Dynamic Analysis of Stated Preference for Travel Modes Using Panel Data

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Abstract

Dynamic analysis of stated preference, for the New Transit System of Light Rail type which was opened in 1994 in Hiroshima, was carried out using the panel data collected for work and school trips at two points in time; 1987 and 90. It was first empirically demonstrated that the stated preference for the NTS is greatly affected by actual travel modes consisting of car and bus, and that the temporal changes of stated preference which were caused by the change of actual travel mode, do not support the Markovian assumptions which indicate the individual's responses to a change of travel environment over the three years. The importance of state dependence was also demonstrated by building dynamic SP mode choice models of Multinomial Logit type.

1. INTRODUCTION

One of the useful aspects of stated preference (SP) data, in case of applying them into mode choice issues is that we can include the non-existing mode in the study area as a hypothetical alternative defined by a set of travel factors. In such an instance the SP for mode choice is believed to be affected by not only the levels of service presented, but also the social situation around us at that time and travel environment of individuals. Therefore, the SP appears not to be stable over time, but it will vary depending on the change of social situation and travel environment.

In modeling transportation based on cross-sectional survey data, the temporal change of travel environment is represented by the variation across individuals at a point in time. It is also uncertain for SP data that the variation of an individual's preference based on each travel environment at a point in time is identical with that caused by temporal change of travel environment.

Travel demand analysis using SP data is often aimed at estimating the actual travel behaviors of individuals after the completion of a project. If both changes are not identical, it is impossible to explain properly the change of individual's behaviors between before and after the project with a single cross-sectional data, especially when the forecasting term between these two time points is long. Although this issue has been broadly examined using revealed preference (RP) panel data (Kitamura *et al*, 1990), relatively little work using SP data has been undertaken.

The objective of this paper is to analyze the

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change of SP caused by temporal change of travel environment using the concept of contemporaneous Markov transition and then to compare it with recent developments of dynamic analysis on RP data. In addition, the history dependence of SP data will be investigated for confirming the significance of its dynamic modeling.

2. OUTLINES OF SP PANEL DATA FOR MODELING MODE CHOICE BEHAVIOR

2.1 Summary of SP Surveys

In order to analyze the effect of changing the travel environment on mode choice, it is essential to obtain panel data which indicate the temporal change of individuals' travel behaviors. We carried out SP surveys three times during 1987 to 1990 for work and school trips in Hiroshima (Fujiwara *et al*, 1991). The study area is located at the north-western residential area along the New Transit System line of Light Rail type (12.7 km in length) which was opened in Autumn, 1994.

All the three surveys were done in November 1987, 88, and 90 by distributing questionnaires to all individuals of households who were 15 years or older selected at random from the housing map and then collecting them a few days later. In SP experiments, three travel modes including the NTS, car and bus were presented and it was asked to rank them in order of preference which were defined by hypothetical profiles generated by combining different levels of travel factors.

Twenty-seven profiles were set up based on three levels of LOS variables (e.g. In-vehicle travel time, Fare, Waiting time, Parking charge and Access/Egress time) depending on the fractional factorial design. These profiles were presented randomly three times in 1987, five times in 1988, and four times in 1990. As a result of checking the collected questionnaires, the numbers of effective respondents accounted for 539, 563 and 629, respectively.

However, the number of panel data between waves 1 and 2 were fairly small (see Table 1) because we did not distribute the questionnaires at wave 2 to the households who had replied not accepting the next repeated survey at wave 1. Accordingly, panel data consisting of 272 (=46+226) respondents between waves 1 and 3 were employed for the following study. The numbers of all responses were different between two waves because of their different replications.

