**Incorporating the travellers' experience value in assessing the quality of transit nodes
A Rotterdam case study**

Groenendijk, Laura; Rezaei, Jafar; Correia, Gonçalo

DOI

[10.1016/j.cstp.2018.07.007](https://doi.org/10.1016/j.cstp.2018.07.007)

Publication date

2018

Document Version

Final published version

Published in

Case Studies on Transport Policy

Citation (APA)

Groenendijk, L., Rezaei, J., & Correia, G. (2018). Incorporating the travellers' experience value in assessing the quality of transit nodes: A Rotterdam case study. *Case Studies on Transport Policy*.
<https://doi.org/10.1016/j.cstp.2018.07.007>

Important note

To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Copyright

Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy

Please contact us and provide details if you believe this document breaches copyrights.
We will remove access to the work immediately and investigate your claim.

Green Open Access added to TU Delft Institutional Repository

'You share, we take care!' – Taverne project

<https://www.openaccess.nl/en/you-share-we-take-care>

Otherwise as indicated in the copyright section: the publisher is the copyright holder of this work and the author uses the Dutch legislation to make this work public.

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

Laura Groenendijk^{a,*}, Jafar Rezaei^b, Gonçalo Correia^c

^a Goudappel Coffeng, Amsterdam, the Netherlands

^b Delft University of Technology, Technology, Policy & Management, Delft, the Netherlands

^c Delft University of Technology, Civil Engineering, Delft, the Netherlands

ARTICLE INFO

Keywords:

Best Worst Method (BWM)
Experience value
Multi criteria decision making (MCDM)
Node-Place model
Transfer
Transit nodes

ABSTRACT

The quality of a transit node is determined by the experience of travellers. However, the reference model for classifying the quality of a transit node, the so-called Node-Place model, does not consider this important dimension (experience). In this paper, we propose a method to add quality from a traveller's perspective to the Node-Place (NP) model by adding the experience value. The new model is called the Node-Place-Experience (NPE) model. A case study in Rotterdam in the Netherlands is used to apply and illustrate our proposal for the model extension to experience. A literature review provided the criteria for the experience value and the weights have been obtained by using a survey among 140 respondents as input for a multi criteria decision making method called Best Worst Method (BWM). The case study shows that the experience value significantly influences the perceived quality of transit nodes and that the new method shows more accurate results.

1. Introduction

Changes in technology, society and urbanization pattern have led to an increase of mobility and average travel distances (Schrijnen et al., 2011). In many countries, cars have become the main mode of transportation which has resulted in congestion and pollution (Beirão and Sarsfield Cabral, 2007). Because of this, a modal shift from car towards public transport is desired. This transition is hard to accomplish because the attitude towards car is more positive than towards public transport (Harms et al., 2007). Subjective reasons such as convenience, speed and individual freedom contribute to the high percentage of car usage (Anable, 2005), while the attitude of travellers towards public transport is negative (Harms et al., 2007). In a public transport journey, travellers negatively experience transfers, waiting time and insecurity. In general, a transfer is experienced as a threshold that most travellers wish to avoid (Peek and van Hagen, 2002).

Van den Heuvel (1997) has shown that mode choice is mostly determined by travel time. The attitude towards a mode and the quality of a mode are both important factors for mode choice (Beirão and Sarsfield Cabral, 2007). Hensher (1998) has shown that by improving the image and quality of public transport, the intention to switch modes by car users and potential public transport users increases. According to STIMULUS (1999), improvement of the service quality of public transport to customers' requirements can lead to a modal shift.

The quality of public transport is to a great extent determined by stations' quality (Van Hagen et al., 2009; van Hagen and Exel, 2012). Cascetta and Carteni (2014) have shown that the value of stations quality is 35–50 euro cents per trip. They state that aesthetics and other quality attributes should be considered in the assessment of station quality. The quality of a station is greatly related to the experience of a traveller (Van Hagen and Exel, 2012). It can be expected that the travellers' experience is becoming increasingly important because we are currently living in an experience economy, which means that the objective quality of goods and services is becoming more homogeneous and it is only the experience that can distinguish one service from the other (Pine and Gilmore, 2007). Over the past ten years, governments have been increasingly investing in station areas (Dammers et al., 2005). These investments are not only focused on the utilization value but also on the experience value (Florida, 2002).

There are several methods to assess the quality of transit nodes (Van Bakel, 2001; Meijers, 2000; Brand-van Tuijn et al., 2001; Everaars, 2001; Vale, 2015). These methods are all based on the model of Bertolini (1999), the Node-Place (NP) model. This model can be applied to measure the quality of transit nodes, which are defined as stations where a traveller can transfer to at least one other mode of transportation. The NP model focuses on the ambivalent character of a transit node: a node in a network and a place in a city (Bertolini, 1996, 2008). According to this model, when there is a strong coherence between the

* Corresponding author.

E-mail addresses: lgroenendijk@goudappel.nl (L. Groenendijk), j.rezaei@tudelft.nl (J. Rezaei), g.correia@tudelft.nl (G. Correia).

<https://doi.org/10.1016/j.cstp.2018.07.007>

Received 30 November 2017; Accepted 12 July 2018

Available online 24 July 2018

2213-624X/ © 2018 World Conference on Transport Research Society. Published by Elsevier Ltd. All rights reserved.

node and the place value, the transit node functions well.

This study contributes to the existing literature in several ways: (i) Even though the experience value is an important factor for the perceived station quality, the NP model does not account for that dimension in measuring the quality of transit nodes. Therefore, in this study we propose an extension to the NP model (Bertolini, 1999) with the experience value in order to provide a more comprehensive measurement. The new model, which is called Node-Place-Experience (NPE) model can function as a guideline for governments and transport operators to discuss the quality of transit nodes. Thus the model extension will not only provide insights into where improvements are needed in the node and place value, but also improvements regarding the experience of travellers; (ii) Currently, the value of experience is a rather vague term whose meaning is not consensual. Therefore, in order to provide the referred model extension, we identify the criteria for the experience value and determine the corresponding weights based on a multi criteria decision making (MDCM) method called Best Worst Method (BWM). The extended model is illustrated by applying it to the case study city of Rotterdam in the Netherlands. We analyse 32 transit nodes in the city by collecting data to measure the node, place and experience values.

The remainder of the paper is structured as follows. In the next section a literature review is conducted in order to provide more insight into a public transport journey, the NP model and the experience value. Section 3 proposes a method to determine the experience value, extend the Node-Place model and measure the transit node quality. Subsequently, in Section 4 the method is applied to a selection of transit nodes in Rotterdam, the Netherlands. Section 5 discusses the results. The final section concludes upon the research and introduces some directions for further research.

2. Literature review

In order to attract more travellers towards public transport, the perceived quality of public transport needs to be improved. Compared to a journey by car, a public transport journey consists of many more components, but not all components of the journey are experienced the same (Wardman, 2004) (see, for instance, Fig. 1). Within a journey, the experience of a traveller differs between the time inside a vehicle, the pre- and post-transport time, and the transfer time. The experience during 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 (Wardman, 2004). This means that every minute of waiting during a transfer is perceived as three minutes of in-vehicle time. Frei et al. (2015) state that ICT devices contribute to the reduction of waiting time disutility. However, during a transfer, a traveller experiences uncertainty and inconvenience (Peek and Van Hagen, 2002). Even though the subjective waiting time will be reduced, the transfer is still an unwanted

interruption in a public transport journey. It can be concluded that the transfer is the least preferred part of a public transport journey. When the transfer at a transit node is improved, the quality of a public transport journey increases.

