The Effect of Travel Time Information on Route Choice Behavior: A Market Segmentation Approach

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1. INTRODUCTION

The objective of this study is to understand car commuter's perception process and route choice behavior in response to travel time information. A previous paper (see Zhao et al., 1995) of this study found that car commuter's perception process was very much dispersed, and it was affected by travel time information types, road types and some of driver's socioeconomic characteristics. In this paper, we use a market segmentation approach (see Ben-akiva and Lerman, 1985) to divide drivers into smaller, more homogeneous groups, by driver's familiarities with network, then conduct a detailed analysis on each group.

The paper is organized as follows. Section 2 discuses driver's route choice behavior in response to travel time information, then section 3 presents a theoretical modelling approach. Section 4 reports some details about the design of stated preference (SP) experiments, and section 5 examines the relationship between driver's perceived and provided travel time information with regression models. Section 6 presents the estimation results of SP models which are based on perceived and provided travel time information respectively. Finally, section 7 concludes this paper.

2. DRIVER ROUTE CHOICE BEHAVIOR IN RESPONSE TO TRAVEL TIME INFORMATION

Let's consider drivers' route choice behavior in response to travel time information.

When travel time information is provided, a driver will first perceive that information, integrating his historical or previous day experience, to form perceived travel time. Then, based on the perception and other factors, he decides his travel pattern, for example, he may choose the same route as previous day. When the trip is over, he will review the actual decision, and the results will influence his next trip as a previous day experience. Driver's perception process toward travel time information is an important part of driver's route choice behavior.

In this paper, we focus on driver's perception process in response to travel time information (Discussion on departure time or driver's learning process is beyond the scope of this paper). We assume two types of travel time information, type 1 and type 2. Type 1 is current travel time information, while type 2 is predictive travel time which includes time variation (i.e. uncertainty). The latter is given by a minim-maximum travel time pairs. This paper mainly examines the following assumptions:

1. In response to travel time information, driver's perceived travel time for each group are different, and may have a tendency to be longer than provided travel time information.

2. Route choice models with perceived travel time have stronger explanatory power than those with provided travel time information.

3. MODELLING APPROACH

3.1. Relationship between Driver's Perceived Travel Time and Provided Travel Time Information

We employ linear regression analysis method to measure the relationship between driver's perceived travel time and provided travel time information quantitatively.

Suppose driver's perceived travel time depends on provided travel time, we can get the following regression models.

$$T_{per,i} = a_0 + a_1 T_{inf,i} + \varepsilon_i \quad (1)$$

$$T_{per,i} = b_0 + b_1 T_{infa,i} + b_2 T_{infb,i} + \varepsilon_i \quad (2)$$

Where
$T_{per,i}$ = perceived travel time of route i,
$T_{inf,i}$ = provided travel time information of route i (type 1),
$T_{infa,i}$ = provided minimum travel time information of route i (type 2),
$T_{infb,i}$ = provided maximum travel time information of route i (type 2),
a_0, a_1, b_0, b_1, b_2 = set of coefficients to be estimated,
ε_i = error term of route i.

3.2. Route Choice Model

Next, with typical disaggregate methods for estimating route choice models, we assume that, for a given driver, each route i has a utility which can be expressed in the following linear form :

$$U_i = \alpha_1 T_{per,i} + \alpha_2 C_i + \beta' X_i + \mu_i \qquad (3)$$

Where
U_i = utility of route i,
$T_{per,i}$ = perceived travel time of route i,
C_i = provided travel cost of route i,
X_i = vector of additional attributes of route i,
μ_i = influence of unobserved factors affecting utility of route i,
$\alpha_1, \alpha_2, \beta$ = set of coefficients to be estimated.

In the case of provided travel time information type 1 and type 2, the utility function will be equation (4) and (5), respectively.

$$U_i = \alpha_{11} T_{inf,i} + \alpha_{12} C_i + \beta_1' X_i + \mu_i \qquad (4)$$
$$U_i = \alpha_{21} T_{infa,i} + \alpha_{22} T_{infb,i} + \alpha_{23} C_i + \beta_2' X_i + \mu_i \qquad (5)$$

Where
$T_{inf,i}$ = provided travel time information of route i(type 1),
$T_{infa,i}$ = provided minimum travel time information of route i (type 2),
$T_{infb,i}$ = provided maximum travel time information of route i (type 2),
$\alpha_{11}, \alpha_{12}, \alpha_{21}, \alpha_{22}, \alpha_{23}, \beta_1, \beta_2$ = set of coefficients to be estimated,
other variables are same as in equation (3).

