THE EFFECTIVENESS OF SOCIAL EXPERIMENTS ON VERIFICATION OF PRE-ESTIMATED ROUTE CHOICE MODEL

Yalcin Alver, Kumamoto University, Graduate School of Science and Technology
Shoshi Mizokami, Kumamoto University, Civil and Environmental Engineering

Conference paper
WS.2.1

The Expanding Sphere of Travel Behaviour Research

11th International Conference on Travel Behaviour Research
Kyoto, 16-20, August 2006

THE EFFECTIVENESS OF SOCIAL EXPERIMENTS ON VERIFICATION OF PRE-ESTIMATED ROUTE CHOICE MODEL

Author 1 : Yalcin Alver
Department : Graduate School of Science and Technology
Organization : Kumamoto University
Country : Japan
Phone: 081-96-342-3541
Fax: 081-96-342-3507
E-mail: yalcinalver@yahoo.com

Author 2 : Shoshi Mizokami
Department : Kumamoto University
Organization : Civil and Environmental Engineering
Country : Japan

Abstract

In this study, a route choice model was investigated with the information of discounted expressway toll in Kumamoto, Japan. To convert some of the truck traffic from ordinary roads to expressway one pre-survey and two experiments were conducted. After the pre-survey a modeling effort was done. In this modeling effort, both Revealed Preference (RP) and Stated Preference (SP) data were combined and a combined RP/SP model were proposed for the estimation on route choice decision of freight and production companies. Modeling was done in four steps and finally a combined RP/SP model was estimated. Afterwards two social experiments were conducted in Kumamoto Prefecture considering discount on expressway toll. These experiments were conducted to identify the effects of toll discount by applying 50% discounted toll to expressway. The effects of the experiments were identified by discussing the surveys and traffic counts, which were done before and during the experiments. The ability of proposed model to estimate the actual route choice decisions of considered companies were tested. Results showed that proposed model could estimate the actual route choice decisions of companies under toll discounts 75% in average. The estimation results for the second experiment were better, which covers longer part of the expressway than the first one. Transferability of the proposed model with pre-surveys' data were tested to pooled data which includes both actual conditions and pre-survey conditions.

Keywords

Route choice model, Transferability, Social Experiment.

1. Introduction

Increasing motorization and limited space for transportation networks cause congestion problems in Japan. Traffic problems occur in Kumamoto City, Japan. In the city, ordinary roads are not wide enough and truck traffic usually passes trough the city center. On the other hand, Kyushu expressway is passing through the city center and easily accessible with several Interchanges (IC). The main objective of this study is to convert some of the truck traffic from city (ordinary roads) to expressway with discounted expressway toll. For this purpose, Local Government of Kumamoto Prefecture conducted a pre-survey and two experiments to identify the effects of discounted expressway toll.

First, a pre-survey was conducted to clarify the actual conditions. Survey had two main parts, first one is traffic survey to identify the traffic condition both on expressway and ordinary road at the city center. Second, a mailed route choice survey was conducted. The target respondents in this study are mainly freight and production companies within Kumamoto Prefecture. These company vehicles are usually trucks and cause more traffic problems than the private cars. However, they do not use expressway because of budget constrains.

Afterwards, two social experiments were conducted to clarify the effects of discounted toll. Both experiments have same specifications except for the covered interchanges. In the first experiment five ICs (37.8 km) and in the second one six ICs (56.2 km) were covered. 50% discount was applied to the trips between covered ICs. During the experiments, traffic surveys were conducted to identify the variation in traffic volume. Questionnaire surveys were conducted to freight and production companies, bus drivers, commuters and people living along the ordinary roads.

After the pre-survey a modeling effort spent to estimate a route choice model with information of discounted expressway toll. In this study, two data types were considered and combined in the final model; Revealed Preference (RP) and Stated Preference (SP). RP data are based on choices made under real situations. For example, actual route choice decision of driver between origin and destination with information of attributes of each alternative route can be considered as RP data. Another type of data used in route choice analysis is SP data. Different from RP, SP data are used to improve alternative set by creating hypothetical scenarios. SP data are collected when alternatives are not yet present. The model was estimated in four steps. Finally, a nested logit type structure is established to estimate the combined RP/SP model. Model has three roots; ordinary road (RP), expressway (RP), and expressway (SP).

Verification of the proposed model was done by using the data collected from social experiments. First, the pre-estimated model was used to estimate the actual route choice decision of the companies, which mailed questionnaire surveys were delivered during the experiments. Estimated results for these companies with the help of proposed model were compared with the actual choices of these companies. The estimation accuracy of the proposed model was investigated.

Finally, the effectiveness of three pooled data was tested. Data used in the pre-estimation and data collected during the route choice experiments from freight and production companies were combined in three different ways. First, collected data during the pre-survey was combined with data collected during social experiment 1. In the second pooled data, pre-surveys data was combined data from social experiment 2. Finally, all three data; pre-survey and both social experiments were combined. By using nested likelihood ratio test, transferability of the model estimated before the experiments to pooled data (actual conditions) was tested. Pooled data were prepared to create new data sets, which combined SP related data collected during the pre-survey and actual data collected during the experiments.