2.2 Modeling on Cross-sectional SP Data

At the outset, taking the first ranked mode as the chosen one, mode choice models of Multinomial Logit type were developed using 1987 and 1990 SP data as shown in Table 2. The explanatory variables consist of three travel service factors and actual travel mode which represents the travel environment in this study. The latter variable is defined as a car specific dummy variable; 1.0 if using a

Table 1 Outline of SP Panel Survey

	Wave 1	Wave 2	Wave 3
Year	1987	1988	1990
No. of panelers	46	46	46
	8	8	
	226		226
		89	89
No. of new participants	239	420	268
Total	539	563	629
No. of replications	3	5	4
No. of waves 1–3 panelers	272		272
No. of responses	765		1023

Table 2 Specification of Mode Choice Models

Variable*		Model 1 ('87)	Model 2 ('90)	Model 3 ('87)	Model 4 ('90)
In-vehicle travel time (min)	[G]	−0.033 (4.91)	−0.028 (7.14)	−0.048 (13.5)	−0.029 (16.2)
Waiting time (min)	[G]	−0.146 (9.60)	−0.145 (5.88)	−0.069 (4.99)	−0.002 (0.07)
Total travel cost (100 yen)	[G]	−0.359 (8.05)	−0.187 (4.81)	−0.450 (8.95)	−0.289 (7.06)
Alternative specific const	[N]	−0.336 (1.42)	−0.264 (1.46)		
Actual travel mode (1987)	[C]			1.962 (10.4)	
Actual travel mode (1990)	[C]				1.582 (11.2)
L (0)		−840.3	−1123.7	−840.3	−1123.7
L ($\hat{\beta}$)		−716.6	−992.2	−653.6	−926.2
Rho-bar squared		0.145	0.115	0.220	0.174
% Correct		55.3	53.8	56.9	55.8
No. of samples		765	1023	765	1023

*) [G]: Generic variable, [C]: Car specific, [N]: NTS specific; t-statistic in parentheses

car for work or school at the time of survey, and 0 if using a bus. All the LOS variables presented at the SP experiments could not be included in the models, because some of them were highly correlated with other LOS variables.

It is seen that base models introducing only LOS variables (i.e. Models 1 and 2) represent a good degree of fit, because all the coefficients are significant and have the expected signs. Since car and bus specific constants were highly correlated with other independent variables, only the NTS specific constant was included here. The addition of actual travel mode to the base models (i.e. Models 3 and 4) improved greatly the Rho-bar squared which indicates the fit of models both for 1987 and 1990. This signifies that the SP is serially correlated with the actual mode choice which corresponds to RP data (Morikawa *et al*, 1992).

3. EFFECTS OF CHANGING THE TRAVEL ENVIRONMENT ON SP DATA

3.1 Markovian Assumptions

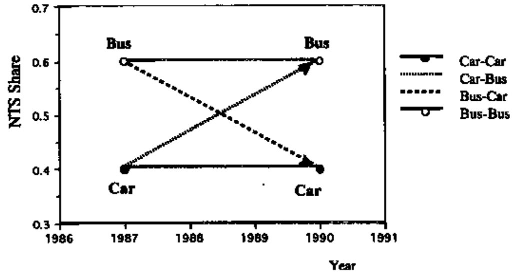
It is demonstrated by Kitamura *et al* (1987) that conventional travel demand models based on cross-sectional data are dependent on the following Marcovian assumptions;

- the individual's response to a change is instantaneous without any time lag,
- the response is reversible, and
- behavior is stationary.

Using the above concept, the temporal relationship between individual's travel environment (i.e. actual travel mode) and the SP (i.e. share of NTS) is set out in Figure 1. The vertical axis indicates the share of NTS given by SP experiments, while the horizontal axis represents the year of survey. The shares of NTS were plotted for both years by actual mode (i.e. car or bus). As a consequence, four straight lines indicate the hypothetical transition of the NTS share with changing the actual mode (i.e. car to bus and bus to car) and without changing (i.e. car to car and bus to bus).

The first Markovian assumption indicates that if

Figure 1 Concept of Contemporaneous Markov Transition



the actual mode changes from bus to car (or car to bus), the NTS share of the individuals agrees with that of permanent car (or bus) users. The second assumption indicates that the change of NTS share caused by changing the actual mode from bus to car is identical with that of changing from bus to car. The third assumption indicates that if actual modes do not change, the NTS share is stable over time.

