Analysing the influence of station characteristics and perceived safety on public transport ridership: A case study from the Greater Copenhagen Area

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1 Introduction

Perceptions of personal safety and security has been highlighted to be of major importance for passengers in the public transport system. Results from a UK study suggested that 10% would reconsider using public transport if their fears were addressed (Crime Concern, 2004), and in Denmark only 77% of passengers reported to be satisfied with safety in the public transport system according to a recent satisfaction survey (Passagerpulsen, 2017). Furthermore, perceived safety and security has been reported as an important parameter across multiple other passenger satisfaction studies, e.g. Fellesson and Friman (2012); Iseki and Taylor (2010); Spears et al. (2013); Stuart et al. (2000), together with the traditional service level elements, e.g. service coverage, frequency, and travel speed (Lierop et al., 2017; Mouwen, 2015).

While no direct correlation between reported crime levels and fear of crime has been found a potential fear might have an influence on whether travellers choose to use public transport or not. Despite this, only few studies have analysed specifically the influence of perceived safety on travel behaviour in general and on public transport ridership in particular. Kim et al. (2007) analysed factors influencing mode choice between home and light rail stations, i.e. access/egress trip legs, and found that crime had a significant impact on mode choice as female transit riders were more likely to be dropped off and picket up at the station instead of walking. In Börjesson (2012) the influence of perceived safety on valuation of walking time was analysed. This study found that walking in closed environments were associated with higher disutility for both women and men during night hours suggesting an effect of perceived safety. Only Delbosc and Currie (2012) have analysed explicitly the influence of safety perceptions on public transport usage finding a significant impact on public transport use frequency, which was only slightly smaller than the negative effect of car ownership. This finding was consistent across gender and age groups suggesting the importance of perceived safety across most user groups of public transport. However, a main limitation of this study was the use of a small convenience sample of 535 respondents, which were not representative of the general population (Delbosc and Currie, 2012).

While these studies highlight the influence of perceived safety as a contributing determinant of travel behaviour they do have shortcomings in terms of analysing its significance on actual public

transport ridership. This study fills the gap in research by analysing on a larger scale the influence of perceived safety on mode choice of public transport in the Greater Copenhagen area. The contribution is two-fold.

Firstly, the study deploys a large-scale dataset based on the national Danish travel survey (Christiansen, 2015). This ensures a large representative sample of the general population as approximately 10,000 responses are collected every year. The survey data holds a vast amount of information about the respondents, including important socio-economic background information. This allows for controlling for important characteristics about the trip and the traveller, which previous research has highlighted as important determinants of ridership (Taylor and Fink, 2013).

Secondly, the study analyses the actual influence of perceived safety at the station-level for each trip performed by travellers. This allows for estimating the effect on mode choice, thereby estimating the actual effect on ridership in the public transport system. Furthermore, important characteristics influencing the perceived safety level, e.g. station characteristics in terms of availability of shops, and the time-of-travel, can be included as these characteristics might also influence the perceived safety level.

2 Data and methods

2.1 Travel survey data

This study mainly deploys the travel survey data (TU) from the Greater Copenhagen area (Christiansen, 2015). The data is a travel diary covering all trips performed by the respondent during the interview-day. As 10-12.000 respondents are interviewed every year the dataset used for this study covering the Greater Copenhagen area in the period 2009-2015 included more than 70,000 trip legs.

In addition to information on all trip legs the survey also collects a vast amount of background information about the respondent including socio-economic characteristics (e.g. gender, age, household and respondents' income, education level, job type) and travel related characteristics (e.g. car availability, drivers license, bicycle ownership, public transport season ticket, distance to nearest station). The detailed information makes it possible to include many relevant parameters in the model estimation, thereby allowing to control for the relevant determinants of mode choice.

2.2 Station characteristics

The travel survey data was linked to characteristics related to every station in the study area. This included the characteristics related to the perceived safety level experienced by passengers. The main variable was the result of a passenger survey on perceived safety at each station measured on a 10-point Likert scale. The survey is performed by the state railway company, DSB, every year in the period 2009-2015. The average number of respondents per station was 100-300 for the years included in this study.

Other variables related to the perceived safety level can be added to the dataset. This includes the availability of shops which is hypothesised to be related to the perceived safety as stations might

be perceived as more attractive when shops are available. The availability of shelters, i.e. small or large, and whether the station is located underground can also be included. Finally, the ease of wayfinding at the station can be included as this might have an effect on whether passengers perceive station as attractive. This data is taken from Dyrberg and Christensen (2015).