The objectives of the study are:

- To test the effectiveness of the route choice experiments,
- To create an effective data set by combining data from pre-survey and social experiments,
- To verify the estimation accuracy of the pre-estimated model.

2. Conducted Surveys and experiments

For the aim of this study, a questionnaire survey was conducted. This survey will be called pre-survey. After the pre-survey two social experiments were conducted to identify the effects of discounted expressway toll on different individual groups from different perspectives. These experiments will be named as Route Choice Experiments (RCE) in this paper, because main objective of the experiments is to identify the route choice behaviour of drivers between expressway and ordinary roads under discounted expressway toll.

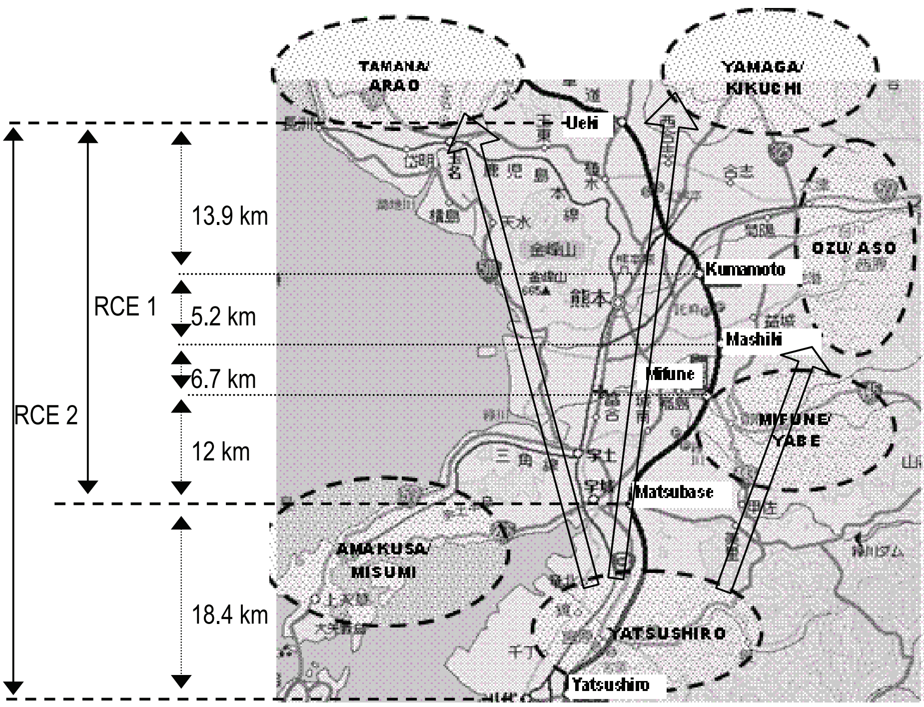

Figure 1 Study Area: Covered ICs and Distances Between Them

2.1. Pre-survey

First survey was conducted with the help of Local Government of Kumamoto Prefecture. Pre-survey was conducted between 25 November to 5 December 2003. The aim of the pre-survey is to collect data for the future toll policy's decisions to convert traffic from ordinary road to expressway. In the survey, route choice decisions and conversion characteristics of freight and production companies were investigated under different discounted toll levels. In addition, traffic counts and surveys were conducted to clarify the actual traffic conditions both on the expressway and on the ordinary roads at the city center. A total of 150 questionnaires were delivered, 50 to production and 100 to freight companies. Finally, 32 of them from production and 39 from freight companies were collected.

Pre-survey was conducted to identify the route choice decision of freight and production companies under different discount rates. Questionnaires was made of three main parts; socioeconomic characteristics and general attitudes of the company, actual route choice decision and travel attributes of these trips as RP data, and hypothetical discount scenarios for expressway toll as SP data.

In the first part general information as number of employees, number and types of vehicles were asked. In addition, companies were asked some questions about their actual route choice decisions and factors that effect those decisions.

