Commuters' satisfaction with public transport

Abstract

Introduction: Previous studies have shown that people's satisfaction with their commute can have an impact on their subjective well-being and general quality of life. Public transport users tend to be less happy with their commute than pedestrians, cyclists and car users. A relevant question then is what explains the low satisfaction among public transport users, and what can be done to make public transport commuting more satisfying.

Methods: This study measures commuters' satisfaction with their last trip to work, to investigate how different public transport journey characteristics affect commute satisfaction. Characteristics included in the analysis are distance to public transport stations, whether commuters have to transfer modes along the way and waiting time while transferring. The study is based on a comprehensive travel survey in Oslo, Norway (N=7.630).

Results: Findings indicate that efficient transport routes with short waiting time and reliable time use are more important than short distance to stations and direct routes. However, these characteristics have a stronger effect on satisfaction among people with long commutes.

Conclusion: The findings in this study are useful for policy makers planning public transport services. Both to make the service more satisfying for the current users, and also in order to make public transport an attractive alternative to car use.

1 Introduction

Studies of travel satisfaction, as well as commute satisfaction, has received increased attention in recent years. Several studies have found that factors such as commute length and mode choice have a large impact on commute satisfaction, and especially that public transport commuters tend to be less satisfied than other mode users (see for example Smith, 2017; Ye and Titheridge, 2017).

In Oslo, as well as other European cities, there are political goals to reduce car use and increase the use of public transport, cycling and walking. Norway even has a "zero growth goal" which states that all increase in personal transport in the largest cities should be absorbed by public transport, cycling and walking. In order to achieve this, measures have recently been introduced to improve public transport services and cycling infrastructure, while restrictions have been put on car use through toll roads and removal of parking spaces (Tennøy and Hagen, 2020). At the same time, the Oslo region has seen an increase in public transport commuting (Hjorthol et al., 2014).

While travel behavior studies traditionally have focused on objective measures of generalized travel costs, many now suggest that more subjective factors should be included in studies and models concerning travel mode choice. Subjective well-being (SWB), it is argued, could complement conventional ways to measure benefits and losses, for example in research on travel behavior (Kahneman, 1999; Smith, 2017). Several studies have found that people's satisfaction with their travel can have an impact on SWB and quality of life (Bergstad et al., 2011; Olsson et al., 2013). When deciding on measures to increase the use of public transport, it is therefore important to address people's travel experiences. Earlier, the service quality of public transport has been found to greatly influence travel satisfaction as well as behavioural intentions (De Oña et al., 2016; Lai and Chen, 2011; Van Lierop and El-Geneidy, 2016). However, more knowledge about how satisfaction with public transport is affected by service quality is useful both to increase users' SWB and to make public transport an attractive alternative to car use.

This study addresses these issues with an in-depth study of public transport journey attributes and their effects on commute satisfaction. Statistical models are conducted to investigate which characteristics of public transport journeys affect commute satisfaction, and also how these effects vary among specific sub groups of public transport commuters. The analysis is split in two parts. Firstly, we study the satisfaction of all public transport users, asking which characteristics of the journey affect commute satisfaction. Secondly, we compare five sub groups of public transport users, investigating how satisfaction varies among these groups.

The paper is organized as follows. Previous research on commute satisfaction and subjective well-being is described in section 2, and data materials and methods are presented in section 3. Section 4 presents the study results in two parts, while section 5 consists of conclusions and some policy implications.

2 Previous research on commute satisfaction and subjective well-being

People's satisfaction with travel has been found to have an effect on their average well-being and life satisfaction (Bergstad et al., 2011; Ettema et al., 2010; Friman et al., 2017; McCarthy and Habib, 2018; Smith, 2013). Feeling stressed or worried while travelling can lead to lower SWB and quality of life. De Vos (2018) shows that the link between travel and well-being works in different ways. Most importantly, people's perceptions of trips can have a direct effect on their general life satisfaction. When evaluating recent trips, people who report that they experienced positive emotions while travelling also tend to report higher degrees of life satisfaction. In addition, travel can have an indirect effect on life satisfaction as it enables people to participate in out-of-home activities. Studies have shown that travel satisfaction, and even SWB, is affected by the activities one can conduct at the destination of commute and leisure trips (Bergstad et al., 2011; De Vos, 2018).

