FACTORS AFFECTING TRAVELLERS' SATISFACTION WITH ACCESSIBILITY TO PUBLIC TRANSPORTATION

Mintesnot G. Woldeamanuel
California State University, Northridge

Rita Cyganski
Institute of Transport Research
German Aerospace Centre (DLR)

Abstract

Accessibility to public transportation is one of the important attributes to assess the effectiveness of a transit system and the integration of transportation with land use. The level of accessibility can be a determining factor for users' perception and satisfaction with the overall transit system. Previous studies on travellers' satisfaction with public transportation focus on variables directly related to the service such as bus stop facilities, drivers' behaviour, schedule adherence, bus frequency, vehicle cleanliness etc. However, external and subjective variables such as how people perceive ease of access as a function of walking, biking or even driving to reach to the closest rail or bus stops got little attention. This research applies a panel binomial probit model to analyse the parametric relationship between the level of travellers' satisfaction with accessibility to public transport services and the socio-economic as well as mode-related variables (such as gender, age, occupation, public transport connectivity, car ownership etc.). The study also estimates the likelihood of travellers' satisfaction for each survey year using a German Mobility Panel (1997-2008). The modelling results indicate a remarkable relationship between the explanatory variables and satisfaction with accessibility to public transport. The probabilistic estimate also shows that there is a time variant effect of satisfaction with accessibility.

Keywords: Accessibility, public transportation, travellers' satisfaction and perception, panel probit model

1. INTRODUCTION

In a multimodal transportation system, accessibility is an important attribute to assess the effectiveness of a transit system and to facilitate the integration of transportation with land use. Although there are objective measurements of accessibility (such as walking or cycling distance to public transportation services), there are also subjective components that could partly be measured in terms of perception and satisfaction. A positive perception on ease of access could be seen as reflecting public confidence, loyalty and willingness to use the service. However, quantifying the level of satisfaction with accessibility is not easy because of the difficult-to-measure perception of travellers and the complexity of transport-land use interaction. Generally, people tend to be satisfied when their perceptions of the service they receive match their expectations, and the expectation could be subjective or objective. When the service falls short of their expectations they tend to be dissatisfied. Here, the absence of some factors (for example easy access) can have a strong impact on dissatisfaction levels, while the presence of others may sometimes be taken for granted. Moreover, people may be willing to tolerate small variations in some of these factors without any impact upon their level of satisfaction with the service (Donovan et al., 2001).

Public transportation accessibility is one of the most important predictor variables that indicate the level of performance of a transit system. Especially for daily commuters, travellers without private vehicle and to those with limited mobility public transportation accessibility is a significant quality-related characteristic and a determinant factor for their decision on usage, route preference, departure time selection, mode choice etc. Improving accessibility could also be one of the persuasive factors for car-dependents to change their mode choice in response to environmental concerns of car use. If the fundamental purpose of transit-oriented design is to create land-use patterns that make transit *accessible* to potential riders, then transit access should be within easy walking distance of a rider's origin and destination. Thus, it can be stated that walking or biking accessibility to public transport is an important factor for integrating land use with transit planning. This factor could as well influence the degree of users' perception and *satisfaction* with the overall transit system.

There is a different understanding of the term "accessibility" in different part of the world. In the United States, for example, accessibility refers to the provision of alternative-to-driving option for older travellers when they stop driving or transportation options for physically disabled travellers. According to the Federal Highway Administration, 2001, public transit is considered to provide autonomous travel for those who cannot drive or choose not to drive, although the private automobile remains the primary travel mode for a majority of older adults (Hess, 2009). On the other hand, within European research, accessibility is interpreted as access to public transportation regardless of age or disability (Brons et al., 2009; Givoni and Rietveld, 2007; Hine and Scot, 2000; Rietveld, 2000). The analysis in this research focuses on the latter interpretation.

A number of research papers on public transportation have reflected that walking is the most natural and significant mode to access public transport. Walking accessibility to public transport is used to indicate the quality or performance of public transport service. In recent studies, public transport accessibility is associated with a certain value that is related to walking distance or walking time. 400 to 800 meters of walking distance or 10 to 15 minutes of walking time is often considered to entitle a public transportation service to be accessible, therefore, inaccessibility or poor accessibility of public transport means that the distance or time to walk to access public transport terminal is longer than these values (Wibowo and Olszewski, 2005; APLT, 2003). The German guideline for accessibility is 600m for small towns and countryside and 300 meter for inner cities (VDV, 2001) while in the case of Zurich distances range between 400 and 750 meters (Schäffeler, 2004). Although walking is the most significant way of accessing public transit services *biking* also plays a significant role in facilitating accessibility to public transportation. For example, in the Netherlands where natural conditions and infrastructure are conducive, the bicycle is a potentially attractive access mode for railways. At the home end of the trips, the bicycle appears to play a large role as an access mode (with a share of 35%). However, at the activity ends (from the station to the place of activity), the share is much smaller (Rietveld, 2000). *Car* as an access mode is rare but used well in places where park-n-ride or kiss-n-ride policies were put in place.

Also, there is a subjective measurement of accessibility as to what people perceive of an easy access. Longer access time may be perceived as short or the vice versa according to the way every individual perceive it or have satisfied with it.

Previous literature and surveys on travellers' perception and satisfaction with public transportation services focused on variables such as bus stop facilities, drivers' behaviour, schedule adherence, bus frequency, vehicle cleanliness etc. Although a number of research papers on public transportation have reflected the importance of walking and biking accessibility to public transport, travellers' perception on those aspects got little attention or rarely ever used as indicators of the quality or performance of a public transport system. Thus, this current study seeks to examine the parametric relationship between the level of travellers' satisfaction with accessibility to public transport services (considered as the dependent variable) and socio-economic as well as mode-related variables such as gender, age, occupation, public transport connectivity, car ownership etc. (independent variables) using a panel binomial probit model. In addition to the parametric relationship between the dependent and independent variables, the probability of being satisfied with public transportation accessibility is calculated for the total sample of each year using the estimated coefficients. The data used for the analysis is the German Mobility Panel (1997-2008).

