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Valuing in-vehicle comfort and crowding reduction in public transport

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Abstract
The purpose of the present study is to estimate the WTP for comfort, i.e. to get a seat, and crowding reduction on board local public transport in Sweden, including the modes metro, tram, commuter train, and local bus. We use data from an stated preference-study conducted in the three largest urban areas of Sweden. Respondents were recruited both during a trip and from a web panel. The Spstated preference-questions consisted of four attributes: travel cost, travel time, seating or standing during the trip, and crowding level. Crowding level was illustrated by pictures showing different number of standing travelers per square meter. The estimated results suggest a WTP for seating of SEK 30 to 37 (SEK 10 ≈ EUR 1) per hour depending on the crowding level. A reduction to no standing passengers from 4 and 8 standing passengers per square meter is valued SEK 12-13 and 27-32 respectively, depending on seating or standing condition. A reduction to no standing passengers from 1 standing passenger per square meter is not worth anything when the traveler is seating but SEK 8 when the traveler is standing. If we instead interpret our estimated results as value of travel time saving-multipliers, the worst travel condition in our study, i.e. standing in a crowding of 8 standing passengers per square meter, has a multiplier of about 2.1. All in all, our results seem plausible as they lies in the middle of comparable estimated results from earlier studies that have valuated comfort and crowding reductions. Finally, sensitivity analysis also show that the results seem to be both robust and in line with value of travel time savings-knowledge.

Keywords: Public transport, Comfort, Crowding, Willingness to pay, Value of travel time savings

JEL Codes: C25, R41

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1. Introduction

Urbanization and concentration of urban areas can be seen as a good way to increase public transport traveling which in turns may decrease environmental externalities of the transport sector. Problems may arise, however, with crowding on board public transport as the demand for such services increases. The supply can be increased as well to meet increased demand but to find optimal supply of public transport is a really difficult issue.

Cost benefit analysis (CBA) is an economic tool which has been important for transport planners for long time, both to analyze the investments in the transport sector and to evaluate measures (Eliasson & Lundberg, 2012). To examine CBA we need accurate estimates of the costs and benefits. Increased supply of public transport may reduce discomfort and crowding on board public transport and the travelers may experience an increased utility from such changes. This increased utility in terms of the monetary willingness to pay (WTP) metric is to be included in CBA of supply changes of public transport.

Non-market goods, such as comfort and crowding reduction, are mostly valued based on stated preference (SP) or revealed preference (RP) data (Swärdh & Algers, 2014). RP has its well-known advantage of being based on actual behavior but there is often difficult to find relevant data and also often difficulties to estimate unbiased preference parameters. SP, with hypothetical scenarios, has the main and powerful advantage that the analyst can design the

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scenario and thus estimate the preferences that is the objective of the study without considering the availability of real data. There are known problems with SP as well, e.g. the risk that the WTP estimates will suffer from hypothetical or strategic bias meaning that respondents will not answer SP-questions in the same way as they would make real choices in the similar context.

In the literature, SP data is mainly used to estimate WTP for comfort and crowding in public transport. Still there is some variation in the method used, especially considering the way to present the crowding levels to the respondents. Also, the estimated WTP differs substantially across different studies around the world. The WTP may be dependent on different, e.g. cultural conditional, preferences across the world but also due to the fact that the income level is very different in different countries.

This potential problems highlight the benefit transfer problem, i.e. when WTP-studies are transferred from one place to another. Empirical evidence about the risks of benefit transfers are relatively common in the literature, e.g. Rozan (2004). Thus, it is important that the WTP used in CBA origins from preferences based on the study place of the analyzed supply change of public transport. In other words, the knowledge of the local travelers' WTP for comfort and crowding reductions in public transport may be important for efficient planning of the public transport network.

The purpose of the present study is to estimate the WTP for comfort, i.e. to get a seat, and crowding reduction on board local public transport in Sweden, including the modes metro, tram, commuter train, and local bus. The WTP measure can also be calculated as multipliers of the value of travel time savings (VTTS) for a reference travel condition, which is common in the literature (e.g. Haywood & Koning, 2015; Tirachini et al., 2013; Wardman & Whelan, 2011). As an example, a VTTS-multiplier of 2 for a given travel condition means that the benefit of reducing travel time given this travel condition is twice as large as reducing travel time in the reference condition. In other words, the traveler is indifferent between 1 minute of travel time in the worse travel condition and 2 minutes of travel time in the reference condition.

Because previous studies regarding crowding in the Swedish public transport mainly concentrated on Stockholm, the present study will be conducted in the three largest Swedish urban areas, i.e. in addition to Stockholm also Göteborg and Malmö. We will also expand the study with infrequent travelers as this travel group not has been included in the previous Swedish studies. Infrequent travelers have also been shown to often have higher values of travel time savings than habitual travelers (Transek, 2006).

There is a relatively large body of literature considering the benefits of comfort and crowding reduction in public transports. For an overview, see for example Wardman and Whelan (2011) or Li and Hensher (2011).

Wardman and Whelan (2011) performed a meta-study of 17 UK studies of rail crowding valuations in different travel contexts. They interpret the seating and crowding WTP as VTTS multipliers which they argue are more transferable than monetary estimates. Their main conclusions are that the valuations increases with load factor and varies with respect to journey purpose. The estimated multipliers for load factors of 100 percent up to 200 percent ranges from 1 to some 1.8 for seating and from 1.5 to some 2.5 for standing.

In Mumbai city, India, suburban train travelers' valuing of crowding were investigated by Basu and Hunt (2012). The WTP-value for travel time at light crowding was around 0.35 Indian Rupee per minute (0.21 EUR/h). The WTP-values for travel time at moderate crowding, travel time at heavy crowding, and travel time at very heavy crowding were 0.49 Indian Rupee per minute (0.30 EUR/h), 0.60 Indian Rupee per minute (0.36 EUR/h), and 0.70 Indian Rupee per minute (0.42 EUR/h), respectively. To illustrate the different levels of crowding, the participants were shown photographs with different amounts of people standing at a square meter. This presentation of crowding is also used by Whelan and Crockett (2009) and suggested for future research by Wardman and Whelan (2011).

Tirachini et al. (2013) estimate the VTTS under crowding conditions using data of a choice experiment between the existing bus service or car and a proposed metro line. The crowding level is explained by drawn figures over the travelers in the vehicle. The results are in line with the meta-study of Wardman and Whelan (2011) with a VTTS multiplier taking the highest value of 3 in the error correction model and when the load factor is 2.5 (250 percent).

Haywood and Koning (2015) estimate the crowding cost in the public transport of Paris. They used showcards with different crowding levels to estimate VTTS multipliers for the number of standing travelers per square meter ranging from 0 to 6. The results showed a benefit of crowding reduction lower compared to Wardman and Whelan (2011) and Tirachini et al. (2013), which for the highest density of 6 passengers per square meter was still a VTTS multiplier below 2. According to Haywood and Koning (2015), this difference may be due to the use of a metropolitan public transport network compared to regional public transport networks in the other studies.

Swedish evidence relies mostly on a study by Transek (2006), where SP-data was used to estimate habitual public transport travelers' values of delays, crowding and seat availability on board buses, metro and commuter trains in Stockholm, the capital of Sweden. Subjects were asked to choose between different options with varying travel costs and crowding levels. The results showed that the WTP for seating varied between SEK[2] 7 per hour (on board metro with little crowding) and SEK 16 per hour (on board commuter trains with a high degree of crowding). The WTP for seating was higher the more crowding there was on the vehicles, and the WTP seemed to be higher on commuter trains than on the metro. Given that the travelers were given a seat during the trip, it was, however, no sacrifice to travel with crowding on board the vehicle. The three different crowding levels were illustrated by photographs taken into vehicles through the open doors on the metro and commuter trains.