Improving the time spent in a transit node means an improved waiting experience. Peek and van Hagen (2002) have proposed three strategies that can be used to improve the transfer:

- Acceleration
- Condensing
- Enhancement

By *acceleration*, the time travellers spend in a transit node is decreased. This can be done by increasing the frequencies of transport modes to reduce waiting times. By *condensing*, urban facilities such as housing, workplaces and leisure centers are situated closer to the transit node. Because activities are now at walking distance from the transit node the need for access and egress modes can be reduced so a traveller does not experience the low valued transfer time. With *enhancement*, the waiting during the transfer is changed into a pleasant or useful experience. This way, the objective waiting time is not decreased, but travellers feel as if they have waited less. Investments in the enhancement area are not often considered as a strategy to improve the quality of a transfer, because it is difficult to measure the effects (Peek and Van Hagen, 2006).

The importance of applying all three strategies simultaneously is explained by Vaessens (2005). In his research, he evaluated the effects of the strategies on the performance of ten stations by means of 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 the transit node quality improves.

Improving the quality of public transport can only be accomplished by understanding the travellers’ needs. Olsson et al. (2012) write that the experience of service is multidimensional. It consists of a cognitive dimension related to the service quality and two affective dimensions related to positive activation and deactivation. However, it is not clear what criteria contribute to the service quality of public transport. Van Hagen et al. (2000) have developed a model that addresses the different needs of a traveller during a journey. The different needs are ranked in a pyramid according to their importance based on the perception of quality by the NS (Dutch Railways) but is also used in scientific literature (Van Hagen, 2011; De Bruyn and De Vries, 2009) (Fig. 2). The basic needs *security*, *cleanliness* and *reliability* form the base of the pyramid (Van Hagen et al., 2000). These are followed by *speed*, *ease*,

Fig. 1. Experience of a public transport journey (Peek and Van Hagen, 2002).

Fig. 2. The pyramid of customer needs (Van Hagen et al., 2000).

comfort and experience.

During a transfer, activities of travellers can be distinguished in two states; moving and staying (Peek and Van Hagen, 2006). When travellers move through a transit node, *speed* and *ease* are of high importance (Wakefield and Blodgett, 1994). However, when staying at a transit node the *comfort* and *experience* are more important. Because moving travellers and staying travellers have different needs, it is necessary to focus on all needs of the pyramid.

The three strategies of Peek and van Hagen (2002) satisfy different needs of the customer need pyramid (Fig. 2). Acceleration aims at satisfying *speed*, condensation focuses on satisfying *speed* and *ease*, and enhancement satisfies *comfort* and *experience*. Therefore, this means that all three strategies must be applied to satisfy all the needs of the customer need pyramid and thus to improve the station quality.

Iseki and Taylor (2010) have surveyed 749 transit users in Los Angeles to investigate determinants of user satisfaction. According to them, the user satisfaction has little to do with the physical characteristics of a waiting area. Frequent and reliable service in an environment of personal safety are the most important determinants. This means that when the basic needs are not up to standard, meeting the customers' additional wishes is pointless; people will avoid the station.

2.1. The Node-Place model

In order to determine the quality of transit nodes, the Node-Place (NP) model was developed (Bertolini, 1999). The main idea behind the NP model is to determine the functionality of a transit node by analysing the relation between node and place properties. The NP model is based on the reasoning of the land use feedback cycle (Wegener and Furst, 2004). That is, improving the transport supply (or node value) of a location through improving accessibility, creates conditions favourable to the further development of the location. In turn, the development of a location (or increase its place value) will create conditions favourable to further development of the transport system because of a growing demand for transport. Transit oriented development is the integration of urban development and the development of public transport networks (Bertolini, 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). According to Chorus and Bertolini (2011), when there is a strong coherence between the node and place value, a transit node functions well. However, the NP model cannot predict developments but can help identify where there is room for further improvement.

The NP model (Bertolini, 1999) is a theoretical model, which is not applicable in practice. In existing literature several applications of the NP model have been developed (Peek et al., 2006; Reusser et al., 2008). The most recent is the one developed by Vereniging Deltametropool (Delta Metropolis Association) in 2013 (Fig. 3). This application is commonly used in practice in the Netherlands. It was used in order to assess the quality of stations in the province Noord-Holland, the city region of Rotterdam (Vereniging Deltametropool, 2013a,c), the train corridor 'Oude Lijn' and the southern part of the Randstad area (Zuidvleugel Stedenbaanplus, 2013a,b). According to this application, the node value is characterized by the position of a transit node in the public transport network, road network and slow traffic network. The place value is characterized by the intensity of inhabitants and employees, the mixture and the proximity. The quality of a transit node is relative, which means that the quality is determined by the other transit nodes in a network, or a selection of them. By normalizing the scores for each criterion, the relative score of a specific transit node can be calculated in relation with the others. This paper will elaborate on the most recent application of the NP model (Vereniging Deltametropool, 2013c).

In order to classify and compare the transit nodes with each other and indicate possible improvements, twelve transit node typologies are

Fig. 3. The most recent application of the Node-Place model (Vereniging Deltametropool, 2013c).

Fig. 4. Transit node typologies (Vereniging Deltametropool, 2013b).

distinguished (Fig. 4) (Vereniging Deltametropool, 2013b). The typologies were based on Dutch stations with different characteristics regarding living, working and facilities. However, the typologies could be different for another country. 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 in the typologies and comparing them with the current quality, areas for improvements emerge.

The NP model helps to identify where improvements regarding acceleration and condensation are needed. However, the NP model does not identify where there is a need to enhance. Acceleration influences the node value; condensation influences the place value, but enhancement is not part of the model. Therefore, the NP model needs to be extended with a third dimension that provides insight into improvements regarding comfort and experience; the experience value.

2.2. The experience value

The experience value is a rather vague term that has changed meaning over the years. Moreover, the experience value is not the same in every region. On top of that, different types of people value the experience of certain places in a different way. Human behaviour is very complex, because travellers have different expectations, needs and attitudes towards public transport and transit nodes. In order to extend the NP model with the experience value, it is needed to find general criteria. 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 actually entails. This is done by taking a closer look at a waiting environment, because this is where the public transport service takes place and where travellers experience waiting time.

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 and Smidts, 1998). The waiting experience determines if someone thinks he

has 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.

Bitner (1992) distinguishes three criteria that contribute to the quality of the waiting environment: ambient elements, spatial layout and functionality, and signs, symbols and artefacts. According to Baker and Cameron (1996) and Brady and Cronin (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. Sub criteria of ambient elements 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 of design elements 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 a service environment, such as a store or a station.

Existing literature shows different criteria that contribute to the waiting environment. We expect that the experience of travellers differs per culture. Therefore, an additional study must be carried out to define what criteria contribute to the transit node environment for a specific country, or even city.

3. Methodology

This section proposes a method to extend the NP model with the experience value in order to measure the quality of transit nodes.