2. PREVIOUS RESEARCHES

Previous studies on travellers' satisfaction with public transportation focus on objective parameters directly related to the service (Wallace, 1997; Foote and Stuart, 1998; Eboli and Mazulla, 2007; Woldeamanuel and Takano, 2008) giving little or no attention to external and subjective parameters. One of those parameters is people's perception and/or satisfaction with accessibility to public transportation as a function of walking, biking or even driving to reach to the closest rail stations, bus stops or terminals. However, there are recent research developments that included accessibility as determinant factor for travels' satisfaction. Brons et al., 2009, for example used the Dutch Railways customer satisfaction survey and applied a principal component analysis to assess the relative importance of the 'access-to-the-station' part of a rail journey for the passengers overall satisfaction. Givoni and Rietveld, 2007, analyzed the effect of passengers' perception of the station and of the journey to the station on the overall perception of travelling by rail. The results show that most of the passengers choose walking or bicycle to access the railway station; and that the availability of a car does not have a strong effect on the choice of access mode to the station. The quality of the station and the access/egress facilities was found to have an important effect on the general perception of travelling by rail. Hine and Scot, 2000, also explore how public transportation interchange is perceived and how this perception deters public transport use amongst car users or limits public transport use amongst public transport users.

The traditional method of measuring satisfaction is to compare a yearly satisfaction percentage. For example, the Scottish Executive Social Research on bus passengers' satisfaction considered 29 bus service variables (accessibility to bus stop being one of them) to analyze the percentage change of travellers' satisfaction year-by-year (Buchanan, 2004). Although similar methods are used by several consultants and transit service providers (for example, by Ostlere and Lund, 2008), there are attempts to use probability models to analyze travellers' satisfaction with services. Gorter et al., 1999, for example, estimated satisfaction using a latent variable binomial logit model. Eboli and Mazulla, 2007, used a structural equation model to show the relationship between passenger satisfaction with bus services and the attributes of the services supplied without considering the effect of socio-economic background of the respondents. Some researchers applied Geographic Information Systems (GIS) to measure accessibility (Lewis-Workman and Brod, 1997; Hsioa et al., 1997).

Building up on the previous work, we focus on satisfaction with accessibility to public transportation with the objective of creating the parametric relationship between satisfaction and socio-economic background of the travellers, travel pattern and mode-related variables using data from the German Mobility Panel. The study will answer the question 'which factors affect the level of satisfaction with accessibility to public transportation?' Additionally, the likelihood of satisfaction will be estimated for each survey year.

3. METHODOLOGY: PANEL BINOMIAL PROBIT MODEL

We apply a panel binomial probit model to describe the level of travellers' satisfaction with the accessibility to public transport services. The standard panel data model with a binary dependent variable is

$$y^*_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it}, \text{ for } i=1,...,N \text{ and } t=1,...,T \quad (1)$$

Where:
α_i is the constant term, β is a vector of parameters to be estimated, x_{it} is a vector of explanatory variables for an individual i and time t, ε_{it} is the disturbance term where $\varepsilon_{it} = u_{it} + v_i$, with u_{it} being an error term and v_i a time variant, y^*_{it} is a latent variable which determines the value of the observed variable y_{it} according to the following scheme:

$$y_{it} = \begin{cases} 1 \text{ if } y^*_{it} > 0 \\ 0 \text{ if } y^*_{it} \leq 0 \end{cases} \quad (2)$$

On the basis of this assumption we get:

$$\text{Prob}(y=1|\text{satisfied}) = \text{Prob}((\alpha_i + x_{it}\beta' + \varepsilon_{it})>0) = \text{Prob}(\varepsilon_{it} < -\alpha_i - x_{it}\beta') = 1-F(-\alpha_i - x_{it}\beta'), \quad (3)$$

Where F( ) is the distribution function, therefore for probit model, F() is specified as the normal distribution function

As with cross sectional data, the two main methods that are employed to estimate (1) are logit and probit, with the choice of method determined by the distributional assumptions we make for u_{it}. As with panel data containing continuous dependent variables, we assume the α_i is either fixed or random (i.e., the individual specific effects are either constant parameters or they have a distribution with a mean and variance). A key difference between the binary and continuous cases is that the choice between fixed and random effects determines the distributional assumptions we will make for the disturbance term, and consequently, whether we will use logit or probit. Adopting the probit framework by assuming a normal distribution for u_{it} can be more suitable for large T. However, we need to assume random effects instead of fixed effects, as the fixed-effects probit model lacks a consistent estimator of β (Wawro, 1999). A random effects panel probit model specifies $\varepsilon_{it} = u_{it} + v_i$ where u_{it} is normally distributed with mean zero and is independent across all periods and individuals. Also it assumes that the individual specific term, v_i is uncorrelated with the included variables x_{it} in all periods, is independent across individuals, and is time invariant. This produces the modified covariance matrix $\sigma_{ts} = \sigma_v^2/(\sigma_u^2+\sigma_v^2) = \rho$ for $t \neq s$ and $\sigma_{tt} = \sigma_v^2 + \sigma_u^2 = 1$ (Greene, 2000).

4. DATA

The data used in this study is obtained from the German Mobility Panel, 1997-2008. The panel includes a household and a personal travel survey. Both data sets were merged to maximize the inclusion of important household and personal variables. Since 1994, the German Mobility Panel survey has been carried out on annual basis to gather information on essential socio-economic and travel characteristics such as mode use, income, household type, etc. To collect such information, households and individuals were interviewed about their travel behaviour. Households (HHs) and individuals remain in the survey for the maximum of 3 years and are then replaced by a new set of interviewees. In this study, the 1994, 1995 and 1996 entries were excluded to avoid some data misrepresentation (some variables are added later in the panel year). Only respondents with 2 or 3 years of observation in the panel are considered in order to observe the time effect of satisfaction with accessibility to public transportation. Table 1 shows details on the composition of the data set.