When studying travel satisfaction and its effect on average well-being, it is especially important to study commute trips, as these account for a large part of people's daily travels. Among all daily trips in Norway, 21 per cent are work related, according to the National Travel Survey (Hjorthol et al., 2014). Olsson et al. (2013) show that satisfaction with the commute can in fact contribute to overall happiness, and other studies have shown that people with longer commutes systematically report lower SWB (Handy and Thigpen, 2018; Lorenz, 2018; Stutzer and Frey, 2008). At the same time, work travel is necessarily a product of people's choice of place of residence and place of work. Previous studies have even found that people's satisfaction with their residential location can have an effect on travel satisfaction (see for example De Vos et al., 2016). Travel satisfaction is also affected by the access it provides to activities, such as work, and many will even accept a longer and more complex commute journey in exchange for their preferred job and/or place of residence (De Vos et al., 2013; Waygood et al., 2017). In the short run, commute trips may therefore have an impact on people's quality of life and SWB in two ways, both through subjective evaluations of trip experiences, and since the commute may enable people to work at their desired work place and live at their desired residential location. In the long run, commuting may affect people's physical and psychological health, and it may deprive the time that could otherwise be spent on more desired activities. Both these factors may have an effect on commuters' SWB.

Previous research has proved that commute satisfaction varies significantly between users of different transport modes. There is most often found a difference between active modes (walking and cycling) and motorized modes (car and public transport) where active commuters tend to be more satisfied with their commute trips. In addition, public transport users tend to be less satisfied with their commutes than others (Lancée et al., 2017; Smith, 2017; St-Louis et al., 2014; Ye and Titheridge, 2017). However, the difference between modes is not unambiguous. Rissel et al. (2014) for example, investigated self-reported stress with the commute and found that car users tended to be more stressed than pedestrians, cyclists and public transport commuters. Public transport has also been found to be more satisfying than car commuting, as it enables the commuters to engage in different activities during the commute, such as reading and socializing with other passengers (Ettema et al., 2012; Olsson et al., 2013). Several studies have also found that the service quality and comfort of public transport affects travel satisfaction (De Oña et al., 2016; Lai and Chen, 2011; Van Lierop and El-Geneidy, 2016). Another important factor is commute time. With longer commutes, people tend to report lower satisfaction (Mokhtarian et al., 2015; Olsson et al., 2013; Smith, 2017). Although not completely refuted, this relationship has been questioned by Olsson et al. (2013). As mentioned, they found that engaging in activities on board may reduce stress and boredom. With exciting on board activities, the disadvantage of a long commute can be reduced. In addition to mode and commute length, several other factors have been found to have an effect on commute satisfaction, such as congestion and seat availability (Smith, 2017; Wong et al., 2017; Ye and Titheridge, 2017), travel time reliability and delays (Singleton, 2019; Wild and Woodward, 2019; Wong et al., 2017), level of service (Ye and Titheridge, 2017) and the weather (St-Louis et al., 2014). In general, findings show that efficient and short public transport journeys, with little congestion and reliable travel times are more satisfying than more complex journeys. However, additional research is needed on factors affecting the satisfaction of public transport commuters, especially since this group often is the least satisfied among all mode users. Further, it is relevant to study how characteristics of public transport service affects satisfaction, as these are factors that can be improved by policy makers and public transport planners. Most studies on travel satisfaction and travel's effect on SWB are however conducted after trips have taken place, and not during the trip. This is also the case for this study. As a consequence, study results cannot be claimed to capture the immediate feelings travellers experience, but rather the retrospective evaluations of trips.

This study draws on the theoretical framework of Ettema et al. (2010), which specifies how travel influences SWB. The framework indicates that both affective factors (safety, cleanness, etc.) and instrumental factors (travel time, frequency, cost) influences SWB. We focus on the model's instrumental factors such as travel time and the complexity of travels and their influence on commute satisfaction. This study contributes to the research on commute satisfaction in two ways. First, we compare several characteristics of the public transport service in order to reveal which factors affect the satisfaction of commuters. Second, we investigate how the effect of these factors vary among different sub groups of public transport users. This approach allows us to build on and expand the conceptual framework of Ettema et al. (2010).

3 Material and methods

3.1 Survey

The data for this study was obtained through a travel survey among municipal employees in Oslo. Transport mode was registered by asking respondents how they had travelled to work the previous day. Respondents reporting that they had used several modes were asked which mode they used for the longest distance. The main mode, which is the basis for this analysis, is therefore defined by the mode used for the longest distance when several modes have been used. The survey also included questions about commute distance, travel time and whether they had any errands on their way to and from work, as well as questions about commute satisfaction. In addition, respondents were asked to specify details about the public transport service they used to and from work: Walking distance to stations, frequency of departures, whether they had to transfer to a similar or different public transport mode underway and how long they had to wait while transferring. Thus, information about journey characteristics used in this study is self-reported.