In an earlier Swedish study, Olsson et al. (2001) investigated commuting trips, also in Stockholm. As a measure of crowding they used a guaranteed seat. The results of the study showed that travelers would on average be willing to pay SEK 84 more per month to get a seat on buses, and SEK 89 more per month to get a seat on the metro and on commuter trains. By assuming 40 trips per month and 25 minutes per one-way trip, WTP for a seat is some SEK 5 per travel hour.

As shown above, in-vehicle crowding has been illustrated in different ways. In the present study, we have chosen to define comfort by seat availability and crowding by the number of passengers standing per square meter, the latter illustrated by pictures. Compared to illustrate crowding by different load factors, which will have different implications for the discomfort of standing across different modes or different types of the same mode, passengers per square meter is also a measure that is recommended by Wardman and Whelan (2011). The result thus is a more flexible and mode-generic valuation of comfort and crowding reductions.

2. Crowding and density

When studying how travelers value different levels of crowding it is a point to distinguish between the concepts of crowding and (passenger) density because the same density level does not mean the same level of crowding to different persons. Cox et al. (2006, p. 248) describes the difference between crowding and density in the following way:

[2] SEK 10 ≈ EUR 1.

> ”Crowding is essentially a psychological phenomenon; it is a perception created from an interplay of cognitive, social and environmental factors, whereas density refers to objective physical characteristics of the situation.”

To capture the dimensionality of crowding, Mohd Mahudin et al. (2012) developed an instrument which distinguishes physical density from the subjective evaluation of crowding. The instrument was developed for use in a rail passenger context with an expectation that it could be used in other transportation settings as well. The model behind the instrument says that experience of crowding is defined by three latent factors: (1) evaluation of the psychosocial aspects of the crowded situation, (2) evaluation of the ambient environment of the crowded situation, and (3) affective reactions to the crowded situation. The first two components, along with passenger density, are assumed to influence the third component, which in turn may influence experience of stress and feelings of exhaustion (see Figure 1).

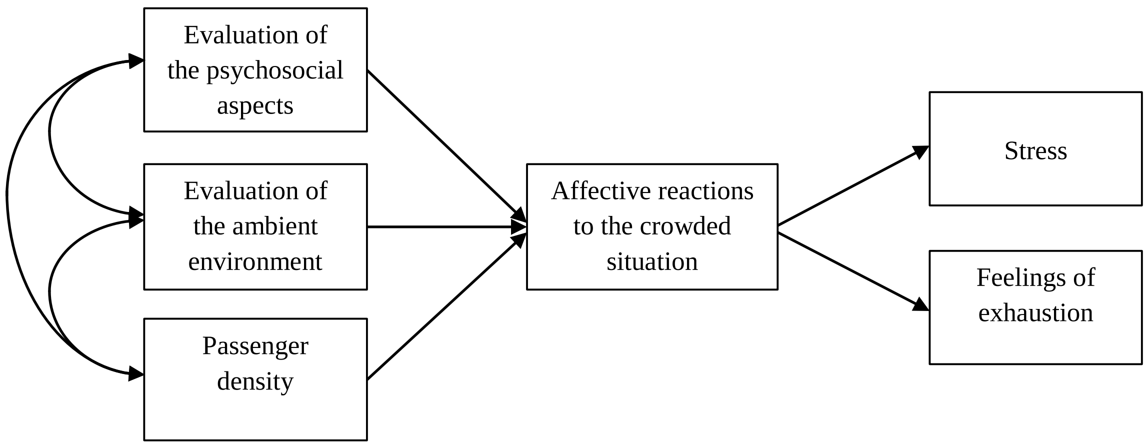

Figure 1 – The relationship between the three psychological components of crowding, passenger density, experienced stress, and feelings of exhaustion (after Mohd Mahudin et al., 2012).

In the present study we will not investigate passengers’ stress and feelings of exhaustion. Instead, we will estimate a structural equation model with *Affective reactions to the crowded situation* as dependent variable, and thereafter compare persons high and low in this variable regarding their WTP for comfort, i.e. to get a seat, and crowding reduction. We will therefore only use the two first columns in Figure 1.

3. METHOD

3.1 Participants and procedure

Two different types of data collections were carried out in the three largest Swedish urban areas: Göteborg, Malmö, and Stockholm.[3] In Göteborg and Stockholm travelers were recruited at bus stops (both cities), station platforms for metro (Stockholm), tram stops (Göteborg), station platforms for commuter trains (both cities), and by an existing national web panel of people which we had access to through an established market research company. In Malmö the travelers were recruited only by the national web panel. The reason why these three cities were chosen was that they fulfilled the criteria that it should be possible to travel by either metro, tram or commuter train. It should also be possible to go by local bus as an alternative to the other travel modes. Although we in this study do not investigate mode choice, we want to ensure that any differences in traveler's values between rail transport and bus obtained in the study are due to mode specific characteristics, and not differences between the cities.

The two types of data collection was motivated by the risk of oversampling of frequent travelers when recruiting during the trip only. To include also travelers from a web panel, we will get more infrequent travelers in our sample.

We chose to not recruit travelers during a trip in Malmö. To recruit during a trip is resource demanding and thus we used that method only in two urban areas to have a sufficiently large sample for partial analysis in a given urban area and for each recruitment method.

Before the main study was conducted, we carried out a pilot study in Göteborg to check the procedure and the questionnaire. The pilot study included 50 participants recruited during a trip and 61 participants recruited by the web panel. After the pilot study we increased the travel time of the longer trips and omitted the variable waiting time. The pilot study was conducted in March 2015 and the main study was conducted in April to May 2015. Only data from the main study is included in the analysis presented in this paper.

An information card about the study and a link to the online survey was distributed to travelers during a trip in Göteborg and Stockholm. Only travelers who were 18 years and older and understand Swedish were recruited. E-mail addresses were collected and information and the link was subsequently sent to the recruited travelers. Then also reminders were sent out to those

[3] The urban area of Göteborg has 928,629 inhabitants, the urban area of Malmö has 656,355 inhabitants, and the urban area of Stockholm has 2,054,343 inhabitants, all dated 31st of December 2010 (Statistics Sweden, 2015a).

that had not completed the survey within 3-4 days. Of those who received the information, including the link, 288 travelers in Göteborg and 287 in Stockholm chose to log in and answer the online survey. Of these questionnaires, 286 respectively 283 were suitable for further analyses. The participants recruited during a trip all received a digital lottery ticket, valued SEK 30, in exchange after the study was conducted. In total, 600 travelers in each of Göteborg and Stockholm received the information card. Some of the collected e-mail addresses were shown not to be correct, meaning that the e-mail information and the reminders were not distributed correctly. Thus, a response rate calculated on 600 travelers, i.e. 48 percent in both areas, is probably somewhat underestimated.

From the existing web panel we recruited 500 persons each from Göteborg and Stockholm, and 463 persons from Malmö. The criteria for being recruited in the panel were that the persons should be between 18 and 74 years old and have done at least one local journey with bus, metro, commuter train, or tram during the last month. The sample of the web panel was representative to the population in Swedish large cities regarding proportions of males and females in each of the age categories 18-24 years, 35-49 years, and 50 years or older. The participants recruited from the web panel were reimbursed by the company who administrated the panel. Here, the web panel administrator closed the survey when our predetermined number of respondents had completed the survey and therefore no response rate can be calculated. Also in Malmö, 500 respondents was the target but the web panel members were too few in some gender and age categories to reach that target.