Table 1: Wave of the panel data

Year	**New entry to the panel**	**From previous year**	**Total**
1997	931	0	931
1998	423	926	1349
1999	514	877	1391
2000	424	975	1399
2001	750	970	1720
2002	562	982	1544
2003	600	1049	1649
2004	551	1010	1561
2005	414	997	1411
2006	302	453	755
2007	690	595	1285
2008	0	908	908
Note: 3165 persons have 2 years observations and 3171 persons have 3 years of observation			

In the analysis, the dependent variable is taken to be a binary response of satisfaction with accessibility to public transportation. For each survey year, respondents have been asked whether they are satisfied with *accessibility to public transportation* with the expectation of a ‘yes’ or ‘no’ answer. The trend of satisfaction throughout the survey years is given in figure 5. The greater majority of the respondents appeared to be satisfied for all the years and the overall dissatisfaction remains roughly stable as the year goes by (see figure 5). In order to create the functional relationship between these various variables and satisfaction with accessibility to public transportation, the independent/ explanatory variables chosen to include the trip-makers characteristics (gender, age, occupation, place of residence, place of work, household size), the characteristics of the trip itself (e.g. public transport connectivity), availability of public transportation within walking distance from place of residence, ownership of car and bicycle etc.. Some of the variables are continuous and some of them have a categorical nature with ranking order. There are few independent variables with binary nature (e.g. gender) (see table 2).

Accessibility is a function of distance from a place of activity to the nearest public transportation stops, stations or terminals (and the availability of the service), hence, before proceeding to the modelling process, we tried to analyse public transportation availability using the data set. Figures 1 to 4 show the relationship between the characteristics of residence location and availability of public transportation services. It appears that bus is available regardless of locational factors (both urban and rural area). This is not a surprise given the spatial coverage of bus service in many cities of Germany. On the other hand, street cars, S-Bahn (underground trains) and U-Bahn (commuter rail) are providing services to the urban areas. Regional trains run through cities and have station in several places including small cities and rural towns as they are gaining importance by connecting suburban areas with urban foci.