3.2 Shares of Three Travel Modes by Change of Actual Mode

The 272 respondents who participated in two time-period panel surveys were classified into four groups depending on their actual modes at each time point and effects of changing actual modes on the SP were investigated to examine the significance of Markovian responses. Four pairs of actual modes consisting of car and bus are referred to as car to car (C–C), car to bus (C–B), bus to car (B–C) and bus to bus (B–B), and the numbers of responses (respondents) and shares of three travel modes presented at SP experiments are tabulated by paired groups as in Tables 3 for 1987 and 4 for 1990.

As can be seen in Tables 3 and 4, there are 127 car users and 110 bus users who did not change their travel modes during three years. However, there are only 14 respondents who changed their travel modes from car to bus, and 21 respondents who changed from bus to car. We can also see that the NTS share of C–B group increases greatly from 33.3 to 40.4%, likewise 20.5 to 40.4% for bus, while it decreases sharply from 46.2 to 19.2% for car during three years. This is because the actual mode changes from car to bus, as a result of which it is probable that the change of travel environment will greatly affect the SP data.

The shares of NTS, car and bus which were ranked as the best mode were for 51.5, 29.2 and

Table 3 Shares of Three Travel Modes by Change of Actual Mode (1987)

'90		Car user			Bus user			Total	
'87	N	C	B	N	C	B	N	C	B
Car user		365 (127)			39 (14)			404 (141)	
	43.6	47.1	9.3	33.3	46.2	20.5	42.6	47.0	10.4
Bus user		50 (21)			311 (110)			361 (131)	
	62.0	10.0	28.0	61.4	9.0	29.6	61.5	9.1	29.4
Total		415 (148)			350 (124)			765 (272)	
	45.8	42.7	11.6	58.3	13.1	28.6	51.5	29.2	19.3

Upper: No. of responses (respondents), Lower: Shares by travel mode (%); N: New Transit System, C: Car, B: Bus

Table 4 Share of Three Travel Modes by Change of Actual Modes (1990)

'90		Car user			Bus user			Total	
'87	N	C	B	N	C	B	N	C	B
Car user		469 (127)			52 (14)			521 (141)	
	52.2	39.2	8.5	40.4	19.2	40.4	51.1	37.2	11.7
Bus user		77 (21)			425 (110)			502 (131)	
	51.9	35.1	13.0	56.2	12.5	31.3	55.6	15.9	28.5
Total		546 (148)			477 (124)			1023 (272)	
	52.2	38.6	9.2	54.5	13.2	32.3	53.3	26.8	19.9

Upper: No. of responses (respondents), Lower: Shares by travel mode (%); N: New Transit System, C: Car, B: Bus

19.3% in 1987, whereas they were 53.3, 26.8 and 19.9% in 1990. It is found that the expectation for the NTS which will be the first modern rapid transit using a guideway in Hiroshima is very great for the residents who commute to the central area.

3.3 Markovian Transition of Three Modal Shares

In order to confirm the above results, the temporal change of modal shares for four paired groups were illustrated based on the Markovian response pattern (see Figure 1) as in Figure 2 for NTS, Figure 3 for car and Figure 4 for bus. The second and third Markovian assumptions cannot be strictly examined using our panel data because the experimental design of SP survey is different between two time points, even though that difference is not so great as to greatly affect the share of each experimental mode. The reason why they are different is that they were set up depending on the actual traveling conditions including bus fare and traffic congestion which have changed during three years. Nevertheless, the first assumption deals with the second time SP experiment and it is not directly affected by the first time experimental design. So here after we discuss mainly the first Markovian assumption.

Figure 2 illustrates the temporal transition of NTS share by actual mode group. It can be seen that the NTS share is quite different between car and bus users in 1987, suggesting that bus users tend to choose the NTS more than car users. Besides, the NTS share is also greatly different between C–C and C–B groups which are both car users in 1987 even though they should be equivalent at that time. As the reason is not clear for the moment, we will discuss it later again.

We can also see that the NTS shares of two car user groups are resemble each other in 1990 even though they use different modes in 1987. This means that car users changing from bus have the same preference instantaneously for the NTS as the permanent car users without a lag. On the contrary, the SP of bus users in 1990 are very different depending on the actual mode in 1987, that is, car users in 1987 prefer the NTS much less to permanent bus users. This means that the NTS preference of mode switchers from car to bus will depend on the state of preference when using cars in 1987. This leads to the rejection of the first Markovian assumption.