3.1. Three-dimensional model

In order to provide insight into where the three strategies

Table 1
Scores for attributes of the criterion slow traffic.

a	Parameter	Description	Condition	S_a
1	PTB	Public transport bicycle		25
2	RC	Railway crossing		50
3	BPR_1	Bicycle parking places	$(BP_t/BA_t)*100 > 30\%$	50
4	BPR_2	Bicycle parking places	$15\% > (BP_t/BA_t)*100 > 30\%$	25

* BP_t is the number of bicycle parking places at transit node t ; BA_t is the number of people boarding and alighting at transit node t .

(acceleration, condensing and enhancement) must be applied, the NP model by Bertolini (1999) is extended with the experience value. In the NP model, the node and place value each have an equal share in the transit node quality. The share of the experience value must be determined to extend the NP model. However, it is undesirable to ask people's preference between the node, place and experience value to the user in a survey. In that case, a trade-off between the values is made by only one stakeholder, the user. According to Vaessens (2005) the three strategies must be applied simultaneously in order to obtain an increased performance. Based on this research, it was decided to assume that the influence of the experience value on transit node quality has the same importance as the other two.

The criteria, weights and scores for the node and place value are already known (Vereniging Deltametropool, 2013c). Because the criteria for the experience value differ per culture, it is required to first determine the criteria of the experience value before extending and applying the model. The steps below show how to add the experience value to the model and subsequently to measure the transit node quality.

3.1.1. Identify a set of transit nodes

Before measuring the transit node quality, a selection of transit nodes must be made. Because the quality of a transit node is based on the best and the worst in the selection (see Section 2.1), it is advised to select multiple transit nodes with different strengths and weaknesses.

3.1.2. Determine the criteria for the experience value

In order to quantify the value of experience, a set of criteria is needed. According to Dammers et al. (2005) it is vital that the number of criteria is limited, the overlap is minimal, and the data is practically obtainable. The criteria for the experience value can be determined by conducting a literature review which can then be made more national-specific by conducting interviews among experts/policy-makers in the country of study. Another possibility is to interview travellers in order to gain insight into their needs. The amount of criteria depends on the desired thoroughness of the research and available budget.

3.1.3. Find the weights for the criteria of the experience value

The weights for the experience value can be found using a multi-criteria decision-making method. In this paper we use, the Best Worst Method (BWM). Section 3.2 explains why this method was chosen and how it can be applied.

3.1.4. Collect the data for all three values

The data for the node and place value can be easily collected by using open source data such as Google maps. How to collect the data for the experience value depends on the chosen criteria. Data for objective criteria can be collected by visiting the transit nodes or consulting transport operators. Data for subjective criteria can be collected best by conducting a survey to question travellers on their opinion.

3.1.5. Calculate the values

The node, place and experience values can be calculated by multiplying the scores for the different criteria with the corresponding weights. For the node and place value, the criteria and weights are

already given. For the experience value, the criteria and weights are determined in step 2 and step 3.

In the next three sub sections we explain how the three node, place and experience values can be calculated

3.1.5.1. The node value. The node value for transit node t , $Vnode_t$, is obtained by calculating a simple average of the values of slow traffic network, $N_{1,t}$, the public transport network, $N_{2,t}$, and the road network, $N_{3,t}$ (Vereniging Deltametropool, 2013c):

$$Vnode_t = \sum_{g=1}^3 \frac{N_{g,t}}{3} \quad (1)$$

The three values used in (1) are calculated as follows. The value for slow traffic is given by:

$$N_{1,t} = \sum_{a=1}^4 (x_{a,t} S_a) + \frac{3}{2} LR_t \quad (2)$$

where:

$x_{a,t}$ is a binary variable which indicates the presence of an attribute a at transit node t ,
 S_a is the score for attribute a ,
 LR_t is the number of local roads within 300 m of transit node t .

The attributes of the criterion slow traffic can be scored according to Table 1.

The value for public transport is given by:

$$N_{2,t} = \sum_{a=1}^6 (x_{a,t} S_a) + \sum_{a=1}^6 \left(\sum_{c=1}^{r_a} \left(\frac{x_{a,t} S_a f_c r_{a,c}}{5} \right) \right) \quad (3)$$

where:

$x_{a,t}$ is a binary variable which indicates the presence of an attribute a at transit node t , where in this specific equation each attribute is a different mode,
 S_a is the score for attribute a ,
 r_a is the number of connections for attribute (mode) a ,
 f_c is the frequency per hour for connection c [trains/h],
 $r_{a,c}$ is the number of directions for connection c of mode a .

The attributes of the criterion public transport can be scored according to Table 2.

The value for road is given by:

$$N_{3,t} = \sum_{a=1}^6 (x_{a,t} S_a) + \sum_{a=1}^6 \left(\sum_{c=1}^{r_a} (x_{a,t} S_a 0.5 r_{a,c}) \right) \quad (4)$$

where:

$x_{a,t}$ is a binary variable which indicates the presence of an attribute a at transit node t ,
 S_a is the score for attribute a ,
 r_a is the number of connections for attribute a , $a \in \{1, \dots, 4\}$ (only for the road attributes),

Table 2
Scores for attributes of the criterion public transport.

a	Parameter	Description	S_a
1	HSL	High speed line [$v > 200$ km/h]	125
2	IC	Intercity [130 km/h $> v < 200$ km/h]	100
3	LR	Light rail [$v < 130$ km/h]	75
4	RB	Regional bus	50
5	LB	Local bus	25
6	TR	Tram	25

Table 3
Scores for attributes of the criterion road.

a	Parameter	Description	Condition	S_a
1	HE	Highway exit within 1200 m		75
2	H	Highway exit within 3200 m		50
3	RR_t	Regional road within 1200 m		25
4	RR_2	Regional road within 3200 m		10
5	CPR_1	Car parking places	$(CP_t/BA_t)*100 > 5\%$	50
6	CPR_2	Car parking places	$5\% < (CP_t/BA_t)*100 > 2.5\%$	25

* CP_t is the number of car parking places at transit node t ; BA_t is the number of people boarding and alighting at transit node t .

$r_{a,c}$ is the number of directions for connection c of attribute a , $a \in \{1, \dots, 4\}$ (only for the road attributes).

The attributes of the criterion road can be scored according to Table 3.

In order to be able to compare the transit nodes with each other, the value for each criterion of the node value N for each transit node t , $N_{g,t}$ must be normalized based on the maximum and minimum value for each criterion for the node value of all transit nodes.

$$\hat{N}_{g,t} = \frac{N_{g,t} - \min(N_g)}{\max(N_g) - \min(N_g)} \quad (5)$$

3.1.5.2. The place value. The place value of transit node t , $V_{place,t}$ is obtained by calculating a simple average of the values of proximity, $P_{1,t}$, intensity, $P_{2,t}$, and mixture, $P_{3,t}$ (Vereniging Deltametropool, 2013c):

$$V_{place,t} = \sum_{g=1}^3 \frac{P_{g,t}}{3} \quad (6)$$

The three values used in (6) are calculated as follows. The value for proximity is given by:

$$P_{1,t} = \frac{IH_{300m,t} + EP_{300m,t} + VT_{300m,t}}{IH_{1200m,t} + EP_{1200m,t} + VT_{1200m,t}} \times 100 \quad (7)$$

where:

$IH_{300m,t}$ is the number of inhabitants within 300 m of transit node t ,
 $EP_{300m,t}$ is the number of employees within 300 m of transit node t ,
 $VT_{300m,t}$ is the number of visitors within 300 m of transit node t ,
 $IH_{1200m,t}$ is the number of inhabitants within 1200 m of transit node t ,
 $EP_{1200m,t}$ is the number of employees within 1200 m of transit node t ,
 $VT_{1200m,t}$ is the number of visitors within 1200 m of transit node t .