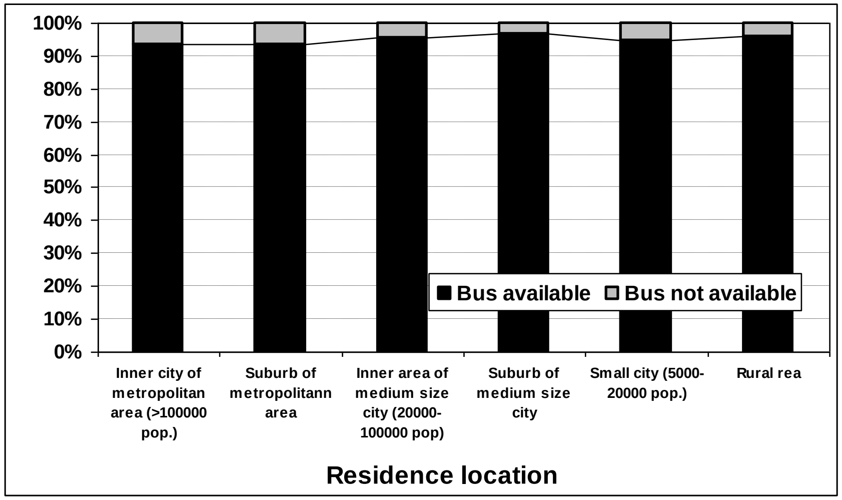

Figure 1: Residence location vs. availability of bus

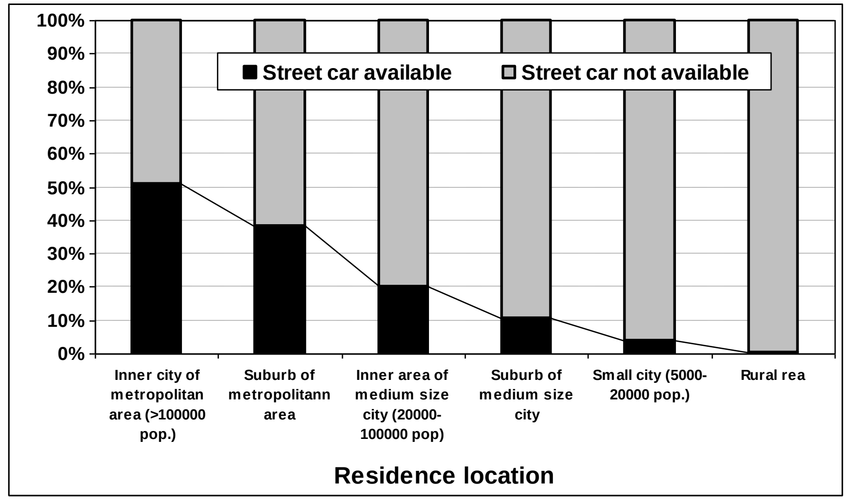

Figure: 2 Residence location vs. availability of street car

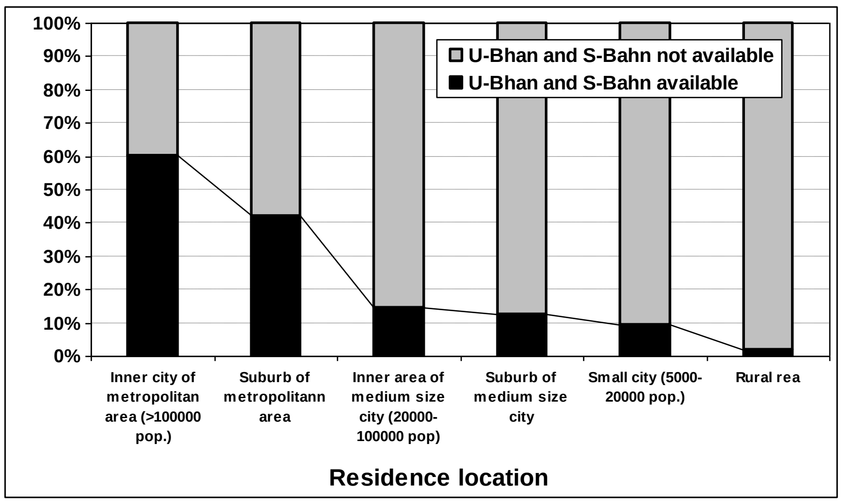

Figure 3: Residence location vs. avail. of U-Bhan and S-Bahn

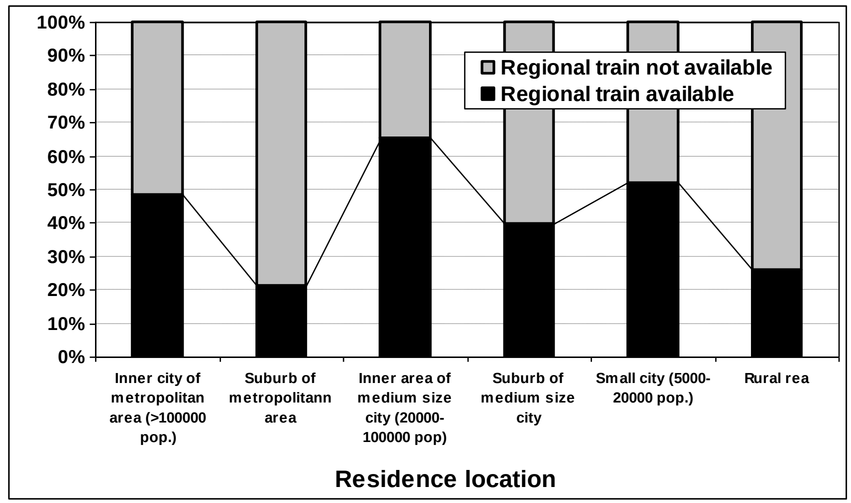

Figure 4: Residence location vs. avail. of regional trains

Table 2: Description of independent variables

Variables (N=15903)	Count of cases
Person data	
Gender: 1=male/0=female	7545/8358
Age:1= < 18 (1457), 2= 18-25 (1038), 3=26-35 (1764), 4=36-50 (4746), 5=51-59 (2575), 6=60-69 (3011), 7=70+ (1312)	Refer the paranthesis
Education: dummy variable, 1= High school without vocational training, 0 otherwise	714/15189
Education: dummy variable, 1= High school with vocational training, 0 otherwise	3840/12063
Education: dummy variable, 1= Middle school, 0 otherwise	4530/11373
Education: dummy variable, 1= University degree, 0 otherwise	5096/10807
Education: dummy variable, 1= Not completed school, 0 otherwise	1457/14446
Occupation: dummy variable, 1= Full time employee, 0 otherwise	2904/12999
Occupation: dummy variable, 1= Part time employee, 0 otherwise	7304/8599
Occupation: dummy variable, 1= Unemployed, 0 otherwise	230/15673
Occupation: dummy variable, 1= In school or university, 0 otherwise	768/15135
Occupation: dummy variable, 1= In vocational training, 0 otherwise	119/15784
Occupation: dummy variable, 1= Housewife, 0 otherwise	304/15599
Occupation: dummy variable, 1= retired, 0 otherwise	1346/14557
Work location: dummy variable, 1= inner city of metropolitan area (>100000 pop.), 0 otherwise	2516/13387
Work location: dummy variable, 1= suburb of metropolitan area, 0 otherwise	1206/14697
Work location: dummy variable, 1= core of medium size city (20000-100000 pop), 0 otherwise	1544/14359
Work location: dummy variable, 1= suburb of medium size city, 0 otherwise	1455/14448
Work location: dummy variable, 1= small city (5000-20000 pop.), 0 otherwise	2509/13394
Work location: dummy variable, 1= rural area, 0 otherwise	430/15473
Public transportation connectivity: 1= no connection with public transportation (1031), 2= more than one transfer (1013), 3= one transfer (810), 4= slow direct connection (1340), 5= Fast direct connection (3638), 0= I don't know/no information (8071)	Refer the paranthesis
Walking distance from work place to the nearest public transportation: 1= less than 10 minutes (2394), 2= 10 to 20 minute (1345), 3= longer than 20 minute (3958), 0= don't know/no information (8246)	Refer the paranthesis
Parking problem at working place: 1=very difficult (8249), 2=difficult (539), 3= Not so difficult (922), 4= Not at all difficult (1764), 0= no information (4429)	Refer the paranthesis
Bicycle ownership: 1 = yes/0 = no	3058/12845
Household data	
Residence location: dummy variable, 1= inner city of metropolitan area (>100000), 0 otherwise	1459/14444
Residence location: dummy variable, 1= suburb of metropolitan area, 0 otherwise	3219/12684
Residence location: dummy variable, 1= core of medium size city (20000-100000), 0 otherwise	1032/14871
Residence location: dummy variable, 1= suburb of medium size city, 0 otherwise	2859/13044
Residence location: dummy variable, 1= small city (5000-20000 pop.), 0 otherwise	3645/12258
Residence location: dummy variable, 1= rural area, 0 otherwise	3653/12250
Household size	mean=2.717
Number of cars in the household	mean=1.368
Parking situation around residence: 1=very difficult (838), 2=difficult (1978), 3= Not so difficult (4309), 4= Not at all difficult (7642), 0= no information (1136)	Refer the paranthesis
Availability of bus (1–2 km radius): 1 = yes/0 = no	15119/784
Availability of tram (1–2 km radius): 1 = yes/0 = no	2663/13240
Availability of underground train- U-Bahn (1–2 km radius): 1 = yes/0 = no	1163/14740
Availability of commuters train S-Bahn (1–2 km radius): 1 = yes/0 = no	2635/13268

Availability of regional train (1–2 km radius): 1 = yes/0 = no	6055/9848
Availability of shop for daily needs (1–2 km radius): 1 = yes/0 = no	13652/2251
Availability of shop for other needs (1–2 km radius): 1 = yes/0 = no	7874/8029
Availability of cafes and clubs (1–2 km radius): 1 = yes/0 = no	13063/2840
Availability of cinemas and theatres (1–2 km radius): 1 = yes/0 = no	3469/12434
Availability of sport activities (1–2 km radius): 1 = yes/0 = no	10563/5340
Trip data	
Total number of trips per week	mean=24.670
Total number of trips per week using regional train	mean=0.269
Total number of trips per week using bus or tram or U-Bahn or S-Bahn	mean=1.818
Travel distance per week (km)	mean=276.044
Travel distance per week using regional train (km)	mean=22.106
Travel distance per week using bus or tram or U-Bahn or S-Bahn (km)	mean=19.637
Seasonal tickets (week, month or year pass): 1 = yes/0 = no	3008/12895
Trip making using bus or tram or U-Bahn or S-Bahn: 1 = yes/0 = no	4679/11224
Trip making using regional train: 1 = yes/0 = no	1221/14682