Figure 3 displaying the transition of car shares presents a comparatively close response pattern to the idealized Markovian pattern. The B–C group has less preference for car as compared with the C–C group, while the C–B group has more preference for cars than the B–B group in 1990. Both of these results indicate that the SP for car use in 1990 is affected by that in 1987, which will not support the first Markovian assumption. The change in car share caused by changing the actual mode from bus to car is almost equivalent to that by changing from car to bus, so that the second Markovian assumption would be accepted in this case.

Figure 4 displays the transition of bus share. The C–B group has a higher preference for bus than the expected share at each point in time. This group seems to have different choice behaviors from other groups. They might change their actual modes from car to bus positively by evaluating the utility of bus use. This makes the NTS share lower as much as the increased bus share which was already shown in Figure 2. Besides, the B–C group has slightly higher preference for bus than the C–C group, which will result in rejecting the first Markovian assumption.

Above discussions resulted in that the first Markovian assumption would be rejected in some of these cases. It may be, therefore, concluded that the SP for travel modes does not always change instantaneously when the actual mode changes and that the SP in 1990 depends substantially on the travel environment in the past as a whole. This conclusion is the same as that of other case studies (Kitamura *et al*, 1987; Nishii *et al*, 1992) using RP data.

However, it is obvious that the variation of SP does not always depend on only the change of actual

Figure 2 Temporal Change in NTS Share

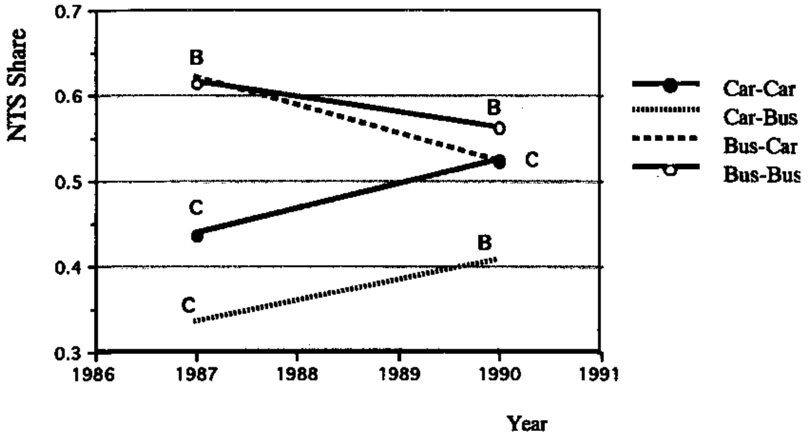


Figure 3 Temporal Change in Car Share

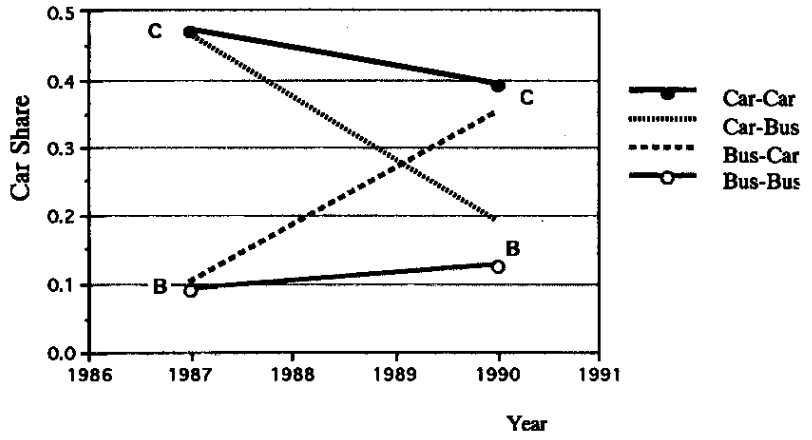
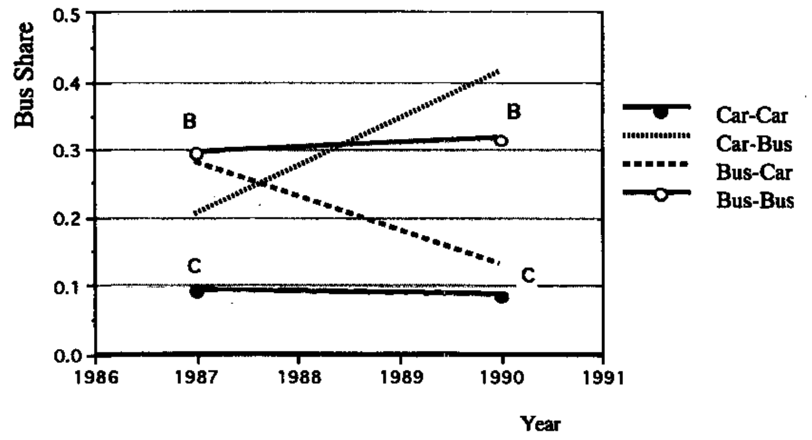


