MODELLING TRAVEL BEHAVIOR OF RAILWAY PASSENGERS UNDER TRAVEL TIME UNCERTAINTY

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Abstract

Reliability of travel time affects travel behavior such as departure time decision, transportation mode choice and also route choice. Therefore, the influence of travel time uncertainty of urban railway on railway commuters was focused on in this study.
Internet survey was conducted to collect data from railway commuters living in Tokyo metropolitan area. Stated preference for railway service was executed in the survey. Four alternatives were presented to the respondent and each respondent was requested to choose the most preferable service. Average travel time, shortest travel time, longest travel time uncertainty, variability of travel time, congestion level in a vehicle and fare were considered as the compared factors. Meanwhile, it is thought that extent of interest in travel time reliability depends on trip purpose. Therefore, four kinds of trip purpose were considered in the survey. Four kinds of trip purpose were to commute, to attend business meeting, to go shopping and to go to airport. The data obtained by the stated preference choice experiments was used for parameter estimation of railway service choice model. At first, multinomial logit model were estimated by trip purpose and the weight for the travel time uncertainty was verified.
Subsequently, latent class logit model was estimated and the validity of considering multiclass to estimate choice behavior model was examined. According to the Bayesian information criterion, it was demonstrated that latent class logit model was more useful to explain the choice behavior in travel for shopping and going to airport.

Keywords: travel time reliability, stated preference survey, choice model, latent class model

1 Introduction

Reliability of travel time is one of the factors affecting travel behavior such as departure time decision, transportation mode choice and route choice. Therefore, travel time reliability of urban railway in Tokyo metropolitan area was focused on in this study and influence of the uncertainty of travel time on travel behavior of railway passenger was quantitatively analyzed.
Internet survey was conducted by utilizing a commercial net-survey services. Targeted respondents of the survey were people commuting by rail. The number of samples was 1000. Stated preference choice experiments of urban railway service was executed in the survey. Travel time, uncertainty of the travel time, walking time from arrived station to destination, fare and congestion level were considered as the variables determining level of service.
Using the choice result data, disaggregate choice model such as multinomial logit model and latent class logit model were estimated. As a result, it became clear that a negative evaluation for the travel time uncertainty is larger when people goes to airport and business meeting than when people goes to office and shopping.

2 Questionnaire survey

2.1 Outline of survey

Internet survey was conducted in this study. Survey monitors contracted with a commercial survey company were respondents of the survey. Screening of the monitors was executed to select appropriate respondents to the survey. The respondents were railway commuters living in Tokyo metropolitan area. Outline of the survey is described in Table 1. Main question item for this study is stated preference experiments regarding railway service choice. The details of the experiment are described in the following section.

Table 1 Outline of the survey

Dates	28, 29 March 2015
Targeted railway users	Commuter using railway Frequent railway user (more than 5 day a week) Residents in Tokyo metropolitan area
Question items	Socio-economic attributes Current status of railway use (origin and destination, transit station, frequency of railway use, estimates of travel time, desired arrival time at arrival station, departure time, distribution of arrival time, encounter the delay of railway operation, etc.) Stated preference experiments (under supposed eight scenarios)
Samples	1000

2.2 Stated preference experiments

A stated preference experiment is useful survey method to collect data when revealed preference data does not exist. Many previous studies conducted stated preference experiment in order to develop a travel behavior model.

For example, Basu et al. conducted stated preference experiment to capture the data of suburban train mode choice behavior and estimated choice model using different modelling techniques such as multinomial logit and mixed logit model [1]. Meanwhile, Mabit et al. focused on the international long-distance travel preferences related to travel between Scandinavia and Central Europe. They conducted stated preference survey to collect data in order to develop a discrete choice model estimating the value of travel time savings of long-distance travellers [2]. Carrion et al. reviewed many previous studies investigating travel time variability and conducting stated preference experiment [3]. In this study, a stated preference experiment was also conducted and obtained data was used to estimate discrete choice model regarding urban railway service choice.

Table 2 Summary of the attributes and levels used in the choice experiment

Average travel time	40 min, 45 min, 47 min
Shortest travel time	30 min, 35 min, 40 min, 45 min
Longest travel time	45 min, 50 min
Standard deviation of travel time	0 min, 4.47 min, 8.94 min
Walking time from station to destination	2 min, 5 min
Congestion ratio in the vehicle	100%, 200%
Fare	JPY 500, JPY 800

In the experiments, average travel time, shortest travel time, longest travel time, variability of travel time, walking time from arrived station to final destination, congestion level in vehicle and fare were considered as the variables determining level of service. The design of stated preference experiment was executed by setting appropriate value for each variable. Table 2 shows the adopted value for the experiment.

Meanwhile, Figure 1 and 2 show the questionnaire used for the choice experiments. Four services having different level of service were presented to each respondent and the respondent was requested to choose most preferable service. The experiment was conducted two times for each trip purpose so that totally every respondent answered eight questions.

