Vol is vol? De relatie tussen drukte, druktebeleving en klanttevredenheid in het OV

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Samenvatting

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In de OV-wereld zijn (over)volle voertuigen een terugkerend thema. Volle voertuigen leiden niet alleen tot ontevreden reizigers, maar ook tot een verslechterd beeld in de publieke opinie. Bovendien kan een ontevreden concessieverlener boetes opleggen indien de gemiddelde klanttevredenheid te laag is. Het is logisch dat drukte een negatief effect heeft op de klanttevredenheid. Minder duidelijk is echter hoe de samenhang tussen drukte en druktebeleving er precies uitziet, noch is veel bekend over hoe beiden de algehele klanttevredenheid beïnvloeden.

Gebaseerd op klanttevredenheids- en ritdata over het gehele netwerk van HTM in Den Haag is een Structural Equation Model ontwikkeld. Dit model verklaart aan de hand van de prestatie van een bepaalde rit en de persoonskenmerken van een reiziger hoe de algehele klanttevredenheid tot stand komt. De belangrijkste conclusie is dat er een overduidelijke relatie is tussen zowel daadwerkelijke als ervaren bezetting als tussen bezetting en algehele klanttevredenheid. Het model heeft een verklaarde variantie van 78,9%.

De relatie tussen daadwerkelijke en ervaren bezetting blijkt allesbehalve 1-op-1: bij een verandering in de bezetting verandert de ervaren bezetting (gemeten aan de hand van de beoordeling van de zitplaatskans) maar half zo snel mee (correlatie van -0.469). De daadwerkelijke bezetting is hierbij uitgedrukt in Load Factor: de verhouding tussen het aantal passagiers en het aantal zitplaatsen. Als de Load Factor met 20 procentpunt toeneemt, daalt de beoordeling van de zitplaatskans met 0,6 punt.

Het effect van bezetting op algehele tevredenheid is duidelijk aanwezig. Er is sprake van een indirect effect van bezetting (zowel daadwerkelijk als ervaren) op klanttevredenheid: reiscomfort vormt de belangrijkste tussenliggende variabele. Omgerekend naar concrete getallen leidt een toename van de Load Factor met 20 procentpunt tot een daling van het totaaloordeel met 0,1 punt. Indien de zitplaatskans door een reiziger met één punt lager wordt beoordeeld gebaseerd op zijn ervaring, dan daalt het totaaloordeel met 0,15 punt.

De resultaten zijn gebruikt om inschattingen te maken van de impact die veranderingen in de vervoersvraag danwel het vervoersaanbod hebben op de klanttevredenheid in het netwerk van HTM. Voorbeelden hiervan zijn dat het beter verdelen van reizigers over bestaande ritten leidt tot een toename van de beoordeling van de zitplaatskans met 0,3 punt, en dat het vervangen van oudere voertuigen door nieuwe exemplaren de algehele klanttevredenheid over het hele netwerk met 0,1 punt kan doen stijgen.

1. Introduction

In many large cities, mobility is one of the main challenges which is faced today. The number of inhabitants continues to grow and congestion issues show that having everybody transport themselves by car is difficult. Due to its ability of carrying large numbers of passengers without using a lot of space Urban Public Transport offers a natural and logical alternative.

Passengers will use Public Transport if they find this to be a comfortable way of travel. As a result, over the past years regulators have put an increasing focus on using passenger experience as a metric for operator performance. Dutch law allows regulators to reward or penalise operators in case of good or bad performance. As a result, lower bounds have been set for the minimum evaluation that passengers have to give a trip on average and benchmarks have been set to ensure the aim for continuous improvement. This can be seen, for example in the rail concession for the city of Den Haag, where operator HTM receives a fine if overall customer satisfaction is below 7.5 [1].

Crowding is one of the aspects known to impact how passengers experience a trip [2]. It is clear that travelling in an overcrowded vehicle is valued by passengers as much worse than travelling when enough seats are available [3]. Research into the effect of crowding on customer satisfaction up to this moment is, however, limited. Having quantitative insight into the form and shape of this relation is useful as this helps operators in identifying measures to solve the problems of crowding. The resulting main question which is to be answered in this paper is:

What is the relation between objective and subjective in-vehicle crowding in Public Transport and customer satisfaction?

This paper is based on a MSc thesis; more details may be found in [4].