In total, 2,038 individuals filled in the questionnaire. Of these, 2,003 questionnaires were appropriate for further analyses. In Table 1 we present the individual characteristics of the respondents. The respondents consist of slightly more women than men, which is consistent with the true distribution in the public transport network in these areas. The average age is some 44 years. The income of the respondents is following the pattern of Sweden as a whole, the median income is in the interval of SEK 20,000 to 30,000 per month, 34 percent has a lower income and 39 percent a higher income so the median monthly income is probably somewhere around SEK 26,000. This can be compared with the median monthly income for *employed* individuals in Sweden as a whole which is around SEK 29,000 (Statistics Sweden, 2015b). Then we can notice that there are students and pensioners in the sample but also that the residents in urban areas have on average higher income than the rest of Sweden. Another way of noticing this is that over 60 percent of the respondents have a university degree compared to only 35 percent in the whole of Sweden (Statistics Sweden, 2015c). A majority of the respondents are employed and substantial parts of the respondents are students and pensioners, respectively. Other occupations consists of small parts only.

Table 1 – Individual characteristics of the respondents.

Variable	**Mean value/percent (standard deviation)**
Proportion women	54.9%
Age (years)	43.8 (16.3)
Monthly gross income (SEK)	
- 0-10,000	16.3%
- 10,001-20,000	17.5%
- 20,001-30,000	27.5%
- 30,001-40,000	23.8%
- 40,001-50,000	8.6%
- Over 50,000	6.2%
Education	
- University degree	61.1%
- High school	30.5%
- Elementary school	6.4%
- Other	2.0%
Occupation	
- Employed	56.9%
- Self-employed	4.5%
- Student	16.1%
- Unemployed	3.3%
- Pensioner	14.9%
- Parental leave	1.7%
- Other	2.7%

3.2 Questionnaire

The questionnaire consisting of four different parts was written in Swedish and administered together with written information and instructions online.[4]

The first part of the questionnaire asked questions about the travelers' last journey with their main travel mode (web panel), or the journey they did when they were recruited (travelers recruited during a trip). The main travel mode could be bus (all cities), metro (only Stockholm), commuter train (all cities), or tram (mostly Göteborg but also a small share in Stockholm). One of the questions was how the participants experienced the crowding condition on board the

[4] A copy of the questionnaire is available from the authors upon request.

main travel mode, where the pictures (see Figure 2) show number of standing persons per square meter.

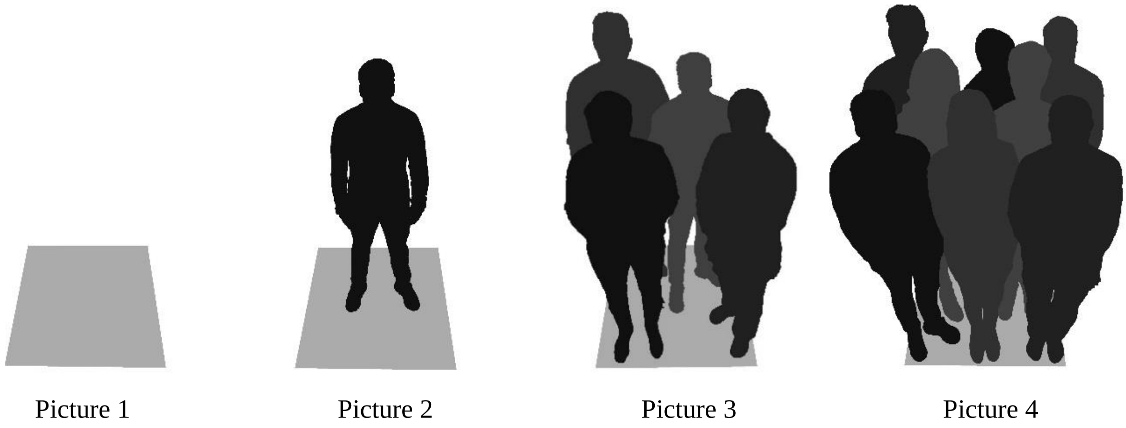

Figure 2 – Four levels of crowding, representing number of persons standing per square meter.

The second part of the questionnaire consisted of questions regarding the subjective evaluation of the crowding on board the main travel mode, representing the three latent factors of Figure 1. These questions were taken from Mohd Mahudin (2012) and Mohd Mahudin et al. (2012) and were translated and back-translated into Swedish. The first question consisted of seven items, or words, and asked about the travelers' experience of how crowded the main travel mode was (*Evaluation of the psychosocial aspects*). The seven words in this category were: *dense*, *disorderly*, *confining*, *unpleasant*, *chaotic*, *disturbing*, and *cluttered*. The next question asked about how the travelers feel inside the main travel mode (*Affective reactions to the crowded situation*). This category consists of the following nine words: *squashed*, *tensed*, *distracted*, *uncomfortable*, *frustrated*, *restricted*, *irritable*, *hindered*, and *stressful*. The third and last question asked about how the travelers experienced the physical environment inside the main travel mode (*Evaluation of the ambient environment*). This category consists of the four words: *hot*, *stuffy*, *smelly*, and *noisy*. Each word was presented on a five-degree scale ranging from "extremely" to "not", e.g. *extremely dense*, *very dense*, *dense*, *slightly dense*, *not dense*. The structural equation models are estimated by the *sem* command in Stata 12 (StataCorp, 2011) using maximum likelihood estimation.

The third part of the questionnaire consisted of eight SP-questions where the travelers were asked to choose between two journeys. One example of these questions are presented in Figure 3 and the attributes and levels used are summarized in Table 2. As can be seen, the two journeys differed according to travel time within the main travel mode, the one-way cost of the entire trip, sitting or standing in the main travel mode, and finally the level of crowding represented by one of the four pictures shown in Figure 2. The participants also had the possibility to choose the alternatives *indifferent* and *none of the alternative trips*. Depending on the participants' actual travel time with the main travel mode, the attribute levels for travel time in the stated preference situations were 5, 9, or 14 minutes for actual trips that were 15 minutes and shorter, and 18, 25, or 34 minutes for actual trips that were longer than 15 minutes. The price per one-way trip was 20, 36, or 44 SEK. The seating attribute had two levels: sitting the whole trip within the main travel mode, or standing the whole trip within the main travel mode. The levels of crowding were four, as said earlier illustrated by the pictures in Figure 2. In the scenario, the pictures was stated to illustrate the crowding level around the respondent. This means that we can combine standing with Picture 1 and that it in this case the respondent is the only one who is standing in the vehicle. Furthermore, the scenario always stated that all seats were occupied to avoid problems with voluntary standing although there are seats available.

Alternative A	**Alternative B**
The travel time within your main mode is **5 minutes**	The travel time within your main mode is **9 minutes**
The price of the one-way trip is **44 kronor**	The price of the one-way trip is **44 kronor**
You are **standing** during the whole trip within your main mode	You are **seating** during the whole trip within your main mode
The picture illustrate the view around you in the vehicle 	The picture illustrate the view around you in the vehicle 
☐ I choose alternative A	☐ I choose alternative B
☐ I choose neither of the alternatives	
☐ I am indifferent between the alternatives	

Figure 3 – Example of an SP-question used in the survey.

Table 2 – SP attributes and levels used in the survey.

Attribute	Description	Levels
Travel Cost	Travel cost per one-way trip including other public transport modes. Given in SEK.	20, 36, 44
Travel Time	In-vehicle travel time of the main mode. Given in minutes.	5, 9, 14 (if reference trip up to 15 minutes) 18, 25, 34 (if reference trip longer than 15 minutes)
Comfort	Seating or standing during the whole trip of the main mode.	Seating, Standing
Crowding	Crowding level of standing travelers per square meter in the vehicle, illustrated by pictures of the view around the participants inside the vehicle.	0, 1, 4, 8

We used a fractional factorial design (Kocur et al., 1982) with in total 16 SP-choices. These were combined together in a way that avoided dominant choices. Subsequently, the 16 SP-questions were randomly split into two blocks with 8 questions each. The respondents were assigned randomly to one of the SP-blocks regardless of urban area, long or short trip, and web panel or recruited during a trip.

