An Estimation of RP/SP Combined Route Choice Model Between Expressway and Ordinary Road Based on the Social Experiment Data

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1. Introduction

Kumamoto Prefecture decided to conduct a social experiment that verifies the effectiveness of conversion of ordinary road traffic to Kyushu Expressway by expressway toll pricing. A route choice model based on discrete choice analysis, between ordinary road and expressway was established. In the route choice analysis, RP and SP data are used together.

The study aims to achieve the following objectives; to provide the effective usage of expressway by toll pricing policy, specify route choice behavior of freight and production companies separately, and evaluate the Value of Time (VOT) for the efficiency of the combined model.

2. Route Choice Survey

Trucks and cars on business are the active vehicles on traffic and cause more traffic problems than the private cars. Local government of Kumamoto Prefecture conducted a mailed route choice survey for freight and production companies within the prefecture to investigate the expressway toll policy for effective usage of expressway.

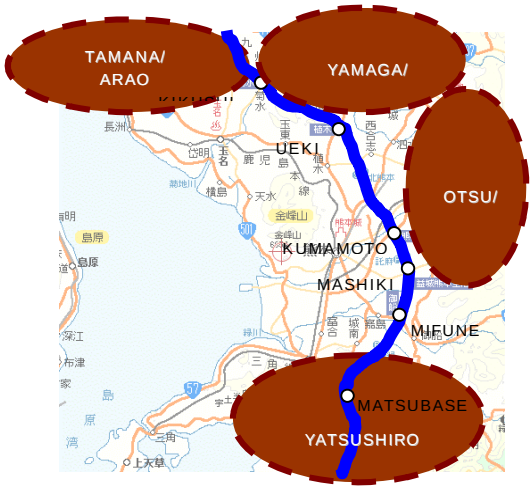

Figure 1. Study area

The survey was conducted from 25 November to 5 December 2003. Totally 150 questionnaires were delivered, 100 to freight and 50 to production companies. The response rates are 39% and 64% respectively**. Q**uestionnaires can be divided into three main parts. In the first part, characteristics and general attitudes were asked; as address, the number of employees and vehicles, the factors affect the route choice, etc.

Second part is Revealed Preference (RP) data. Study are is divided into 4 zones, as shown in Figure 1. In this part respondents were asked to indicate on the map usual route taken when going to the other zones within prefecture. Based on the route, mapped between origin and destination, attributes of route chosen and most appropriate alternative route as distance, travel time and toll were calculated. Travel times are computed by the help of H11 national census of travel time in Japan roads. A company from one zone will be asked to map routes when going to other three zones, so a maximum of three data can be derived from each respondent as RP data.

Stated preference data: For ordinary road users for each route chosen SP questions are conducted to determine at what discount rate the respondent will convert to using expressway. A sample structure of the stated preference question is shown below. An ordinary route choice from one interchange to another will have corresponding stated preference questions for conversion

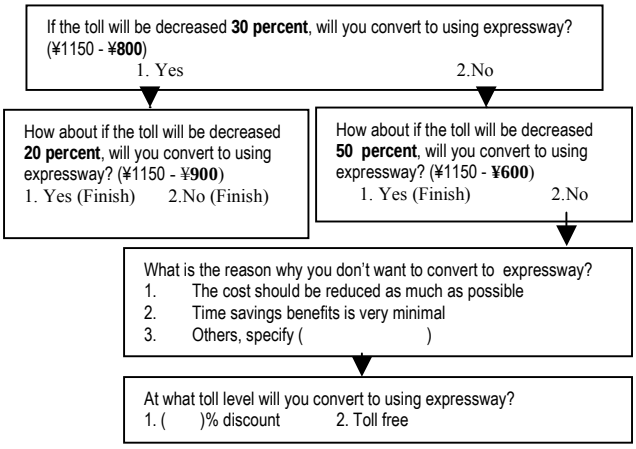

Figure 2. Stated preference scenario

3. Social Experiment

Social Experiment (SE) was the second part of the local governments' survey series. This experiment is a good chance to verify the model and see how discount rate works. SE was conducted from November 1 to December 25 of 2004. 50% discounted toll was applied to the expressway from Ueki IC to Matsubase IC. Experiment comprises all kinds of vehicles and for 24 hours during the experiment. Toll program was changed to count the discounted toll. Questionnaires were delivered at the off interchange and collected by mail, everybody could join the experiment. As seen in Figure 3 Traffic volume increased during SE between all IC couples.

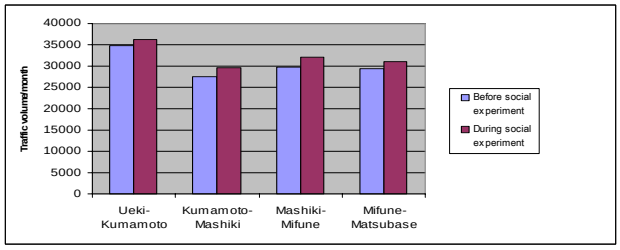

Figure 3. Traffic volume difference between IC couples

Key words: Route choice model, Toll pricing policy, Combined RP/SP data, VOT
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4. Modeling Methodology and Results

Our route choice model has four steps; first segmentation model is estimated, RP route choice model is estimated by using the choice group, SP convert model is established to clarify the convert behaviors of respondent and finally combined RP/SP model is estimated. The structure of the model is shown in Figure 4, number of the data is written in the parenthesis for each.