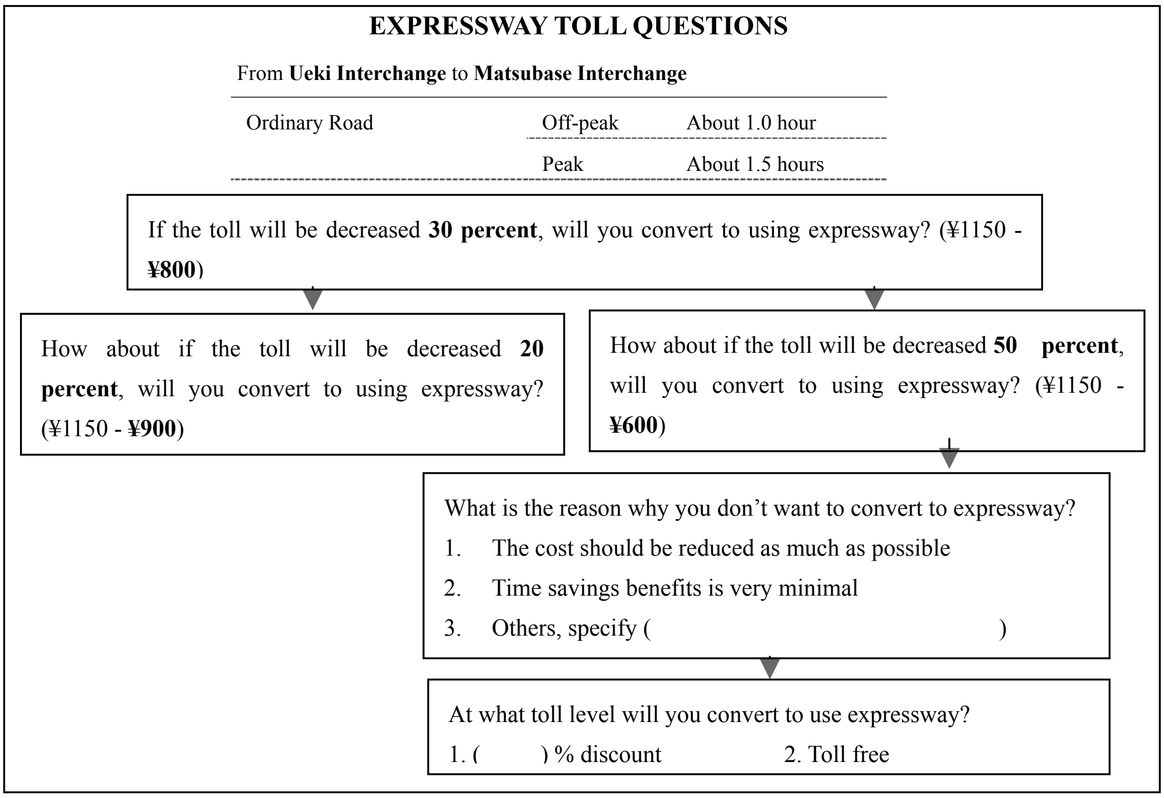

Figure 2 A Sample Scenario for SP questions

Second part of the questionnaire aimed to collect RP data. RP data are based on decisions made under actual situations as the travel attributes of each alternative between origin and destination. In the second part, first, a background page was shown which includes a map of Kumamoto area with zones same as in Figure 1. Then, companies were asked to draw actual routes taken for various destination routes. Each company was asked to indicate on the map three routes, which was chosen and shown depending on the company's location. . As an example, a company located at Yatsushiro area was asked to indicate the routes when traveling to clients in Tamana/Arao, Yamaga/Kikuchi and Ozu/Aso areas. Travel time, distance and travel cost were considered as RP data for actual route choices of companies from collected questionnaires.

Third part consists of hypothetical discount questions. These questions were asked to determine at what discount rate the respondent will convert to expressway from ordinary road. For each route indicated in the map and asked as an RP data, an SP scenario was added afterwards. As shown in Figure 2, first, the travel time of ordinary road and alternative expressway was shown to the respondent. Then, a bidding of discount rate that will attract the respondent to convert follows. Due to the answer for the first question follow up bids were asked. This part aimed to identify the acceptable discount rate for expressway toll to convert to use expressway. Details about the pre-survey were discussed deeply in Alver et al., 2005.

2.2. Route Choice Experiments

Route choice experiments are used to clarify the effects of discounted toll on route choice decision of drivers. There are two alternative routes for drivers: First one is ordinary road without any fee but unreliable travel time and congestion. Second one is expressway, with expressway toll depends on the distance, reliable travel time and free flow traffic.

One of the main reasons, which effect the route choice decision of drivers, is travel cost. In these RCEs, expressway toll is discounted 50% to identify the effect of expressway toll on the route choice decision. In these RCEs, 50%-discounted toll was applied to all kinds of vehicles for 24 hours a day. Both experiments were lasted approximately for one month. The covered interchanges and distances between them are shown in Figure 1.

Before the experiments, details of the experiments were advertised with the help of written and visual media. When the drivers who use expressway during the experiments were asked if they had heard about the social experiment, "Yes" response for the question was only 96% for the first experiment and 98% for second one.

First, route choice experiments was conducted from November 1st to December 25th 2004, approximately one year after the pre-survey. Fifty percent discount rate was applied to the trips between five ICs; Ueki, Kumamoto, Mashiki, Mifune, and Mastubase. Totally, 37.8 km of the Kyushu expressway was covered for this experiment. Second route choice experiment was conducted from February 7th to March 4th 2005. In this experiment, Yatsuhiro IC was added to the covered area and covered interchanges became six. Fifty percent discount rate was applied to 56.2 km of Kyushu Expressway from Ueki IC to Yatsushiro IC.