Please image a hypothetical situation. You are going to take a train to attend the business meeting. As shown in the following figure, four services are available for you trip. These four services have different level of service in average travel time, shortest travel time, longest travel time, fluctuation of travel time, walking time from arrived station to meeting fucility. If you choose a service with large fluctuation in travel time, possibility to be late becomes large. In such situation, please choose the most preferable service amoung four sevices.

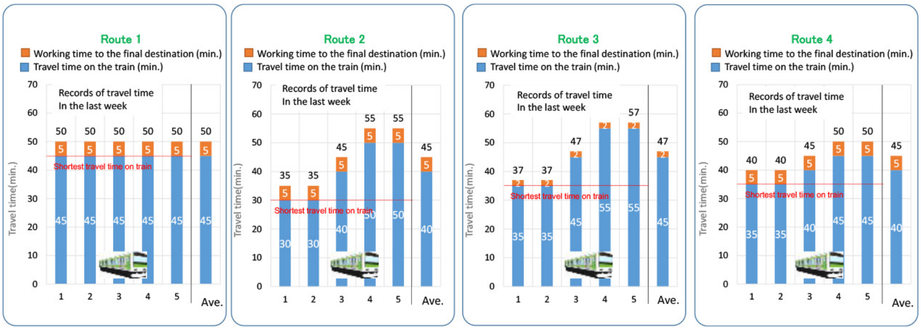

Figure 1 Stated preference experiment (business meeting)

Please image a hypothetical situation. You are going to airport to go on board. There are four alternatives to be chosen for you trip. As shown in the following figure, four services are available for you trip. These four services have different level of service in average travel time, shortest travel time, longest travel time, fluctuation of travel time, congestion level and fare. If you choose a service with large fluctuation in travel time, a possibility to miss a flight becomes large. In such situation, please choose the most preferable service amoung four sevices.

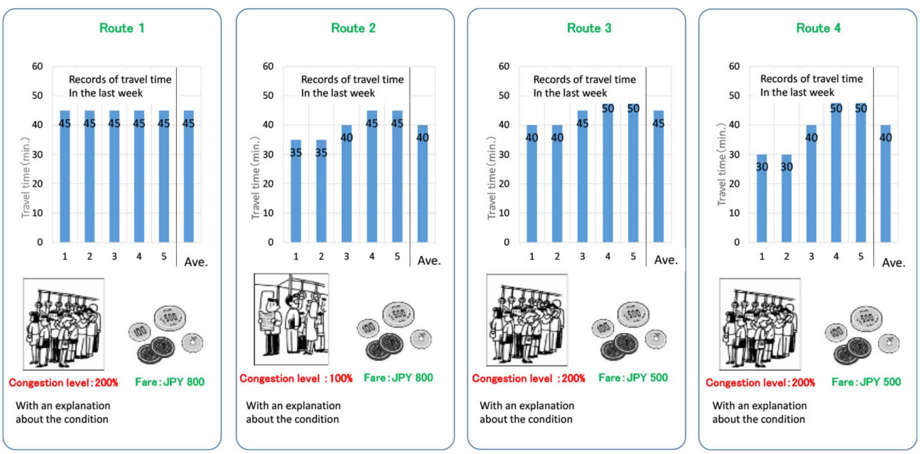

Figure 2 Stated preference experiment (for going to airport)

Choice experiment was executed two times for each trip purpose. Table 3 shows the result of the choice experiments. Value in the table indicates the number of respondent choosing each alternative. Each alternative is sorted in order of having high chosen ratio. As shown in the table, more than half respondent chose certain alternatives. However, other alternatives were also chosen in all experiments. It indicates the existence of the heterogeneity of the preference for railway service.

Table 3 Results of the choice experiments

Experiments	Most high ratio	2nd most	3rd most	4th most
1. Commuting (1 of 2)	640	185	118	57
2. Commuting (2 of 2)	593	196	131	80
3. Business meeting (1/2)	667	201	69	63
4. Business meeting (2/2)	618	186	126	70
5. Shopping (1/2)	411	247	205	137
6. Shopping (2/2)	571	191	172	66
7. Going to airport (1 of 2)	452	322	119	107
8. Going to airport (2 of 2)	539	282	117	62

3 Estimation of choice model

3.1 Multinomial logit model

At first, multinomial logit model was applied to estimate coefficients of service choice model. The considered explanatory variables alter by trip purpose. Average travel time (ATT), shortest travel time (STT), longest travel time (LTT), standard deviation of travel time (SDTT) and walking time from arrival station to destination (WTSD) were considered in the model of business purpose trip. In addition to the variable for the model of bisiness trip, congestion level in vehicle (CLV), and fare (FARE) were considered in the model for personal trip. Table 4 shows the result of parameter estimation for each trip purpose. Appropriateness of sign and statistical significance were confirmed. The column of t-test shows the statistical significance level. The asterisks * and ** indicate that the coefficients are statistically different from zero at the 5% and 1% level respectively.