The web-based survey was sent via e-mail to all municipal employees in Oslo in February and March 2018. In total, 41.641 people received the survey. 14.015 valid responses were collected, giving a response rate of 33.7 percent. Among these, 7.630 commuted mainly by public transport the previous day, which gives a public transport share of 54 percent. In Oslo as a whole, the public transport share on commute trips is 42 percent (Hjorthol et al., 2014). The respondents' work places include schools and kindergartens, nursing homes, municipal agencies and different operating facilities (e.g. waste management, fire stations, water and drainage facilities, etc.). The 1.200 workplaces are spread throughout the municipality, both in the inner city and the suburbs. There is however a tendency that the largest workplaces are located in the inner city, which could explain the high public transport share. Compared to the suburban parts of Oslo, the inner city is served by a more comprehensive and efficient public transport service (Gundersen et al., 2017; Lunke and Fearnley, 2019). In addition, several restrictions on car use have been implemented in the inner city in recent years, such as increased toll fares and removal of parking spaces (Tennøy and Hagen, 2020).

In order to measure commute satisfaction, we asked respondents to evaluate their last trip to work in three questions: Whether they felt stressed or calm, tired or energized, and worried or confident while travelling. The questions were structured along a seven step scale, ranging from -3 to 3, with the following statement: "On your last trip to work, how stressed/calm did you feel? If you were stressed, select -3. If you were neither stressed nor calm, select 0. If you were calm, select 3". The three questions are drawn from the affective dimension of the Satisfaction with Travel Scale (STS) (as defined by Ettema et al., 2011). The cognitive dimension of the STS was not included in our survey for two reasons: Firstly, the cognitive dimension refers to the general quality and efficiency of the transport system, while the affective dimension measures how good respondents felt while travelling (Ettema et al., 2011). As the service quality is among the control variables in our analysis, we decided to leave this dimension out. Secondly, only three questions were included to reduce respondent burden and because some questions did not translate well to Norwegian. We estimated a Cronbach's Alpha of .853 on the three questions, which indicates a good internal consistency based on the guidelines of George and Mallery (2003). We therefore calculated the average score of the three questions, which is the variable representing travel satisfaction in this study.

3.2 Statistical analyses, independent variables and study groups

In this study, ANOVA tests and T-tests are used to compare the average commute satisfaction among transport modes. Linear regression models are used to investigate which factors can explain variations in commute satisfaction among 1) all public transport users and 2) among different sub groups of public transport users. The dependent variable in the analyses is average commute satisfaction, as described above.

Each regression model includes seven independent variables, all related to the characteristics of the commute journeys. All of these are defined as dichotomous variables: Walking distance (two variables, if respondents have to walk more than 500 meters from home and work place to the nearest transit station), frequency (if respondents have less than four departures per hour from their nearest stop), the need to transfer underway and waiting time while transferring. Dichotomous independent variables are chosen because of the questioning in the survey. For example, respondents were not asked to report the exact distance from their home to their public transport station, but rather to choose between four intervals (0-250 meters, 250-500 meters, 500-1000 meters and over 1000 meters). The selected dichotomous thresholds are based on the distribution among the respondents. The goal was that the distribution should be as uniform as possible, both in the data as a whole and in the different sub groups, as shown in table 1 and 2.

The last variables concern delays (if respondents experienced that the commute took longer time than planned) and if they accompanied children to school or kindergarten on their way to work. The first regression model (among all public transport users) also includes independent variables on travel time (two dummy variables) and dummy variables for each public transport mode (with bus as the reference category).

All independent variables have been tested for collinearity. The highest correlation was found between the transfer and waiting time variables (Pearson's Correlation = .72, $p > .01$). This is still below the recommended value of .8 in Meyers et al. (2016) and both variables are therefore included in the analyses.

In this study, the attention is mainly on the service quality of the journeys, as it is defined by (De Oña et al., 2016). Other variables, such as socio-demographic variables, could have had an impact on the analysis. However, a previous study found that such characteristics had just a small impact on commute satisfaction (Lancée et al., 2017).

In order to study differences between groups of public transport users, we extract five sub groups from the data set. The sub groups are as follows:

- Train users with more than 40 minutes' door to door travel time
- Bus and tram users with less than 20 minutes' door to door travel time
- Subway users with more than 40 minutes' door to door travel time
- Subway users with less than 20 minutes' door to door travel time
- Bus users with more than 40 minutes' door to door travel time

The motivation to define the groups by mode choice and travel time is based on previous research on the subject, which has shown that transport mode and travel time are among the most important factors in explaining public transport commuters' satisfaction (see for example Ettema et al., 2012; Páez and Whalen, 2010; St-Louis et al., 2014; Ye and Titheridge, 2017). We have omitted ferry users from this part of the study, as only 95 respondents travelled mainly by ferry. We have also omitted commuters with 20 to 40 minutes' travel time from this part of the analysis. By choosing these two levels of travel time, we get a clear separation between the sub groups. This enables us to investigate how the journey characteristics affect satisfaction differently among users of the same public transport mode with either short or long travel times. It also allows us to compare different mode users with similar travel time intervals.