2. Background

2.1. Literature review

Academic research into customer satisfaction in Public Transport remains a relatively young field: a large increase in the amount of research can be seen over the past 10 years. Customer satisfaction, in some studies also called service quality, is generally defined in literature as the gap between a customers' expectation of a service and his experience [5] [6]. The logical next question is what factors influence these experiences and expectations. Literature identifies two types of factors:

- Service-related factors, such as frequency and punctuality.
- Customer-related factors, such as age or gender.

In research regarding service-related factors, two approaches can be seen. Some research (e.g. [7]) identifies specific aspects (e.g. price, punctuality) which determine customer satisfaction and link these aspects directly to customer satisfaction. Other studies [8] choose a more layered approach. These studies categorise relevant aspects in a few factors (e.g. 'convenience', 'service planning and reliability') and state that these factors determine customer satisfaction. The second method has been slightly more often used. Table 1 provides an overview of relevant research into service-related factors affecting customer satisfaction in Public Transport. Regardless of the categorisation of attributes, recurring factors and aspects in literature include comfort, frequency, reliability, fare prices and travel speeds.

Table 1: literature review of service aspects affecting customer satisfaction

Author	Year	Modality	Dimensions
Yaya, Fortià, Canals, Marimon [6]	2015	Bus	Functional Quality, Physical Environment Quality, Convenience Quality
de Oña, Eboli & Mazzulla [7]	2014	Bus	Fare, information, courtesy, safety, accessibility, cleanliness, space, temperature, proximity, speed, punctuality and frequency
Morton, Caulfield & Anable [8]	2016	Bus	Convenience, Perceived Cabin Environment, Ease of Use
Abenoza, Cats & Susilo [9]	2017	Bus, tram, metro	Customer interface, operation, network, travel time
Abenoza, Cats & Susilo [10]	2018	Bus, tram, metro	Waiting times, Satisfaction with access and egress legs
Fellesson & Friman [11]	2008	Bus, Tram, Metro	System, comfort, staff, safety
Redman, Friman, Gärling, Hartig [12]	2013	None*	Frequency, fare prices, speed, reliability
Eboli & Mazzulla [13]	2007	Bus	Service planning and reliability, comfort and other factors, network design
Olsson, Friman, Pareigis, Edvardsson [14]	2012	Bus, Tram	Positive activation, positive deactivation, cognitive evaluation

**This is a literature review study, the dimensions found are an aggregate of other research.*

Table 2 shows a summary of the customer-related factors found to affect customer satisfaction. It can be seen most studies find factors such as gender, age, education level and income to play a role in some way.

Customer satisfaction and crowding have rarely been linked quantitatively in academic research up to now. Only Haywood et al. (2017), investigating the Paris metro, analysed the effect of perceived crowding on customer satisfaction [21]. They found this relationship to be linear. Nevertheless, from research into the effects of crowding it can be deduced that crowding has a definite effect on passenger experience [2]. Experienced travel times and costs become much higher in case of crowding, which occurs when passenger numbers become high. The most often used metrics to measure crowding are Load Factor (the ratio between the number of passengers in a vehicle and the number of seats) and Standing Passenger Density (the ratio between the number of standing passengers in a vehicle and the space available for standing) [3], with the first in general being more usable on lower passenger numbers and the latter in crowded situations [22].

Table 2: literature review of personal characteristics significantly affecting customer satisfaction

Author	Year	Modality	Factors
Yaya, Fortià, Canals, Marimon [6]	2015	Bus, Tram, Metro	Age, Possession of Drivers' license, education
Morton, Caulfield & Anable [8]	2016	Rural Bus	Age, Gender, Education level, main occupation
Abenoza, Cats & Susilo [9]	2017	Bus, Tram, Metro	Frequency of PT Use, Age, Car Access
Theler & Axhausen [15]	2013	Urban Bus	Age, Frequency of PT Use
van Lierop & El-Geneidy [16]	2016	Metro	Income, Car access
Van 't Hart [17]	2012	Bus, Tram, Metro	Frequency of PT Use, Age, Gender, Location, Travel Purpose
Diana [18]	2012	Bus (Urban and rural)	Frequency of PT Use, Location
Mouwen [19]	2015	Bus, Tram, Metro, Train	Age, Past Experiences
Friman, Edvardsson & Görling [20]	2001	Bus, Tram, Metro	Past Experiences
Koning, Haywood & Monchambert [21]	2017	Metro	Income

One possible reason for the lack of research on the effect of crowding on customer satisfaction might be the time investment coming with collecting enough data on occupancy rates. The introduction of Smart Card payment systems such as the OV-Chipkaart in the Netherlands opens up a lot of possibilities for gathering occupancy data, which allows for much richer data set than used to be possible. As Yap et al. (2018), Hörcher et al. (2017), Hong et al. (2016), and Ticharini et al (2016) show, the increasing use of Smart Cards as payment measure in Public Transport provides a very rich data source for occupancy rates which was unavailable up to this point [23][25][25][26].

