Proceedings of the Eastern Asia Society for Transportation Studies, Vol. 5, pp. 1155 - 1166, 2005

TEMPORAL ANALYSIS ON THE DISCRETIONARY TRIP GENERATION CONSIDERING THE MUTUAL RELATIONSHIP BETWEEN WEEK AND WEEKEND DAYS

Iv LIM
Doctoral Student
Department of Environment and Life Eng.
Toyohashi University of Technology
1-1 Tempaku, Toyohashi, Aichi,
441-8580 Japan
Fax: +81-532-44-6831
E-mail: li987653@acserv.tutrp.tut.ac.jp

Yasuhiro HIROBATA
Professor
Department of Architecture and Civil Eng.
Toyohashi University of Technology
1-1 Tempaku, Toyohashi, Aichi,
441-8580 Japan
Fax: +81-532-44-6831
E-mail: hirobata@acserv.tutrp.tut.ac.jp

Eisaku SHIBATA
Prefectural official
Toyota Public Works Office
Aichi Prefectural Government
3-28 Tokiwa, Toyota, Aichi,
471-8609 Japan
Fax: +81-565-35-1311
E-mail: eshibata@hotmail.com

Abstract: This study mainly focuses on the urban travel behavior on weekdays and weekend, and aims to build a model of trip generation for discretionary trips. After examining the actual condition of urban discretionary trips, we hypothesize that there is a common factor which affects the generation of discretionary trips performed on both weekdays and weekend days, and that weekday and weekend trips are mutually influenced. Then, by applying a covariance structural model we examine the hypothesis and estimate the affect of various factors. Finally, temporal structural comparisons of trip generation are examined and discussed. Consequently, statistical results suggest that there is a common factor which affects travel behavior on weekdays and weekend as well as factor which is specific to either weekday or weekend. In ten years from 1991 to 2001, weekday and weekend discretionary trips had become less dependent on the common factor.

Key Words: discretionary trip, trip generation, covariance structural model

1. INTRODUCTION

Recently in many local cities of Japan, travel patterns have been diversified due to the tempo-spatial changes of city structures or traveler characteristics caused by the rapid development of motorization, socio-economic structure, etc. And yet at the same time, in transportation demand modeling, more accurate analysis by considering these changes of social structure is absolutely required. Furthermore, many conventional urban transportation planning were drawn up mainly in consideration of commuting trips or business trips, which are typical and undertaken only on weekdays. However, in recent years the traffic for discretionary activities such as shopping, entertaining, leisure and so on becomes more active by changes in life-consciousness or the increase of leisure time, and consequently various

traffic problems are stressed especially on weekend, and that the necessity of corresponding urban transportation planning is also needed accordingly (e.g., Yai, 1990). Moreover, in spite of increasing importance of conducting analysis or formulating prediction model for discretionary trips on weekend days, while considering that discretionary activity is a flexible activity in which the decision-making made by each traveler is not so strict, the previous researches including those on weekdays are not necessarily enough and it can be said that more detailed analysis is still sorely needed (e.g., Isobe and Kawakami, 1990). Especially, since discretionary activity is carried out mainly on leisure time, the activity-based approach is required (e.g., Kondo, 1987) to clearly take into account the relation of other activities, the conditions of individual time constraints, etc. Furthermore, many conventional empirical analyses used only the travel survey data on one specific day due to the difficulties of data collection even though discretionary activity in any particular day is not performed independently from the other days, but mutually influenced by the traveler decision-making between days. The empirical analyses using not only the survey data obtained from one specific day, but also the survey data from two or more are required and effective (e.g., Hirsh *et al.*, 1986; Kitamura and van der Hoorn, 1987; Tanimoto *et al.*, 1996).

From the above viewpoints, this paper investigates simultaneously the discretionary activities on both weekdays and weekend days of which the same individual performed, and tries to analyze the discretionary travel behavior in consideration of mutual relationship between week and weekend days by using time-series data from the actual urban travel behavior surveys, while taking into account the activity-based approach. However, there are various dimensions of travel behavior needed to be studied such as trip frequency, mode choice, trip destination, etc.; this paper remains to focus specifically on discretionary trip frequency in which the mutual relationship between week and weekend days is significant. In this stage, it is assumed that one discretionary activity is corresponding to one discretionary trip, and thus the frequency of discretionary trips performed by each individual in a certain day is directly made applicable to analysis. Furthermore, time-series changes of discretionary trip generation mechanism considering the mutual relationship between week and weekend days are discussed.

