CASPT 2018 Extended Abstract

The underlying effect of public transport reliability over users' satisfaction

Jaime Soza-Parra · Sebastián Raveau · Juan Carlos Muñoz

Abstract Service reliability has an important impact in the satisfaction of public transport users. Its main source is found in headway variance which not only affects waiting time, but also distributes passengers unevenly across vehicles. However, even nowadays it is unclear how headway irregularity, with its impact in waiting, crowdedness and reliability, affect travellers' service satisfaction. Different stated preference studies have tried to identify non-linear impacts produced by overcrowding, however, none of them is directly related with users' satisfaction evaluation. In this study, we try to demonstrate this non-linearity in users' satisfaction caused by both the crowding level and the uncertainty about expected waiting time. As a first approach, a simultaneous Ordered Logit Model was calibrated. Overall, there is a significant and negative impact for bus, meaning that users have a more negative perception of the level of service experienced inside a bus. Also, the impact of missing a vehicle is larger for metro while the impact of traveling seated is larger for bus users.

Keywords: Public transport satisfaction · Headway irregularity · Crowding level · Waiting time

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1 Introduction

Within public and high-frequency transport modes, metro plays a structuring role in many cities. Both authorities and users tend to prefer investment in this mode over surface alternatives such as buses and trams. Thus, when travel demand over a corridor is high enough and resources are available, many cities choose to serve this demand with a metro line. Metro usually offers its users a trip with four fundamental characteristics that are highly valued by travellers: it is fast, has short waits, has a high transport capacity and is reliable. In this case, reliability is understood as how the level of service experienced by a user who makes a trip in a repetitive manner (in similar conditions) does not vary substantially.

An element that strongly influences the reliability of a public transport line is its headway variance. This variability has a strong impact in users' satisfaction. For example in Santiago, Chile, a survey showed that headway irregularity along with insufficient frequency was at the top of the issues requested to be improved (DTPM, 2016). Unfortunately, the inherent variability in demand patterns and travel times causes headway instability leading to the well-known phenomenon of vehicle bunching. Headway variability has several harmful effects on travellers when compared with the same frequency being offered under regular headways. Among the most direct effects are an increase in average waiting time, its variability, and comfort deterioration, since the demand is not homogeneously distributed between the vehicles, causing more travellers experience crowded vehicles than empty ones (Delgado et al., 2016).

In the literature, there are several stated and revealed preference studies that provide a direct monetary value for travel and waiting time (Ortúzar & Willumsen, 2011). However, it is unclear what is the best methodology for valuing experienced comfort in public transport. To advance in this direction, in the last years different studies have been conducted in order to understand how the overcrowding degree inside a vehicle generates changes in travellers' behaviour (Batarce et al., 2015; Cats et al., 2016; Kim et al., 2015; Li & Hensher, 2011; Tirachini et al., 2013; Tirachini, Hurtubia, et al., 2016; Tirachini, Sun, et al., 2016). For instance, Batarce et al. (2016) found that the value of time in an overcrowded situation (i.e. six standing passengers per square metre) is 2,5 times larger than the value of time when there are empty seats available. The authors identify a non-linear relation between the value of travel time and the level of crowdedness the travellers suffered.

Still, it is not clear how different crowding levels, produced by headway irregularity, and the uncertainty caused by unknown waiting times affect travellers' service satisfaction. Different stated preference studies have tried to identify non-linear impacts produced by overcrowding, without getting conclusive and generalizable results, which does not necessarily prove that this does not happen. In this study, we try to demonstrate this non-linearity in users' satisfaction caused by both the crowding level and the uncertainty about expected waiting time.

2 Motivation

Let's assume there is a non-linear relationship between the vehicle load during a trip and the satisfaction of a user experiencing it. Figure 1 illustrate this relation in which service satisfaction drops non-linearly with increasing vehicle occupancy.

The impact of this non-linear relation in the level of service perceived by users is only partially understood. We will use Figure 1 to illustrate the underlying damage to public transport service quality perception caused by headway irregularity. Let us consider a bus service that is planned to operate with an average headway of 6.5 minutes and that this implies an average passenger density of 4.5 passengers per square metre. The curve of Figure 1 tells us that the expected satisfaction of users of this service should be 79.6% as long as the buses keep regular headways, and therefore, identical loads (green point in Figure 2). However, let´s assume that due to lack of control strategies, the headways between buses are 4 and 9 minutes alternately. According to this sequence, the expected bus load will be 2.8 and 6.3 passengers per square metre respectively. The satisfaction of users of both types of buses will be quite different; while users of the first type will present a 94% satisfaction, in the second type it will be of only 10%. By averaging both evaluations, the average satisfaction evaluation between all buses drops to 51.8%, as illustrated by the yellow dot in Figure 2.