However, while some researchers (e.g. [27]) have explored some parts of the relationship between crowding and customer satisfaction no one has tried quantitatively to capture either:

- The exact relationship between objective and subjective crowding

- The effect of both objective and subjective crowding on customer satisfaction.

We developed a framework which captures both these relationships, as shown in Figure 1. Rectangles show observed variables and ovals represent latent variables. Variables which were excluded in alter analysis due to data and time restrictions are marked in red, those which were included are marked in green. Customer satisfaction is explained using a multi-layered structure, in line with, for example, Eboli and Mazzulla (2007) and Morton and al (2016) [8] [28]. Customer satisfaction is constructed as the sum of customer perception in three latent factors: service quality, comfort and safety.

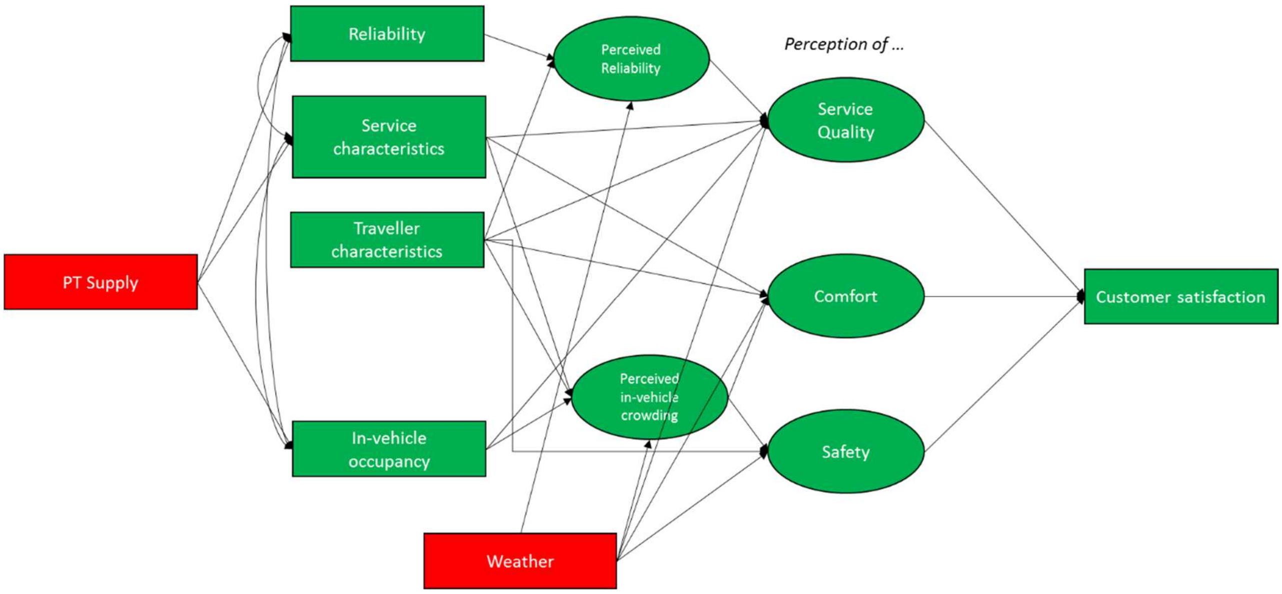

Figure 1: Framework used for analysis

The framework is innovative in suggesting that the relation between occupancy and customer satisfaction is indirect. Previous studies such as those mentioned in table 1 do not consider crowding to be an important determinant of customer satisfaction. However, they do not search for indirect effects. It is logical that the effect of crowding on customer satisfaction is indirect. Our hypothesis is that passengers do not dislike overcrowding because there are a lot of people in a vehicle, they dislike overcrowding because of the discomfort that comes with it.

2.2. Case Study Background

This research has been conducted at HTM Personenvervoer NV. HTM operates all urban rail lines in the Den Haag region and all urban bus lines within Den Haag, under concessions granted by the Metropoolregio Rotterdam-Den Haag (MRDH). The network consists of 12 tram lines and 14 bus lines. In 2018, HTM transported a total number of 100 million passengers in the Den Haag area: 84 million in trams, 16 million in urban buses [29]. For its tram lines HTM uses three types of trams: from old to new these are GTL-8, Regio Citadis and Avenio. HTM used one bus type for all bus lines in 2018, the year which was used as a basis for analysis. Starting in December 2018 a second, electric bus type was introduced.