A comparison of the whole data set and the different sub groups (table 1) shows both differences and similarities. Walking distance is longer and the need to transfer is generally higher when commute time increases, and low frequency and long waiting times are most common among train and bus commuters with over 40 minute commutes. Delays happen less frequently on short subway journeys, while the share which accompany children is similar among all groups. Among all public transport commuters, 24 percent travel less than twenty minutes, while 31 percent travel for more than forty minutes. The share of people living in the inner city is higher among tram users, as well as the groups with under 20 minutes' travel times.

[Table 1 appx. here]

A bivariate analysis has also been conducted to compare the independent variables with the different public transport modes (table 2). The results show that low frequencies, the need to transfer and waiting time is most common among train and ferry users. These two groups also have the longest commute times on average.

[Table 2 appx. here]

Before investigating satisfaction among public transport users, we do a background analysis on all mode users. In general, the average commute satisfaction score among all respondents is quite high (1.38, S.D. 1.409). While public transport users are the least satisfied, pedestrians and car users are most satisfied (table 3). The one-way ANOVA test shows a statistically significant difference ($p<.001$) in commute satisfaction between the different modes. T-tests suggests there are no significant differences between pedestrians and car users, while there are significant differences between the other groups. These results are partly in line with previous studies showing a low satisfaction among public transport users. However, the low satisfaction among cyclists compared to car users is unlike several previous studies, where cyclists are usually more satisfied (Lancée et al., 2017; Smith, 2017; St-Louis et al., 2014; Ye and Titheridge, 2017).

An investigation of the three dimensions used to measure commute satisfaction shows that cyclists score low on the worried/confident dimension (0.80) and higher on the stressed/calm and tired/energized dimensions (1.36 and 1.64 respectively). Public transport users on the other hand, score higher on the worried/confident dimension (1.70) and lower on the other two dimensions (0.69 and 0.72 respectively). This means that the relatively low satisfaction among cyclists is largely explained by the worried/confident dimension. This is in line with previous empirical research from Oslo, showing that many cyclists feel unsafe (Lunke et al., 2018). Public transport users, on the other hand, feel confident, but they are clearly more stressed and tired compared to other commuters. Including other dimension in the analysis could therefore have slightly changed the average satisfaction scores.

[Table 3 appx. here]

4 Results

4.1 Part I: Commute satisfaction among all public transport users

Among public transport users, the average satisfaction is 1,035 (S.D. 1,4), and the distribution is skewed to the right (skewness -.318), as shown in figure 1. Following the findings of Lumley et al. (2002), this should not have any implications on the validity of the regression analyses, as the sample is quite large.

[Fig 1 appx. here]

In table 4, we compare the average satisfaction among users of different public transport modes. The one-way ANOVA test shows a significant difference between the different modes ($p<.001$). Further, tram, subway and ferry users have a significantly higher satisfaction than bus and train users, our T-test shows. In table 3, however, we have not controlled for different characteristics of the commute trips, which is the subject of the next section.

[Table 4 appx. here]

To answer the first research question, about which characteristics of the public transport journey affect commute satisfaction, we conduct a linear regression analysis among all public transport users. In the analysis, we control for the journey characteristics mentioned in section 3.3 as well as the different public transport modes. The results of two linear regression models, with and without controlling for the different modes, are reported in table 5.

[Table 5 appx. here]

First, we see that there is little change in the coefficients' strength in the two models. One difference is found in frequency, where the effect disappears when controlling for public transport mode. Secondly, the effect of travel time increases in the second model.

When controlling for the different journey characteristics we find that train, ferry and subway commuters are significantly more satisfied than bus commuters (p<.001). Tram users on the other hand, show no significant difference from bus commuters. Although a small group (N=95), ferry users seem to be the most satisfied commuters, followed by train users. However, ferry users tend to have long commute times and often transfer underway, which reduces the average satisfaction score. Secondly, the different surroundings of ferry and rail based commuters, with open waters in the former, could have a positive effect on stress and be parts of the explanation why ferry users are more satisfied. The high satisfaction among train users is in line with previous research, such as St-Louis et al. (2014), who found that train users were significantly more satisfied than bus and subway commuters. One explanation for these differences – although not controlled for in this study – could be seat availability, which is most likely lower on bus/tram than on the other modes. Another could be that the speed of trains and subways are generally higher than trams and buses, as the latter two often don't have dedicated lanes and are therefore slowed down by traffic.