5. MODELLING RESULTS

After running the model using LIMDEP 7.0 software, variables with t-value above the acceptable critical value of |1.676| with 95% confidence level and the degree of freedom of 52 were taken for hypothesis testing (as indicated with dot (•) in table 3). According to the result of the panel binomial probit model, most of the independent (explanatory) variables are statistically significant which makes it possible to infer the influence of those explanatory variables on the dependent variable (satisfaction with accessibility to public transportation services.) There are few variables that are considered to have significance with 90% confident level (critical t-value |1.299|). Those variables are indicated by single asterisk (*) in the result table (table 3). The panel model is well fit with the data as the chi-square and the log likelihood ratio are within acceptable range. The estimate of ρ = 0.728 shows that there is time variant effect of satisfaction with accessibility. The likelihood estimate also shows that there is a slight variation of satisfaction throughout the survey years (refer to table 3 and figures 5 to 7).

Table 3: Modelling result

Independent / Explanatory Variables	β coefficient	t-value
Constant (α)	0.002	0.004
Person data		
Gender	-0.133	-2.208•
Age	0.165	5.888•
Education: High school without vocational training	0.094	0.492
Education: High school with vocational training	0.073	0.460
Education: Middle school	0.146	0.921
Education: University degree	-0.038	-0.237
Education: Not completed school	0.545	3.117•
Occupation: Full time employee	-0.074	-0.794
Occupation: Part time employee	-0.082	-1.207

Occupation: Unemployed	0.024	0.122
Occupation: In school or university	-0.014	-0.103
Occupation: in vocational training	-0.027	-0.099
Occupation: Housewife	-0.001	-0.003
Occupation: retired	0.041	0.356
Work location: inner city of metropolitan area (>100000 pop.)	-0.076	-0.699
Work location: suburb of metropolitan area	-0.589	-5.211•
Work location: inner city of medium size city (20000-100000 pop)	-0.363	-3.274•
Work location: suburb of medium size city	-0.733	-6.557•
Work location: small city (5000-20000 pop.)	-0.444	-4.883•
Work location: rural area	-0.391	-2.533•
Public transportation connectivity	0.066	3.836•
Walking distance from work place to the nearest public transportation	0.016	0.793
Parking problem at working place	0.034	1.337*
Bicycle ownership	0.121	1.806•
Household data		
Residence location: inner city of metropolitan area (>100000 pop.)	0.671	1.175
Residence location: suburb of metropolitan area	0.144	0.257
Residence location: inner city of medium size city (20000-100000 pop)	0.125	0.221
Residence location: suburb of medium size city	0.026	0.046
Residence location: small city (5000-20000 pop.)	-0.463	-0.831
Residence location: rural area	-0.828	-1.478*
Household size	-0.076	-2.560•
Number of cars in the household	-0.183	-4.485•
Parking situation around residence	0.022	0.934
Availability of bus (1–2 km radius)	0.092	0.729
Availability of tram (1–2 km radius)	0.733	7.031•
Availability of underground train- U-Bahn (1–2 km radius)	0.339	2.411•
Availability of commuters train S-Bahn (1–2 km radius)	0.387	4.474•
Availability of regional train (1–2 km radius)	0.346	6.280•
Availability of shop for daily needs (1–2 km radius)	0.627	8.913•
Availability of shop for other needs (1–2 km radius)	0.107	1.853•
Availability of cafes and clubs (1–2 km radius)	0.179	3.044•
Availability of cinemas and theatres (1–2 km radius)	0.415	5.710•
Availability of sport activities (1–2 km radius)	0.170	3.438•
Trip data		
Total number of trips per week	0.006	2.560•
Total number of trips per week using regional train	0.033	1.112
Total number of trips per week using bus or tram or U-Bahn or S-Bahn	-0.007	-0.609
Travel distance per week	-0.001	-0.517
Travel distance per week using regional train	0.001	0.364
Travel distance per week using bus or tram or U-Bahn or S-Bahn	-0.001	-0.787
Seasonal tickets (week, month or year pass)	0.153	1.783•
Trip making using bus or tram or U-Bahn or S-Bahn	0.097	1.276
Trip making using regional train	-0.170	-1.439*
Estimated coefficient (of time variant)		

Rho	0.732	61.879
-Number of observations -Log likelihood function -Restricted log likelihood -Chi-squared -Degrees of freedom	15903 -6403.810 -7402.983 1998.345 52	
* *Statistically significant variables with 95% confident level* **Statistically significant variables with 90% confident level*		

5.1. Influence of the Independent Variables on Satisfaction

The inferential statistics based on the t-values and the sign of the β coefficients are presented in order to observe how the explanatory variables influence survey respondents' perception and satisfaction. The explanatory variable *gender* included into the model shows a negative utility value (β_{gender}), indicating that male respondents have less likelihood of satisfaction with accessibility. Similarly, *Age* is a statistically significant variable with a positive β coefficients and a fairly large t-value showing that 'relatively younger' respondents have a lower likelihood of satisfaction. *Education* shows no significance except to those who have not completed high school, in which case the satisfaction with accessibility tends to be high. *Occupation* was expected to have an effect on travellers' perception; however the variable turned out to be statistically insignificant. The variable *household size* showed a negative β coefficient informing that respondents of bigger families have less probability of satisfaction with accessibility to public transportation. Also *the number of cars owned* is a statistically significant variable with a negative utility value attached to it, showing that the likelihood of satisfaction with ease of access decreases with increasing car ownership.

Parking problems at working place is one of the factors that persuade people to use public transportation. True as it is, the result in this study show that respondents who said they have parking problems at working place have high satisfaction with accessibility to public transportation. However, parking at residence location appeared to have no significant influence.