HTM aims at offering its passengers a travel experience as pleasant as possible. As a result, it is useful for HTM to have knowledge of how passengers experience in-vehicle crowding. This insight can help HTM to further improve its services.

3. Methodology

A quantitative analysis of the framework presented in figure 1 requires data on both objective occupancy rates as well as subjective perceived in-vehicle crowding and customer satisfaction. For this study, data on vehicle occupancy is collected at HTM measuring transactions with the OV-chipkaart system. The usage of the OV-chipkaart provides enough data on occupancy rates for a large-scale analysis of the impact of in-vehicle crowding on customer satisfaction. For customer satisfaction data HTMs own customer evaluation panel (HTM Klantenpanel) was chosen as a data source, using all data for the year 2018. When evaluating a trip via the klantenpanel, a respondent is asked to give 13 aspects a mark from 1 (low) to 10 (high), with the possibility of answering 'I do not know' or 'did not apply to this trip' as well. Table 3 provides an overview of all these aspects as well as how they were categorised per latent variable as shown in figure 1.

Table 3: Indicators per dimension

Factor	Indicator [1-10]
Comfort	Comfort
	Cleanliness of vehicle
	Cleanliness of stop
	Friendliness of staff
	Ease of buying a ticket
	Driving style of driver
Perceived Crowding	Probability of finding a seat
Perceived Reliability	Punctuality
Safety	Feeling of safety during this trip
	General feeling of safety in PT
Service Quality	Information supply on stop
	Information supply during delays or disruptions
	Frequency

In order to analyse the effect of objective and subjective in-vehicle crowding on customer satisfaction objective data needs to be coupled to the customer satisfaction responses. Therefore, each response was coupled to the service which it evaluated and occupancy and punctuality data was retrieved for this service. As a measurement of crowding the Load Factor on boarding was chosen. If no corresponding occupancy data could be found or if there existed any ambiguity regarding what service was evaluated the data was deleted. As a result, the evaluation of 2858 trips was used for analysis. Table 4 provides an overview of all objective characteristics used in analysis.

The relation between occupancy and overall satisfaction was modelled as linear after some testing. This was done by fitting a linear, quadratic and cubic polynomial on the data for these variables. While the explained variance found was quite low, all polynomials were found to be significant ($p = 0.000$) and using a non-linear polynomial resulted in little extra explained variance.

Because of the complex and multi-layer framework, it was chosen to use Structural Equation Modelling (SEM) to analyse the relation between crowding and customer satisfaction quantitatively. SEM is suited for this type of models and moreover is able to estimate relationships between unobserved constructions based on measured variables [30].

Table 4: List of observed variables used in analysis

Category	Attribute	Unit
Personal characteristics	Age	Year
	Gender	Male/Female
	Education Level	Elementary/MBO/HBO/WO
	PT Travel Frequency	Trips per year
	Travel Motive	Commute/business/ education/leisure/other
	Experienced Disruption or delay	Yes or no
Service characteristics	Frequency	Services per hour
	Vehicle Type	Avenio/Citadis/GTL/Bus
	Travel moment during rush hour	Yes or no
In-vehicle occupancy	Load Factor on boarding	% (number of passengers / number of seats)
Reliability	Departure delay on boarding	Seconds

4. Results

4.1. Measurement Model

Before estimating the Structural Equation Model, a Confirmatory Factor Analysis (CFA) was carried out. This analysis tests if the latent factors are explained sufficiently by the attributes which should explain them. In essence this means testing whether the distribution of indicators to factors as shown in Table 3 is correct. In this test two questions need to be answered:

1) Does an indicator load sufficiently on its corresponding factor? This is measured using the indicator weight.
2) Do all indicators coupled to a factor sufficiently explain this factor? This is measured using the Average Variance Extracted (AVE).

Table 4 shows the resulting weight at which each indicator loads on its respective factor and the average variance extracted on each factor.

One indicator (marked in red) just fails to meet the 0.5 threshold for the weight of individual indicators and the AVE is a tad low for the factors Perceived Service Quality and Perceived Comfort. Further analysis showed, however, that deleting the indicators with poorer fit to get the AVE above 0.5 significantly decreased overall model fit. Hence the decision was made not to leave out any indicators of the model.