Finally, the questionnaire consisted of a part with socio-economic questions, i.e. gender, age, driving license or not, occupation, number of persons in the household, number of children younger than twelve years in the household, income, education, and type of accommodation.

In Table 3 we present frequencies of different travel modes and recruitment methods by urban areas. Note that metro is by far the most common mode in Stockholm, but are not available in the other urban areas. Tram is very common in Göteborg but almost exclusively in that urban area. Commuter train is most common in Malmö but is also available in all urban areas. Finally, bus is the most common mode in total.

Table 3 – Frequency of urban areas, mode, and recruitment method, quantity and percent.

	Göteborg	**Malmö**	**Stockholm**	**Total**
Travel mode				
Bus	302 (38.8%)	295 (65.1%)	189 (24.5%)	786 (39.2%)
Metro	-	-	418 (54.2%)	418 (20.9%)
Commuter train	105 (13.5%)	158 (34.9%)	152 (19.7%)	415 (20.7%)
Tram	372 (47.8%)	-	12 (1.6%)	384 (19.2%)
Total	779 (100%)	453 (100%)	771 (100%)	2,003 (100%)
Recruitment method				
Web panel	493 (63.3%)	453 (100%)	488 (63.3%)	1,434 (71.6%)
Recruited during a trip	286 (36.7%)	-	283 (36.7%)	569 (28.4%)
Total	779 (100%)	453 (100%)	771 (100%)	2,003 (100%)

In Table 4 we present descriptive statistics of the travel characteristics, i.e. the variables that characterize the respondents' reference trip. It is shown that the mean time spending on board the main travel mode is about 24 minutes, whereas the entirely trip is about 38 minutes on average. The most common single purpose with the trip is to travel to or from work, and, on average, the respondents have been commuting with the current mode for around twelve years. Most of the respondents (61 percent) had a seat the entire trip, 45 percent traveled with the same mode the entire trip, and 59 percent started their trip the same time as usual. The most common crowding level was 4 standing passengers per square meter, even if 1 standing passengers per square meter was also very common. Remarkable is that almost 9 percent experienced a trip with a crowding level of 8 standing passengers per square meter, which implies a very heavy crowding. The respondents who have made the same trip more than once indicated in most cases that the crowding level was as high as usual.

Table 4 – Descriptive statistics of travel characteristics.

Variable	Mean value/percent (standard deviation)
Time total trip (minutes)	38.4 (27.8)
Time on board main travel mode (minutes)	24.2 (17.1)
Purpose with the trip	
- To/from work	41.0%
- To/from studies	10.4%
- Business trip	4.8%
- Other	43.7%
Years of commuting with the current mode	11.8 (10.8)
Same travel mode the entire trip	45.0%
Seating	
- Was seating the entire trip	60.9%
- Was seating the most part of the trip	22.2%
- Was standing the most part of the trip	8.8%
- Was standing the entire trip	8.2%
Level of crowding	
- 0 standing passengers/m^2	20.6%
- 1 standing passenger/m^2	32.2%
- 4 standing passengers/m^2	38.7%
- 8 standing passengers/m^2	8.5%
Started same time as usual	58.5%
Comparison with usual crowding level	
- More crowded	6.4%
- Same level of crowding	79.5%
- Less crowded	14.1%

3.3 Estimation method

The outcome of the SP-choices are analyzed by a mixed logit model (see e.g. Hensher & Greene, 2003) within a random utility framework, which is a standard discrete choice method for bivariate discrete choice. The utility of an individual *i* is given by the equation:

$$U_{ijk} = \mathbf{x}'_{ijk}\beta_i + \varepsilon_{ijk}, \tag{1}$$

where *j* (1,2) denotes the alternative trips in the specific question, *k* (1,…,8) denotes the different questions, β_i denotes the parameters to be estimated, and **x** denotes the variables included in the SP-experiment. ε_{ijk} is the random part that is not observed by the analyst.

Alternative 1 is chosen if $U_{i1k} > U_{i2k}$ and by assuming an individually independent extreme value distributed error term the model can be estimated by the mixlogit command in Stata 12 (StataCorp, 2011). As recommended by Revelt and Train (1998), 500 Halton draws are used for the simulated maximum likelihood as the bias of the simulating procedure decreases when the number of draws increases.

The mixed logit model allows for random parameters but can be sensitive to which parameters that are treated as random and the assumed distribution for the parameters. The normal distribution is the simplest distribution to assume but it has the drawback of taking positive values for some individuals although the theoretical guidance states that the marginal utility always is non-positive, as for e.g. travel time and travel cost. Instead, the log-normal distribution can be used, which restricts the marginal disutilities to a given sign for all individuals. Travel time (TT in the equations hereafter), Travel cost (TC), and Crowding levels (CL) are all assumed to have a non-positive marginal disutility and we assume their parameters to be log-normally distributed. For Standing (ST), on the other hand, we assign a normally distributed marginal utility in our estimation. The main argument is that it is relatively common to observe travelers in the local public transport that are standing in the vehicle although there are available seats. Thus not all travelers will have a negative utility change by standing instead of seating.

In the model, we also include interaction terms between Standing and Crowding levels, which means that the effect of seating is allowed to vary with the crowding level and the effect of reduced crowding is allowed to be different for seating condition and standing condition. These parameters have no specific theoretically expected sign although we except that it is more likely for those parameters to be negative than positive. Negative parameters mean that crowding is afflicted with more disutility when the traveler is standing compared to when the traveler is sitting. Still, the unpredictable sign implies that we use a normal distribution for the parameters of these interacted variables.

For the random parameters with a log-normal distribution we follow the recommendation by Meijer and Rouwendal (2006) to interpret the median as the marginal utility. The reason for not using the mean is that the log-normal distribution can be heavily skewed to the right with a long tail which in such cases imply that the mean value is not representative for the respondents. The median of a log-normal distribution is calculated as $\exp(\beta_i)$.

We also in Section 4.3 analyze the distributions of the random parameters with focus on interpreting the fraction of travelers with non-expected sign of the marginal utilities.

In the data for analysis we have excluded choices where the respondent has chosen neither of the alternative trips, i.e. have chosen *indifferent* or *none of the alternative trips*.

To estimate WTP for comfort and crowding reductions, based on the estimated model, we divide the marginal utility of each travel condition with the estimated marginal utility of the travel cost. As an example the formula for the WTP of reducing the crowding from 8 standing passengers per square meter to 0 standing passengers per square meter will, if the traveler is seating, be given as:

$$WTP_{CL8} = \frac{\exp(\beta_{CL8})/\overline{TT}}{\exp(\beta_{TC})}, \tag{2A}$$

or if the traveler is standing by:

$$WTP_{ST,CL8} = \frac{(\exp(\beta_{CL8}) + \beta_{ST*CL8})/\overline{TT}}{\exp(\beta_{TC})}. \tag{2B}$$

Note that the indicators of seating and crowding level in our model is not adjusted for travel time. Thus we also need to divide these coefficients with the mean travel time ($\overline{TT}$) of the SP-questions. WTP for other travel conditions are calculated analogously.