Residence location is statistically insignificant variable although the positive sign attached to the utility coefficients ($\beta_{residence}$) of larger and medium cities informs that trip makers living in high density areas tend to satisfy with accessibility to public transportation. However, the lower than the critical t-value for small city and the –ve β coefficient for rural areas show that accessibility could be a concern for rural communities and small town residents. This may be because of the lack of availability of public transportation services. Contrary, work location showed to be significant with a negative sign attached, with the exception of working places located in the inner city of metropolitan areas being statistically insignificant. Generally, this explanatory variable shows that respondents working further away from the inner city show lower probability of satisfaction.

Another statistically significant variable is *connectivity* among different public transport routes/trips. There is high likelihood of satisfaction with accessibility where there is direct interconnection between different public transport modes. Accordingly, a lack of connection among public transportation routes could be one of the reasons for trip makers to acquire less satisfaction with accessibility.

Availability of public transportation within a walking distance is the major factor of accessibility and was expected to have a great influence on travellers' satisfaction. As anticipated, the positive β coefficient for all modes of transportation (except bus) confirms that when the respondent state the existence of a public transportation stop close to where they live, they have a higher likelihood of being satisfied with accessibility to public transportation. However, it appeared that the variable 'bus' is statistically insignificant. Additionally, the *availability of shopping and entertainment activities* within a walking distance is included in the data set in order to observe how availability of those variables affect people's perception towards accessibility to public transportation. The result shows that people have a positive perception about accessibility to public transportation when there is availability of shopping and entertainment activities in their neighbourhood (with fairly high β and t-values).

In order to relate satisfaction with ease of access to the actual usage of the public transportation, trip and mode related variables were incorporated in the model. Most of those variables are statistically insignificant, however, when the total number of trips per week is concerned, the higher t-value indicated that people who are more mobile, represented by a higher number of trips per week, tend to show a higher satisfaction. While the total number of trip yielded an aggregate result, we attempted to sort trips by public transportation users in order to observe their view on accessibility. The total number of trips by public transportation didn't turn out with a significant t-value; neither did other indicators of public transport usage, such as the distance travelled or actual trip-making indicators. In the latter case, only the usage indicator of the regional train showed to be statistically significant. However, those who own seasonal tickets (weekly, monthly and yearly tickets of public transportation use) show significant influence with 90% significant level, revealing that the potential public transportation users show satisfaction with accessibility to public transportation.

5.2. Probability Estimates

In addition to the parametric relationship between the dependent and independent variables described above, the probability of being satisfied with accessibility to public transportation is calculated for the wave of the panel as well as for the total sample of each year using the estimated β and α coefficient. Generally, the probability estimate shows that there is a high degree of satisfaction with accessibility to public transportation (≈70% likelihood). However, when analysing satisfaction on annual basis, a continuous increase of satisfaction is observed between the years 1997 and 1999 and in the subsequent years, the tendency appears to be levelled although there are slight changes (see figure 5).

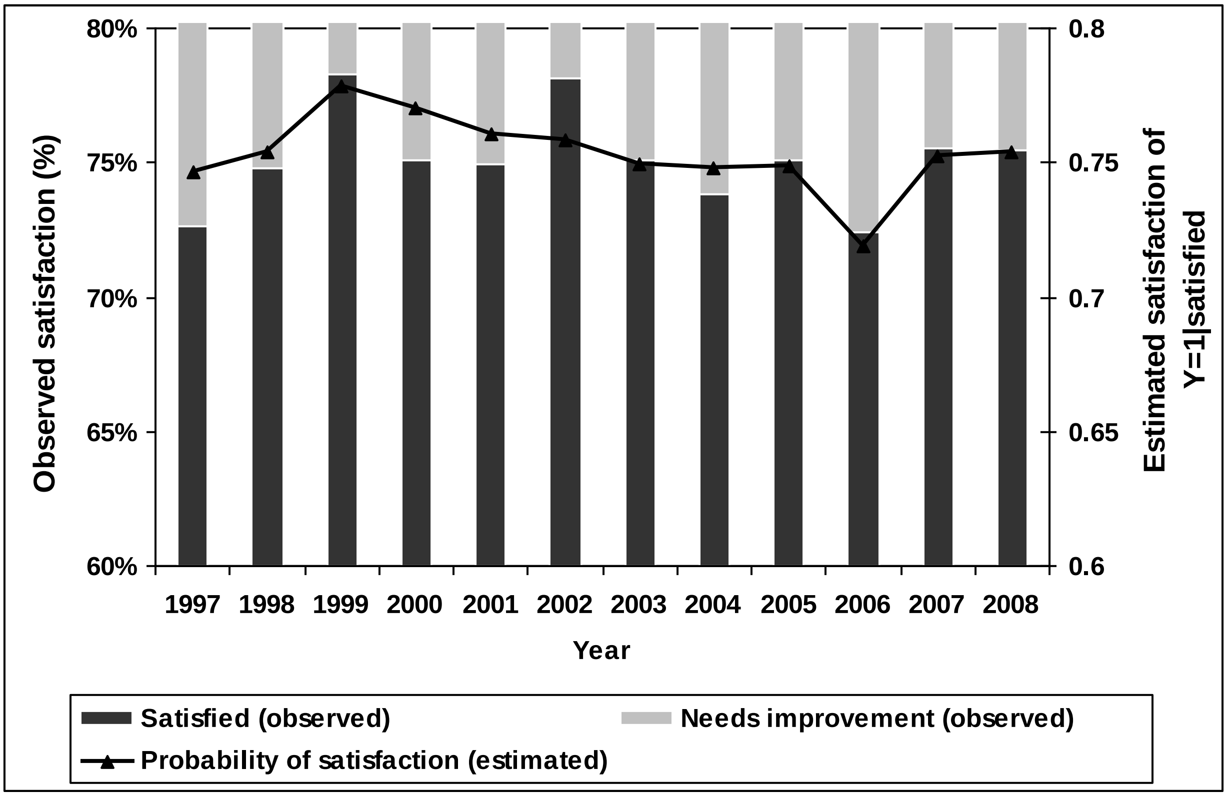

Figure 5: Probability estimate for each year (taking the total sample of the year)

In order to observe some relationships and to examine the sensitivity of the model, the probability estimate is related with selected variables. Figure 6 shows that as age increases so does satisfaction and an increase in number of cars in the HH lowers the probability of satisfaction. Figure 7 turned out to give interesting insight that satisfaction increases with the number of trips per week. Besides, when the public transportation usage is concerned, the likelihood of being satisfied decreases for those without seasonal tickets.