The value for intensity is given by:

$$P_{2,t} = \frac{IH_{IA,t} + EP_{IA,t} + VT_{IA,t}}{IA_t} \quad (8)$$

where:

$IH_{IA,t}$ is the number of inhabitants in the influence area of transit node t ,
 $EP_{IA,t}$ is the number of employees in the influence area of transit node t ,
 $VT_{IA,t}$ is the number of visitors in the influence area of transit node t ,
 IA_t is the influence area (ha) of transit node t .

The influence area differs for train and metro stations. In the

application of the Vereniging Deltametropool (2013c), the influence area for train stations is the region encompassed by a circle with a radius of 1200 m and for metro stations by a circle with a radius of 800 m.

The value for mixture is given by:

$$P_{3,t} = \frac{\min(IH_{IA,t}, EP_{IA,t})}{\max(IH_{IA,t}, EP_{IA,t})} \quad (9)$$

where:

$IH_{IA,t}$ is the number of inhabitants in the influence area of transit node t ,

$EP_{IA,t}$ is the number of employees in the influence area of transit node t ,

IA_t is the influence area (ha) of transit node t .

In the application of the Vereniging Deltametropool (2013c), the mixture in the influence area is determined by calculating the mixture per squared cell of 100×100 m. Because these data is not widely available, it was decided to leave this part out of the equation.

In order to be able to compare the transit nodes with each other, the place value P for each transit node t , $P_{g,t}$ must be normalized based on the maximum and minimum node values of all transit nodes.

$$\hat{P}_{g,t} = \frac{P_{g,t} - \min(P_g)}{\max(P_g) - \min(P_g)} \quad (10)$$

3.1.5.3. The experience value. The criteria and weights for the experience value are determined in step 2 and step 3 of the methodology (Section 3.1). Based on the criteria and weights, the following equation can be used to calculate the experience value of node t ($V_{experience,t}$) as follows:

$$V_{experience,t} = \sum_{g=1}^r (E_{g,t} w_g) \quad (11)$$

where:

r is the number of criteria,

$E_{g,t}$ is the value for criterion g at transit node t ,

w_g is the weight for criterion g .

In order to be able to compare the transit nodes with each other, the experience value for each transit node must be normalized based on the maximum and minimum node value of all transit nodes.

$$\hat{E}_{g,t} = \frac{E_{g,t} - \min(E_g)}{\max(E_g) - \min(E_g)} \quad (12)$$

3.2. The best worst method

As mentioned before, the third dimension of node quality, experience, which is proposed to be part of the original NP model, is a perception-based dimension. That is to say, passengers might have different experience with a single node. The experience dimension is a complex concept which have several aspects. By evaluating these aspects and aggregating them one could arrive at an overall single score for the experience. It should be considered that different aspects of this construct might be of different importance. Therefore it appears that in order to evaluate the experience, we could use a multi-criteria decision-making (MCDM) method. MCDM methods are used in situations where we face a number of decision criteria each of which is of different importance. There are several MCDM methods in existing literature. In order to see the most commonly used MCDM methods one could refer to Fig. ueira et al. (2005) among others. MCDM methods are different with respect to several features such as aggregation vs. disaggregation, data requirements and output. In this paper we use the Best Worst Method

(BWM) (Rezaei, 2015a,b) which has been shown to be an efficient method considering its data requirement, and a structured method which leads to more reliable results. The BWM has been applied to several real-world problems including supplier selection and segmentation (Rezaei et al., 2015; Rezaei et al., 2016), technological innovation (Gupta and Barua, 2016), air freight bundling configuration (Rezaei et al., 2016), scientific output assessment (Salimi, 2017), university-industry collaboration (Salimi and Rezaei, 2016), and airport and airline service evaluation (Shojaei et al., 2017; Gupta, 2017). In what follows, the steps of the BWM are presented.

3.2.1. Determine a set of decision criteria

The decision/evaluation criteria (here, experience criteria) should be first identified. The alternatives (here, nodes) are evaluated with respect to these criteria.

3.2.2. Determine the best and the worst criteria

The best criterion (e.g. the most desirable, the most preferred, the most important) and the worst criterion (e.g. the least desirable, the least preferred, the least important) are selected by the decision-maker (or expert or user) from among the criteria identified in Step 1.

3.2.3. Determine the preference of the best criterion over all the other criteria

A number between 1 and 9 (1: B has equal preference to j ; 9: B is extremely preferred to j) is used by the decision-maker (or expert or user) to indicate the preference of the best criterion over all the other criteria. The resulting Best-to-Others vector would be:

$$A_B = (a_{B1}, a_{B2}, \dots, a_{Bn})^T, \quad (13)$$

where, a_{Bj} represents the preference of the best criterion B over criterion j .

3.2.4. Determine the preference of each of the other criteria over the worst criterion

A number between 1 and 9 (1: j has equal preference to W ; 9: j is extremely preferred to W) is used to indicate the preference of criterion j over the worst criterion W . The Others-to-Worst vector would be:

$$A_W = (a_{1W}, a_{2W}, \dots, a_{nW})^T, \quad (14)$$

where, a_{jW} represents the preference of the criterion j over the worst criterion W .

3.2.5. Find the optimal weights

To find the optimal weights of the evaluation criteria, the maximum absolute differences $\{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\}$ for all j should be minimized, which is formulated as follows (Rezaei, 2015b):

$$\min \max_j \{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\}$$

$$\begin{aligned} \text{s. t.} \\ \sum_j w_j &= 1, \\ w_j &\geq 0, \text{ for all } j. \end{aligned} \quad (15)$$

Model (15) can be converted to the following linear programming problem:

$$\begin{aligned} \min \xi^L \\ \text{s. t.} \\ |w_B - a_{Bj}w_j| &\leq \xi^L, \text{ for all } j, \\ |w_j - a_{jW}w_W| &\leq \xi^L, \text{ for all } j, \\ \sum_j w_j &= 1, \\ w_j &\geq 0, \text{ for all } j \end{aligned} \quad (16)$$

Solving (16) results in the optimal evaluation criteria weights

$(w_1^*, \dots, w_n^*)$ and the optimal objective value ξ^{L*} , which is defined as the consistency indicator of the comparison system. The consistency indicator means that the closer ξ^{L*} is to a zero the more consistent the comparison system.

3.3. Comparing the quality with the typologies

By comparing the quality of a transit node with its corresponding typology, insight will be gained into the possible improvements that can be made to the transit node. Below we explain how the difference can be calculated.

3.3.1. Classify the transit nodes in typologies

It is recommended to classify the transit nodes in typologies with a diverse and large group of people, because the classification is not only based on the current situation, but often also influenced by the ambitions of a policy-maker. This means that the classification is subjective. Therefore, the larger and more diverse the group of people, the more representative the outcome.

3.3.2. Determine the typical typology scores for the criteria of the experience value

As explained, possible improvements can be determined by comparing a transit node with its corresponding typology. The Vereninging Deltametropool (2013b) has determined typical values for the node and place value (Table 4). These values represent a situation where the transit node performs best. A typical value for the experience value is yet to be determined. A traveller is satisfied when the actual experience meets her/his expectations (Parasuraman et al., 1988). Therefore, the typical scores for the experience value at each transit node should be based on the expectations of the travellers.