Table 4 Estimation of multinomial logit model (MNL)

Purpose	Commuting		Business Meeting		Shopping		Going to airport	
ATT (min.)	-0.69	*	-0.53	*	-0.82	**	-0.38	*
STT (min.)	-0.07		-0.08		-2.53	**	-0.08	
LTT (min.)	-0.23	*	-0.09		-1.31	*	-0.19	*
SDTT (min.)	-3.52	**	-7.13	**	-0.33		-4.56	**
FARE (JPY 100)	-		-		-0.38	*	-0.26	*
CLV (100%)	-		-		-0.25	*	-0.10	
Log-likelihood	-2119		-2031		-2428		-2329	
Adjusted R-squareds	0.23		0.27		0.12		0.16	
Hit ratio	61.7%		64.3%		49.1%		49.6%	
Observations	2000		2000		2000		2000	
**: 0.05 significance level **: 0.01 significance level*								

Here, the relation between trip purpose and evaluation for travel time uncertainty is examined. Sign of the coefficient of SDTT are minus for all trip purpose. It demonstrates the existence of negative evaluation for the travel time uncertainty. Coefficient of STDD of the model for shopping is not significant. According to the largenss of the coefficients for other three models, people take care of the travel time uncertainty especially for going to business meeting. Meanwhile, the explanatory powere of the models for shopping and going to airport are lowere than other models for communitng and business meeting. it is thought thta one of the reason is no consideration of the heterogeneity of the preference for the service. Therefore the latent class model (LCM) was adopted to consider the hetrogeneity by refereing previous studies [4-7].

3.2 Latent class logit model

The latent class model with different numbers of segments was estimated and model performance was assessed in order to determine the best number of segments. In this study, the minimum Bayesian information criterion (BIC) was adopted as the indicator [8]. BIC is defined as $-2*\ln(L)+K*\ln(N)$, where L is the likelihood value, K is the number of parameters and N is the sample size. Table 5 shows the BIC of the LCM and it indicates that the best number of segment are 1, 1, 2 and 2 for the model of commuting, business meeting, shopping and going to airport respectively.

Table 6 shows the estimation result of the LCM for shopping and goin to airport. As shown in the table, a model was estimated for each class. The size of class is shown in the table. Moreover, hit ratio increases by appling LCM which means that the validity of the LCM is vertified.

Table 5 BIC of LCM by trip purpose and number of classes.

Number of classes	Commuting	Meeting	Shopping	Airport
1	4445.6	4291.5	5160.2	5225.1
2	4473.3	4328.2	5132.1	5181.4
3	4499.8	4364.9	5202.1	5265.5
4	4532.1	4401.9	5226.7	5297.2

Table 6 Estimation of latent class mode (LCM)

Purpose	Shopping				Going to Airport			
	Class-1		Class-2		Class-1		Class-2	
ATT (min.)	-0.54	*	-1.11	**	-0.33	*	-0.36	*
STT (min.)	-0.86	*	-2.32	**	-0.18		-0.13	
LTT (min.)	-0.21		-1.84	*	-0.12		-0.09	
SDTT (min.)	-1.94	**	-0.82		-4.65	**	-2.63	**
FARE (JPY 100)	-0.23		-0.40	*	-0.35	*	-0.12	
CLV (100 %)	-0.78	**	-0.38		-0.61	*	-0.14	
Latent class size	67.1%		32.9%		76.2%		23.8%	
Hit ratio	64.5%				63.1%			
Observations	2000				2000			
**: 0.05 significance level **: 0.01 significance level*								

Each class of the model for shopping is examined. The significant coefficients are different in each model. Class-1 considers travel time uncertainty but Class-2 does not do so. Meanwhile, Class-2 considersed fare.

Similarly, each class of the model for going to airport is examined. Class 1 consideres the travel time uncertainty stronger than Class-2. Moreover, Class-1 teakes care of fare and congestion level.

4 Conclusion

In this study, the travel time uncertainty of railway service was focused on. In order to examine the evaluation of railway user to the uncertainty, discrete choice mode was developed. To estimate the parameter of the choice model, internet questionnaire survey was conducted and stated preference experiment was executed in the survey.
The choice model was developed by trip purpose. Four kinds of situation such as commuting, attending business meeting, shopping, and going to airport were considered.
The multinomial logit model was developed and it becomes clear that the traveller going to business meeting mostly consider the travel time uncertainty.
Meanwhile, both models for shopping and for going to airport did not present enough explanatory power as indicated by the hit ratio so that the latent class model was adopted to develop the model that can consider the heterogeneity of the preference for railway service. According to the BIC, it was indicated that the best number of segment is two for both trip purposes. Then the latent class model with two classes was estimeted and evaluated. Finally, it was verified that the latent class logit model can predict choice result more precisely in case for shopping and going to airport.

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