4. SURVEY CONTEXT

In order to examine above approach, we conducted a mail-back SP (stated preference) survey in the Tokyo metropolitan area at the end of 1994. The sample was composed of 111 car commuters who had used any route of Tokyo metropolitan toll expressway. Each respondent gave a detailed account of his usually travel pattern, including most frequently used toll expressway and its alternative surface road, travel times for each route and his attitudes toward existing travel time information provision. The respondent was then asked to select his most familiar route among the eight typical toll expressway routes from suburban to the central area of Tokyo. These questions were followed by a number of SP experiments.

The SP experiments were designed to measure driver's perceived travel time and route choice results. For each toll expressway route and its alternative one, travel time information and travel cost are provided (distance of each route is fixed with 15 kilometers), and each respondent was asked to give his route choice results among the two routes, and answer his perceived travel time for each route. Table 1 gives the attributes and their levels used in the SP experiments. Figure 1 is an example of the SP questionnaire in respect to travel time information type 2.

Table 1 Attributes and levels of the SP experiments

Attributes	Attribute levels
Travel time for toll expressway route (in minutes)	15, 30, 45, 60
Travel time for surface road route (in minutes)	25, 40, 55, 70
Range of travel time* (in percentage)	0%, ±10%, ±20%, ±30%, ±40%
Travel cost (in yen)	400, 700, 1000, 1300

*Level of 0% is only used for current travel time information type 1.

Suppose two routes are available for you to choose, predictive travel time information and cost regarding each route are provided as below:

Travel information	Toll expressway route	Surface road route
Travel time (in minutes)	27 ~ 63	63 ~ 77
Cost (in yen)	700	0
Which one do you choose? (please mark with O)	( )	( )

and in selecting the route, how many minutes did you assume for each route?

Toll expressway route	Your assumption is :	minutes
Surface road route	Your assumption is :	minutes

Figure 1 An example of SP questionnaire

5. SOME EMPIRICAL FINDINGS

With the data collected, we classified the respondents into two groups: group 1 includes respondent who utilizes toll expressway more than once a week, while group 2 includes the other respondents. Then, we estimated the regression models described in section 3. The results are given in table 2 and table 3, respectively.

Table 2 Regression analysis results in respect to type 1 (t-statistics in parentheses)

Variable	Group 1+2	Group 1	Group 2
a_0	2.572	2.479	3.597
	(1.551)	(1.303)	(1.063)
$T_{inf,i}$	1.095	1.109	1.031
	(31.256)	(27.935)	(13.928)
R-square	0.7210	0.7346	0.6736
No. of respondents	95	71	24
No. of observations	380	284	96

Table 3 Regression analysis results in respect to type 2 (t-statistics in parentheses)

Variable	Group 1+2	Group 1	Group 2
b_0	4.991	3.146	10.578
	(2.787)	(1.472)	(3.314)
$T_{infa,i}$	0.251	0.255	0.209
	(3.056)	(2.639)	(1.376)
$T_{infb,i}$	0.733	0.765	0.653
	(14.051)	(12.245)	(7.077)
R-square	0.6815	0.6865	0.6763
No. of respondents	95	71	24
No. of observations	380	284	96

The findings from table 2 and table 3 are follows:

1. In response to current travel time information (type 1), drivers of group 1 perceive it around 10 percent extra, while drivers of group 2 around 3 percent extra.

2. In response to predictive travel time information (type 2), for all three cases, coefficients of maximum travel time are larger than those of minimum ones (the ratio of minimum vs. maximum travel time is about 1:3). This implicates the number of risk-averse drivers is larger than that of risk-prone drivers.

6. ESTIMATION RESULTS OF ROUTE CHOICE MODELS

Next, we estimated route choice models given by equation 3, 4 and 5, in respect to provided and perceived travel time of type 1 and type 2, respectively. The results are shown below:

Table 4 Provided travel time information (type 1: t-statistics in parentheses)

Variable	Group 1+2	Group 1	Group 2
Toll expressway constant	2.180	2.279	1.425
	(2.755)	(2.506)	(0.820)
Travel cost	-0.0033	-0.0033	-0.0045
	(-4.738)	(-4.045)	(-2.371)
Provided travel time	-0.0948	-0.0957	-0.1012
	(-6.957)	(-5.923)	(-3.410)
E	-1.007	-0.972	0.0280
	(-1.647)	(-1.476)	(0.016)
ρ^2	0.5434	0.5285	0.6241
Percent correctly predicted	87.89	88.03	95.83
No. of respondents	95	71	24
No. of observations	190	142	48

note:
E = Driving experience dummy variable (specific to toll expressway constant), 1 if driving experience is more than 10 years, 0 otherwise.