3.3.3. Compare with transit node typologies

By comparing the current scores for the criteria of the values per transit node t with the corresponding typology, the difference m can be determined. Table 4 shows the typical scores per typology for the node and place value. In step 2, the typical scores for the experience value are determined.

The difference between typology and scored criteria of the node value, $mN_{g,t}$, is given by:

$$mN_{g,t} = N'_g - \hat{N}_{g,t} \quad (17)$$

where:

N'_g is the typical value for criterion g

$\hat{N}_{g,t}$ is the normalized value for criterion g for transit node t .

The difference between typology and scored criteria of the place

Table 4

Typical scores per typology (Vereninging Deltametropool, 2013b).

Typologies	Criteria node value			Criteria place value		
	N'_1	N'_2	N'_3	P'_1	P'_2	P'_3
World city	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
City centre	1.0	0.8	0.4	0.8	0.8	1.0
Metropolitan centre	0.8	0.8	1.0	1.0	0.8	0.8
Regional centre	0.8	0.6	0.8	0.8	0.6	0.8
Modern city	0.8	0.6	0.8	0.8	0.6	0.4
Gate quarter	0.8	0.3	0.8	0.8	0.3	0.4
Hub village	0.8	0.2	0.8	0.8	0.2	0.8
Suburb	0.6	0.4	0.4	0.4	0.4	0.8
Public transport quarter	0.6	0.3	0.4	0.4	0.3	0.4
Centre village	0.6	0.2	0.4	0.4	0.2	0.8
Outside gate	1.0	0.2	0.2	1.0	0.2	0.2

value, $mP_{g,t}$, is given by:

$$mP_{g,t} = P'_g - \hat{P}_{g,t} \quad (18)$$

where:

P'_g is the typical value for criterion g

$\hat{P}_{g,t}$ is the normalized value for criterion g for transit node t .

The difference between typology and scored criteria of the experience value, $mE_{g,i}$, is given by:

$$mE_{g,t} = E'_g - \hat{E}_{g,t} \quad (19)$$

where:

E'_g is the typical value for criterion g

$\hat{E}_{g,t}$ is the normalized value for criterion g for transit node t .

4. Application

In this section, the method is applied to the city of Rotterdam in the Netherlands. The application of the method on the case study provides valuable insight in the usability and performance of the method.

4.1. Introduction of the case study

The method is applied to the city of Rotterdam in the Netherlands. Currently, the 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 there is room for improvement (Gemeente Rotterdam, 2012). The municipality of Rotterdam has shown great interest in a method that can be used to improve transit nodes which contributes to a modal shift from car towards public transport.

Rotterdam is the second largest city of the Netherlands with approximately 600,000 inhabitants. The public transport network has several levels. Multiple trains run through Rotterdam, among which the high speed connection between Amsterdam and Paris. At a lower level, the city is served by a metro network with five lines and over 50 metro stations. At a few stations a transfer can be made to trains and at most stations a traveller can transfer to a bus and/or a tram.

In consultation with the municipality of Rotterdam and the local transport operator, 32 transit nodes were selected based on the node values and classified in the transit node typologies (Fig. 5).

4.2. Data collection

A literature study was carried out to determine criteria for the experience value. It was decided to only take objective criteria into account in order to develop a method that can be easily applied to transit nodes in the city of Rotterdam. The only criterion that is not objective is the criterion 'architecture'. From the literature review can be concluded that the station quality has a significant influence on the customer satisfaction, therefore it was decided to include 'architecture' as well. Based on the literature relevant to The Netherlands transport systems (Galetzka and Vries, 2012; Brons and Rietveld, 2007; Boes, 2007; Van Hagen et al., 2009; Van Hagen and Exel, 2012; Van Hagen and Heiligers, 2011), the following three main criteria and seven sub criteria are selected:

- Comfort
 - Comfortable waiting
 - Entertainment
 - Useful activities
 - Facilities

- Ambient elements
 - Architecture
 - Recently renovated
- Social elements
 - Presence of personnel

According to the literature, several aspects contribute to the criteria (Galetzka and Vries, 2012; Brons and Rietveld, 2007; Boes, 2007; Van Hagen et al., 2009; Van Hagen and Exel, 2012; Van Hagen and Heiligers, 2011). These aspects are given scores, so that the experience value can be easily determined. The scores are based on the presence of facilities at the selected transit nodes. In order to operationalize the scoring of the aspects, we have assumed that there are two or three levels for every criterion. The criterion 'architecture' can be scored based on a survey distributed among train travellers (N = 1781) (Boes, 2007). The following table (Table 5) was used to score the criteria of the experience value.

Data for the node and place value were collected by making use of open source data. In order to collect the necessary data for the experience value, all 32 transit nodes were visited.

4.3. Obtaining the weights using BWM

In order to obtain the weights using the BWM, it was decided to conduct a survey to base the weights on the opinion of the population of Rotterdam. A questionnaire specifically designed for the BWM (see, Rezaei, 2015a) was distributed by social media. This way, the weights were obtained based on the opinions of public transport travellers, car users and people who hardly travel. We received completed questionnaires from 140 respondents from the Rotterdam urban area. The characteristics of the group of respondents differ from when a random sample was taken from the population of Rotterdam. Most respondents (69%) were between 18 and 35 years old, whereas the share of this group in Rotterdam is 27% (Rotterdam Buurtmonitor, 2015a). Also, no people below 18 are part of the respondents, while this share is normally 20%. Mostly higher educated people (60%) filled in the survey. In Rotterdam, only 31% of the inhabitants is higher educated (Rotterdam Buurtmonitor, 2015b). Therefore, it cannot be concluded that the sample represents the population of Rotterdam correctly, which means that there is a possible bias.

The respondents were asked to answer three types of questions:

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

The answers on the questions were used as input for the BWM. Finally, solving model (16) for all 140 respondents and making an average, the following weights for the criteria have been obtained (Table 6).

The $\xi^* \in [0, 1]$ is considered as an indicator for the consistency of the comparisons (Table 7). The closer the values of the ξ^* to zero, the more consistent the comparison system, hence the more reliable results.

From the results it can be concluded that the respondents valued 'comfort' much more important (0.85) than the other two main criteria ('ambient elements': 0.08, and 'social elements': 0.07). In the research by Boes (2007) among train passengers of the Dutch Railways (N = 1781), comfort was also ranked higher than aesthetics and social contact. Considering all the sub criteria it appears that 'comfortable waiting' is the most important sub-criterion with the weight 0.42. Also 'spending time usefully' and 'facilities' were found to be relatively more important (0.17 and 0.18 respectively) than the other sub-criteria. From Table 7 it can also be seen that all the ξ^* are close to zero which show

Fig. 5. Selection of transit nodes in Rotterdam, the Netherlands.

Table 5
The measurement system of the experience value criteria.

Criteria	Scores			
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	
	Useful activities			
	■ Wi-Fi	Yes = 1	No = 0	
	■ Supermarket	> 1 = 1	1 = 0.5	0 = 0
	Facilities			
Ambient elements	■ Stores	> 3 = 1	1 to 3 = 0.5	0 = 0
	■ Restaurants	> 3 = 1	1 to 3 = 0.5	0 = 0
	■ Toilets	Yes = 1	No = 0	
	Architecture	Classic = 1 Modern/futuristic = 0.4	Modern classic = 0.8 Artistic = 0.2	Homely = 0.6 Trendy = 0
Social elements	Recently renovated	Most recent year of renovation (normalized)		
	Presence of personnel	Yes = 1	No = 0	

high consistency of the pairwise comparison systems hence high reliability of the results.