Figure 4 Temporal Change in Bus Share



mode, so that further analysis will be continued in the next section by excluding the effect of different levels of travel service set up in 1987 and 1990.

4. MODE CHOICE MODELS INTRODUCING THE CHANGE OF TRAVEL ENVIRONMENT

The levels of service presented at SP experiments to rank three travel modes in order of preference were not always equivalent at two different point in time. Therefore, in order to exclude the effects of different service levels, mode choice models of Logit type considering the biases which will be caused by change of travel environment were developed. These biases are introduced in the model as independent alternative specific dummy variables set by paired actual modes in 1987 and 1990. For a case of NTS specific dummy variable, the utility function of NTS (Un) consists of LOS variables and three NTS specific dummy variables as shown in Equation (1). On the other side, utility functions of car and bus (Uc, Ub) have only LOS variables.

$$\left.\begin{array}{l} U_n=\alpha LOS_n+\beta_1 BC+\beta_2 CB+\beta_3 CC+\varepsilon_n \\ U_c=\alpha LOS_c+\varepsilon_c \\ U_b=\alpha LOS_b+\varepsilon_b \end{array}\right\} \quad (1)$$

Where, LOS: Level-of-service variables, n: NTS, c: car and b: bus, ε: Disturbance and α, β: Coefficients

BC, CB and CC dummy variables indicate the bias of the NTS utility which cannot be explained by only LOS variables and they influence the share directly depending on the group which they belong to as follows:

BC: If belongs to the B–C group, 1 and if not, 0
CB: If belongs to the C–B group, 1 and if not, 0
CC: If belongs to the C–C group, 1 and if not, 0

Models using above utility functions were calibrated for 1987 and 90 as shown in Table 5. The SP for mode choice seems to be fairly affected by the NTS specific dummy variables because of the significance of some t-statistics.

In the same way, other models which introduced car and bus specific dummy variables were calibrated to examine the effects of paired actual modes on the SP for car and bus shares as shown in Tables 6 and 7. Since the models 7 and 8 (see Table 6) introducing car specific dummy variables provides the highest Rho-bar squared of three cases, we can understand that the travel environment which is represented by actual modes affects most greatly the share of car.

The temporal change of these coefficients (β_1, β_2

Table 5 Mode Choice Models Introducing NTS Specific Dummy Variables

Variable*		Model 5 ('87)	Model 6 ('90)
In-vehicle travel time (min)	[G]	−0.035 (10.6)	−0.026 (11.9)
Waiting time (min)	[G]	−0.149 (11.6)	−0.145 (5.85)
Total travel cost (100 yen)	[G]	−0.356 (7.95)	−0.188 (4.87)
C–C Dummy	[N]	−0.715 (4.62)	−0.190 (1.48)
C–B Dummy	[N]	−1.201 (3.27)	−0.587 (1.96)
B–C Dummy	[N]	0.002 (0.01)	−0.226 (0.91)
$L(0)$		−840.3	−1123.7
$L(\hat{\beta})$		−702.9	−990.5
Rho-bar squared		0.160	0.116
% Correct		55.2	54.6
No. of samples		765	1023