These RCEs include many questionnaire surveys and traffic counts; before, during and after the experiments. Traffic surveys were done on the expressway and on the alternative ordinary roads to identify the traffic volume before and during the experiments. Traffic volume increased on the expressway and decreased on the alternative ordinary roads during the experiments. Figure 3 shows the average traffic volumes on the expressway on different time-periods. These traffic volumes also include the transit users, which did not use the discounted section. For each route choice experiments, three traffic volumes are indicated in the figure; average traffic volumes; one year before the experiments, one month before the experiments and during the experiments. Parallel with the increase of expressway usage, traffic volume decreased on the alternative ordinary roads in average 10%.

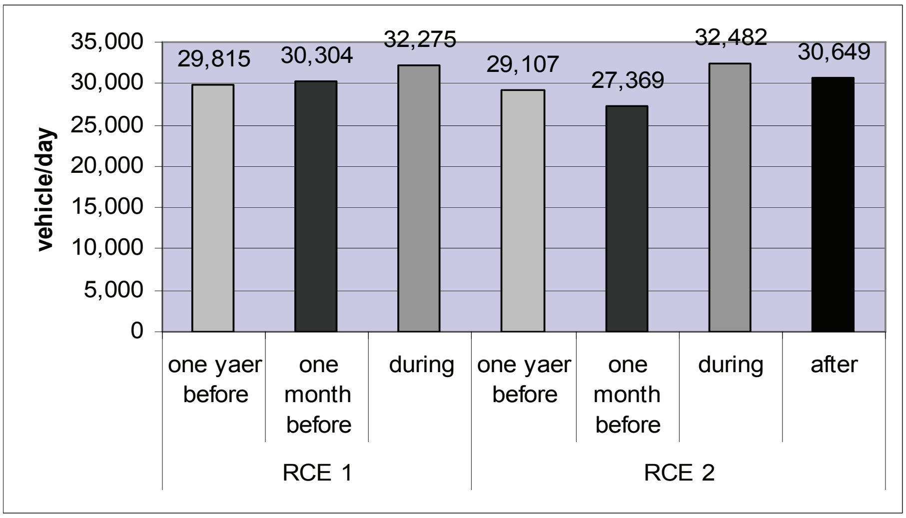

Figure 3 Comparison of Expressway Traffic Volumes for RCE 1 and 2

Questionnaires were delivered to expressway users at the egress ICs. Questionnaires were not only delivered to expressway users but also some other individual groups; people living along the alternative ordinary roads, freight companies, production companies, bus drivers, and commuters. The aim of these questionnaires was to investigate how people react to the experiment and if their route choice decision has changed during the experiment. In this study, we had focused on the route choice decisions of freight and production companies. Thus, only questionnaires delivered to freight and production companies were considered. In addition, questionnaires delivered to expressway users were discussed by aggregating the data into freight and production companies with a basic classification.

2.2.1. Questionnaires delivered to freight and production companies

In this part, questionnaires delivered to freight and production companies during the expressway toll discounts were considered. Some of the respondent are same companies answered the questions in the pre-survey. Questionnaires were delivered and collected by mail.

The questionnaires delivered to freight and production companies have some similar parts with the questionnaires conducted to same type companies during the pre-survey. Questionnaires conducted to freight and production companies are almost same except some small details. In the first part, three routes were asked depending on the company location. Thus, six different questionnaires were prepared for different six zones as indicated in Figure 1. For each direction, route choice decision and travel time were asked in two steps; before the experiment and during the experiment. Then, if the companies do not use expressway they were asked to choose the reason from listed ones. The questions about the effects of the experiment followed and finally, the opinions and suggestions were asked in two open-ended questions.

In Table 1, delivered and collected questionnaires were indicated. Each company was asked for three routes and some of them did not filled all routes. Routes were indicated inside the parenthesis.

Table 1 Details about the questionnaires delivered to expressway users

		RCE 1	RCE 2
Questionnaires delivered to	All companies	69(204)	69(204)
	Freight companies	38(114)	38(114)
	Production companies	31(90)	31(90)
Questionnaires collected from	All companies	40(76)	46(53)
	Freight companies	25(51)	23(33)
	Production companies	15(25)	24(20)

2.2.2. Questionnaires delivered to expressway users

During the experiments postcard shaped questionnaires were delivered to the drivers at the covered ICs when drivers are leaving the expressway. Drivers could join to the survey by filling and sending back the paid postcards. In the questionnaires trip purpose and vehicle type were asked to the respondents with other questions. From these answers, we had classified the freight and production companies. Details about the collected questionnaires are indicated in Table 2.

Table 2 Details About the Questionnaires Delivered to Expressway Users

	RCE 1	RCE 2
Total number of respondents	1503	1137
Expressway users before	593	460
Ordinary road users before	910	677
Freight companies	147	61
Expressway users before	18	8
Ordinary road users before	129	53
Production companies	330	342
Expressway users before	297	61
Ordinary road users before	33	282

As seen from Table 2, most of the respondent were ordinary road users before the experiment and converted to expressway because of discounted toll. Among the considered companies; freight and production, approximately 83% of them were using ordinary road before the experiment. In the second experiment, this rate is around 89%.