4.4. Extending the Node-place model with the experience value

Now that the weights of the experience value are known, the NP model can be extended with the experience value. This leads to the model visualized in Fig. 6, called Node-Place-Experience (NPE) model.

The typologies should be extended as well in order to be able to compare the value with the typical experience value at each transit node. The typical experience value for each typology is based on the expectations of the traveler. It can be assumed that the expectation of a

traveller varies for different transit nodes. In order to determine these typical values, experts from the local transport operator and the Municipality of Rotterdam were asked to together determine the typical scores, based on their experience and knowledge of the customers' expectations. During the expert session, it was stated 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. The complete transit node typologies can be found in Fig. 7.

Table 6
The weights of the criteria of the experience value.

Criteria	Weight
Comfort	0.85
Comfortable waiting	0.42
Entertainment	0.08
Spending time usefully	0.17
Facilities	0.18
Ambient elements	0.08
Architecture	0.03
Looked after	0.05
Social elements	0.07
Presence of personnel	0.07

Table 7
Consistency of the criteria.

Criteria	ξ^*
Main criteria	0.173
Comfort	0.154
Ambient elements	0.143
Social elements	0.175

Fig. 6. The proposed Node-Place-Experience (NPE) model.

4.5. Calculating the values and comparing them with typologies

For all 32 selected transit nodes in the Rotterdam area, the three values have been calculated. For the experience value, the criteria values were multiplied with the calculated weights. This has resulted in a list of the 32 transit nodes with node, place and experience values. All values are normalized in order to be able to compare them with the typologies. This means that the best and the worst transit nodes determine the range of scores.

By comparing the values with the typologies, insight is provided into where most improvements are required. Based on the differences between the values and the typologies, the transit nodes are ranked in order to prioritize them based on the improvements that are needed (Table 8). The transit node with the largest difference between the values and the typology is metro station Zuidplein. Fig. 8 shows the application of the method to that station. The grey background in Fig. 8 represents the transit node typology and the colours represent the current situation. Besides condensing and accelerating, in order to meet the demands it is also crucial to enhance the transit node. The experience value can be increased by improving comfort and ambient

elements. This can be done by facilitating the transit node with heated waiting areas, a supermarket and Wi-Fi. Ambient elements can be improved by renovating the station in a more classic type of architecture.

5. Discussion

5.1. Comparison with Node-Place model

The NP model without the experience value was also applied to the selection of 32 transit nodes in Rotterdam. Both results have been ranked according to the difference between the current quality and the typology scores. This means that when the typology score is higher, more improvements to the transit node should be made. By comparing the ranking of the NP and NPE models, it can be seen that the priority list changes significantly (Table 8).

The transit nodes Zuidplein, Rotterdam Alexander and Spijkenisse have the highest priority when applying the new method. In the application of the NP model, Zuidplein has also the highest priority, but is closely followed by Wilhelminaplein and Rotterdam Centraal. When we showed these results to the municipality of Rotterdam they concluded that the new method (NPE) better represent the reality of the city in their eyes when compared to the results obtained for the NP model. There are already plans to renovate Zuidplein and Rotterdam Alexander, so the high priority of the transit nodes matches the expectations of the municipality of Rotterdam. There are also existing plans to renovate Rotterdam Blaak. Rotterdam Blaak is ranked fourth on the priority list of the NPE method, whereas the transit node is positioned fifteenth on the list of the NP model. The results of the comparison study shows the validity of the new NPE method.

5.2. Rotterdam Central station

In order to demonstrate the influence of the experience value on the perceived station quality, we use the case of Rotterdam Central station. This station is one of the transit nodes that was recently renovated and where attention was paid to the experience value. By comparing the quality of the transit node before and after the renovation, insight is provided into the added value of the experience in measuring the transit node quality.

Before the renovation in 2004, Rotterdam Central station was an unpleasant place. The old station was home for homeless, addicts and drug dealers which resulted in travellers avoiding the station at night. In 2014, the new station was officially inaugurated. Ever since, inhabitants are proud of their station and tourists can be seen taking pictures daily. Fig. 9 shows Rotterdam Central station before and after the renovation.

By comparing both applications of the method, it can be seen that most changes have been made to the experience value (Fig. 10). The node and place value have hardly changed. Rotterdam Central station is a completely different station than ten years ago, while only the experience value has changed. From this example it can be concluded that the experience value significantly influences the perceived quality of transit nodes.

6. Conclusions and recommendations

6.1. Conclusions

In this paper we propose a method to extend the existing Node-Place (NP) model with a third dimension, the experience value, to measure the quality of transit nodes, which results in a new model, the Node-Place-Experience (NPE) model. The proposed method finds the criteria and weights for the experience value, after which the method can be applied to a selection of transit nodes. By comparing the transit node quality with the corresponding typologies, possible improvements are identified. We expect that the criteria for the experience value differ in

Fig. 7. The transit node typologies for the NPE model.

Table 8
Comparison Node-Place-Experience model with Node-Place model.

Node-Place-Experience model				Node-Place model			
1	Zuidplein	17	Schenkel	1	Zuidplein	17	De Akkers
2	Rotterdam Alexander	18	Heemraadlaan	2	Wilhelminaplein	18	Kralingse Zoom
3	Spijkensie Centrum	19	Graskruid	3	Rotterdam Centraal	19	Rotterdam Lombardijen
4	Rotterdam Blaak	20	Akkers	4	Leuvehaven	20	Schenkel
5	Wilhelminaplein	21	Schiedam Nieuwland	5	Rotterdam Alexander	21	Rotterdam Noord
6	Rotterdam Centraal	22	Kralingse Zoom	6	Capelsebrug	22	Graskruid
7	Leuvehaven	23	Rotterdam Lombardijen	7	Oostplein	23	Voorschoterlaan
8	Capelsebrug	24	Oosterflank	8	Spijkensie Centrum	24	Maashaven
9	Stadhuis	25	Hoogvliet	9	Stadhuis	25	Schiedam Nieuwland
10	Schiedam Centrum	26	Voorschoterlaan	10	Vijfsluizen	26	Delfshaven
11	Oostplein	27	Vlaardingen Oost	11	Eendrachtsplein	27	Hoogvliet
12	Eendrachtsplein	28	Delfshaven	12	Dijkzigt	28	Poortugaal
13	Beurs	29	Maashaven	13	Heemraadlaan	29	Vlaardingen Oost
14	Rotterdam Noord	30	Poortugaal	14	Beurs	30	Marconiplein
15	Vijfsluizen	31	Slinge	15	Rotterdam Blaak	31	Slinge
16	Dijkzigt	32	Marconiplein	16	Schiedam Centrum	32	Oosterflank

each country or city. Therefore, the criteria can be determined based on literature and interviewing experts, policy-makers and users (travelers). The weights for the criteria are obtained by applying the Best Worst Method (BWM), a multi criteria decision making (MCDM) method. In this paper, we have demonstrated the importance of the experience value in measuring transit node quality by means of a case study in Rotterdam, the Netherlands. In the case study, the criteria for the experience value are determined by means of a literature study. A survey amongst 140 respondents was used as input for the BWM. The case study has shown that adding the experience value to the NP model has resulted in a more accurate prioritization of transit nodes where improvements are necessary.