Beside the analysis of factor loads, general model fit of the measurement model is also important to analyse. The Comparative Fit Index (CFI) of the measurement model is 0.916, above the threshold of 0.9 indicating good model fit. The Root Mean Square Error of Approximation (RMSEA) is 0.087, just above the threshold of 0.08 which indicates the upper bound for good model fit. In conclusion, the fit of the measurement model was considered to be good enough for the structural model to be estimated.

Table 4: Standardised coefficients of measurement model. The colours (green, yellow, red) indicate good (> 0.7), acceptable (> 0.5) and poor (< 0.5) fit of individual indicators. The Average Variance Extracted (AVE) per factor ideally is at least 0.5.

Factor	**Indicator**	***Weight***	***Average Variance Extracted (AVE)***
Perceived Safety	Feeling of safety during this trip	0.739	0.716
	General feeling of safety in PT	0.942	
Perceived Service Quality	Frequency	0.708	0.496
	Information supply during delays or disruptions	0.710	
	Information supply on stop	0.696	
Perceived Comfort	Cleanliness of vehicle	0.751	0.477
	Comfort	0.780	
	Driving style of driver	0.728	
	Cleanliness of stop	0.634	
	Friendliness of staff	0.721	
	Ease of buying a ticket	0.492	
Perceived Reliability	Punctuality	1*	1*
Perceived Occupancy	Probability of finding a seat	1*	1*

** Set to 1 per definition, as for these factors only one indicator is available.*

4.2. Structural Model

Based on the positive results of the analysis of the measurement model and all data a structural model was estimated. The results can be seen in Figure 3, which gives a visual overview of the value of the relations in the framework. All effects shown are standardised, which means the relative strength of relationships is shown well. The model fit of the structural model is good: the CFI is 0.910 and the RMSEA is 0.059. The explained variance is 78.9%.

Figure 2 shows an overview of the relation between occupancy and customer satisfaction. Results show an evident effect of crowding on customer satisfaction: the standardised effect of the Load Factor on overall satisfaction was found to be -0.111. The effect of perceived crowding was even a bit stronger at 0.215. The effect of occupancy on subjective crowding was estimated to be -0.469 – one of the strongest relations in the model but still far from a one-on-one relation. Perceived crowding can thus not be fully explained using just occupancy. The relation between objective and perceived crowding has a negative sign due to the method of measurement: the occupancy is measured using the Load Factor, in which a higher number means more crowding. On the other hand, perceived crowding is measured using the mark given for the probability of finding a seat on boarding, in which a higher value means less crowding.

The hypothesis that the effect of occupancy on customer satisfaction is indirect seems to be verified by the results. Both perceived comfort and perceived service quality are found to be significant mediating factors, wherein the relation via perceived comfort is strongest.

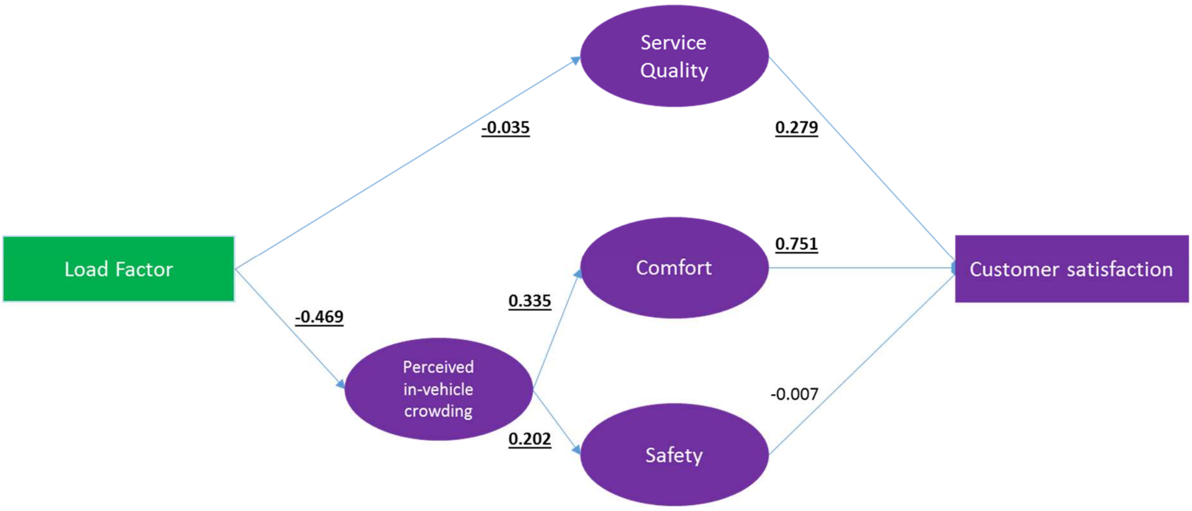

Figure 2: Link between occupancy and customer satisfaction. Bold, underlined relations are significant at the 0.05 level.