3. Modelling Approach

In this study, the route choice modeling consists of four steps; segmentation model, RP route choice model, SP conversion model and finally combined RP/SP model. This modeling effort was done before the route choice experiments by using data collected from pre-survey. The flow chart of the modeling approach is indicated in Figure 4. In this paper, the main objective is the verification of the proposed combined model structure with the RCEs. Thus, only final model will be introduced in this paper, all modeling approach was discussed in previous paper (Alver et al., 2006).

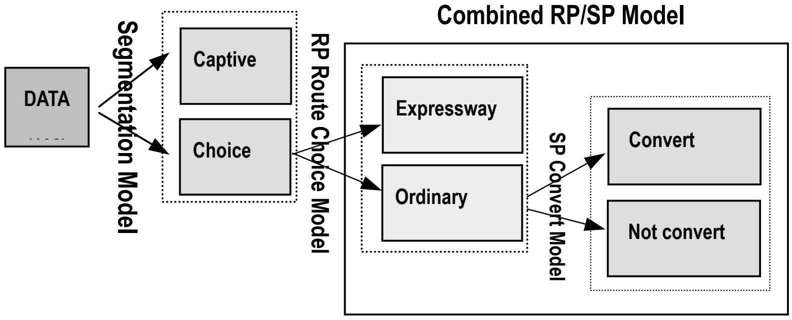

Figure 4 Flowchart for the Modelling Approach

Segmentation model is estimated as the first step of the modeling methodology. This model was established to divide the respondents into two groups; ordinary road captive and choice groups. Ordinary road captive group includes the users who do not want to use expressway even if there is no toll. Choice group covers the users who are using expressway at the moment and ordinary road users who want to convert under discounted toll. After the segmentation step, a route choice model was estimated by using choice group. Route choice model depend on the RP data only. A conversion model was decided for ordinary road users after the route choice model as the third step. The aim of the conversion model is to identify the conversion characteristics of ordinary road users under discounted toll. As discussed an SP survey was conducted in the pre-survey to identify the willingness to pay of ordinary road users to convert to expressway. Finally, both RP and SP data are combined in a route choice model.

3.1. Combined RP/SP Model

RP and SP data have their own advantages and disadvantages. The point is some of the disadvantages of RP data are the advantages of SP data. Some researchers in different fields recognized this idea and they tried to combine these two data types. In transportation studies, some studies were conducted to combine two data types to estimate more efficient models (Ben Akiva, Morikawa, 1990; Swait and Louviere, 1993; Bradley and Daly, 1997). In transportation literature, the typical application is to the choice of transportation modes. The RP data is the current choice and the SP data involves a future choice among current and new transportation alternatives. The combination of RP and SP data seeks to exploit the contrasting strengths of the various approaches while minimizing their weakness. This was described in the study of Louviere (2000) as “data enrichment” paradigm.

Discrete choice models are the main modeling methodology in combining the RP and SP data. This study is focused on the estimation of models with discrete choice models. In recent transportation related studies, combined RP/SP approach is an attraction for the researchers because of the advantages of using both data types. As an example, Ortuzar and Iacobelli, (1998) used combined estimation method for the mode choice between coach and train, Cherchi and Ortuzar 2002 study is the impact of new train service, which was investigated before the service improvement. Combining both data can help to the researcher to estimate better models. However, combining RP and SP data has some difficulties. The main problem in combining the RP and SP data is the different nature of their errors. The variance of the RP and SP error terms are different from each other. Still it is not stated that the variance of which error terms are bigger, it depends on the empirical context.

Ben-Akiva and Morikawa (1990) developed a framework for combining the two types of data considering differences in nature of errors. Two types of data are considered in the approach; first data type provides direct information about the main parameters to be modeled and second data type provides additional information about these parameters (indirect information). Differences in the errors of RP and SP data can be denoted as a function of their variance ($\sigma_{RP}^2, \sigma_{SP}^2$).

$$\sigma_{RP}^2 = \mu^2 \sigma_{SP}^2 \tag{1}$$

Many model structures were proposed and tested. The most significant and logical structure used in the estimation is indicated in Figure 5. In the estimated models three roots are considered; ordinary road (RP), expressway (RP), and expressway (SP). Note that for SP alternatives, it does not emerge directly from the root or branch, but from a particular nest with scale parameter μ. Nest parameter ($1/\lambda$) is introduced because of the correlation between expressway RP and expressway SP, since both utilities use same time variables Expressway (RP) represents the expressway users who actually use expressway before the discount. Ordinary road (RP) users are the ordinary road users who do not want to use expressway after the discount. Expressway (SP) users are the ones who wanted to use expressway under discounted toll, only this data depends on the SP choices.