6.2. Insights for policy and recommendations

In many countries, a modal shift from car towards public transport is desired because of increasing congestion and pollution (Davison and

Knowles, 2006). This transition is hard to accomplish because the quality of and the attitude towards public transport need to change in many cases. In this paper we have proposed a method to measure the quality of transit nodes, the Node-Place-Experience (NPE) model, thus we are putting the transit node in a central position of the attractiveness of using transit. By improving transit nodes, value is added to the stage of a public transport journey that has the highest disutility, the transfer. This method does not only identify improvements regarding the node and place values, but also takes the quality from a traveller's experience into account. Applying all three strategies simultaneously leads to satisfying the needs of a customer during a transfer. The NPE model can function as a guideline for governments and transport operators to discuss the quality of transit nodes. By comparing the current quality of the transit nodes with their typology, the method provides insight into improvements that are needed. We recommend municipalities and public transport operators to apply the method to a selection of transit nodes in their areas. By improving transit nodes, the entire quality of

Fig. 8. Application of the Node-Place-Experience model on metro station Zuidplein.

Fig. 9. Rotterdam central station in 1958 (left) (Rotterdam010, 2016), and in 2014 (right) (ARCADIS, 2016).

Fig. 10. The method applied to Rotterdam Central station 2004 (left) and 2014 (right).

public transport journey will improve which will attract more travellers and contribute to facilitating a modal shift from car towards public transport.

6.3. Future research

We think this study can be extended in several directions. In this paper, we assume that the influence of the experience value on the transit node quality has the same importance as the node and place values. Further research is needed to determine the importance of the three values in relation to the quality of transit nodes. It is also

interesting to apply the NPE method to countries and cities with a different culture than Rotterdam, in the Netherlands. We expect that, for example, in Singapore, hygiene would be an important criterion of the experience value. By applying the method to other cultures, we expect that different criteria and weights of the experience value will emerge. In the application of the method to Rotterdam, it was decided to only take objective criteria into account. However, it will be interesting to find criteria and weights for subjective aspects of the experience value, such as security and crowdedness. This study is based on the NP model, but other methods that assess the quality of transit nodes could be developed as well. Further research is needed to explore other

methods, but we would like to emphasize the importance of the experience of travellers.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.cstp.2018.07.007>.