This paper describes the actual condition of discretionary trip generation in section 2, and then proposes a new hypothesis on trip generation mechanism used as the basis for demonstrating the mutual relationship between week and weekend days in section 3. Subsequently, it shows the outline of a covariance structural model for quantifying the generation behavior of discretionary trips based on the above-mentioned hypothesis in section 4, and thus the estimated results are to be discussed. Finally, the results of this research and suggestion for future issues are summarized in section 5.

2. TRAVEL SURVEY AND THE ACTUAL CONDITION OF TRIP GENERATION

2.1 Travel Survey

Toyohashi city, which was selected as a case study area, is situated at the southeastern edge of Aichi prefecture in Japan. By the end of January 2001, its population was around 370,000 with city area of about 261 km^2. It also serves as the central city of East Mikawa metropolitan area.

Data used in this analysis were obtained from the actual travel behavior surveys conducted by

authors in Toyohashi city in 1991 and 2001. The outline of data sets is mentioned below, and since there is a constraint in data analysis, we keep our focus only on the travel behavior of individual over the age of eighteen. The survey questionnaire was designed and carried out expressly for the recent individual travel behavior on both weekdays and weekend day at the time of filling in.

The travel surveys are outlined as follow:

- Respondent: residents of over 18 years old in 1991, and over 15 years old in 2001 are targeted.
- Extraction method: household from the commercial housing map and three appropriate people in each household are selected randomly as the respondent of questionnaires.
- Questionnaire: one household questionnaire and three individual questionnaires are carried out.
- Survey items: individual and household attributes, actual trip conditions (all trip attributes such as trip purpose, destination, mode, etc. which are performed in a specific day on both weekdays and weekend days) are included.
- Survey period: October to November in 1991, and September to November in 2001.
- Survey method: postal method (postal distribution and postal collection) is implemented.
- Data collection: 552 effective responses from 1,501 households (collection rate: 36.8%) corresponding to 1,422 individuals in 1991; and 894 effective responses from 2,114 households (collection rate: 42.3%) corresponding to 1,642 individuals in 2001 are collected.

2.2 The Actual Condition of Trip Generation

In order to examine the actual condition of trip generation on both weekdays and weekend days and to understand the mutual relationship between week and weekend days, first we describe the actual condition of trip generation of all purposes and of discretionary purpose which are performed by the same individual (after preliminary processing for missing data, final samples of 694 and 878 individuals were identified in 1991 and 2001, respectively). However, in this analysis discretionary trip is defined as trip for daily shopping, non-daily shopping, entertainment and leisure, etc. excluding trip for work, school, business and home.

Table 1 shows the time-series changes of trip frequency by all purposes on both weekdays and weekend days. The most commonly performed is two-trip, which on weekdays it shares about 50% whereas on weekend days it shares about 40%. This indicates that there is a difference in making activities among the day types as well as from the other trip frequency. During those ten years from 1991 to 2001, it had been showing no change on weekdays while on weekend days it was increased. Moreover, non-activity rate (zero-trip) on weekend days is greater than on weekdays, which demonstrates that an individual is likely to stay home on weekend days, and in those ten years there was an increase on weekdays but a decrease on weekend days.

On the other hand, by examining time-series changes of trip frequency by discretionary purpose, as given in Table 2, biggest share on weekdays is zero-trip, and on weekend days is one-trip which can be inferred that individual prefer making one discretionary trip on weekend. The proportion of zero-trip is about 50% on weekdays which is larger by 20% compared to weekend days, indicating that on both weekdays and weekend days many individuals do not perform discretionary trips. During those ten years, the proportion of

zero-trip had decreased slightly on weekdays, while there was no change on weekend days. The proportion of one-trip had increased on both weekdays and weekend days. Moreover, it is commonly noticed that there are many people performing discretionary trips on weekend days rather than on weekdays.

