Travelers' Sensitivity to Public Transport Related Planning Measures

Peter van der Waerden, Eindhoven University of Technology, Urban Planning Group, P.O. Box 513, Eindhoven, 5600 MB, The Netherlands, p.j.h.j.v.d.waerden@tue.nl

Mike Bérénos, Hasselt University, Transport Research Group, Science Park 5, P.O. Box 6, B-3590 Diepenbeek, Belgium, Email: mike.berenos@uhasselt.be

Harry Timmermans, Eindhoven University of Technology, Urban Planning Group, P.O. Box 513, Eindhoven, 5600 MB, The Netherlands, h.j.p.timmermans@tue.nl

ABSTRACT

This paper presents the findings of a study of travelers' sensitivity to sixteen public transport related planning measures. Travelers who use the car or the bike for their regular trips are invited to indicate if certain planning measures might stimulate them to change travel mode in favor of the bus. Three answers were available: Yes, I will change to public transport; Yes, I will consider a change towards public transport; and No, I will not change my current mode choice.

The study was carried out in the Eindhoven region, the Netherlands. The data of 896 respondents could be used for the analyses that are described in this paper. It appears that an improvement of the connection to trains and extension of the service in the morning and the evening might trigger travelers to the bus. The effect is significantly influenced by personal characteristics, especially gender and the fact that the traveler rarely uses public transport. Small differences are found regarding the characteristics of regular trips.

Keywords: Public Transport, planning measures, ordinal regression

INTRODUCTION

To increase the market share of public transport in urban areas, both municipalities and public transport companies are searching for interesting planning measures. Several measures have been implemented with varying degrees of success. The success of

planning measures for public transport companies depends on many factors such as available funds, passenger volumes, communication, commitment of residents, and additional measures (e.g., Vuchin, 2005). To set up an efficient transit planning policy, information concerning the (potential) success of the measures is required. The required information concerning the success of different measures can be gathered from existing and/or hypothetical projects.

In this paper we investigate travelers' sensitivity towards a set of hypothetical planning measures. In the study, sixteen different hypothetical measures were investigated in more detail. The measures can be initiated by local and regional authorities or by the public transport company and cover a variety of aspects of the public transport system such as safety, comfort, travel speed, and service.

The remainder of the paper is organized as follows. First, a brief introduction is given of the study on effects of planning measures that is set up by the Eindhoven University of Technology. Next, the adopted research approach is discussed followed by a description of the data collection. The analyses are described in section 5. The paper ends with the conclusion and discussion.

EFFECT OF PLANNING MEASURES

To attract travelers to public transport both public transport companies and local planners have a variety of planning and marketing measures available. Planning and marketing measures initiated by public transport companies can be organized into various categories covering accessibility and problem solving projects, the introduction of new services, and several promotion activities (e.g., TCRP, 1999). Municipalities mainly focus on infrastructural measures such as building bus lanes, locating bus stops, and introducing traffic light regimes (e.g., Abdelghany et al, 2004).

In the past, most studies focused on the (direct) effect of the characteristics of alternative transport modes on travelers' transport mode choice behavior. Transport modes were described by means of travel time, travel cost, comfort level, and availability. Only a few studies paid extra attention to specific characteristics of public transport such as bus frequency, distance from home to nearest bus stop, type of bus stop, and guarantee on seat in bus (Van der Waerden *et al*, 2006). In the studies little attention has been paid to the effect of changes in the characteristics of the transport modes due to planning measures.

In 2005 Van der Waerden *et al* (2007) started a study to get insight into the effects of planning measures on the willingness of travelers to change mode from car/bike to public transport. A limited number of ten planning measures were investigated in more detail. Respondents were asked to select five measures that would stimulate them to move from the car or bike to public transport. In addition, respondents were asked to put these five measures in order from a little important to most important. It appeared that the effect of planning measures strongly depends on mode used for the

trip (car or bike). Most successful planning measures to stimulate car drivers to use public transport are travel time and travel cost related measures. Bicyclists will mainly be influenced by travel time, seat guarantee, and storage costs. The selected planning measures were defined relatively fuzzy, diminishing the risk of presenting respondents unrealistic options.

As a follow up to the previous study a new study was set up in 2008. In this new study the planning measures were directly related to the respondents' decision for not choosing public transport. In addition, respondents had more possibilities to indicate if they would change transport mode due to the measure (see next section).