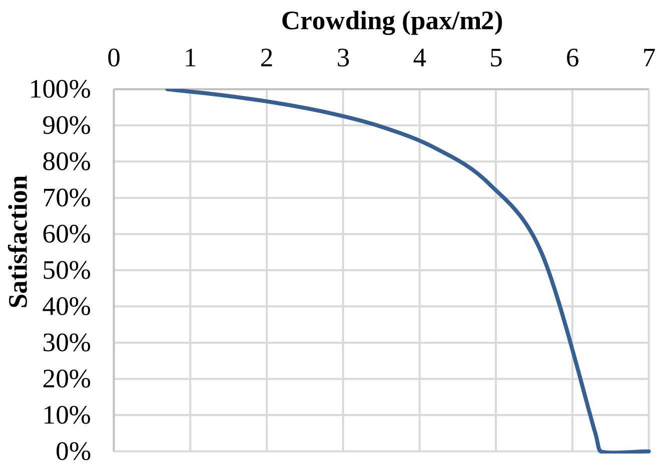
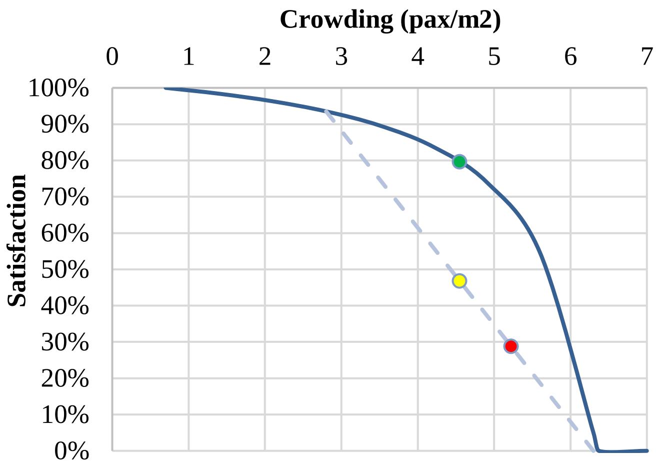


Figure 1 Non-linear relationship between vehicle load and users' satisfaction.

However, this average between average satisfaction of both vehicle types hides the fact that there are fewer travellers inside the first type of buses than in the second type, and our interest is to obtain the average evaluation perceived across users, not buses. Considering the number of travellers that each type of bus carry, the average crowding perceived by them rises to 5.2 passengers per square metre and the average evaluation drops to 35.7% (red dot in Figure 2). Thus, the system was planned for an average evaluation of 79.6%, while it dropped to 35.7% due to the headways' irregularity.

This very worrying situation is aggravated as people tend to remember their bad experiences over their good ones. Thus, level of service variability affects their appreciation by unbalancing it to those experiences with long delays and big discomfort. It would not be surprising then that, in the experiment proposed, travellers remember more their worst experiences when they are evaluating the system. This fact will be important not only in the design of the survey but also in the analysis of the results.



	Average crowding	**Average evaluation**
Optimum	4.5 pax/m2	79.6%
Vehicles	4.5 pax/m2	51.8%
Users	5.2 pax/m2	35.7%

Figure 2 Satisfaction fall due to headway irregularity.

3 Methodology

The aim of this research section is to generate a methodology able to identify and model this non-linear effect. To this end, a survey was conducted on public transport services presenting high headway variability and / or passenger density within the vehicle. The survey collected the perception or satisfaction perceived by users about the waiting time and travel comfort of the trip they just finished.

This survey was conducted during 4 days in the third week of July during the extended morning peak hour, from 07:00 am until 12:00 pm, to obtain observations in periods when capacity binds and when it does not. Users were asked to report their experience regarding their last travel-leg by train or bus only (i.e. their most recent experience).