In conclusion, on the average, individual makes 0.85 discretionary trips on weekdays and 1.25 on weekend days. In those ten years from 1991 to 2001, the trend had been increasing on weekdays whereas on weekend days it had been almost unchanging.

Table 1. Changes of Trip Frequency on Weekdays and Weekend Days (all purposes)

	Weekdays		Weekend days	
Trip frequency	1991 (N = 694)	2001 (N = 878)	1991 (N = 694)	2001 (N = 878)
0	6.3	10.9	26.8	23.7
1	0.0	0.6	0.0	1.8
2	46.8	46.9	36.3	40.7
3	13.0	12.5	14.4	11.4
4	18.0	13.7	14.0	10.1
5	7.5	5.6	4.2	5.6
6	5.0	4.4	2.3	3.8
7	1.6	1.8	0.9	1.5
8	1.7	3.5	1.2	1.5
Total	100.0	100.0	100.0	100.0
Gross trip rates (trips/person)	2.97	2.82	2.22	2.31
Net trip rates (trips/person)	3.17	3.19	3.03	3.09

Table 2. Changes of Trip Frequency on Weekdays and Weekend Days (discretionary purpose)

	Weekdays		Weekend days	
Trip frequency	1991 (N = 694)	2001 (N = 878)	1991 (N = 694)	2001 (N = 878)
0	53.2	48.4	30.5	30.4
1	25.2	27.6	34.4	37.5
2	12.8	13.6	21.2	17.8
3	5.0	5.8	8.4	7.3
4	2.9	3.0	3.9	4.4
5	0.3	1.1	1.4	1.8
6	0.6	0.2	0.0	0.5
7	0.0	0.3	0.1	0.3
Total	100.0	100.0	100.0	100.0
Gross trip rates (trips/person)	0.82	0.93	1.26	1.27
Net trip rates (trips/person)	1.76	1.81	1.81	1.82

Table 3. Changes of Joint Distribution of Individual Discretionary Activity

Year 1991 (N = 694)		Weekend days			Year 2001 (N = 878)		Weekend days		
		Trips	No trip	Total			Trips	No trip	Total
Weekdays	Trips	70.3	23.3	93.7	Weekdays	Trips	71.3	18.2	89.5
	No trip	2.9	3.5	6.3		No trip	5.6	4.9	10.5
	Total	73.2	26.8	100.0		Total	76.9	23.1	100.0

Table 3 shows the time-series changes of joint distribution of individual whether performing discretionary activities or not on both weekdays and weekend days. In 1991, the percentage of individuals who make discretionary activities on both weekdays and weekend days is about 70% and on weekdays only is about 23%, whereas the percentage of individuals who perform discretionary activities only on weekend days or do not perform on both weekdays and weekend days are very few (<4%). During those ten years, the behavior of joint distribution of discretionary activity in 2001 was almost similar as in 1991; however the change on weekend days had been increasing remarkably.

Next, by examining the joint distribution of weekday and weekend discretionary trips, as shown in Fig. 1 and 2, farther from the non-activity point, joint trip distribution becomes decreasing. When there are many trips on weekdays, it appears to be the same on weekend days, showing that frequency distribution of weekend discretionary trip is differed dependently on weekday trips. During those ten years, it has been showing no exhaustive difference but totally demonstrates similar pattern; however, the frequency of one-trip which is performed only on weekend days had increased in 2001.

From the above results, it proves that both weekday and weekend trips which are undertaken by the same individual are not performed independently, but appears to have a certain mutual relationship between each other. However, the correlation coefficients are small in 1991 and 2001, whose values are only 0.17 and 0.23, respectively.