RESEARCH APPROACH

To get insight into the travelers' sensitivity the following research approach is adopted. First, travelers who use the car or the bike for their regular trips were asked to indicate the reason(s) for not choosing public transport. A predefined list of 16 different reasons was presented to the respondents (Table 1). Next, per selected reason a general improvement was suggested, followed by the question if this improvement might stimulate the traveler to choose public transport instead of car or bike for their regular trip. A regular or repetitive trip is defined as a home originated trip made on a regular base (per week, month, or year) by car or bicycle. Three answers were available: Yes, I will change to public transport; Yes, I will consider a change towards public transport; and No, I will not change my current mode choice. In addition, the importance of the selected reason was asked on a 5-points scale ranging from less important to very important. Three different types of trips were considered: home-work, home-shopping, and home-leisure trips.

Table 1 - List of aspect for not choosing the bus

Number	*Aspects*	*Reasons*
1	Distance	Long distance between dwelling and nearest bus stop
2		Long distance between bus stop and final destination
3	Time schedule	Limited bus frequency
4		No direct connection with final destination
5	Travel time	Unbalanced travel time ratio between bus and bike
6		Unbalanced travel time ratio between bus and car
7	Service	Difficulties to carry luggage etc.
8	Costs	Too expensive
9	Time schedule	No service early in the morning
10		No service late in the evening
11		No connection to trains
12	Service	Too crowded
13		Too few information concerning time schedule
14		Too few seats
15		Not customer friendly
16		Not safe at the bus

The questions regarding the travelers' sensitivity to public transport related planning measures was incorporated in an internet based questionnaire (see Figure 1). The questionnaire also contained questions concerning the travelers' personal characteristics and some characteristics of the regular trip, and the travelers' evaluation of the regional bus system.

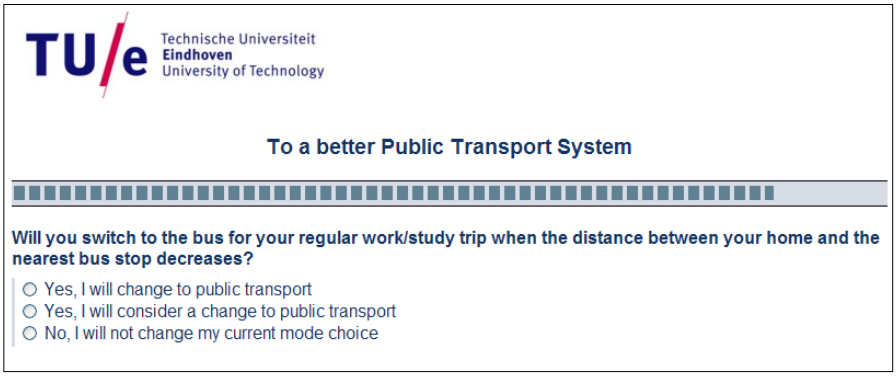

Figure 1 - Part of the internet questionnaire

THE DATA

The data were collected in the region of Eindhoven, a region in the South of the Netherlands. In September 2008, approximately 33.500 invitation cards were distributed across the cities and villages of the region. The cards explained the purpose of the research and invited residents to participate in the internet questionnaire. Almost 1450 residents filled out the questionnaire (response rate 4.3 percent) without sending a reminder or providing an incentive. The data of 896 respondents could be used for the analyses that are described in this paper. This group of respondents uses the car or the bike for their regular trips and completed the part of the questionnaire that dealt with reasons for not choosing public transport. Table 2 shows per characteristic the distribution across the levels. The distribution shows that the research sample is not representative for the Dutch population indicating that the findings can not be generalized.

Table 2 - Overview of personal characteristics

Characteristic	*Level*	*Frequency*	*Percentage*	*Coding*
Gender	Male	541	60.4	1
	Female	355	39.6	2
Age	45 years and younger	336	62.5	1
	Older than 45 years	560	37.5	2
Educational level	Medium	467	52.1	1
	High	429	47.9	2
Family composition	Family without children	581	64.8	1
	Family with children	315	35.2	2
Residential location	Country side	358	40.0	1
	City	538	60.0	2
Public transport use	Rarely	502	56.0	1
	Regular	394	44.0	2
Total		896	100.0	

The respondents described almost 2000 regular trips. The characteristics of these trips are presented in Table 3.