References

- Anable, J., 2005. 'Complacent car addicts' or 'aspiring environmentalists'? Identifying travel behaviour segments using attitude theory. *Transp. Policy* 12 (1), 65–78.
- ARCADIS, 2016. Station Rotterdam Centraal. Retrieved on May, 31st, 2016 from http://www.nationalestaalprijs.nl/uploads/projecten/1064/rotterdam_centraal_aanzicht_stadszijde.jpg.
- Baker, J., Cameron, M., 1996. The effects of the service environment on affect and consumer perception of waiting time: an integrative review and research propositions. *J. Acad. Mark. Sci.* 24 (4), 338–349.
- Beirão, G., Sarsfield Cabral, J., 2007. Understanding attitudes towards public transport and private car: a qualitative study. *Transp. Policy* 14 (6), 478–489.
- Bertolini, L., 1996. Nodes and places: complexities of railway station redevelopment. *European Plann. Stud.* 4 (3), 331–345.
- Bertolini, L., 1999. Spatial development patterns and public transport: the application of an analytical model in the Netherlands. *Planning Practice Res.* 14 (2), 199–210.
- Bertolini, L., 2008. Station areas as nodes and places in urban networks: an analytical tool and alternative development strategies. In *Railway development* (pp. 35–57). Physica-Verlag HD.
- Bertolini, L., 2013. Legitimatie en realisatie van het TOD-concept. *S + RO* 3, 22–27.
- Bitner, M.J., 1992. Servicescapes: the impact of physical surroundings on customers and employees. *J. Marketing* 57–71.
- Boes, J.M.E., 2007. Stations? Daar zit muziek in!: een onderzoek naar de effecten van muziektempo op stationsbeleving.
- Brady, M.K., Cronin Jr., J.J., 2001. Some new thoughts on conceptualizing perceived service quality: a hierarchical approach. *J. Marketing* 65 (3), 34–49.
- Brand-van Tuijn, H.A., Fanoy, J.A., Schotanus, B., 2001. Zandlopermodel: uitbreiding van het model van Bertolini, Paper presented at Colloquium Vervoersplanologisch Speurwerk 2001: Wie doet wat?, Amsterdam, 29–30 November.
- Brons, M.J., Rietveld, P., 2007. Betrouwbaarheid en klanttevredenheid in de OV-keten: een statistische analyse: Internal research report for the Transumo project Betrouwbaarheid van transportketens (in Dutch).
- Cascetta, E., Carteni, A., 2014. The hedonic value of railways terminals. A quantitative analysis of the impact of stations quality on travellers behaviour. *Transp. Res. Part A: Policy Practice* 61, 41–52.
- Cervero, R., Ferrell, C. Murphy, S., 2002. Transit-oriented development and joint development in the United States. A literature review. *TCRP research results digest* (52).
- Chorus, P., Bertolini, L., 2011. An application of the node-place model to explore the spatial development dynamics of station areas in Tokyo. *J. Transport Land Use* 4 (1), 45–58.
- Dammers, E., Hornis, W., Vries, J.D., 2005. Schoonheid is geld!. In: In: Dammers, E., Hornis, W., Vries, J.D. (Eds.), *Schoonheid is geld!: naar een volwaardige rol van belevingswaarden in maatschappelijke kosten-batenanalyses* NAI Uitgevers & Den Haag: Ruimtelijk Planbureau, Rotterdam, pp. 13–50.
- Davison, L.J., Knowles, R.D., 2006. Bus quality partnerships, modal shift and traffic decongestion. *J. Transp. Geogr.* 14 (3), 177–194.
- De Bruyn, M., De Vries, B., 2009. Het belang van kwaliteitsaspecten: uitdieping van het klantwensenonderzoek. Paper presented at the Colloquium Vervoersplanologisch Speurwerk, Antwerpen.
- Everaars, J.J., 2001. Locatieontwikkeling: Relatiemodel Tussen Ruimte, Economie En Verkeer En De Invloed Van Actoren Hierop in Beeld Gebracht. Universiteit Twente, Enschede (Master Thesis).
- Figueira, J., Greco, S., Ehr Gott, M., 2005. Multiple criteria decision analysis: state of the art surveys, vol. 78 Springer Science & Business Media.
- Florida, R.L., 2002. The rise of the creative class: and how it's transforming work, leisure, community and everyday life: Basic books.
- Frei, C., Mahmassani, H.S., Frei, A., 2015. Making time count: traveler activity engagement on urban transit. *Transp. Res. Part A: Policy Practice* 76, 58–70.
- Galetzka, M., Vries, P., 2012. Motieven, omgeving en gedrag: Wat beweegt de mus-treiziger? Transfercapaciteit op perrons, stijgpunten, traverseruimtes en halvoorzieningen.
- Gemeente Rotterdam, 2012. Verplaatsingen in Rotterdam, stadsregio en Nederland, 2004–2012.
- Gupta, H., 2017. Evaluating service quality of airline industry using hybrid best worst method and VIKOR. *J. Air Transport Manage.*
- Gupta, H., Barua, M.K., 2016. Identifying enablers of technological innovation for Indian MSMEs using best-worst multi criteria decision making method. *Technol. Forecast. Soc. Chang.* 107, 69–79.
- Harms, L., Jorritsma, P., Kalfs, N., 2007. Beleving En Beeldvorming Van Mobiliteit. Kennisinstituut voor Mobiliteitsbeleid, Den Haag.
- Hensher, D.A., 1998. The imbalance between car and public transport use in urban Australia: why does it exist? *Transp. Policy* 5 (4), 193–204.
- Iseki, H., Taylor, B.D., 2010. Style versus service? An analysis of user perceptions of transit stops and stations. *J. Public Transp.* 13 (3), 23–48.
- Meijers, E.J., 2000. Knooppunten Binnen Stedelijke Netwerken. Katholieke Universiteit Nijmegen, Nijmegen.
- Olsson, L.E., Friman, M., Pareigis, J., Edvardsson, B., 2012. Measuring service experience: applying the satisfaction with travel scale in public transport. *J. Retailing Consumer Services* 19 (4), 413–418.
- Parasuraman, A., Zeithaml, V.A., Berry, L.L., 1988. Servqual. *J. Retailing* 64 (1), 12–40.
- Peek, G.J., Bertolini, L., De Jonge, H., 2006. Gaining insight in the development potential of station areas: a decade of node-place modelling in The Netherlands. *Plann. Practice Res.* 21 (4), 443–462.
- Peek, G.-J., van Hagen, M., 2002. Creating Synergy in and around stations: three strategies for adding value. *Transp. Res. Record: J. Transp. Res. Board* 1793 (1), 1–6.
- Peek, G.-J., Van Hagen, M., 2006. Maak het snel mooier!. *NovaTerra* 6 (2), 31–35.
- Pine, B.J., Gilmore, J.H., 2007. Authenticity. What consumers really want. Harvard Business School Press, Boston.
- Pruyn, A., Smidts, A., 1998. Effects of waiting on the satisfaction with the service: Beyond objective time measures. *Int. J. Res. Mark.* 15 (4), 321–334.
- Reusser, D.E., Loukopoulou, P., Stauffacher, M., Scholz, R.W., 2008. Classifying railway stations for sustainable transitions—balancing node and place functions. *J. Transp. Geogr.* 16 (3), 191–202.
- Rezaei, J., 2015a. Best-worst multi-criteria decision-making method. *Omega* 53, 49–57.
- Rezaei, J., 2015b. Best-worst multi-criteria decision-making method: Some properties and a linear model. *Omega*.
- Rezaei, J., Hemmes, A., Tavasszy, L., 2016. Multi-criteria decision-making for complex bundling configurations in surface transportation of air freight. *J. Air Transport Manage.*
- Rezaei, J., Nispeling, T., Sarkis, J., Tavasszy, L., 2016. A supplier selection life cycle approach integrating traditional and environmental criteria using the best worst method. *J. Cleaner Prod.* 135, 577–588.
- Rezaei, J., Wang, J., Tavasszy, L., 2015. Linking supplier development to supplier segmentation using Best Worst Method. *Expert Syst. Appl.* 42 (23), 9152–9164.
- Rotterdam Buurtmonitor, 2015a. Bevolking Rotterdam. Retrieved December 11th, 2016 from <https://rotterdam.buurtmonitor.nl/jive/report/?id=bevolking&openinputs=true>.
- Rotterdam Buurtmonitor, 2015b. Opleiding, werk en inkomen. Retrieved December 11th, 2016 from <https://ggd-rotterdam.buurtmonitor.nl/jive/report/?id=werk&openinputs=true>.
- Rotterdam010, 2016. Het nieuwe centraal station, 1958. Retrieved May, 31st, 2016 from <http://www.rotterdam010.nl/403-Herinneringen/03-Centraal-Station.html>.
- Salimi, N., 2017. Quality assessment of scientific outputs using the BWM. *Scientometrics* 2017, 19.
- Salimi, N., Rezaei, J., 2016. Measuring efficiency of university-industry Ph. D. projects using best worst method. *Scientometrics* 109 (3), 1911.
- Schrijnen, J., Gerretsen, P., Rutten, N., Van Wijmen, P., 2011. Benut bestaande stad en netwerk.
- Shojaei, P., Haeri, S.A.S., Mohammadi, S., 2017. Airports evaluation and ranking model using Taguchi loss function, best-worst method and VIKOR technique. *J. Air Transport Manage.*
- STIMULUS, 1999. Segmentation for transport in markets using latent user psychological structures. Transport Research Fourth Framework Programme, Office for Official Publications of the European Communities.
- Vaessens, B., 2005. Synergie op stationslocaties. Doctoraal scriptie Sociale Geografie, Faculteit Geowetenschappen, Afdeling Economische Geografie, Universiteit Utrecht, Utrecht.
- Vale, D.S., 2015. Transit-oriented development, integration of land use and transport, and pedestrian accessibility: Combining node-place model with pedestrian shed ratio to evaluate and classify station areas in Lisbon. *J. Transp. Geogr.* 45, 70–80.
- Van Bakel, M., 2001. Stedelijke ontwikkeling van knooppunten in de Deltametropool: Een model dat een keuzevoor de locatie van te ontwikkelen knooppunten kan onderbouwen, Masters Thesis (Utrecht, University Utrecht).
- Van den Heuvel, M.G., 1997. Openbaar vervoer in de randstad: een systematische aanpak.
- Van Hagen, M., 2011. Waiting experience at train stations: Eburon Uitgeverij BV.
- Van Hagen, M., Exel, M., 2012. De reiziger centraal: Bureau Spoorbouwmeester.
- Van Hagen, M., Heiligers, M., 2011. Effect of station improvement measures on customer satisfaction. Paper presented at the European Transport Conference 2011.
- Van Hagen, M., Boes, J., Van den Heuvel, E., 2009. Naar een standaard belevingsinstrument. Paper presented at the Colloquium Vervoersplanologisch Speurwerk, Driebergen.
- Van Hagen, M., Peek, G.-J., Kieft, S., 2000. De functie van het station: een visie. Paper presented at the Colloquium Vervoersplanologisch Speurwerk 2000: Wie betaalt bepaalt.
- Vereniging Deltametropool, 2013a. Knooppunten in de stadsregio Rotterdam.
- Vereniging Deltametropool, 2013b. Knooppuntenmilieus.
- Deltametropool, Vereniging., 2013c. Maak Plaats! Werken Aan Knooppuntontwikkeling in Noord-Holland. Provincie Noord-Holland, Haarlem.
- Wakefield, K.L., Blodgett, J.G., 1994. The importance of servicescapes in leisure service settings. *J. Serv. Mark.* 8 (3), 66–76.
- Wardman, M., 2004. Public transport values of time. *Transp. Policy* 11 (4), 363–377.
- Wegener, M., Furst, F., 2004. Land-use transport interaction: state of the art. Available at SSRN 1434678.
- Zuidvleugel Stedenbaanplus, 2013a. Corridors en Stationsprofielen 'Oude Lijn'.
- Zuidvleugel Stedenbaanplus, 2013b. Monitor Stedenbaanplus.