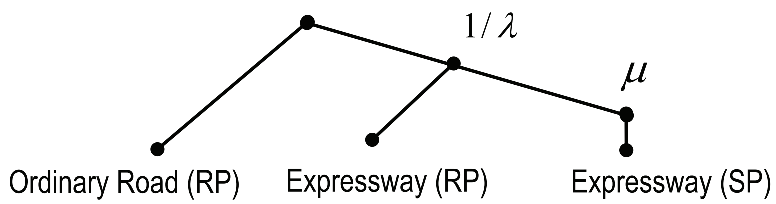

Figure 5 Proposed Model Structure

Among the considered models most significant models is the estimated combined RP/SP model. The estimation details and results were discussed in Alver et al. (2006). In this paper we have tested the estimation accuracy of the proposed model with the conducted RCEs.

4. Transferability of the Proposed Model

4.1. Pooled Data

Conducted RCEs provide valuable data sets to test the pre-estimated model. We have proposed that if the data of pre-survey is combined with the data, which is collected during the RCEs from freight and production companies, the data set will be improved. Thus, the applicability of pre-estimated model was tested with these data sets, which contains the actual route choice decisions of companies under discounted toll. In the first step, pre-surveys' data is combined with the data from RCE 1 and 2, separately. In addition, in the final step, all data sets; pre-surveys' data and data from both RCEs are combined. The combined RP/SP model structure was used in the estimation same as the one that we considered in the verification. The estimation results of the proposed combined RP/SP model and pooled models are shown in Table 3.

In the pooled data, pre-surveys' data and data from RCEs are combined. Data from RCEs were enlarged by using their route choice decision before the experiments. For the enlarged data, discount rate was not considered for the route that was used before the experiment by considered companies. Proposed combined RP/SP model and pooled data were estimated separately and results are not so different from each other. The transferability of the pre-estimated model was tested to the pooled data, which considers application conditions.

Table 3 Estimation Results: Pre-estimation, Pooled Data

Variables	Combined RP/SP	Combined RP/SP + RCE1	Combined RP/SP + RCE2	Combined RP/SP + RCE1 + RCE2
	Estimate(t-stat.)	Estimate(t-stat.)	Estimate(t-stat.)	Estimate(t-stat.)
Constant	1.3091 (2.27)	0.8426 (4.14)	1.3111 (2.72)	0.4718 (2.30)
Travel Time	-0.0305 (-3.28)	-0.0266 (-3.91)	-0.0289 (-2.04)	-0.0146 (-2.37)
Cost (Expressway toll)	-0.0014 (-2.97)	-0.0008 (-4.62)	-0.0013 (-3.11)	-0.0004 (-2.50)
Company dummy (freight.=1, production.=0)	1.2605 (2.96)	0.8548 (4.33)	1.1668 (3.42)	0.3993 (2.48)
Number of employee	0.0030 (1.93)	0.0023 (3.03)	0.0006 (1.14)	0.0005 (1.06)
λ	0.0925 (0.50)	0.0788 (1.59)	0.0621 (0.76)	0.0442 (1.13)
μ	0.9339 (14.93)	0.9964 (32.27)	0.9538 (15.91)	0.9538 (30.86)
Number of Samples	91	169	129	207
ρ^2	0.37	0.33	0.35	0.32
VOT(JPY/min.)	21.52	31.15	22.23	32.90

4.2. Transferability

Transferability is the application of a pre-estimated model to a context different from which it was estimated in (Koppelman and Wilmot, 1982). Transfer of a model can be defined as the use of all or part of a model in another context (time, region etc.) than the one in which it was estimated.

The transfer of proposed model to a new application context can help the researchers to estimate more efficient model with a small data set. In addition, transferability helps to reduce the model development effort, which takes a lot of time. Thus, especially in transportation literature several empirical studies have been conducted to measure the effectiveness of model transfer from one context to another. Some of these studies have examined model transfer from one spatial context to another (Atherton and Ben-Akiva, 1976; Galbraith and Hensher, 1982; Koppelman et al., 1985).

A variety of tests and measures has been used to compare the predictive ability of choice models. Many of these tests operate at the aggregate level comparing observed and predicted market shares or in this case observed and predicted route choice decisions. Measures of model transferability were used to asses the effectiveness of models when they are transferred for use in an application context that is different from their calibration context. The indices and t-statistics are all based on log likelihood measure. In this study, two tests are considered; likelihood ratio test and asymptotic t-test.

4.2.1. Likelihood ratio test

Results of this test show the statistical similarity of the estimation and application model coefficients. In this test, the null hypothesis is that the coefficients of the estimated model do not deviate significantly from the coefficients estimated from the entire set of application data. We have combined the pre-estimated data with the actual route choice surveys and examined whether the proposed model parameters have remained stable over time and most importantly under the real conditions of discounted toll. Likelihood ratio test (X_1^2) uses the log likelihood values to test the transferability of the models as follows:

$$X_1^2 = -2\left[L_{A+B}(\theta_{A+B}) - L_A(\theta_A) - L_B(\theta_B)\right] \quad (2)$$

Where,

$L_{A+B}(\theta_{A+B})$: Log likelihood values of the pooled models with the model parameters estimated from pooled conditions.
$L_A(\theta_A)$: Log likelihood value of the pre-estimated model with the model parameters estimated from pre-survey conditions.
$L_B(\theta_B)$: Log likelihood values of the RCEs with the model parameters estimated from RCE conditions.