Table 3 - Overview of trip related characteristics

Characteristic	*Level*	*Frequency*	*Percentage*	*Coding*
Travel mode	Car	1255	63.8	1
	Bike	712	36.2	2
Travel purpose	Work	542	27.6	1
	Other	1425	72.4	2
Travel frequency	Less than 3 times per week	1269	64.5	1
	3 times or more per week	698	35.5	2
Departure time	Before noon	1007	51.2	1
	After noon	960	48.8	2
Travel distance	Less or equal to 10 km	787	40.0	1
	More than 10 kilometer	1180	60.0	2
Total		1967	100.0	

It appears that for most characteristics the trips are not equally distributed across the separated levels. Despite this unequal distribution each group consists of an acceptable number of observations.

REASONS FOR NOT CHOOSING THE BUS

The analyses consisted of two parts. First, an overview is made of the reasons for not choosing the bus. Table 4 presents per trip purpose the number of times a reason for not choosing the bus as part of the total number of trips administered by the respondents. For example, for 14 percent (76 trips) of the regular work/study trips the reason 'long

distance between dwelling and bus stop' is mentioned as reason for not choosing the bus.

In general, the distribution across the reasons for all trip purposes is more of less equal. The reasons 3 until 8 are often mentioned, while the number of times that the other reasons are mentioned is limited. Looking to the other reasons some interesting differences can be found. For example, reasons 4 (No direct connection) and 6 (Unbalanced travel time ratio between bus and car) are more often mentioned in the case of work and leisure trips than in the case of shopping trips. In contrast, reason 7 (difficult to carry luggage) is more often mentioned in the case of shopping trips. Reason 9 (No service early in the morning) is often mentioned in relation to work trips while reason 10 (No service late in the evening) is often mentioned in the case of leisure trips.

Table 4 - Reasons for not choosing the bus, per trip purpose (percentages)

Number	*Reasons*	*Work*	*Shopping*	*Leisure*
1	Long distance between dwelling and nearest bus stop	14.0	15.9	10.1
2	Long distance between bus stop and final destination	12.5	8.9	22.8
3	Limited bus frequency	33.6	21.3	25.1
4	No direct connection with final destination	50.7	30.7	50.4
5	Unbalanced travel time ratio between bus and bike	37.8	33.1	19.7
6	Unbalanced travel time ratio between bus and car	44.5	29.2	46.7
7	Difficulties to carry luggage etc.	10.9	48.1	16.3
8	Too expensive	27.7	23.5	24.6
9	No service early in the morning	18.8	3.5	6.7
10	No service late in the evening	15.9	8.6	22.5
11	No connection to trains	7.9	3.8	8.9
12	Too crowded	18.8	8.5	6.2
13	Too few information concerning time schedule	10.5	10.4	8.6
14	Too few seats	12.0	6.0	4.4
15	Not customer friendly	7.0	5.4	4.0
16	Not safe at the bus	3.9	4.0	4.2
Number of observations		542	719	706

TRAVELERS' REACTIONS

In the second part of the analyses, the travelers' reactions are investigated in more detail. As mentioned before, in the case a traveler indicates a certain reason for not choosing the bus, an improvement related to this reason is suggested. Travelers were asked to indicate if this improvement will trigger them to change travel mode in favor of the bus. Table 5 presents the travelers' reactions per planning measure. It appears that relatively offering a connection to trains will be the most successful planning measure. Of all travelers who mentioned the absence of a connection to trains as reason for not choosing the bus (133 times), almost 90 percent indicate that when a connection to the

train is realized they might switch to the bus. Also improvements of service in the morning and the evening seem to trigger travelers to the bus. The more frequent mentioned reasons (see Table 4) regarding bus frequency, connection, and travel time ratio will stimulate travelers to change travel mode in favor of the bus. The willingness to change travel mode is less than in the case of train connection and services in the morning and evening. The increase of the space for luggage in buses seems to be not very stimulating. The same holds for decreasing the distance between dwelling and bus stop, en the distance between bus stop and final destination.