When looking at Figure 3 more insights can be retrieved than just the relation between occupancy and customer satisfaction as visualised in Figure 2. To start with, a significant correlation (0.263) between occupancy and delay was found. This means that fuller vehicles are more often delayed and vice versa.

Next, the effect of service and personal characteristics can also be analysed. Vehicle type has an impact on perceptions. The newer Avenio trams are evaluated as significantly more comfortable than other tram types and buses. As a result, these trams also have a significant better overall satisfaction. Frequency and travel moment only have a significant impact on perceived service quality which is not very strong. As a result, their effect on overall customer satisfaction, while significant, is small.

Looking at the effect of personal characteristics, the effect on perceived crowding is comparable to the effect on overall satisfaction in significance, sign and size. The elderly are more satisfied than younger travellers and females are slightly more satisfied than males. Interestingly the effect of education level on customer satisfaction is negative and strong: the model predicts a difference of a whole point on a scale of 1 to 10 between very low and high education. Delay perception has a large impact on customer satisfaction as well: passengers who mention having experienced a delay or disruption during their trip evaluate their overall satisfaction with their trip 1.2 points lower than passengers who did not experience a delay or disruption.

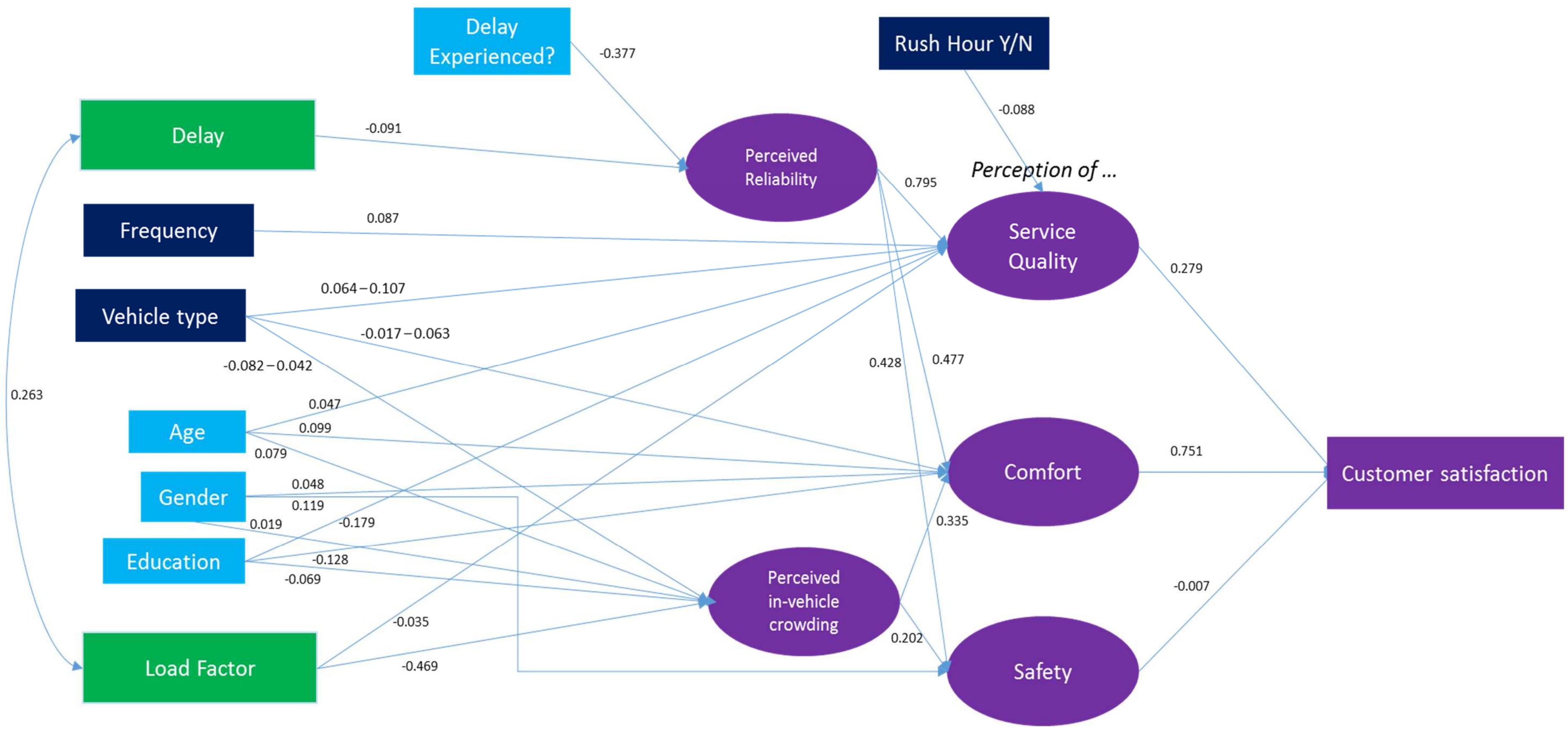

Figure 3: Estimated structural model with standardised effects. If a variable had no significant (p < 0.05) effect on any other variable it was left out of this figure. Colours represent the type of variables: personal characteristics in light blue, service characteristics in dark blue, operational service performance in green, and customer evaluation of (aspects of) a trip in purple.

5. Implications

The main aim of this research was to gain insight in the relation between objective and subjective crowding and overall customer satisfaction. These insights can also be used to estimate the effect of policy measures on customer satisfactions as well as to explore the effects of upcoming developments on customer satisfaction. This section will provide four examples: the replacement of old trams, distribution of passengers over services, the effect of passenger growth and the impact of frequency changes.

For example, in the upcoming years the remaining old GTL-8 trams will be replaced with new trams. As the newer trams score significantly better overall, an increase in overall satisfaction as a result of this replacement can be expected. The model predicts an increase in overall customer satisfaction with 0.25 point if a GTL service is replaced by an Avenio service. This value can also be converted to the network as a whole. In 2018 35% of passengers travelled on lines driven by a GTL (lines 1, 6, 12, 16). Assuming the average Load Factor of 40.6% found in the dataset used for analysis, replacing all GTL trams with Avenio trams will lead to an expected increase in overall satisfaction of circa 0.09 for the HTM network as a whole.