In the similar way, the WTP for travel time reductions, conventionally known as the value of travel time savings (VTTS) is given by:

$$VTTS = \frac{\exp(\beta_{TT})}{\exp(\beta_{TC})}. \tag{3}$$

Equation (3) is showing VTTS for the reference case in the estimated model, which we set to seating in a crowding level of 0 standing passengers per square meter. To calculate VTTS in other travel conditions we need to incorporate the coefficient of these indicators in the numerator of Equation (3). As an example, the VTTS for standing in a crowding level of 8 standing passengers per square meter is calculated as:

$$VTTS_{ST,CL8} = \frac{\exp(\beta_{TT}) + (\beta_{ST} + \exp(\beta_{CL8}) + \beta_{ST*CL8})/\overline{TT}}{\exp(\beta_{TC})}. \tag{4}$$

Dividing $VTTS_{ST,CL8}$ calculated in Equation (4) with $VTTS$ calculated in Equation (3) implies the expression for the multiplier for standing in a crowding level of 8 standing passengers per square meter, i.e. how travel time savings in that particular travel condition is valued relatively to travel time savings in the reference travel condition:

$$Multiplier_{ST,CL8} = \frac{VTTS_{ST,CL8}}{VTTS} = \frac{\exp(\beta_{TT}) + (\beta_{ST} + \exp(\beta_{CL8}) + \beta_{ST*CL8})/\overline{TT}}{\exp(\beta_{TT})}. \quad (5)$$

The multipliers for the other travel conditions will be calculated analogously. In total, 7 multipliers relative to the reference VTTS are estimated. These are: sitting in a crowding of 1 standing passenger per square meter, sitting in a crowding of 4 standing passengers per square meter, sitting in a crowding of 8 standing passengers per square meter, standing in a crowding of 0 standing passengers per square meter[5], standing in a crowding of 1 standing passenger per square meter, standing in a crowding of 4 standing passengers per square meter, and standing in a crowding of 8 standing passengers per square meter. Finally, note that WTP and multipliers are estimated in the statistical software Stata (StataCorp, 2011) and that their standard errors are calculated by the delta method (see e.g. Cameron & Trivedi, 2005, p. 231-2).

4. RESULTS

4.1 ESTIMATED DISCRETE CHOICE MODELS AND WTP VALUES

In Table 5, the estimated results of the discrete choice model specification are presented. All coefficients in the model are set as random. Travel cost, travel time, and crowding are considered as disutilities and cannot be positive and therefore the coefficients were estimated by assuming log-normal distributions. Standing, and the interaction coefficients between standing and crowding can be either positive or negative and therefore we estimate them by assuming normal distributions.

[5] Here, the respondent is the only standing person in the vehicle.

Table 5 – Estimates from the discrete choice models. Medians and standard deviations.

Variable	**Coefficients (Standard errors)**
Medians	
Travel Cost	-.197*** (.010)
Travel Time	-.179*** (.009)
Seating	Reference
Standing	-1.897*** (.144)
Crowding 0/m^2	Reference
Crowding 1/m^2	-.038 (.043)
Crowding 4/m^2	-.790*** (.141)
Crowding 8/m^2	-1.729*** (.125)
Standing*Crowding 1/m^2	-.485* (.192)
Standing*Crowding 4/m^2	-.054 (.135)
Standing*Crowding 8/m^2	-.295 (.183)
Standard deviations	
Travel Cost	.311*** (.032)
Travel Time	.150*** (.019)
Standing	2.130*** (0.113)
Crowding 1/m^2	7.590 (8.664)
Crowding 4/m^2	.315** (.104)
Crowding 8/m^2	.337 (.192)
Standing*Crowding 1/m^2	1.830*** (.204)
Standing*Crowding 4/m^2	.004 (.049)
Standing*Crowding 8/m^2	-.025 (.173)
Log-likelihood	-6,687.777
Pseudo R-square[a]	0.283

Notes: The estimations are based on 13,459 choices of 2,003 respondents. Number of Halton draws is 500.
*p < 0.05, **p < 0.01, ***p < 0.001.
[a] Estimated by $1 - \frac{\ln \hat{L}(M_{Full})}{\ln \hat{L}(M_{Intercept})}$.

The estimated results show that the parameters estimating the main effects are statistically significant, which includes a negative marginal utility for all attributes, except for crowding with 1 passenger standing per square meter. Compared to no standing passengers, 1 passenger standing per square meter seems not to be considered as negative by the travelers, given that the traveler oneself is seating. There are no strongly significant interaction effects between standing and crowding, indicating that the effect of standing does not vary substantially with respect to the crowding level. The interaction between standing and crowding of 1 standing passenger per square meter is negative and significant at the five-percent level. The interpretation is that crowding of 1 standing passenger per square meter is worse for a standing traveler than for a seating traveler. The estimated standard deviations show large variation for some marginal utilities and remarkably small variation for other marginal utilities. In Section 4.3, these preference distributions are analyzed.

In Table 6, we present the WTP-values for crowding reductions, seating, and travel time savings calculated as described in Equations (2) and (3). Note that the WTP for simultaneous crowding reduction and comfort improvement can be calculated by adding up the corresponding WTP estimates.

Table 6 – Estimated hourly WTP for changes in crowding, comfort, and travel time.

Reduction of crowding		**WTP (SEK/h) [Confidence interval]**
Before change	**After change**	
Seating, crowding 1/m^2	Seating, crowding 0/m^2	1 [-1 – 2]
Seating, crowding 4/m^2	Seating, crowding 0/m^2	12 [8 – 16]
Seating, crowding 8/m^2	Seating, crowding 0/m^2	27 [23 – 31]
Standing, crowding 1/m^2	Standing, crowding 0/m^2	8 [3 – 13]
Standing, crowding 4/m^2	Standing, crowding 0/m^2	13 [11 – 16]
Standing, crowding 8/m^2	Standing, crowding 0/m^2	32 [27 – 36]
Increasing comfort (seat)		
Before change	**After change**	
Standing, crowding 0/m^2	Seating, crowding 0/m^2	30 [25 – 35]
Standing, crowding 1/m^2	Seating, crowding 1/m^2	37 [33 – 41]
Standing, crowding 4/m^2	Seating, crowding 4/m^2	30 [25 – 36]
Standing, crowding 8/m^2	Seating, crowding 8/m^2	34 [30 – 38]
VTTS		
Reference condition (seating, crowding 0/m^2)		54 [49 – 60]

Notes: The confidence intervals are at 95 percent level and calculated based on standard error calculated with the delta method. The WTP estimates are either a change from a travel condition with crowding to a travel condition without crowding, or from a standing travel condition to a seating travel condition. Given in SEK, SEK 10 ≈ EUR 1.

Crowding reductions from a crowding of 1 passenger standing per square meter to no crowding is worth SEK 1 per hour, when seating, and SEK 8 when the traveler is standing. Note, however, that the WTP in the former case is not statistically significant from zero. If the crowding level "before change" instead is higher, the WTP is, as expected, higher. The WTP for increased comfort, i.e. to get a seat, is worth between SEK 30 and SEK 37 depending on the crowding level. It seems a little bit strange that the WTP estimates when 4 or 8 passengers are standing per square meter are lower than when only one person is standing per square meter. However, all confidence intervals are overlapping, indicating, as already mentioned above, that the travelers experience about the same disutility of standing regardless of the crowding level.

As described earlier, VTTS-multipliers are commonly used (e.g. Wardman & Whelan, 2011) to interpret the comfort and crowding reducing benefits. In these cases, the WTP for reducing the travel time in a given travel condition is calculated relatively to VTTS for the reference travel condition. Recall that we have defined the reference travel condition as seating in a crowding level of 0 standing passengers per square meter. In Table 7, the estimated VTTS-multipliers are presented.

Table 7 – Estimated VTTS-multipliers for standing, and crowding.