*) [G]: Generic variable, [N]: NTS specific; t-statistic in parentheses

Table 6 Mode Choice Models Introducing Car Specific Dummy Variables

Variable*		Model 7 ('87)	Model 8 ('90)
In-vehicle travel time (min)	[G]	−0.042 (12.9)	−0.029 (16.2)
Waiting time (min)	[G]	−0.070 (4.96)	−0.007 (0.23)
Total travel cost (100 yen)	[G]	−0.449 (8.91)	−0.293 (7.14)
C–C Dummy	[C]	1.947 (9.80)	1.651 (11.0)
C–B Dummy	[C]	1.902 (5.06)	0.621 (1.63)
B–C Dummy	[C]	−0.199 (0.39)	1.477 (5.42)
L (0)		−840.3	−1123.7
L ($\hat{\beta}$)		−653.5	−924.7
Rho-bar squared		0.219	0.175
% Correct		56.9	55.9
No. of samples		765	1023

*) [G]: Generic variable, [C]: Car specific; t-statistic in parentheses

Table 7 Mode Choice Models Introducing Bus Specific Dummy Variables

Variable*		Model 9 ('87)	Model 10 ('90)
In-vehicle travel time (min)	[G]	−0.021 (9.05)	−0.015 (8.29)
Waiting time (min)	[G]	−0.091 (6.34)	−0.145 (2.05)
Total travel cost (100 yen)	[G]	−0.401 (8.66)	−0.250 (6.46)
C–C Dummy	[B]	−1.203 (5.66)	−1.493 (8.37)
C–B Dummy	[B]	−0.267 (0.63)	0.408 (1.40)
B–C Dummy	[B]	0.141 (0.41)	−0.108 (2.97)
L (0)		−840.3	−1123.7
L ($\hat{\beta}$)		−698.3	−942.0
Rho-bar squared		0.166	0.159
% Correct		56.2	56.7
No. of samples		765	1023

*) [G]: Generic variable, [B]: Bus specific; t-statistic in parentheses

and β_3) of alternative specific dummy variables listed in Tables 5, 6 and 7 are illustrated by setting the effect of B–B group to be zero in Figures 5, 6 and 7, respectively. They indicate the magnitude of biases in the utility function which directly influence the shares of NTS, car and bus after excluding the effects of LOS variables.

The variation patterns of these biases seem to have a strong correlation with those of three modal shares (see Figures 2, 3 and 4). As a result, the conclusion with respect to the Markovian assumptions given in the previous section would be more firmly supported again. Now it is almost clear that the SP depends on the past travel environment, so the significance of past SP, namely the state dependence of SP will be also checked for another possibility of dynamic handling in the remaining pages.