A second example considers the distribution of passengers over services on lines with high frequencies. Several lines on the HTM network, for example lines 3, 4 and 9, suffer from skewed occupancy between services. This is mainly an issue during rush hour, when this skewedness results in overcrowded vehicles followed a few minutes later by vehicles with empty seats. As a result, while the total capacity is sufficient passengers in the overcrowded services do not experience a comfortable journey. It was estimated how much customer satisfaction could be gained by distributing passengers evenly. If all passengers in a given time frame were distributed perfectly even over services, overall customer satisfaction can be improved by up to 0.05 point and perceived crowding can be improved by up 0.3 point on a scale of one to ten. It is thus advisable to put effort in trying to distribute passengers more evenly among trams during rush hour.

The third example considers passenger growth. General expectations are that in cities the usage of Public Transport will continue to increase in the coming years. Without supply changes this will lead to higher occupancy rates in vehicles and thus to more crowding. The effects of these higher passenger numbers on customer satisfaction have been estimated, assuming no changes on the supply side (so no increase in frequency or vehicle length, etc.).

Table 5 shows how long it takes before overall satisfaction drops with 0.1 due to increased passenger numbers for a yearly passenger growth of 1% and 3% per year, ceteris paribus, for varying current occupancy numbers. Table 5 provides two relevant insights. Firstly, the effects are found to be highly dependent on the size of this growth: in case of a growth of 3%/year a measurable impact on customer satisfaction can be seen within five years, while if growth is only 1%/year this time period is more than twice as long. Secondly, in services which are busy as of today the effect will be measurable much quicker than in quiet services.

Lastly, the effect of a change of frequency can also be estimated. Table 6 gives an overview of what happens with customer satisfaction in case of a change in frequency for a variety of current Load Factors. This calculation is again done assuming ceteris paribus. It can be seen that the positive effect of increasing the frequency when crowding occurs is much larger than the negative effect of lowering frequency in quiet times. The change in overall satisfaction presented in table 6 is the change per individual passenger. As much more passengers travel on busy lines compared to quiet lines, this effect becomes larger when all passengers are considered instead of one.

Table 5: expected time (in years) before overall satisfaction drops 0.1 on average due to growth of passenger numbers.