The above equation is Chi-squared distributed with degrees of freedom equal to number of restrictions (coefficients in this model). If the calculated value from above formulation is smaller than the critical Chi-squared, the null hypothesis is accepted. As discussed, we have created three pooled data, which combines the RCEs and pre-survey. Results of likelihood ratio test for these models are indicated in Table 4.

Table 4 Chi-Squared Values for Pooled Data Sets

Variables	Combined RP/SP + RCE1	Combined RP/SP + RCE2	Combined RP/SP + RCE1 + RCE2
X_1^2	10.66	9.28	11.02
Note: Critical χ^2 (5,0.05) = 11.07			

If we compare the transferability of the pre-survey to pooled conditions, the best results are estimated with the second pooled data. The other models are also transferable. If we remember the verification of the RCE 1 and 2 with the pre-estimated model, proposed model estimated the route choice decisions 78% correctly for the freight and production companies in RCE 2. This result was 72% for the RCE 1. Here, first pooled data is transferable but, X_1^2 for the first model is little higher than the second pooled data. The area covered in the second RCE is longer. Thus, covered discounted section is more suitable for the travels inside the prefecture. Remember in the pre-survey, business trips inside the prefecture were investigated.

4.2.2. Asymptotic t-test

Another test is available to compare the estimated variables one by one. An asymptotic t-test for this purpose is as follows:

$$t = \frac{(\theta_A + \theta_{A+B})}{\sqrt{\sigma_A^2 + \sigma_{A+B}^2}} \quad (3)$$

Where,

θ_A : Estimate of a parameter in pre-survey conditions
θ_{A+B} : Estimate of a parameter in pooled conditions
σ_A^2 : Variance of parameter estimate in pre-survey conditions
σ_{A+B}^2 : Variance of parameter in pooled conditions

This asymptotic t-test allows us to find out which variable differs between the transferred models. If the likelihood ratio test fails, asymptotic t-test can help to define the variable, which is not transferable between the pre-survey and pooled conditions. Results of this test are indicated in Table 5 for three different pooled data sets. In the asymptotic t-test, seven variables are considered as estimated in the model. Critical value is t(7,0.05)=1.895 and all variables in tests for three models are in the limits and transferable. Same as the likelihood ratio test, pooled data with RCE 2 gives better results rather than first one.

The results support that our model is transferable if we create a pooled data, which includes actual conditions under discounted toll and pre-surveys' data. Proposed model is transferable to the actual discounted conditions. Another important finding is second RCE is more effective, transferability tests are better. The reason RCE 2 has better estimate results than first one is the distance. First social experiment covers five interchanges and these interchanges are not enough to cover all trips inside the prefecture. Thus, in the second experiment, one more interchange was added and almost all trips are covered inside the prefecture.

Table 5 Results of Asymptotic t-test

Variables	Combined RP/SP + RCE1	Combined RP/SP + RCE2	Combined RP/SP + RCE1 + RCE2
Constant	0.87	0.01	1.57
Travel Time	0.35	0.31	1.47
Cost (Expressway toll)	0.53	0.10	0.88
Company dummy(freight.=1, production.=0)	0.44	0.16	1.25
Number of employee	0.86	0.17	1.89
λ	0.07	1.09	0.25
μ	0.30	0.21	0.28

5. Verification of Proposed Model

From the estimation results when we compared all the models, we found out that combined RP/SP model have better estimates to clarify the route choice decision of the freight and production companies. Generally, the procedure works in this way and future demand and traffic volume will be estimated by using the estimated most significant model. However, in our study, we had a great chance that we could verify our estimation results with the data that was collected during two route choice experiments. These experiments represent the actual behaviors of drivers. Estimated results were compared with the data collected from route choice experiments.

Verification of the proposed model structure was done by using data collected from freight and production companies during RCEs. These questionnaires are similar to the ones used in the pre-survey. Most importantly in these data, same kinds of companies and vehicle types are considered as the pre-survey. Questionnaires include the information about the travel times, cost as expressway toll, route; before and during the experiment, company type and number of employee.

In the verification, we have used the pre-estimated combined RP/SP model's coefficients and we have calculated the route choice probabilities of all routes for each company. If the actual route choice decision of the company is same as the estimated bigger route choice probability for that company by using the actual data and pre-estimated models coefficients, it is accepted as true and otherwise false. As an example, if the actual route choice is expressway and estimated expressway probability is bigger than ordinary road it is true, otherwise false. The hit ratios for proposed model are indicated in Table 6 for both RCE.