Table 5 - Travelers reaction to suggested planning measures

Number	*Reasons*	*Yes, sure*	*Yes, maybe*	*No*
1	Long distance between dwelling and nearest bus stop	11.1	34.1	54.8
2	Long distance between bus stop and final destination	9.9	31.7	58.4
3	Limited bus frequency	20.5	41.4	38.1
4	No direct connection with final destination	19.0	38.7	42.3
5	Unbalanced travel time ratio between bus and bike	13.3	33.3	53.3
6	Unbalanced travel time ratio between bus and car	23.8	41.9	34.3
7	Difficulties to carry luggage etc.	7.7	31.3	61.0
8	Too expensive	26.4	47.1	26.6
9	No service early in the morning	28.7	46.0	25.3
10	No service late in the evening	30.6	46.3	23.1
11	No connection to trains	34.6	54.1	11.3
12	Too crowded	20.3	50.7	29.0
13	Too few information concerning time schedule	20.2	57.0	22.8
14	Too few seats	21.6	48.9	29.5
15	Not customer friendly	26.7	45.7	27.6
16	Not safe at the bus	27.5	41.3	31.3

To get insight into the relation between the travelers' reactions and the personal and trip related characteristics of the respondents, ordinal regression models were estimated. The ordinal regression model is specifically developed for ordinal data where the distances between categories are unknown (e.g., Long and Freese, 2003). The ordinal regression model is commonly presented as a latent variable model. Defining y* as a latent variable ranging between -∞ to ∞, the structural model is:

$$y^*_i = x_i \beta + \varepsilon_i \quad (1)$$

where,

X_i represents a vector of physical characteristics for respondent *i*;
β represents a vector of regression coefficients.

The measurement model divides y* into J ordinal categories, where the cut-points τ_1 through τ_{J-1} are estimated.

$$y_i = m, \text{ if } \tau_{m-1} =< y^*_i < \tau_m \text{ for } m=1,2,\ldots..,J \quad (2)$$

The cut-points τ_0 and τ_J are set to -∞ and ∞ respectively. The probability of an observed outcome (y) for a given value of attribute vector x is the area under the curve (a normal or logistic distribution) between a pair of cut-points.

$$Pr(y=m|x) = F(\tau_m - x\beta) - F(\tau_{m-1} - x\beta) \quad (3)$$

where,

F() is a logistic cumulative distribution function.

In this study, τ_1 represents the cutting point between the response classes "Yes, sure" and "Yes, maybe", while τ_2 represents the cutting point between "Yes, maybe" and "No". Negative effects of the dependent variables increase the probability of the first or second response class, thus decreasing the probability for a decreasing use.

For each planning measure a model is estimated with the travelers' response as dependent and the travelers' personal and trip characteristics as independent variables. The results of the model estimation process are presented in Table 6 (see at the end of the paper). It appears that most characteristics (except family composition) influence the probability of the answer categories significantly. Gender and public transport use are most often significant. A positive sign in the table means that the base level of the characteristic (as shown in the header of the Table) increases the probability of the answer categories 'Yes, maybe' and 'No' compared to the answer category 'Yes, sure'. Regarding Gender, it appears that Males have a higher preference for the answer categories 'Yes, maybe' and 'No' then Females. The same holds for respondents who rarely use public transport in relation to respondents who use public transport regularly.

CONCLUSIONS

Traditionally, travel mode studies focus on the characteristics of individual travel modes as stimulator of mode choice behavior. In contrast to these traditional approaches this study focuses on travelers' reactions on planning measures. Travelers are asked why they do not use public transport for their regular trip. If a traveler indicates a reason, an improvement is suggested followed by the question if this improvement might trigger the traveler to switch mode. It appears that the improvement of the connection between bus and train is the most successful measure. The least successful measure is the extension of space for luggage. The findings are not valid for all trip purposes.

To get insight into the relation between the travelers' reactions and the personal and trip related characteristics of the respondents, ordinal regression models were estimated. For each planning measure a model is estimated. The results of the model

estimation process show that all characteristics influence the probability of reactions on the planning measures. Only family composition has no influence at al.

For planners this information means that if they want to stimulate car and bike users to change travel mode, they have to focus on bus - train connections, and services early in the morning and late in the evening. The success of these measures is higher if the trips are carried out by women and travelers who already are familiar with the public transport system. When looking to this finding, it has to be noted that the number of travelers mentioning these reasons for not choosing the bus is limited. One could argue that reasons for not choosing the bus that are mentioned more frequently (bus frequency, direct connection, and travel time ratio) are also interesting to focus on. In this case the relative effect is less, but the absolute number of travelers affected is larger.