We also find significant effects of some of the journey characteristics on commute satisfaction. Most importantly, there is a strong effect of having a long waiting time during a transfer. Those who have to wait more than five minutes while transferring show an average satisfaction 0,506 lower than others (p<.001). The need to transfer in itself also shows a significant effect (p<.05), although this is far from as strong as the need to wait longer. This is similar to the findings of Ye and Titheridge (2017) who also found a significant effect of transfers on satisfaction. Frequency seems to have no significant effect, although this variable is probably correlated with the need to wait while transferring. If the number of departures per hour is high, the average waiting time is necessarily reduced. Walking distance to a public transport station also has a significant effect on satisfaction, although this is smaller than the effect of waiting time. Both from home and from the work place, the need to walk more than 500 meters to a station reduces the average satisfaction with around 0,1 (p<.01).

Commute time has previously been found to have an effect on commute satisfaction (Mokhtarian et al., 2015; Olsson et al., 2013; Smith, 2017), although the relationship is not necessarily linear. Smith (2017), for example, finds that 40 minutes is a significant "break point" for commute satisfaction. We find a similar relationship in our data, where there is no significant difference between those commuting 20 to 40 minutes and the reference category (under 20 minutes). From 40 minutes and upwards, however, the average satisfaction is significantly lower (p<.001).

In addition to the journey characteristics mentioned above, we also find that unreliability and accompanying children during the commute significantly reduces satisfaction with public transport. People who experienced a delay on their commute show a much lower satisfaction than others. This finding is in line with previous research showing that unreliability, congestion and longer travel time is associated with lower travel satisfaction (Ettema et al., 2010; Higgins et al., 2018; Smith, 2013). Accompanying children to kindergarten on the way to or from work is less studied in previous research. However, one can imagine that this activity contributes to complicate the journey as it can lead to longer travel times, more transfers and longer walking and driving distances. Since our respondents have reported journey characteristics based on a direct travel from home to work, accompanying children can be considered an extra element to the journey in addition to the other characteristics. The complicating effect of accompanying children is confirmed in the significant, negative effect it has on commute satisfaction ($p<.001$). Testing for multicollinearity we find no tolerance values below .4 which is the recommended threshold in Meyers et al. (2016).

In the next section, the data set is divided into different groups of public transport commuters in order to investigate whether the effect of the journey characteristics vary among these groups.

4.2 Part II: Commute satisfaction among sub groups

Moving on to the second research question, if and how the effects of journey characteristics vary among different groups, the same regression analysis as above is conducted on the five sub groups of public transport users (as described in 3.2). The variables on travel time and transport mode are omitted, as they are embedded in the sub group definitions. The results are reported in table 6.

[Table 6 appx. here]

When all journey characteristics are controlled for (i.e. commuters have short distances to stations, no need to transfer, etc.), we find that subway users and bus and tram users with short commutes are most satisfied. Train and bus commuters with long commutes show the lowest satisfaction scores, as the constant values in table 6 shows.

Among subway users, however, we find no effect of commute distance on satisfaction. Both groups (<20 minute and >40 minute commutes) show an average satisfaction of approximately 1,5 when all other variables are controlled for (table 6). However, longer journeys are typically more complicated than shorter, with more transfers and longer waiting times (as table 1 showed). The need to transfer and waiting while transferring vary some among the two groups of subway users. Subway users with a long commute show a small effect of having to transfer along the way, while there is no significant effect of a long waiting time while transferring. Subway users with short commutes, on the other hand, show a significant and quite large effect (-0.659, p<.001) of having to wait for more than five minutes. This indicates that subway commutes with few transfers are equally satisfying regardless of the commute length. When there is a need to transfer, and this transfer is ineffective (i.e. long waiting time), short distance commuters actually seem to be *less* satisfied than those with longer commutes. At the same time, only eight per cent of the respondents in this group (<20 minutes, subway users) report that they have to wait more than five minutes on transfers (see table 1). Transfers are more common among long distance subway commuters, and this factor shows a significant (although small) effect in table 6. Still, it is interesting to observe that commuting length seem to have a small but positive effect on satisfaction among subway users. This is in contrast to St-Louis et al. (2014), who found that subway users, along with train users, were more negatively affected by long travel times than bus users.

Among the other groups, the need to transfer in itself does not affect commute satisfaction. Long waiting times while transferring does however have a negative effect on both train and bus users with long commutes. Especially, bus users show a considerable effect of waiting time (-0.869, p<0.001).

Table 6 also shows that distance to a public transport station have no significant effect on all groups except one. Bus users with long commutes show a significant (p<.01) and quite large effect of the need to walk more than 500 meters from home to the nearest station. Train and subway users with the same commute length does not show a similar effect. This is interesting, and could indicate that bus users travel differently to the station than other mode users. In the Oslo region, commuter parking (park and ride) is common on train and subway stations, but less so on bus stations. This could mean that train and subway users more often use a car to the station, while bus users walk or cycle. When using a car instead of walking or cycling, the inconvenience of long distances is much smaller.