The verification results show that proposed model (combined RP/SP) estimated the actual route choice decision of the companies more than 72% correctly. In average, our result could estimate the route choice decision on each three companies out of four. Proposed model could estimate the route choice decisions better for the second experiment, because covered interchanges are more and it fits better with the aim of the pre-survey.

Table 6 Hit Ratios for Freight and Production Companies

	RCE 1 (%)	RCE 2 (%)
Combined RP/SP Model	72	78
Average expressway probability	62.1	71.7
Average ordinary road probability	37.9	28.4

As we discussed second experiment covers longer area and fits better with the pre-survey. In average, proposed model could estimate the route choice decision 75% correctly.

6. Conclusion

The aim of the study was to convert some of the truck traffic from the city center to expressway, which passes through Kumamoto City. Expressway toll policy was considered to increase the traffic volume on the expressway. For this aim one pre-survey and two route choice experiments were conducted. After the pre-survey, a route choice model was estimated with information of discounted expressway toll. Estimation was done in four steps, and finally combined RP/SP model was estimated. Combined RP/SP model was the most significant model from the viewpoint of t-statistics and ρ^2 values.

Route choice experiments are conducted to collect information about decisions of the individuals and to identify the effects of discounted toll on traffic and its surroundings. These kinds of surveys are valuable to evaluate the actual conditions and to test the estimation accuracy of the pre-estimated models. To verify our model, we have to wait the policy implementation. However, it would be late if our model could not estimate the demand after the implementation and we have assumed the discount in expressway toll will attract many users.

Before the policy implementation on the expressway toll discount, two experiments were conducted to identify the route choice decisions of users under real conditions. During these experiments 50% discounted toll was applied. In the first experiment, five interchanges were covered and in the second experiment one more interchange was added to the previous range and six interchanges were covered. These experiments allow us to verify our model and to compare the estimated results with the actual data, which presents the situation after the policy implementation.

Data collected before the RCEs and data collected during the experiment were pooled to create an effective data set. Transferability of the proposed combined RP/SP model, with the pre-estimated data was used to test the performance of pooled data. Three pooled data are created; first one, combines the pre-estimated data with first experiments data. In the second one, pre-estimated data was combined with second experiment's data and finally pre-estimated data with both experiments' data were combined.

Transferability tests indicated that model is transferable with the pre-surveys data to the created three pooled data sets. Second model has better transferability results parallel with the verification results depending on the covered distance. Almost all expressway trips could be covered by second experiment. If the transferability of all variables were done separately, all variables would be transferable to pooled conditions.

Finally, the estimated demands during the experiments by using pre-estimated model are compared with the actual route choice decisions of freight and production companies. Proposed model could estimate the actual route choice decision of the companies 72% correctly in the first experiment and 78% in the second experiment. In the second survey, one more IC was added to the previous one and almost all trips inside the prefecture were covered. Pre-survey investigated the trips inside the prefecture. Thus, the estimation results for the second experiment should be higher. In average, linear model could estimate the actual behavior 75%. Verification results of the linear model is better and this result supports that combined RP/SP model was chosen as the proposed model to estimate the route choice decisions of considered companies.

References

Alver Y., Hasiuchi J. and Mizokami S. (2006). A study on expressway toll pricing based on the results of social experiments. Transportation Research Board 85th Annual Meeting, Washington, DC.

Alver Y. Hasiuchi J. and Mizokami S. (2005) A study on exressway toll pricing based on the results of social experiments, ISSOT 2005, Chiba

Atherton T. and Ben-Akiva M., (1976)Transferability and updating of disaggregate travel demand models. *Transportation Research Record*, 610, 12-18

Ben-Akiva M. and Morikawa T., (1990) Estimation of switching models form revealed preference and stated intentions. *Transportation Research A*, 12A, 6,485-495

Cherchi E. and Ortuzar J.D.D., (2002) Mixed RP/SP models incorporating interaction effects, *Transportation*, 29:371-395

Bradley M.A. and Daly A.J., Estimation logit choice models using mixed stated preference and revealed preference information. In: Understanding Travel Behavior in an Era of Change (Ediited by P. Stopher and M. Lee-Gosselin) 209-231, Elsevier Science, Oxford.

Koppelman F.S., Kuah G.K. and Wilmot **C.G.,** (1985) Transfer model updating with disaggregate data. *Transportation Research Record*, No. 1037, Transportation Research Board, National Research Council, Washington DC., 102-107.

Louviere J., Hensher D. and Swait J.D., (2000) *Stated Choice Methods: Analysis and Application*, Cambridge University Press.

Ortuzar J.D.D. and Iacobelli A., (1998) Mixed modeling of interurban trips by coach and train, *Transportation Research A*, Vol. 32, No.5 pp. 345-357.

Swait J. and Louviere J., (1993) The role of the scale parameter in the estimation of comparison of multinomial logit models. *Journal of Marketing Research*, 30, 305-314.