5. MODE CHOICE MODEL CONSIDERING THE STATE DEPENDENCE

It has been known that the change in individual

Figure 5 Temporal Change in Coefficients of NTS Specific Dummy Variables

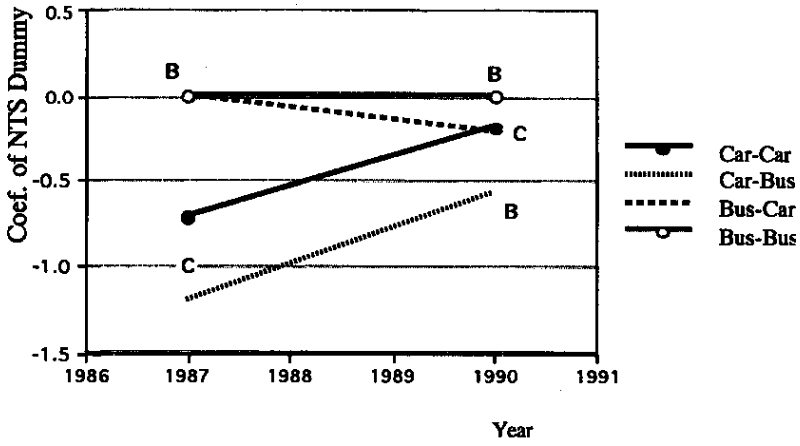


Figure 6 Temporal Change in Coefficients of Car Specific Dummy Variables

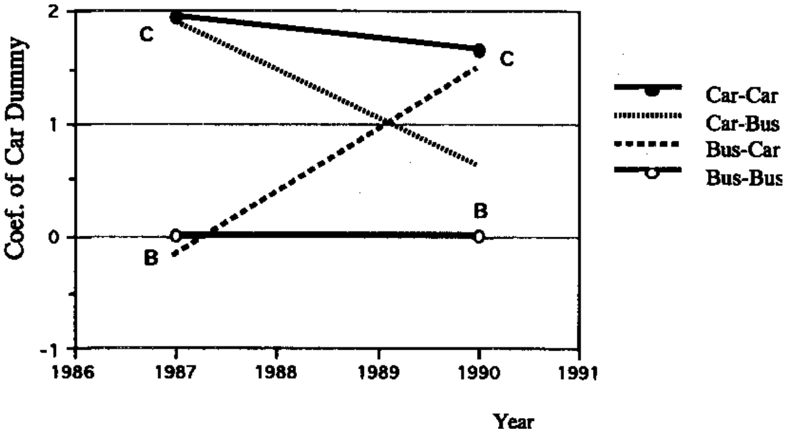
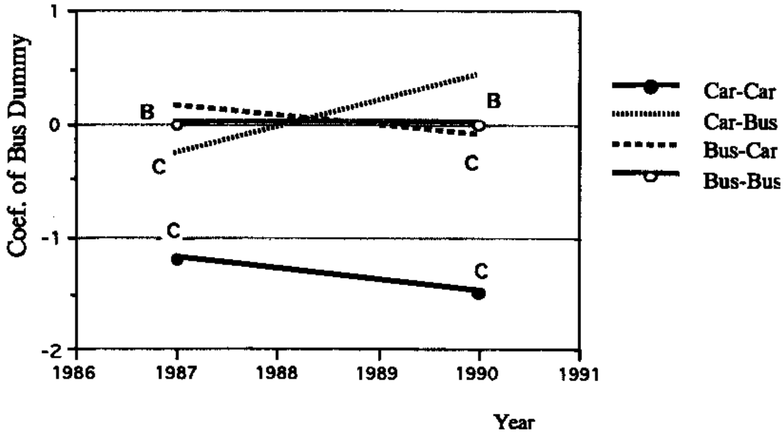


Figure 7 Temporal Change in Coefficients of Bus Specific Dummy Variables



travel behavior caused by a change of travel service is affected by behavioral history (e.g. Hamer *et al*, 1992). In this section, history dependence of SP will be investigated using the same panel data.

A convenient method to model such a history of travel behavior has been proposed by Daganzo *et al* (1982) within the context of Probit models. As this has a difficulty for model specification if the number of alternatives become three or more as in this case, a practical Logit model extended by Morichi *et al* (1989) will be used.

This employs the difference of past choice probabilities as a component of utility function. The difference of choice probabilities is expressed as that between the utility of chosen mode and LOGSUM of the utility of other modes. Utility function U_i^{90} for alternative i in 1990 is as follows:

$$\begin{aligned} U_i^{90} &= V_i^{90} + \rho \ln\{P_i^{87}/(1-P_i^{87})\} + \varepsilon_i^{90} \\ &= V_i^{90} + \rho\,[V_i^{87} - \ln\{\Sigma_{j,j\neq i} \exp(V_j^{87})\}] + \varepsilon_i^{90} \end{aligned} \quad (2)$$

Where, V_i: Deterministic component of utility function U_i, ε_i: Disturbance, and P_i: Choice probability of alternative i.

ρ is refereed to as state dependence, and if it is significantly positive, it tends to choose the past chosen alternative, while if significantly zero, the SP is independent over time. In order to determine the utility function of equation (2), a two-step estimation procedure was employed, which calculates the 1990 coefficients of the utility function after obtaining 1987 coefficients.

Three different choice probabilities are given for an individual since three different responses were obtained in 1987 SP experiments. This means that three different models 11a, 11b and 11c can be specified as shown in Table 8. Models 11b and 11c have smaller numbers of samples than Model 11a since there were some who did not respond at the second and third replications. There seems not to be a significant difference among these three models in terms of model coefficients. It is interesting to see that the choice probabilities of the first replication in 1987 are more significant in building dynamic SP models more than those of other two replications.