When it comes to unreliability and accompanying children underway, there are some interesting, although not surprising findings in table 6. First, delays have a significant effect on all groups, but the coefficients are quite different. Among train and bus users with long commutes the effect of delays is stronger than among the other groups. With short commutes, a delay is not as crucial to satisfaction. Short distance commuters will probably have more opportunities to choose other public transport modes, or to walk or cycle all the way to the work place, if they experience delays and cancellations. Having to accompany children to kindergarten or school shows a different, and inverse effect. Train and bus users with long commutes are unaffected, while the other groups show a significantly lower commute satisfaction when carrying out this activity on the way to work. A possible explanation to this difference is that the additional time spent on accompanying children makes up a larger part of the whole commute time when the commute is shorter. Spending fifteen minutes accompanying children is obviously more complicating to the commute when the commute in itself is only fifteen minutes, as opposed to if the commute is forty-five minutes.

5 Conclusion and policy implications

This study contributes to the literature on commute satisfaction by exploring how the different characteristics of public transport journeys influence people's satisfaction with their commutes. Several studies have investigated similar questions (De Oña et al., 2016; Lai and Chen, 2011; Smith, 2017; Van Lierop and El-Geneidy, 2016), however, few have been conducted in Scandinavia and especially in Norway. While previous studies have often investigated mode choice, commute length and congestion, this study takes other factors into consideration. The findings on how walking distance, waiting time and transfers affect commute satisfaction, and to whom it has an effect, offers an elaboration on the conceptual model of Ettema et al. (2010). We study in detail how the service quality of public transport – measured by travel time, waiting times, interchanges and walking distances – affects travel satisfaction. The findings are highly relevant for transport planners working to develop an attractive and satisfactory public transport service.

The initial analyzes revealed that public transport commuters in Oslo are significantly less satisfied with their commutes than those using other modes. In addition, train and subway users are more satisfied with their commutes than bus and tram users. We also found a negative effect of commute length on satisfaction. These findings are in line with previous research from other cities, such as Montreal (St-Louis et al., 2014), Xi'an (Ye and Titheridge, 2017) and Portland (Smith, 2017). In order to answer the research questions, several linear regression models were conducted. The first research question regarded which characteristics of public transport journeys affect commute satisfaction. The analysis showed that both walking distance to station, transfers and waiting time was negatively associated with commute satisfaction. This makes some relevant contributions to public transport planners. Although the effect of long walking distance is quite small (-0.094 and -0.097), this gives reason to increase the density of stops along public transport routes. The effect on transfers and waiting times provides a reason to develop more direct transit routes, but more importantly to make transfers as efficient as possible. Also, the strong effect of delays on satisfaction shows how important reliable travel times are to making public transport the preferred transport mode for commuters.

The second research question was whether the effects of the journey characteristics vary among different sub groups of public transport users. The investigation of five different public transport user groups proved results that differed to some extent from the conclusions in the first analyzes. First, among the studied groups, only bus users with over 40 minute commutes showed lower satisfaction when having to walk long distances. Second, only subway users with over 40 minute commutes are affected by the need to transfer in itself, while most of the groups are affected by long waiting times while transferring. The only group not affected by transfers and waiting times are bus and tram users with short commutes. The distinction between transfers and waiting time gives new insight compared to previous research which has solely focused on transfers (Ye and Titheridge, 2017). This study shows that some groups seem to tolerate a transfer, as long as the waiting time is not too long. Last, the negative effect of delays on commute satisfaction is significant among all groups, although the coefficients' size varies. It is not surprising that people with long commutes experience a larger effect of delays. With a short commute, a delay will probably not affect your arrival time at work in the same way as with a long commute. In addition, short distance commuters will most likely have more alternative travel routes when one transit service is delayed.

Some factors that previously have been found to have an effect on travel satisfaction are not considered in this study, such as congestion and seat availability, commuters' attitudes toward public transport modes, and the possibility to perform social or entertainment activities during the commute (Páez and Whalen, 2010; Smith, 2017; Ye and Titheridge, 2017). Instead, the focus has been on characteristics of the public transport service that are relevant to transport planners. In short, the findings suggest that transfers should be reduced for subway users, and that the access to bus stations should be made easier. The latter can either be achieved by placing bus stations closer to residential areas, or with increased use of micro-mobility such as e-scooters. More importantly, however, the waiting time while transferring should be as short as possible among all modes. This could probably be solved by increasing the frequency on public transport routes.