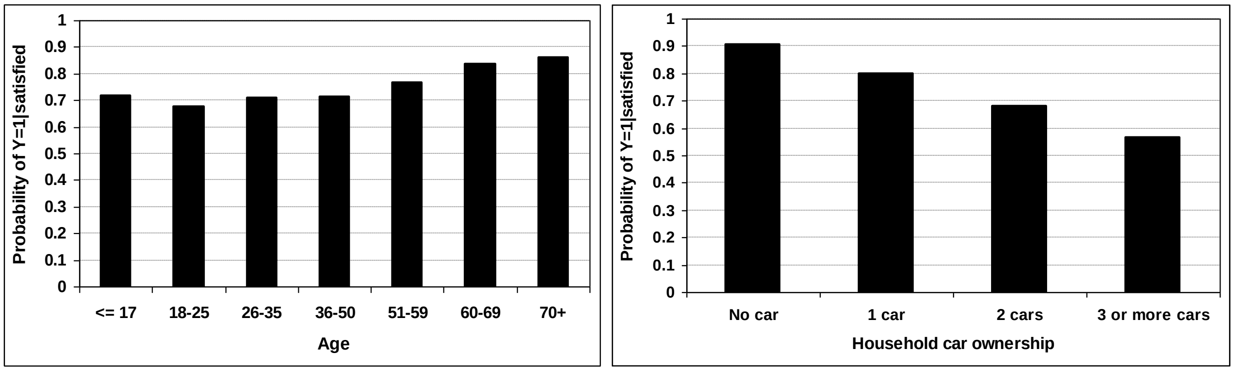

Figure 6: Probability estimate of satisfaction in terms of age and car ownership

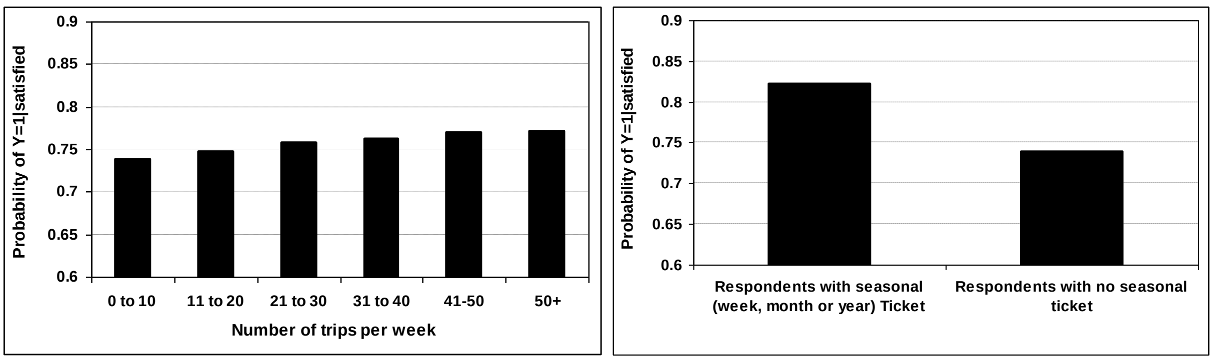

Figure 7: Probability estimate of satisfaction in terms of *No. trips* and *seasonal tickets ownership*

6. DISCUSSION AND POLICY IMPLICATION

The modelling result indicates that there are remarkable parametric relationships between the explanatory variables and perception/satisfaction with accessibility to public transportation. The maximum likelihood estimates show that the more frequent the respondents use public transportation, the higher the likelihood of satisfaction they have. A higher number of trips are related to positive perception. Although the public transportation related variables such as number of trips and distance travelled by public transit are statistically insignificant, there is a significant relation between satisfaction and ownership of seasonal tickets. It is safe to assume that those who own seasonal tickets are frequent and regular users of public transportation. The positive utility value associated with ‘seasonal ticket’ implied that frequent users might have a positive perception towards accessibility to public transportation. It is not necessarily because frequent users have no complains; but the first-hand experience they have with the public transportation service rather than responses based on general observation or second-hand information. Such indicators may imply that the transit service providers and local planning offices ought to take those frequent users into stronger consideration in their planning process.

Also, the policy and strategic solutions would focus on supporting and encouraging public transportation users with no alternative means of transportation. Satisfaction with accessibility measurements can provide valuable information to support such actions, for example, transit operators need to include socio-economic variables such as *gender* and *age* in their transportation planning. The elderly, low income people and other parts of the community (such as children and person with disabilities) are community groups that can be disadvantaged by the public transportation service, therefore facilitating accessibility may increase social inclusion.

One interesting finding in this study is that, although not directly related to accessibility to public transportation, easy access to shopping and entertainment facilities create a positive perception towards access to public transportation. The possible explanation for this could be that most of the shopping and entertainment facilities are located close to public transportation stops. Also, proximity of shopping facilities to residence location could potentially create a positive perception. Speaking of location factors, residence and work locations with reference to the closest public transportation service are important parameter to explain accessibility. In this study, respondents showed a lower likelihood of satisfaction regardless their work location. However, inner city residents showed higher probability of satisfaction with accessibility to public transportation services. This might imply that the residence location and work location variables (agglomeration of activities) are important considerations for the provision of accessible public transportation. Planning and design ought to focus on higher density areas as appropriate sites for transit oriented developments for two reasons. First, in dense areas, a single transit stop can serve more people, and a higher ridership allows more frequent service. Second, dense mixed land use areas allow people to reach many more local destinations on foot once they leave transit (Rood, 1998).

7. CONCLUSION

Compared to the traditional methods, the panel data model used in this study has an ability of capturing the time effect and the parametric and causal relationship between variables. Also, the German Mobility Panel is a very useful data set to grasp the time effect of travellers' behaviour and trip characteristics. Satisfaction with accessibility to public transportation is one of the variables being observed every year in the panel data. Although transit companies and research institutes are conducting customer satisfaction surveys on direct service related parameters, accessibility has often not received appropriate attention for being one of those parameters. On the other hand, it has always been the concern of transportation planners to create an accessible transportation by integrating transportation with the land use. For policies and strategies that encourage the use of public transportation, improving accessibility would be appropriate intervention because of the fact that access to public transportation is a significant component of the overall transportation system. The probabilistic analysis conducted in this study showed that there are parameters (whether related to the trip maker, the trip itself or the public transportation service) which affect the level of satisfaction of the travellers with accessibility to public transportation. There is an appealing finding that travellers who tend to make frequent trips by public transportation (as observed from 'ownership of seasonal ticket' in the model) demonstrate higher probability of satisfaction with accessibility, which could be the point of interest to transit service providers.