Current Load Factor (%)	**Yearly growth**	
	1%	3%
50	31	11
75	22	7
100	17	6
125	13	5
150	12	4
175	10	3.5
200	9	3
250	7	2.5

Table 6: Effect of frequency changes on overall satisfaction

Frequency change [veh/h/dir]	**6 -> 5**	**6 -> 5**	**6 -> 7**	**6 -> 7**
Load Factor per vehicle before change (%)	*25*	*50*	*175*	*250*
Change in overall satisfaction [1-10]	-0.045	-0.054	+0.153	+0.211

6. Conclusions and discussion

This research has quantified the relationship between objective crowding, subjective crowding and customer satisfaction using customer satisfaction survey data and corresponding smart card data. This has been a novelty with possibilities for further research.

This research quantified the relation between vehicle occupancy, perceived in-vehicle crowding and overall customer satisfaction. Due to the variety of factors which affect customer satisfaction a modelling method which is able to model the complex nature of passenger experience was required. Structural Equation Modelling was chosen as a method and found to be an adequate method of analysing this relation.

Subjective in-vehicle crowding was found to be affected heavily by objective vehicle crowding but the correlation found (-0.479) is far from one. Personal characteristics, especially age and education level, also have a significant effect on perceived crowding. The effect of in-vehicle crowding, both objective and subjective, on customer satisfaction was found to be indirect, with comfort being the main mediating variable: if a passenger experiences crowding, this will lead to more discomfort which leads to lower overall satisfaction. Again, service and personal characteristics play a role in individual experiences: newer Avenio trams are evaluated more positively, young people evaluate their trips significantly lower than old people and the evaluation also drops significantly if education level becomes higher.

The estimated model was used to estimate the impact of several possible optimisations of the current service level as well as the impact of trends and developments in Den Haag. The following can be concluded based on these estimations:

- Replacing old vehicles with new ones will lead to an increase in overall customer satisfaction of up to 0.1 point on the network as a whole.
- Given service and passenger numbers, optimal customer satisfaction is reached when passengers are distributed evenly among existing services. If this is achieved, gains can be made up to 0.3 on the evaluation of seating opportunities and up to 0.05 on overall satisfaction.
- The effect of passenger growth on customer satisfaction is highly dependent on the size of that growth and current passenger numbers. A difference in growth with 2% point per year leads to a difference up to a factor three in the time before the effects of growth become measurable in lower customer evaluation due to extra crowding. As a result, close monitoring of passenger growth is advisable to be able to anticipate adequately on the effects of passenger growth.
- Decreasing a high frequency slightly in quiet periods in order to enable a frequency increase at busy times and lines is advisable from a customer satisfaction perspective. In the example considered the increase in satisfaction on the busy services was up to five times as high as the decrease in satisfaction for the quiet service.

Besides these practical implications the study can also be reflected upon from an academic point of view. As this study has been a novelty, possibilities for expansion certainly exist. To start with, this study chose an often-used approach in which attributes were first linked to several latent constructs which in turn affected customer satisfaction. This approach has been used often in literature as well. The high correlations found between these latent constructs suggest that using fewer latent constructs might also be an interesting option of modelling. Experimenting with different set-ups of how customer satisfaction can be defined model wise is useful to get to know what the best construction is.

Moreover, not all variables found in literature to potentially affect the relation between crowding and customer satisfaction could be taken into account, mainly due to data limitations. The model could be expanded by including these factors. This includes, amongst others, the effect which the weather has on passenger numbers (on a rainy day people will tend to use PT more, on a sunny day they might prefer to bike – but little is known on the quantitative form of this relationship) as well as passenger experience.

This research modelled the relation between occupancy and perceived crowding using a linear relationship, which was the best option given the limited number of possible shapes available. This conclusion is in line with [21]. It would be interesting to use more advanced methods to test whether more complex mathematical functions can quantify the relation between objective crowding, subjective crowding and customer satisfaction even better.

If mathematically more advanced methods are used for analysis the metric used to measure occupancy is ideally reviewed as well. Literature suggests that using a variety of metrics for different occupancy levels is ideal, as each individual metric has its own advantages and disadvantages. In this study a choice for a single metric was forced by the methodology, resulting in the usage of Load Factor to represent occupancy.

Lastly, regarding data collection this research was conducted based on existing data provided by members of HTM Klantenpanel. Ideally a customer satisfaction survey is set out based on the conceptual framework which is developed.

This research has shown that it is possible to quantify the relation between occupancy rates, perceived crowding and customer satisfaction in Public Transport. Results can be used to estimate the impact of changes in PT supply and demand on customer satisfaction. This can help operators in tweaking and thereby optimizing passenger flows in their network from a crowding perception point of view.

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