuwland	No	No	No	Yes	No	0	0	0	No	0.0	0.0
Slinge	No	Partially	No	Yes	No	0	0	0	Yes	0.2	0.2
Spijkenisse Centrum	No	Partially	No	Yes	No	0	0	0	Yes	0.2	0.2
Stadhuis	Partially	Yes	No	Yes	No	0	0	0	Yes	0.4	0.4
Vijfsluizen	No	Yes	No	Yes	No	0	0	0	Yes	0.3	0.3
Vlaardingen Oost	No	Yes	No	Yes	No	0	1	1	Yes	0.4	0.4
Voorschoterlaan	Partially	Yes	No	Yes	No	0	0	0	Yes	0.4	0.4
Wilhelminaplein	Partially	Yes	No	Yes	No	0	0	0	Yes	0.4	0.4
Zuidplein	No	Partially	No	Yes	No	0	2	3	Yes	0.3	0.3

F.2 Ambient elements

Table F-2: Data ambient elements

Transit node	Architecture	Looked after	Score	Value
Beurs	Homely	2000	0.1	1.0
Capelsebrug	Homely	1983	0.1	1.0
De Akkers	Homely	2003	0.1	1.0
Delfshaven	Homely	2001	0.1	1.0
Dijkzigt	Homely	1982	0.1	1.0
Eendrachtsplein	Homely	1982	0.1	1.0
Graskruid	Homely	1983	0.0	0.0
Heemraadlaan	Homely	1991	0.1	1.0
Hoogvliet	Homely	1999	0.1	1.0
Kralingse Zoom	Homely	1987	0.1	1.0
Leuvehaven	Homely	1999	0.1	1.0
Maashaven	Homely	1968	0.1	1.0
Marconiplein	Homely	1986	0.1	1.0
Oosterflank	Homely	2005	0.0	0.0
Oostplein	Homely	1982	0.1	1.0
Poortugaal	Modern-classic	1986	0.1	1.0

Transit node	Architecture	Looked after	Score	Value
Rotterdam Alexander	Homely	1983	0.1	1.0
Rotterdam Blaak	Modern/artistic	1993	0.1	1.0
Rotterdam Centraal	Modern-classic	2014	0.1	1.0
Rotterdam Lombardijen	Homely	1996	0.1	1.0
Rotterdam Noord	Homely	1953	0.0	0.0
Schenkel	Homely	1995	0.0	0.0
Schiedam Centrum	Modern-classic	2000	0.1	1.0
Schiedam Nieuwland	Homely	1975	0.0	0.0
Slinge	Homely	2009	0.1	1.0
Spijkenisse Centrum	Homely	2000	0.1	1.0
Stadhuis	Homely	2000	0.1	1.0
Vijfsluizen	Modern-classic	2002	0.1	1.0
Vlaardingen Oost	Homely	1956	0.1	1.0
Voorschoterlaan	Homely	1997	0.1	1.0
Wilhelminaplein	Modern-classic	1995	0.1	1.0
Zuidplein	Homely	1983	0.1	1.0

F.3 Social elements

Table F-3: Data social elements

Transit node	Presence of personnel	Score	Value
Beurs	Yes	0.1	1.0
Capelsebrug	Yes	0.1	1.0
De Akkers	Yes	0.1	1.0
Delfshaven	Yes	0.1	1.0
Dijkzigt	Yes	0.1	1.0
Eendrachtsplein	Yes	0.1	1.0
Graskruid	No	0.0	0.0
Heemraadlaan	Yes	0.1	1.0
Hoogvliet	Yes	0.1	1.0
Kralingse Zoom	Yes	0.1	1.0
Leuvehaven	Yes	0.1	1.0
Maashaven	Yes	0.1	1.0
Marconiplein	Yes	0.1	1.0
Oosterflank	No	0.0	0.0
Oostplein	Yes	0.1	1.0
Poortugaal	Yes	0.1	1.0

Transit node	Presence of personnel	Score	Value
Rotterdam Alexander	Yes	0.1	1.0
Rotterdam Blaak	Yes	0.1	1.0
Rotterdam Centraal	Yes	0.1	1.0
Rotterdam Lombardijen	Yes	0.1	1.0
Rotterdam Noord	No	0.0	0.0
Schenkel	No	0.0	0.0
Schiedam Centrum	Yes	0.1	1.0
Schiedam Nieuwland	No	0.0	0.0
Slinge	Yes	0.1	1.0
Spijkenisse Centrum	Yes	0.1	1.0
Stadhuis	Yes	0.1	1.0
Vijfsluizen	Yes	0.1	1.0
Vlaardingen Oost	Yes	0.1	1.0
Voorschoterlaan	Yes	0.1	1.0
Wilhelminaplein	Yes	0.1	1.0
Zuidplein	Yes	0.1	1.0

G Transit node typologies

Table G-1: Transit node typologies

	Node value			Place value			Experience value		
	Slow traffic	Public transport	Roads	Proximity	Intensity	Mixture	Comfort	Ambient elements	Social elements
World city	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
Big city	1,0	1,0	0,4	0,8	1,0	1,0	0,9	1,0	1,0
City centre	1,0	0,8	0,4	0,8	0,8	1,0	0,5	0,8	1,0
Metropolitan centre	0,8	0,8	1,0	1,0	0,8	0,8	0,6	0,9	1,0
Regional centre	0,8	0,6	0,8	0,8	0,6	0,8	0,6	0,9	1,0
Modern city	0,8	0,6	0,8	0,8	0,6	0,4	0,4	0,8	1,0
Gate quarter	0,8	0,3	0,8	0,8	0,3	0,4	0,3	0,8	1,0
Hub village	0,8	0,2	0,8	0,8	0,2	0,8	0,3	0,8	0,0
Suburb	0,6	0,4	0,4	0,4	0,4	0,8	0,2	0,8	0,0
Public transport quarter	0,6	0,3	0,4	0,4	0,3	0,4	0,2	0,8	0,0
Centre village	0,6	0,2	0,4	0,4	0,2	0,8	0,2	0,8	0,0
Outside gate	1,0	0,2	0,2	1,0	0,2	0,2	0,2	0,8	0,0