The state dependence ρ is significantly positive in all three models, so it reveals that 1990 SP depends largely on the 1987 SP. The Rho-bar squared which is one of model goodness-of-fit indices has become higher than the base model (see Table 2) which does not consider the state dependence.

Another mode choice model (i.e. Model 12) was developed for comparison considering the actual mode instead of choice probabilities in 1987. As the Rho-bar squared of the model is much higher

Table 8 Mode Choice Models Introducing the State Dependence

Variable*		Model 11a ('90)	Model 11b ('90)	Model 11c ('90)	Model 12 ('90)
In-vehicle travel time (min)	[G]	−0.027 (6.70)	−0.030 (7.41)	−0.028 (6.87)	−0.028 (15.9)
Waiting time (min)	[G]	−0.109 (4.23)	−0.128 (4.88)	−0.136 (5.13)	−0.024 (0.86)
Total travel cost (100 yen)	[G]	−0.160 (4.14)	−0.173 (4.40)	−0.167 (4.25)	−0.278 (6.70)
Alternative specific const	[N]	−0.788 (4.01)	−0.649 (3.25)	−0.522 (2.60)	
State dependence ρ	[G]	0.430 (6.70)	0.241 (5.60)	0.241 (4.84)	
Actual mode (1987)	[C]				1.379 (9.87)
L (0)		−1123.7	−1087.5	−1071.0	−1123.7
L ($\hat{\beta}$)		−969.1	−935.2	−923.3	−942.2
Rho-bar squared		0.135	0.138	0.136	0.160
% Correct		56.6	57.1	58.6	55.7
No. of samples		1023	990	975	1023

*) [G]: Generic variable, [N]: NTS specific, [C]: Car specific; t-statistic in parentheses

than Model 11's, it brings out a fact that the SP for mode choice is more dependent on the past history of travel environment than the choice probabilities.

6. CONCLUSIONS

Dynamic characteristics of SP data for mode choice were analyzed in this paper. As a consequence, it is demonstrated by examining two time-period panel data in Hiroshima that the SP is greatly affected by actual modes which is not presented in the experiments. The analysis has also shown that the temporal change of actual mode has an important effect on SP and several interesting evidences on Markovian assumptions were given, suggesting that they do not always hold completely. Besides, it is noteworthy that mode switchers from car to bus have a higher preference for bus but less for the NTS than expected both in 1987 and 90.

The state dependence of SP data was identified by employing the choice probabilities in 1987 into the modeling of 1990 data. This will imply the importance of dynamic analysis on SP data in the same way as RP data. Since actual mode choice data have been already obtained after the opening of the NTS, the state dependence of SP data for the actual data will soon be investigated to confirm the significance of dynamic modeling.

REFERENCES

1) Daganzo, C. F. and Sheffi, Y. (1982), "Multinomial Probit with time-series data: unifying state dependence and serial correlation models", Environment and Planning A 14, 1377–1388.
2) Fujiwara, A. and Sugie, Y. (1991), "Temporal stability of stated preference data", Presented for the 6th International Conference on Travel Behaviour, Quebec.
3) Hamer, R., Kroes, E. and de Boer R. (1992), "Some mode choice models for panel data", PTRC 20th Summer Annual Meeting, Pro. of Seminar E, 303–314.
4) Kitamura, R. and van der Hoorn, T. (1987), "Regularity and irreversibility of weekly travel behavior", Transportation 14(3), 227–251.
5) Kitamura, R. (1990), "Panel analysis in transportation planning: An overview", Transportation Research 24A(6), 405–415.
6) Nishii, K. and Kondo, K. (1992), "Panel analysis of shopping destination choice behavior in Japan", Presented for the First U.S. Conference on Panels for Transportation Planning, University of California.
7) Morichi, S., Yai, T. and Hyodo, T. (1989), "A study on mode choice modeling with temporal changing probability", Presented for the International Conference on Dynamic Travel Behavior Analysis, Kyoto.
8) Morikawa, T., Ben-Akiva, M. and Yamada, K. (1992), "Estimation of mode choice models with serially correlated RP and SP data", Presented for the 6th World Conference on Transport Research, Lyon.