Travel condition	**VTTS-multiplier [Confidence interval]**
Seating, crowding 0/m^2	1 (reference)
Seating, crowding 1/m^2	1.01 [0.99 – 1.04]
Seating, crowding 4/m^2	1.23 [1.15 – 1.31]
Seating, crowding 8/m^2	1.50 [1.43 – 1.57]
Standing, crowding 0/m^2	1.54 [1.47 – 1.62]
Standing, crowding 1/m^2	1.69 [1.61 – 1.78]
Standing, crowding 4/m^2	1.79 [1.70 – 1.87]
Standing, crowding 8/m^2	2.13 [2.00 – 2.25]

Notes: The confidence intervals are at 95 percent level and calculated based on standard error calculated with the delta method.

The multipliers can be used to calculate VTTS of the different travel conditions, i.e. Equation (4). For example, by multiplying VTTS for the reference condition, i.e. seating when 0 passengers are standing, with 2.13 we get the VTTS for the travel condition standing at the crowding level of 8 standing passengers per square meter, which is SEK 115 per hour.

In Figure 4, the VTTS-multipliers are presented graphically. It is clear that the highest crowding level is considered as much worse by the respondents than the other crowding levels. Also note, which is mentioned earlier, that there is no utility difference between 0 standing passengers per square meter and 1 standing passenger per square meter as long as the traveler oneself is seating.

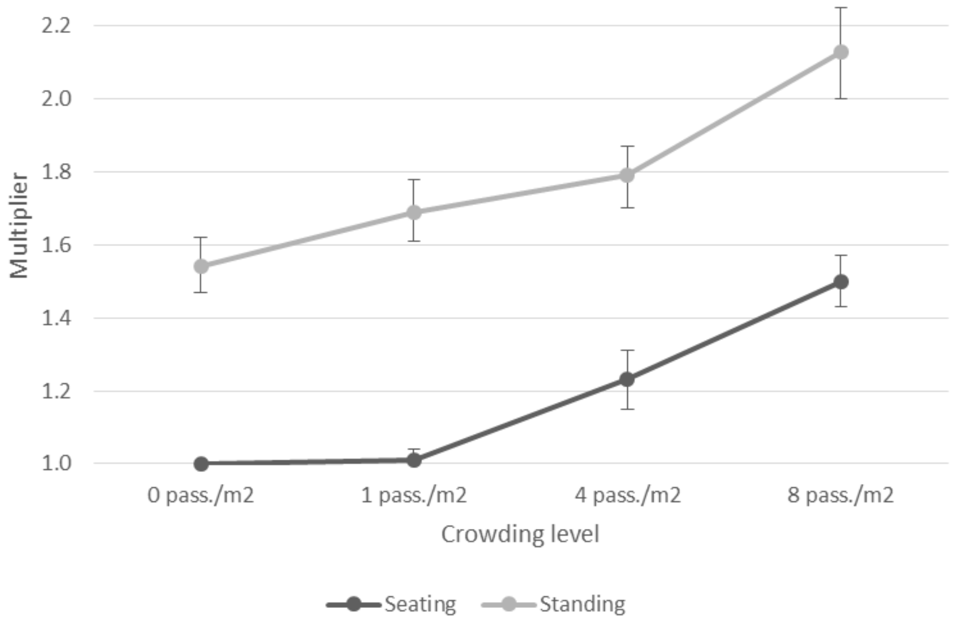

Figure 4 – Estimated VTTS-multipliers for comfort and crowding levels.

4.2 Analysis of robustness

We have analyzed the robustness of the estimated results with respect to different questionnaire and respondent characteristics. The objective of this exercise is to check whether different sub groups have different values of comfort and crowding reduction. The VTTS is well known to differ between different individual characteristics, both theoretically and empirically (Mackie et al., 2001). Examples are that VTTS increase with income and that VTTS is higher for commuting trips than other private trips.

In Table 8, we present the VTTS for different subgroups and note if the estimated result alters. The results show mainly expected patterns. For example, the difference between VTTS for bus and rail in the official Swedish CBA values (Trafikverket, 2015) is also found here. The high income group has a higher VTTS than the low-income group, and the group traveling to/from work has a higher VTTS than the group with other trip purposes. The VTTS was almost identical in the both age groups, and also between women and men after potential income effects were controlled for, i.e. we analyzed only the group that have a monthly income of SEK 20,000 to 30,000. There were also tendencies that people in the panel had lower VTTS than people recruited in the field, and that travelers who received the long trip version in the stated preference part had lower VTTS than the ones receiving the shorter trip version (according to the length of their actual trip).

Table 8 – Descriptions of the analysis of robustness.

	VTTS in SEK/h (seating, crowding 0/m^2)	No. of obs.
Total sample	54 [49 – 60]	13,459
Income		
- Less or equal to SEK 30,000	45 [39 – 50]	8,192
- More than SEK 30,000	77 [65 – 90]	5,267
Main travel mode		
- Bus	46 [39 – 53]	5,203
- Rail	62 [54 – 70]	8,256
Age		
- 40 years old or younger	55 [48 – 62]	6,494
- More than 40 years old	54 [46 – 61]	6,965
Gender given monthly income of SEK 20,000 to 30,000		
- Women	50 [39 – 61]	2,176
- Men	51 [35 – 67]	1,478
Urban area		
- Göteborg	51 [44 – 59]	5,125
- Malmö	52 [42 – 62]	3,081
- Stockholm	61 [51 – 72]	5,253
Sampling method		
- Panel	52 [47 – 58]	9,629
- Field	63 [49 – 77]	3,830
Travel length in SP		
- Short	66 [57 – 75]	4,896
- Long	57 [48 – 66]	8,563
Purpose with the trip		
- Work	70 [59 – 81]	5,515
- Studies/other	43 [37 – 49]	7,303

Notes: The confidence intervals are at 95 percent level and calculated based on standard error calculated with the delta method.

We also compared the multipliers between the groups, showing that in most cases the multipliers were surprisingly equal. However, this does not mean that the WTP for crowding reduction and comfort has to be equal. If the VTTS for the reference situation differ significantly between the groups, it is very likely that the WTP for crowding reduction and comfort also differ. The only multipliers that differ significantly between the groups were the ones for comfort in the comparison of the two age groups, indicating that the older group is, relatively to the reference VTTS, experiencing more disutility from standing compared to the younger group. We also found a significant difference between the multipliers regarding seating in the crowding level of 8 standing passengers per square meter in the long versus short trip groups. Travelers in the short trip group have a higher multiplier. A possible explanation for this is that on shorter trips there are more stops and thus more heterogeneous alighting. Then travelers may response to the fact that it could be more difficult to get off the vehicle if you are seating and there are a lot of standing passengers on board.

4.3 Analysis of preference distributions

As an extension not fundamental to the estimated willingness to pay for comfort and crowding reduction, we briefly analyze the distribution of the estimated parameters to get insights about how the marginal utilities of the different attributes varies across the travelers. For this analysis we re-estimate the discrete choice model and set all parameters mixed with a normal distribution. Then we are able to calculate the absolute z-value of the standardized normal distribution by dividing the absolute value of the estimated mean by the estimated standard deviation of the distribution. Based on the z-value we can calculate the fraction of travelers with a non-expected sign for the variables where we have assigned a given sign of the parameter. We can also calculate the fraction of travelers with the least common sign for the variables without a pre-specified sign of the parameter.

Table 9 – Analysis of random parameter normal distributions.