Being satisfied with ease of access is also important for transit users as their perception affects their usage of the service. Like all other market oriented service organizations, transport companies have to shape their service supply to the demand of their customers. To this end, transit planners might have to make access to transit routes their centre of attention. This study especially could assist transit providers' effort to integrate land use with transportation. The modelling as well as the descriptive results supports policy measures and public transportation service improvement strategies. In order to create an efficient transit-oriented development, the modelling result indicated that the key is locating public transport where there are trip generators and creating a positive perception towards the overall trip. Access management can increase the coordination between different urban functions and public transportation provision.

References

1. APLT (2003) *Measuring Public Transport Accessibility Levels (PTALs).* Transport for London, Department of Transport.
2. Brons, M., Givoni, M., and Rietveld, P. (2009) Access to Railway Stations and Its Potential in Increasing Rail Use, *Transportation Research Part A*, 43 (2) 136-149.
3. Buchanan, C. (2004) *Bus Passengers Satisfaction Survey*. Scottish Executive Social Research, Transport Research Planning Group.
4. Donovan, N., Brown, J., and Bellulo, L. (2001) *Satisfaction with Public Services: A Discussion paper*. Performance and Innovation Unit, UK.
5. Eboli, L., Mazulla, G. (2007) Service Quality Attributes Affecting Customer Satisfaction for Bus Transit, *Journal of Public Transportation*, 10 (3) 21-34.
6. Federal Highway Administration (2001) National Household Travel Survey. Washington, D.C.: Bureau of Transportation Statistics and Federal Highway Administration.
7. Foote, P. J., Stuart, D. G. (1998) Customer Satisfaction Contrasts: Express Versus Local Bus Service in Chicago's North Corridor, *Transportation Research Record: Journal of the Transportation Research Board*, Transportation Research Board of the National Academies, Washington, D.C., vol. 1618, 143-152.
8. Givoni, M., Rietveld, P. (2007) The Access Journey to the Railway Station and Its Role in Passengers' satisfaction with Rail Travel, *Transport Policy*, 14 (5) 357-365.

9. Gorter, C., Nijkamp, P., and Vork, R. (1999) Analysis of Travellers' Satisfaction on Transport Chains. Discussion Paper No. 99-058/3, Vrije University, Amsterdam, the Netherlands.
10. Greene, W. H. (2000) *Econometric analysis*. 4th ed., Prentice-Hall, Inc.
11. Hess, D. (2009) Access to public transit and its influence on ridership for older adults in two U.S. cities, *Journal of Transport and Land Use*, 2 (1) 3-27.
12. Hine, J., Scott, J. (2000) Seamless, Accessible Travel: Users' Views of the Public Transport Journey and Interchange. Transport Policy, 7(3) 217-226.
13. Hsiao, S., Lu, J., Sterling, J., and Weatherford, M. (1997) Use of Geographic Information System for Analysis of Transit Pedestrian Access. *Transportation Research Record: Journal of the Transportation Research Board*, Transportation Research Board of the National Academies, Washington, D.C., No.1604, 50-59.
14. Lewis-Workman, S., Brod, D. (1997) Measuring the Neighbourhood Benefits of Rail Transit Accessibility. *Transportation Research Record: Journal of the Transportation Research Board*, Transportation Research Board of the National Academies, Washington, D.C., No. 1576, 147-153.
15. Morpace International, Cambridge Systematics (MICS) (1999) *A Handbook of Measuring Customers Satisfaction and Service Quality*. TRB's Transit Cooperative Research Program (TCRP) Report No. 47, National Academy Press, Washington, D.C.
16. Ostlere, M., Lund, M. (2008) *The Northamptonshire Sustainable Transport Survey 2007: A Report for Northamptonshire County Council – Executive summary*. UK.
17. Purcell, B. *(2008) Urban Public Transport in Berlin,* <http://www.gettingaroundgermany.info/stadt.shtml >, Accessed on July 8, 2011.
18. Rietveld, P. (2000) The Accessibility of Railway Stations: The Role of the Bicycle in the Netherlands, *Transportation Research Part D*, 5 (1) 71-75.
19. Rood, T. (1998) *The Local Index of Transit Availability (LITA): An Implementation Manual*. The Local Government Commission.
20. Schäffeler, U. (2004) *Netzgestaltungsgrundsätze für den Öffentlichen Personennahverkehr in Verdichtungsräumen*. Phd-Thesis, Zurich Technical University.
21. Transit Cooperative Research Program (TCRP) (2009) *Public Transportation's Role in Addressing Global Climate Change*. Research Results Digest 89, March 2009.
22. VDV (eds.) (2001) *Verkehrserschliessung und Verkehrsangebot im ÖPNV*. VDV-Schriftenreihe, 4 (6).
23. Wallace, R. R. (1997) Paratransit Customer: Modelling Elements of Satisfaction with Service, *Transportation Research Record: Journal of the Transportation Research Board*, Transportation Research Board of the National Academies, Washington, D.C., No. 1571, 59-66.

24. Wibowo, S. S., Olszewski, P. (2005) Modelling Walking Accessibility to Public Transport Terminals: Case Study of Singapore Mass Rapid Transit, *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 6, 147–156.
25. Wawro, G. (1999) A Panel Probit Analysis of Campaign Contributions and Roll Call Votes, Paper presented at the 1999 Annual Meeting of the American Political Science Association, September 2, 1999.
26. Woldeamanuel, M. G., Takano, S. (2008) Modelling the Relationship between Travellers' Level of Satisfaction and Their Mode Choice Behaviour Using Ordinal Models, *Journal of the Transport Research Forum*, 47 (2), 103-118