If public transport services are planned with these findings in mind, it will most likely lead to more satisfied commuters. As previous research has shown, a higher commute satisfaction will in turn lead to an increased SWB and happier commuters. A second effect is that public transport – at least in a travel satisfaction context – will increase its attractiveness, helping planning agencies and policy makers to reach the goals of reduced car use and increased use of public transport.

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Tables/figures

Table 1: Descriptive statistics of all public transport users and among groups of public transport commuters (percentage of each group/column)

	All public transport commuters	Public transport sub groups				
		Train, >40 min	Bus/tram, <20 min	Subway, >40 min	Subway, <20 min	Bus, >40 min
>500 m from home to station	31%	52%	14%	39%	25%	32%
>500 m from work to station	25%	35%	14%	34%	18%	30%
Less than 4 departures per hour	13%	52%	4%	4%	1%	20%
Need to transfer	45%	70%	18%	71%	15%	73%
Waiting time on transfer >5 min	30%	55%	9%	52%	8%	55%
Longer time than planned	15%	24%	13%	15%	5%	21%
Accompanying children	17%	15%	17%	18%	16%	16%
Travel time <20 min	24%	-	-	-	-	-
Travel time >40 min	31%	-	-	-	-	-
Average travel time (minutes)	36,7	65,6	16,2	51,1	16,7	56,5
Inner city residents	42%	30%	59%	27%	42%	23%
N	7 630	835	1 093	720	642	654

Table 2: Descriptive statistics among different public transport mode users (percentage of each group/column)

	Bus	Train	Tram	Subway	Ferry
>500 m from home to station	21%	51%	21%	33%	27%
>500 m from work to station	22%	35%	20%	27%	19%
Less than 4 departures per hour	9%	46%	2%	2%	93%
Need to transfer	43%	65%	32%	41%	91%
Waiting time on transfer >5 min	28%	49%	20%	26%	47%
Longer time than planned	16%	23%	18%	10%	4%
Travel time <20 min	31%	4%	38%	21%	0%
Travel time >40 min	22%	74%	12%	25%	88%
Average travel time (minutes)	32,6	57,2	28,1	33,6	65,2
Inner city residents	46%	30%	60%	36%	0%
N	2 936	1 129	507	2 935	95