Variable	**Estimated mean parameter**	**Estimated standard deviation**	**Calculated absolute z-value of standardized normal distribution**	**Travelers with non-expected or least common sign**
Travel Cost	-0.233	0.159	1.47	7.1%
Travel Time	-0.215	0.118	1.82	3.4%
Standing	-2.08	2.24	0.93	17.6%
Crowding 1/m^2	-0.233	1.06	0.22	41.3%
Crowding 4/m^2	-0.746	0.040	18.7	<0.001%
Crowding 8/m^2	-1.73	0.392	4.41	<0.001%
Standing*Crowding 1/m^2	-0.203	1.65	0.12	45.2%
Standing*Crowding 4/m^2	-0.007	0.077	0.09	46.4%
Standing*Crowding 8/m^2	0.023	0.538	0.04	48.4%

The results are summarized in Table 9. To interpret the z-value of 1.47 for travel cost we can use the standardized normal curve area in one tail above 1.47 to suggest the fraction of the travelers which do not respond to changes in travel cost in these SP-questions. This fraction amounts to about 7.1 percent. In other words, 7.1 percent of the travelers do not care about the cost in their choices. This share of travelers seems to be plausible according to incomes and budget constraints. In addition, 3.4 percent of the travelers are non-sensitive to travel time changes. Also this amount seems plausible with respect to travelers with low scheduling constraints. Furthermore, the highest crowding levels of 4 or 8 standing passengers per square meter are both highly refused by more or less all travelers. The crowding level of 1 standing passenger per square meter has a very large variation across the travelers with more than 40 percent not reacting to this crowding level compared to no crowding. Standing has a large and significant mean, as noted previously in Table 5, implying that most travelers dislike standing on board public transport. Still, the standard deviation of the standing parameter is very high, implying that a relatively large share of about 18 percent of the travelers do not care if they are standing or seating. This seems plausible since many trips in the local public transport are short and it is common to observe people standing although there are available seats. The interaction terms between standing and crowding have all a relatively large variation. Thus all of them have close to 50 percent of the travelers with each sign of the marginal utility. The interpretation is that half of the travelers dislike crowding the most when they are standing while the other half dislike crowding the most when they are sitting.

4.4 Subjective experience of crowding

In Table 10, we present the result from the structural models with the latent variable *Affective reactions to the crowded situation* as dependent variable. In Model A, the only independent variables are dummy variables regarding the density on board the vehicles during the actual trips, according to the participants themselves. The estimates are all significant and indicate that the more standing people in the vehicle, the more negative affections the respondents feel. The coefficients for the indicator variables explaining the latent variable (i.e. *squashed*, *tensed*, *distracted*, *uncomfortable*, *frustrated*, *restricted*, *irritable*, *hindered,* and *stressful*) vary between .794 and .883 and are all significant ($p < 0.01$). In Model B, we add the two subjective variables *Evaluation of the psychosocial aspects* and *Evaluation of the ambient environment* in the structural model, according to Mohd Mahudin et al. (2012). The coefficients for the indicator variables explaining the latent variables (i.e. *dense, disorderly*, *confining*, *unpleasant*, *chaotic*, *disturbing*, and *cluttered*, respective *hot*, *stuffy*, *smelly*, and *noisy*.) are all significant ($p < 0.01$) and vary between .761 and .881, and between .660 and .864. Both subjective variables are significant ($p < 0.01$) with correct sign, i.e. the more negative the travelers experience the psychosocial aspects and the physical environment on board the vehicles the more negative affections they feel. However, when adding the subjective variables, two of the density variables become no longer significant, and the third variable (density 4/m^2) changes sign.

According to Akaike's (AIC) and Bayes Information Criteria (BIC), the model fit decrease markedly in Model B compared to Model A. The Chi-square tests were significant in both models, meaning that none of the models fit the data well. However, this is more a rule than an exception, especially when the sample size is large. The other goodness-of-fit tests show a minor preference for Model B. The Root Mean Square Error of Approximation (RMSEA), which should be less than 0.05 to indicate a close fit between the data and the model and up to 0.08 to represent reasonable errors of approximation (Browne & Cudeck, 1993) is high in both models but somewhat smaller in Model B than in Model A. The standardized root mean squared residual (SRMR), which should be 0 to indicate a perfect fit (StataCorp, 2011), is also somewhat smaller in Model B than in Model A. The comparative fit index (CFI) should be close to 1 to indicate a good fit (StataCorp, 2011), and also this value shows a somewhat better fit in Model A than in Model B.

Table 10 – Estimated coefficients in the structural models. Standard errors given in parenthesis.

	Model A	**Model B**
Density 0/m^2	Reference	Reference
Density 1/m^2	.088*** (.024)	-.014 (.014)
Density 4/m^2	.399*** (.023)	-.044** (.015)
Density 8/m^2	.609*** (.017)	.005 (.015)
Psychosocial aspects		.821*** (.021)
Ambient environment		.150*** (.020)
Log-likelihood	-17,268.18	-37,359.36
Chi-square	1,382.84***	3,847.00***
RMSEA	0.11	0.09
CFI	0.93	0.91
SRMR	0.03	0.04
AIC	34,596.36	74,862.73
BIC	34,764.43	75,266.10

Note. n = 2,003, *p < 0.05, **p < 0.01, ***p < 0.001.

Because of the strange results in Model B, the large difference in AIC and BIC, and the minor difference in the other goodness-of-fit tests, we choose to go further with Model A. We save the predicted estimates from this model and thereafter split the group of respondents in three groups according to the 33.3 and 66.6 percentiles. Then we run two discrete choice models –

one for each of the extreme groups – to compare the two groups according to their VTTS in the reference condition and their WTP for crowding reduction and comfort (based on multipliers). The results show that the group of respondents who feels more negative affections to crowding has a tendency to have higher VTTS in the reference condition (66 SEK/h) than the group feeling less negative affections (52 SEK/h). However, this difference is not significant. The multipliers do not differ between the groups.

5. Discussion

The results of our study is policy relevant for CBA of public transport services, both regarding service frequency and new investment of public transport. This is a relevant topic in many urban areas around the world which suffers from crowding on board public transport.

Compared to the meta-study of Wardman and Whelan (2011), our VTTS-multipliers are somewhat lower. For the highest crowding level used in our study, which is the very high level of 8 standing passengers per square meter, the VTTS-multiplier is slightly larger than two for standing conditions. In Wardman and Whelan (2011), the multiplier of two is for standing travelers found for a load factor of around 125 percent. On the other hand, Haywood and Koning (2015) estimated VTTS-multipliers that are relatively close to our estimates. In addition, our estimated WTP for seating and crowding reductions are generally somewhat higher than previous Swedish estimates as Transek (2006) and Olsson et al. (2001). Thus, our estimated WTP of crowding reductions and comfort can be said to lie in the middle compared to previous empirical evidence, both in Sweden and in other countries.

This brief discussion lead us to the translation between load factor and the number of standing passengers per square meter, which are not easily compared. We have chosen to use the number of standing passengers on a given floor area as it is more general and can be applied to different modes and vehicles. This approach is also used in previous literature (e.g. Basu & Hunt, 2012; Tirachini et al., 2013; Whelan & Crocket, 2009). Tirachini et al. (2013) compare a load factor of 200 percent to about 3 standing passengers per square meter. Then our crowding level of 8 standing passengers per square meter can be considered as extremely high. On the other hand, Basu and Hunt (2012) define 7 standing travelers per square meter as heavy crowding and 12 standing travelers per square meter as very heavy crowding. Recall however that this definition is based on Indian conditions.

Furthermore, we have not in our SP-design analyzed any WTP of crowding below a condition where all seats are taken. In reality, there are probably travelers that can have a willingness to pay for sitting with a free seat next to them. On the other hand, we argue that increased service of public transport cannot target individuals with such preferences, especially when a lot of public transport in urban areas suffers from overcrowding and since public transport are highly financed by the tax payers. Therefore, we decided to not incorporate such alternatives in our SP-design as it would have increased the complexity radically.

There may be other negative effects of crowding that is not captured in this study, i.e. travel time increases as more passengers boarding and alighting the vehicles. Also, more travelers on stations and platforms imply longer walking time which in turns make the entire trip last for a longer time. See Tirachini et al. (2013) for discussion about these additional effects of crowding in public transport.