2.3 Methodology

Logistic regression is performed on the data using the SAS/STAT software, Version 9.4 (SAS Institute Inc., 2014). A binary choice variable is created for each trip leg denoting whether public transport was chosen or not. No distinction is made between different modes of public transport, e.g. bus, suburban train, regional train, metro, etc.

3 Results

The results of the model estimations for the choice of public transport, cf. Table 1, confirms the hypothesis of a positive association between perceived safety and public transport ridership.

Table 1 Logistic regression results for the choice of public transport

Variable name	Estimate	Std. error	p-value
Intercept	-1.8598	0.1894	<.0001
Station characteristics			
Distance to station (km)	-0.3402	0.0146	<.0001
Underground station	0.5391	0.0511	<.0001
Perceived safety	0.0725	0.0242	0.0027
Age			
Age, <16	-0.6569	0.0535	<.0001
Age, 16-25	0.6198	0.0318	<.0001
Income			
Income, low (<100,000 DKK)	0.1619	0.0245	<.0001
Income, high (>400,000 DKK)	-0.6409	0.0648	<.0001
Education level			
Education, high school	-0.3821	0.0372	<.0001
Education, vocational	-0.6283	0.0416	<.0001
Education, university short	-0.4813	0.0554	<.0001
Education, university medium	-0.3852	0.0363	<.0001
Education, university long	-0.1981	0.0407	<.0001
Other			
Male	-0.2586	0.0217	<.0001
Retired	-0.1366	0.0355	0.0001
Unemployed	-0.1656	0.0534	0.0019
Bicycle ownership	0.3896	0.0253	<.0001
Car ownership	-1.2537	0.0234	<.0001
Driver's licence	-0.8653	0.0266	<.0001
Trip length (km)	0.0944	0.0011	<.0001
Number of observations	114,894		
Log Likelihood	-31,785		
R^2 (McFadden)	0.190		

The distance to the nearest station is negatively associated with ridership. Hence, the choice of public transport decreases as the distance to the nearest station increases. This is consistent with findings from other studies highlighting the importance of station vicinity on perceived attractiveness of the public transport system, and hence the ridership. The results also revealed higher public transport usage at underground stations. However, this might be related to service characteristics as underground stations are mostly located in the dense city centre where service frequency is relatively higher.

Males travel less frequently than females whereas children choose public transport less frequently due to often being accompanied by their parents or walking and biking to school and leisure activities. Young adults travel more frequently, often due to being captive users, e.g. students. This can also be seen as the low-income respondents travel less than middle-income respondents while those with higher incomes travel less frequently.

There also seems to be a variation across respondents with different education levels as those with vocational education travel least frequently. Interestingly, university graduates with the longest education travel more frequently than those with short and medium education levels. This could be explained by workplace location differences as high-education jobs are more frequently located in downtown which has good public transport coverage. Finally, those without education level choose public transport more often.

As expected, car ownership and the possession of a driver's license is negatively associated with choosing public transport. On the contrary, bicycle ownership is positively related to choosing public transport. This suggests that these preferences are aligned, possibly due to a general preference for environmentally friendly transport modes or simply because the combination of these two modes is an alternative to having car, e.g. bicycle and walking for short trips and public transport for longer trips. The latter is also suggested by the positive parameter estimate for trip length, i.e. the choice of public transport is higher for longer trips. This is likely due to public transport being more competitive on longer trips whereas access and egress times are a substantial part on shorter trips leading to low average travel times.

4 Future research

While the current analysis suggests that perceived safety at stations significantly influence whether travellers choose public transport, it does have limitations. Mainly, the effects of actual service characteristics are not included, despite it being an important determinant of public transport ridership, e.g. Chen et al. (2010); Jun et al. (2015); Syed and Khan (2000); Taylor et al. (2009). Hence, such characteristics should be taken into account in the final model. As the data spans across multiple years it is not straightforward to add detailed service characteristics for each station. However, similar to other studies on ridership determinants, simpler indicators such as the service frequency (e.g. Chiou et al. (2015); Taylor et al. (2009)) and number of lines serving the station (e.g.

Derrible and Kennedy (2009); Jun et al. (2015); Zhao et al. 2013)) can be added to take into account the attractiveness of the station. This will be included in the final model.

The possible influence of other station characteristics on ridership in general, and on perceived safety in particular, will also be added to final model estimations. This will allow for evaluating perceived safety which might give important insights into how to improve perceived safety on stations in the public transport system.

5 Conclusions

The current study utilised a large-scale travel survey to analyse the influence of perceived safety on mode choice. Utilising a representative sample of both public transport users and non-users allows for estimating the importance of various characteristics on mode choice. The results confirmed the hypothesis of perceived safety at stations being positively associated with choosing public transport, thus highlighting the importance of addressing this when planning public transport.

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