Table 5 Perceived travel time (type 1: t-statistics in parentheses)

Variable	Group 1+2	Group 1	Group 2
Toll expressway constant	2.173	2.343	1.412
	(2.801)	(2.556)	(0.907)
Travel cost	-0.0038	-0.0038	-0.0053
	(-5.203)	(-4.376)	(-2.599)
Perceived travel time	-0.0844	-0.0890	-0.0878
	(-6.879)	(-5.880)	(-3.190)
E	-1.110	-1.073	-0.0289
	(-1.826)	(-1.605)	(-0.019)
ρ^2	0.5229	0.5352	0.5599
Percent correctly predicted	85.79	86.62	87.50
No. of respondents	95	71	24
No. of observations	190	142	48

note:
E = Driving experience dummy variable (specific to toll expressway constant), 1 if driving experience is more than 10 years, 0 otherwise.

Table 6 Provided travel time information (type 2: t-statistics in parentheses)

Variable	Group 1+2	Group 1	Group 2
Toll expressway	1.128	-1.662	2.804
constant	(1.713)	(-1.284)	(1.531)
Travel cost	-0.0020	-0.0019	-0.0029
	(-3.548)	(-2.895)	(-1.902)
Provided minimum	-0.0255	-0.0266	-0.0266
travel time	(-1.636)	(-1.404)	(-0.695)
Provided maximum	-0.0304	-0.0378	-0.0304
travel time	(-2.720)	(-2.689)	(-1.266)
E	-0.3362	2.689	-2.206
	(-0.723)	(2.140)	(-1.698)
ρ^2	0.2695	0.2914	0.4103
Percent correctly predicted	76.84	78.17	79.17
No. of respondents	95	71	24
No. of observations	190	142	48

note:
E = Driving experience dummy variable (specific to toll expressway constant), 1 if driving experience is more than 10 years, 0 otherwise.

Table 7 Perceived travel time (type 2: t-statistics in parentheses)

Variable	Group 1+2	Group 1	Group 2
Toll expressway	0.8557	-1.239	3.049
constant	(1.331)	(-1.078)	(1.675)
Travel cost	-0.0021	-0.0019	-0.0033
	(-3.800)	(-3.005)	(-2.294)
Perceived travel	-0.0561	-0.0621	-0.0671
time	(-6.076)	(-5.398)	(-2.913)
E	-0.2929	2.002	-2.717
	(-0.606)	(1.936)	(-1.851)
ρ^2	0.3046	0.3228	0.4577
Percent correctly predicted	77.89	79.58	81.25
No. of respondents	95	71	24
No. of observations	190	142	48

note:
E = Driving experience dummy variable (specific to toll expressway constant), 1 if driving experience is more than 10 years, 0 otherwise.

The main findings from model estimations are follow:

1. In respect of current travel time information (type 1), estimation results are almost the same in both cases of perceived and provided travel time information. Significance of specific dummy variable E is low. In addition, there is little difference between two groups.

2. In respect of predictive travel time information (type 2), both coefficients of minimum and maximum travel time are almost half of those of perceived travel time. Minimum travel time are not significant at 90 percent level for all three groups, this means drivers prefer to utilize maximum travel time rather than minimum one. In both cases of perceived and provided travel time information, specific dummy variable E, is positive for group 1 and negative for group 2. In addition, explanatory power of models with perceived travel time is a little stronger than those of models with provided travel time information.

7. CONCLUSION

The main results of this study are follows:

1. From the regression analysis, it was found that, in response to current travel time information (type 1), drivers of group 1 perceived it around 10 percent extra, while drivers of group 2 around 3 percent extra, and in response to predictive travel time information (type 2), drivers tended to be risk-averse and risk-neutral as a whole.

2. The estimated route choice models showed that there was little difference in explanatory power between models with perceived travel time and models with provided current travel time information. In respect to predictive travel time information, since provided travel time was dispersed, the route choice models with perceived travel time showed a little stronger explanatory power than those with provided travel time information.

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