The goal was to characterize the effect that comfort and waiting have on travellers' satisfaction. The survey was carried right outside of selected Metro stations and at their surrounding bus stops, approaching alighting travellers to guarantee the randomness of the sample. Five surveyors worked for five hours each day, obtaining a total of 1,161 responses.
The survey gathered information about five aspects, which are detailed below:

3.1. **Satisfaction**
Respondents provided a global satisfaction level, using a 1 to 7 scale (traditionally used for grading in the Chilean education system), to evaluate their perceived experience in the travel-leg they have just completed.

3.2. **Section of the route**
Respondents indicated the boarding station/stop for the travel-leg they had just completed.

3.3. **Number of denied boardings**
To have a more precise estimation of waiting time, respondents were asked about how many vehicles they had to leave due to insufficient capacity before boarding the vehicle they alighted from.

3.4. **Location during the most heavily loaded section**
Given the differences in passenger density within the same vehicle, respondents were asked to indicate where (within the vehicle) they were located during the most heavily loaded moment of their travel-leg.

3.5. **Characterization of the most heavily loaded section**
Finally, respondents characterized the passenger density experienced at the most heavily loaded moment of their travel-leg by choosing one of six images showing different crowding levels.

4 Preliminary results

An Ordered Logit Model (McCullagh, 1980) was calibrated to explain the satisfaction grade given to the trip just finished based on the answers of the survey and socio-economical information about the respondent. Several models were separately calibrated for metro and buses. However, to compare the impacts of different variables obtained between bus and metro users, a simultaneous model was also calibrated.

Since both databases may have different variances, a first model with common parameters and a scale factor λ_{Bus} for bus users was obtained. Also, a shift parameter Δ_{Bus} was calibrated, which acts as an alternative specific constant. This parameter will test if, *ceteris paribus*, there is a difference in the evaluation given by users to the level of service experience inside a bus compared to metro. With this model calibrated, it is possible to test if there are significant differences between each attribute's impact among modes.

The first impact difference tested was among passenger density. There wasn't found any significant difference between bus and metro parameters. Considering this, a common parameter was set for this variable as well as for gender (for woman users), while specific parameters for each mode were set associated to the number of denied boardings and the chance to get a seat.

The parameters obtained are:

Parameter	**Value**
$\beta_{Density}$	-0.343
β_{Sex}	0.217
$\beta_{Seated,Bus}$	0.805
$\beta_{Seated,metro}$	0.437
$\beta_{Busdenied1}$	-0.522
$\beta_{Busdenied2}$	-0.907
$\beta_{Metrodenied1}$	-0.643
$\beta_{Metrodenied2}$	-1.180
Δ_{Bus}	-1.190
λ_{Bus}	0.858

Every parameter is significant with 99% confidence level, except for β_{Sex} (94%) and $\beta_{Busdenied1}$ (92%). Overall, there is a significant and negative shift for bus evaluation, meaning that users have a more negative perception of the level of service experienced inside a bus. Also, the impact of missing a vehicle is larger for metro while the impact of traveling seated is larger for bus users.

As can be seen, crowding non-linear impact has not been tested yet. The results shown were the first modelling approach, with satisfactory results so far. The non-linearity is expected to be presented at CASPT as it is work in progress today.

5 Research Impacts

Being able to prove the relationship proposed between headway reliability and traveller's satisfaction could lead to a change in the perspective public transport systems are planned and operated. Nowadays, most of bus services focus on increasing average speed to improve the level of service offered. This happens as it is understood that increasing the speed not only reduces travelling time but also increases effective frequency and therefore transport capacity (Delgado et al., 2016).

Nevertheless, this research determines that waiting time reliability and crowding levels have a very strong impact on users' satisfaction. Irregular headways generate heterogeneity in vehicles' level of service. An often-ignored problem here is that more travellers experience the more crowded vehicles, reducing the average satisfaction index further than if just buses were compared. A second issue is that crowdedness and waiting time are strongly correlated which should also be incorporated in the model.

To make large cities more sustainable public transport should be one of the preferred modes to use. Thus, transport planners should be very sensitive to public transport traveller's experience. In this scenario, the focus must be placed in reliability, as much as it has been placed in speed in the previous decades. Faster vehicles bring travellers closer to their desired destination, but these benefits may vanish if unreliability causes people to experience long waits and crowded buses, making their traveling experience miserable. Headway irregularity push people away from public transport, making private cars look more attractive.

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