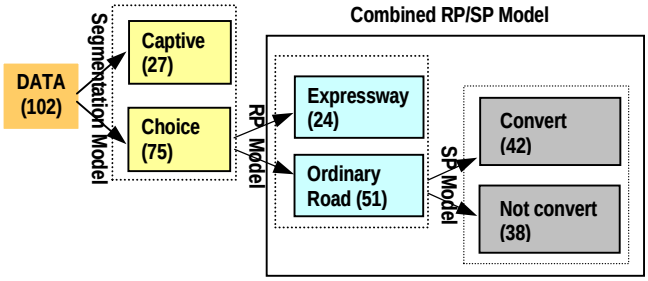

Figure 4. Structure of the model

(1) Segmentation Model

Data was divided into two groups; ordinary road captive and choice. If the portion of access time and egress time in the total travel time is big respondents likely to be ordinary road captive, and freight companies are more likely to be in the captive group.

Table 1. Segmentation model results

Variable	Estimate	t-statistic
Constant	3.9274	3.51
(Accesstime+EgressTime)/On-Exp. Time	0.0574	1.98
Travel time	-0.0114	-1.00
Cost (Expressway toll+Gas)	-0.0004	-1.14
Company dummy (Freight=1, Production=0)	2.6213	2.45
Number of Employees	-0.0013	-1.78
Number of Samples	102	
Log Likelihood	-49.96	
Hit Ratio	0.76	
ρ2	0.29	

(2) RP and SP Models

RP and SP models are estimated by binary logit model. RP model is established to estimate the route choice of choice group even the captive group declared to use only ordinary road. SP model is a convert model for the ordinary road users to evaluate the conversion from ordinary road to expressway by toll pricing policy.

RP and SP results show that freight companies more likely to choose expressway than ordinary road. Travel time and cost are the most significant variables in both models. From ρ^2 value RP model is more consistent than SP model.

(3) Combined RP/SP model

A nested logit type structure was established to estimate the combined RP/SP model. Many other structures were tested and the final model is shown in Figure 5.

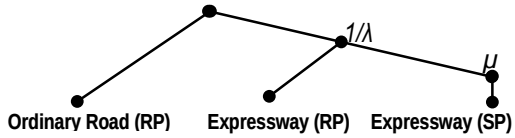

Figure 5. Combined RP/SP model structure

Orthuzar (1998) developed a framework to combine two types of data. RP and SP data errors can be denoted as a function of their variance. Nest parameter (1/λ) is introduced to the model because of the correlation between expressway RP and expressway SP, both are using same time variables as data. Combined RP/SP model is estimated as linear, then to estimate the VOT for freight and production companies a non linear model is introduced. Nonlinear model helps to see the variation in VOT by time and some travel attributes (Morikawa et al., 2002). In both linear and nonlinear combined models ρ^2 values are around 0.36, all variables are significant and the t-statistic increased compared to the RP and SP models separately.

Table 2. RP, SP and combined RP/SP model results

Variables	RP Model	SP Model	RP/SP linear	RP/SP Nonlinear
	Estimate (t-stat.)	Estimate (t-stat.)	Estimate (t-stat.)	Estimate (t-stat.)
Constant (α)	-1.6147(-1.63)	-0.9614(-0.91)	1.3091(2.67)	1.0724(1.48)
Travel Time(β_1)	-0.0225(-1.53)	-0.0256(-1.34)	-0.0305(-3.28)	-0.0082(-1.75)
Cost (Exp.way toll) (β_2)	-0.0008(-1.21)	-0.0012(-1.94)	-0.0014(-2.97)	-0.0009(-1.79)
Comp.(Freight=1, Production=0) (β_3)	3.2619(4.28)	0.4023(0.47)	1.2605(2.96)	1.2863(1.38)
Number of Emp. (β_4)	-0.0005(-0.65)	-0.0004(-0.29)	0.003(1.93)	0.0025(0.99)
λ			0.0925(0.50)	0.1670(0.60)
μ			0.9339(14.93)	0.9204(8.44)
C (Com. Dummy varib.)				-0.4067(-2.2)
Number of Samples	75	80	91	91
Log Likelihood	-31.09	-53.24	-63.34	-64.4
ρ^2	0.4	0.04	0.37	0.36
VOT (¥/min.)	27.86	21.92	21.52	
η				2.7
VOT (30) (¥/min.)	27.86	21.92	21.92	13.61 42.76
VOT (60) (¥/min.)	27.86	21.92	21.92	14.38 54.50

Note: $V = \alpha + \beta_1 t_{in}^{\gamma_n} + \beta_2 c_{in} + \beta_3 x_1 + \beta_4 x_2 \quad \gamma_n = \frac{\eta^* \exp(CZ_n)}{1+\exp(CZ_n)}$

5. Conclusions

The estimation is completed in four steps and finally linear combined RP/SP model is estimated. Nonlinear model is introduced for a detailed estimation for VOT. The verification of the model with SE results is shown in Figure 5.

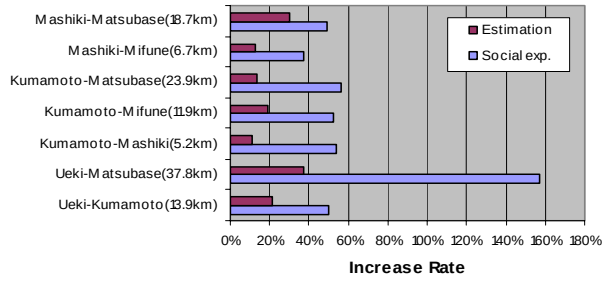

Figure 5. Traffic increase rates between interchanges

VOT estimated for all models are shown in Table 2, estimated VOT rates are low, if they are compared with the rates used in Japan. As a reference VOT for private cars is established around 50 ¥/min in Japan.

References:

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