We could not find any significant difference regarding VTTS in the reference condition or regarding the multipliers depending on subjective experience of crowding. However, there was a tendency that the group of respondents who feels more negative affections to crowding has higher VTTS in the reference condition (66 SEK/h) than the group feeling less negative affections (52 SEK/h).

The risk of hypothetical and strategic bias in our SP-based WTP-estimates need a brief discussion. We have conducted sensitivity analysis and checks of robustness which show that the results are robust to, for example, urban area, gender, and sampling method. As another check of the plausibility of our results, the value of travel time savings (VTTS) are estimated to SEK 54 per hour, which is close to the official Swedish CBA values (Trafikverket, 2015) of SEK 33-69 for short private trips in public transport depending on mode and purpose of the trip. In addition, expected variations of VTTS occur for income, bus or rail, and work trips or other purpose. For example, by splitting the sample with respect to median income, VTTS for the high-income group is SEK 77 and VTTS for the low-income group is SEK 45. All these features are close to our expectations and we thus conclude that we do not have any evidence of problems with hypothetical bias or strategic bias.

6. Conclusion

The purpose of the present study was to estimate the willingness to pay (WTP) for comfort, i.e. to get a seat, and crowding reduction on board local public transport in Sweden, including the modes metro, tram, commuter trains, and local bus. We have used SP-data based on 2,003 respondents consisting of both frequent public-transport users and non-frequent public-transport users.

WTP for seating is estimated to SEK 30-37 per hour depending on the crowding level. The WTP for crowding reductions are estimated to SEK 8 for a reduction from 1 standing passenger per square meter to no standing passengers when the traveler oneself is standing. When the traveler is seating, this crowding reduction implies no utility increase. An elimination of standing passengers starting with 4 standing passengers per square meter has a WTP of SEK 12-13 depending on seating or standing, and a reduction from 8 standing passengers per square meter to no standing passengers is valued SEK 27-32 depending on seating or standing. These estimates are higher than previous Swedish estimates (Olsson et al., 2001; Transek, 2006) as well as the estimates of Basu and Hunt (2012) based on Indian public transport.

If we instead interpreted our estimated results as value of travel time saving-multipliers, the worst travel condition in our study, i.e. standing in a crowding of 8 standing passengers per square meter, has a multiplier of about 2.1. This means that travel time saving in this travel condition is valued 2.1 times travel time saving in the reference travel condition of seating when there are no standing passengers. This multiplier is relatively low compared to the results of a current meta-study (Wardman & Whelan, 2011) where a multiplier of 2 is found for standing already in the relatively moderate crowding level of the load factor 125 percent. It is not easy to translate load factor to number of standing passengers per square meter though, but for most of the modes we can approximate 125 percent with 1 standing passenger per square meter. On the other hand, our estimates are more in line with a recent study of Haywood and Koning (2015). All in all, we conclude that our results seem plausible as they are in the middle of other studies that have valuated comfort and crowding reductions.

In addition, sensitivity analysis and checks of robustness also show that the results varies as expected with respect to income, mode, and purpose of the trip. Along with further robustness checks, we conclude that no evidence of problem with hypothetical or strategic bias occur in our SP-study.

REFERENCES

Basu, D. & Hunt, J. D. (2012). Valuing of attributes influencing the attractiveness of suburban train service in Mumbai city: A stated preference approach. Transportation Research Part A: Policy and Practice, 46, 1465-1476.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), Testing structural equation models (pp. 136-162). Newbury Park, California: Sage Publications.

Cameron, A. C. & Trivedi, P. K. (2005), Microeconometrics: Methods and Applications, New York: Cambridge University Press.

Cox, T., Houdmont, J. & Griffiths, A. (2006). Transportation Research Part A: Policy and Practice, 40, 144-258.

Eliasson, J. & Lundberg, M. (2012). Do Cost-Benefit Analyses Influence Transport Investment Decisions? Experiences from the Swedish Transport Investment Plan 2010-21. Transport Reviews, 32 (1), 29-48.

Haywood, L. & Koning, M. (2015). The distribution of crowding costs in public transport: New evidence from Paris. Transportation Research Part A: Policy and Practice, 77, 182-201.

Hensher, D. A. & Greene, W. H. (2003). The mixed logit model: the state of practice. Transportation, 30, 133-176.

Kocur, G., Adler, T., Hyman, W. & Aunet, B. (1982). Guide to Forecasting Travel Demand with Direct Utility Assessment. United States Department of Transportation, Urban Mass Transportation Administration, Report UMTA-NH-11-0001-82-1, Washington DC.

Li, Z. & Hensher, D. A. (2011). Crowding and public transport: A review of willingness to pay evidence and its relevance in project appraisal. Transport Policy, 18, 880-887.

Mackie, P. J., Jara-Díaz, S. & Fowkes, A. (2001). The value of travel time savings in evaluation. Transportation Research Part E, 37, 91-106.

Meijer, E. & Rouwendal, J. (2006). Measuring welfare effects in models with random coefficients. Journal of Applied Economics, 21 (2), 227-244.

Mohd Mahudin, N. D. (2012). Quality of rail passenger experience: The direct and spillover effects of crowding on individual well-being and organisational behaviour. Doctoral Thesis. University of Nottingham.

Mohd Mahudin, N. D., Cox, T. & Griffiths, A. (2012). Measuring rail passenger crowding: Scale development and psychometric properties. Transportation Research Part F, 15, 38-51.

Olsson, C., Widell, J. & Algers, S. (2001). Komfortens betydelse för spår- och busstrafik. Trafikantvärderingar, modeller och prognoser för lokala arbetsresor. VINNOVA Rapport VR 2001:8. Stockholm: VINNOVA – Verket för Innovationssystem. In Swedish.

Revelt, D. & Train, K. (1998). Mixed logit with repeated choices: Households' choices of appliance efficiency level. Review of Economics and Statistics, 80 (4), 647-657.

Rozan, A. (2004). Benefit transfer: A comparison of WTP for air quality between France and Germany. Environmental and Resource Economics, 29 (3), 295-306.

StataCorp (2011). Stata: Release 12. Statistical Software. College Station, TX: StataCorp LP.

Statistics Sweden. (2015a). Folkmängd per tätort efter region, typ av område och vart 5:e år. Received May 27th, 2015, from http://www.scb.se

Statistics Sweden. (2015b). Genomsnittlig månadslön efter sektor 1992–2014. Received August 31st, 2015, from http://www.scb.se

Statistics Sweden. (2015c). Utbildningsnivå för befolkningen efter inrikes/utrikes född, kön och åldersgrupp 2014. Received August 31st, 2015, from http://www.scb.se

Swärdh, J-E. & Algers, S. (2014). Willingness to accept commuting time within the household: stated preference evidence. Transportation, 23, Article in Press. DOI: 10.1007/s11116-014-9573-y.

Tirachini, A., Hensher, D. A. & Rose, J. M. (2013). Crowding in public transport systems: Effects on users, operation and implications for the estimation of demand. Transportation Research Part A: Policy and Practice, 53, 36-52.

Trafikverket (2015). Samhällsekonomiska principer och kalkylvärden för transportsektorn: ASEK 5.2. Kapitel 7 Värdering av kortare restid och transporttid. Version 2015-04-01. In Swedish.

Transek (2006). Vaneresenärers värderingar av förseningar och trängsel i Stockholms Lokaltrafik. Webbundersökning. Rapport 2006:12. Solna: Transek AB. In Swedish.

Wardman, M. & Whelan, G. (2011). Twenty years of rail crowding valuation studies: evidence and lessons from British experience. Transport Reviews, 31, 379-398.

Whelan, G. & Crocket. (2009). An investigation of the willingness to pay to reduce rail overcrowding. In Proceedings of the First International Conference on Choice Modelling. MVA Consultancy.