REFERENCES

Abdelghany, K.F., Abdelghany, A.F. and Mahmassani, H. (2004) A Modeling Framework for Bus Rapid Transit Operations Evaluation and Service Planning, Compendium of Papers CD-ROM of the 83rd Annual Meeting of the Transportation Research Board, Washington DC.

Long, J.S. and Freese, J. (2003) Regression Models for Categorical Dependent Variables using Stata, Stata Corporation, College Station, Texas.

TCRP (1999) A Handbook of Proven Marketing Strategies for Public Transit, National Academic Press, Washington DC, USA.

Van der Waerden, P., Borgers, A., Timmermans, H. and Bérénos, M. (2006) Order Effects in Stated Choice Experiments: A Study of Transport Mode Choice Decisions, Compendium of Papers CD-ROM of the 85th Annual Meeting of the Transportation Research Board, Washington DC.

Van der Waerden, P., Timmermans, H., Bérénos, M. and Vermeulen, G. (2007) Potential Effects of Public Transport Planning Measures, Proceeding of the European Transport Conference, Noordwijk, The Netherlands.

Vuchin, V.R. (2005) Urban Transit: Operations, Planning, and Economics, John Wiley and Sons, Inc. Hoboken, New Jersey, USA.

Table 6 - Estimation results of the ordinal regression models

Measure	*Cutting points*		*Gender*	*Age*	*Education*	*Origin*	*Family composition*	*PT use*	*Travel mode*	*Travel purpose*	*Travel distance*
	Yes, sure-Yes maybe	*Yes, maybe-No*	*Male*[1]	*45 year and younger*[1]	*Medium*[1]	*Country site*[1]	*Without*[1]	*Rarely*[1]	*Car*[1]	*Work*[1]	*<10km*[1]
Distance dwelling and nearest bus stop	**-1.645**	0.452	0.439	0.424	-0.258	**-0.691**	0.177	**1.310**	-0.182	-0.514	-0.018
Distance bus stop and final destination	**-1.949**	0.129	**0.645**	**0.677**	**-0.781**	**-0.502**	0.107	**1.029**	-0.380	-0.219	0.034
Bus frequency	**-0.890**	**1.165**	0.196	0.035	**-0.389**	**-0.446**	-0.076	**1.278**	0.037	0.298	-0.165
Direct connection	**-1.369**	**0.530**	**0.346**	0.039	**-0.291**	-0.006	0.270	**0.906**	**-0.573**	**-0.730**	**0.373**
Travel time ratio bus-bike	**-1.916**	-0.017	0.041	-0.105	**-0.379**	0.184	0.307	**1.054**	**-0.602**	**-0.895**	-0.148
Travel time ratio bus-car	**-0.975**	**1.041**	**0.532**	0.100	-0.194	-0.229	-0.148	**0.972**	-0.139	**-1.159**	0.047
Carry luggage etc.	**-2.063**	0.033	-0.228	**0.425**	-0.210	0.056	0.061	**0.566**	0.254	**-0.702**	0.053
Expensive	**-0.861**	**1.441**	**0.425**	0.099	**-0.819**	0.015	0.123	**1.189**	**-0.433**	**-0.603**	0.117
Service early morning	**1.363**	**3.745**	**0.992**	-0.138	0.159	-0.280	0.407	**1.570**	0.442	0.244	0.303
Service late evening	**0.861**	**3.202**	**0.703**	0.412	-0.289	0.152	0.365	**1.202**	0.507	0.266	-0.049
Connection to trains	0.783	**3.829**	**1.207**	**1.023**	0.226	-0.486	0.460	0.343	0.453	-0.409	-0.131
Crowded	0.628	**3.373**	**0.864**	0.436	0.173	0.221	0.167	**1.458**	0.070	0.408	0.504
Information	-0.363	**2.574**	**0.693**	0.548	0.313	-0.340	-0.224	**1.325**	-0.071	0.424	-0.552
Seats in the bus	0.515	**3.073**	**0.832**	0.266	0.401	0.009	0.379	**1.737**	-0.496	0.334	0.061
Customer friendly	0.142	**2.593**	**1.164**	-0.080	-0.409	0.600	-0.410	**1.413**	-0.408	**0.891**	0.161
Safety at the bus	0.620	**2.730**	**1.137**	0.094	0.835	0.304	0.290	**1.225**	-0.968	0.672	-0.503

[1] Parameter for other attribute level is set to zero because it is redundant
Bold means significant at 95% confidence level