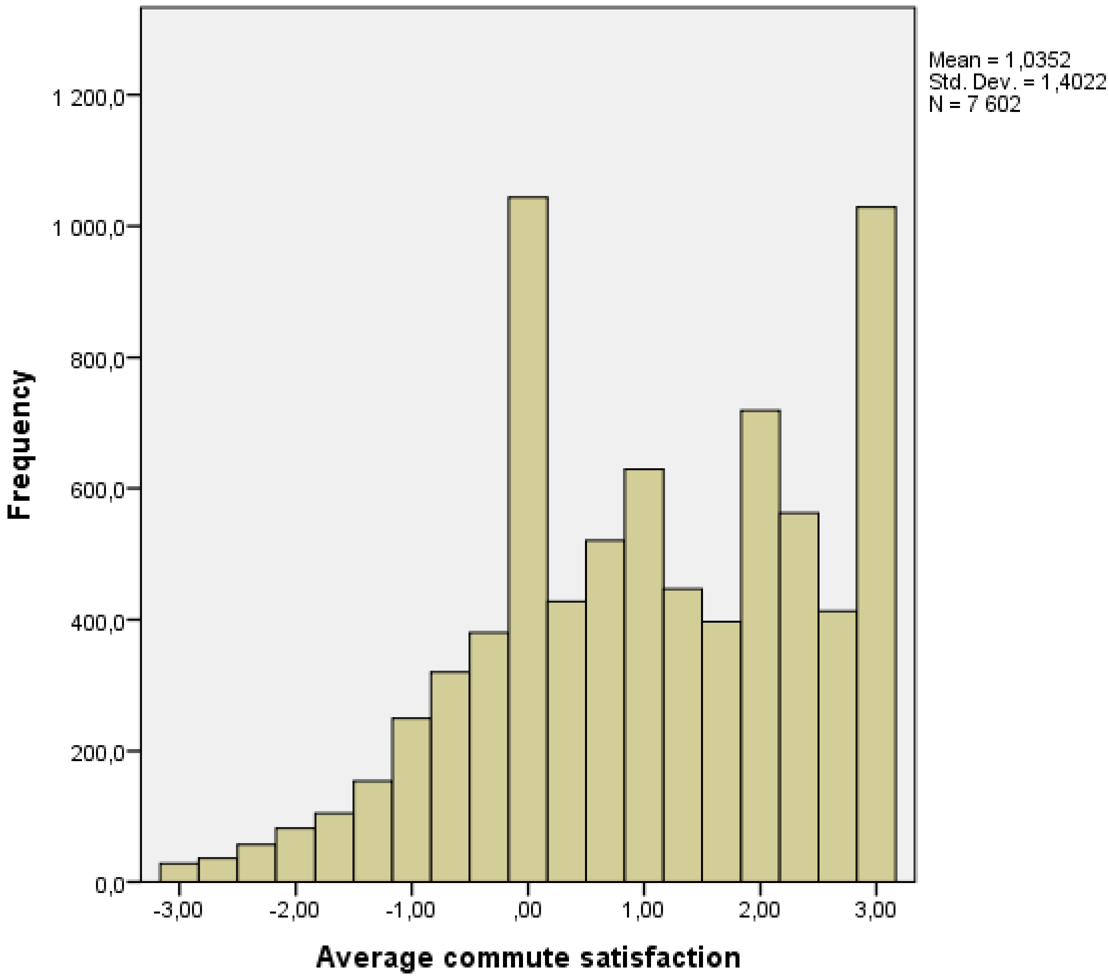

Figure 1. Distribution of commute satisfaction among public transport commuters

Table 3: Average commute satisfaction by mode

	Mode	Mean	N	Std. Deviation	
	Foot	1,8358	2026	1,24344	
	Bicycle	1,2667	435	1,26228	
	Public transit	1,0360	7630	1,40334	
	Car	1,8346	3862	1,31601	
	Other	1,2716	27	1,58259	
	Total	1,3802	13980	1,40835	
ANOVA	Sum of squares	df	MS	F	sig.
Between Groups	2127,952	4	531,988	290,426	0,000
Within Groups	25598,724	13975	1,832		
Total	27726,676	13979			

Table 4: Average commute satisfaction by public transport mode (28 taxi users has been excluded)

	Mode	Mean	N	Std. Deviation	
	Bus	0,9482	2936	1,44466	
	Train	0,9480	1129	1,43977	
	Tram	1,0855	507	1,37314	
	Subway	1,1316	2935	1,34128	
	Ferry	1,5088	95	1,33674	
	Total	1,0352	7602	1,40220	

ANOVA	Sum of squares	df	MS	F	sig.
Between Groups	80,664	4	20,166	10,307	0,000
Within Groups	14864,157	7597	1,957		
Total	14944,821	7601			

Table 5: Linear regression models of average commute satisfaction (Reference group: Bus commuters)

	Model I		Model II	
	B	sig.	B	sig.
Constant	1,470	0,000	1,402	0,000
>500 m from home to station	-0,068	0,055	-0,094	0,008
>500 m from work to station	-0,097	0,009	-0,097	0,009
Less than 4 departures per hour	0,156	0,002	0,055	0,319
Need to transfer	-0,089	0,055	-0,097	0,035
Waiting time on transfer >5 min	-0,514	0,000	-0,506	0,000
Longer time than planned	-0,649	0,000	-0,632	0,000
Travel time 20-40 min	-0,046	0,256	-0,069	0,088
Travel time >40 min	-0,153	0,002	-0,227	0,000
Accompanying children	-0,300	0,000	-0,303	0,000
Train			0,289	0,000
Tram			0,074	0,251
Subway			0,167	0,000
Ferry			0,720	0,000
N	7602		7602	
R^2	0,298		0,308	

Table 6: Linear regression models of average commute satisfaction among public transport sub groups

	Train, >40 min		Bus/tram, <20 min		Subway, >40 min		Subway, <20 min		Bus, >40 min	
	B	sig.	B	sig.	B	sig.	B	sig.	B	sig.
Constant	1,364	0,000	1,406	0,000	1,513	0,000	1,523	0,000	1,284	0,000
>500 m from home to station	0,019	0,854	-0,156	0,202	-0,047	0,606	0,070	0,553	-0,394	0,002
>500 m from work to station	-0,034	0,758	-0,014	0,907	-0,088	0,385	-0,161	0,160	-0,136	0,296
Less than 4 departures per hour	0,222	0,024	-0,155	0,460	-0,229	0,469	0,455	0,413	0,097	0,493
Need to transfer	-0,154	0,331	-0,202	0,175	-0,257	0,038	-0,149	0,359	0,215	0,219
Waiting time on transfer >5 min	-0,480	0,001	-0,197	0,322	-0,245	0,102	-0,659	0,000	-0,869	0,000
Longer time than planned	-0,898	0,000	-0,484	0,000	-0,592	0,000	-0,549	0,000	-0,847	0,000
Accompanying children	-0,136	0,313	-0,431	0,000	-0,438	0,000	-0,413	0,009	-0,212	0,170
N	835		1093		720		642		654	
R^2	0,340		0,202		0,259		0,356		0,379	