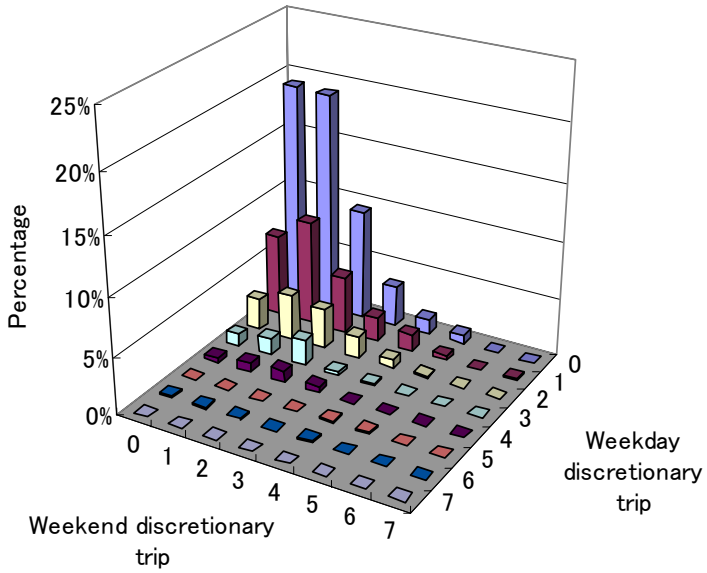

Figure 1. Joint Distribution of Weekday and Weekend Discretionary Trips (1991)

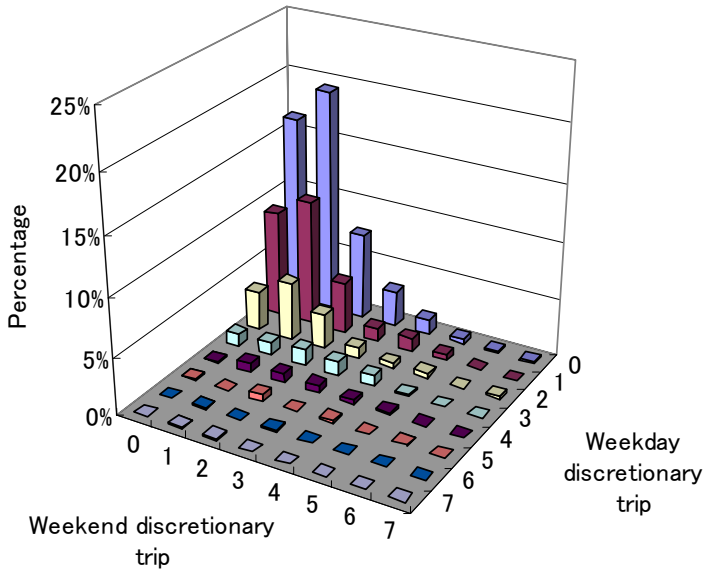

Figure 2. Joint Distribution of Weekday and Weekend Discretionary Trips (2001)

3. HYPOTHESIS ON GENERATION MECHANISM OF DISCRETIONARY TRIP

A new hypothesis on generation mechanism of discretionary trips is drawn up, and used as the basis to demonstrate the mutual relationship between weekdays and weekend days. It is also built as a foundation for quantitative analysis using covariance structural model.

In this analysis, each individual is assumed to have his/her own "activity demand intensity" in making discretionary trips regardless of weekday or weekend, and its size is varying by individual characteristics, etc. As an example shown in Fig. 3, group A representing individuals who necessarily do shopping frequently or who prefer doing leisure activities has a strong activity demand intensity, whereas Group C which represents those who seldom do shopping or leisure activities has weaker intensity. Furthermore, individual is supposed to distribute and carry out various discretionary activities on either weekdays or weekend or on both weekdays and weekend according to this activity demand intensity. Also, even if individual carries out the same discretionary activities, the value of making activities is different dependent on weekdays or weekend days. As an example, this difference can be demonstrated in Fig. 3 as "weekday priority type" or "weekend priority type" which is varied among individuals.

On the other hand, while implementing discretionary activities, various constraints such as time constraint, budget constraint, etc. are taken into account; and thus not all the activity demand can be actualized. Additionally, because of these constraints, the activity which, under normal conditions, can be performed with higher value on weekdays shall be carried out on weekend days, or vice versa. Moreover, among discretionary activities, there are some that are carried out on weekdays, become unnecessary to be done on weekend, which shows that there is a substitution relation between weekdays and weekend days. On another front, there is a case where an activity is carried out on weekdays, then its related activities are also necessary to be carried out on weekend days, which demonstrates there is a complimentary relation between weekdays and weekend days.

In this analysis, through the existence of above-mentioned factors and the mutual relationship between week and weekend days, discretionary activity both on weekdays and weekend days are actualized, and then the discretionary trips are performed.

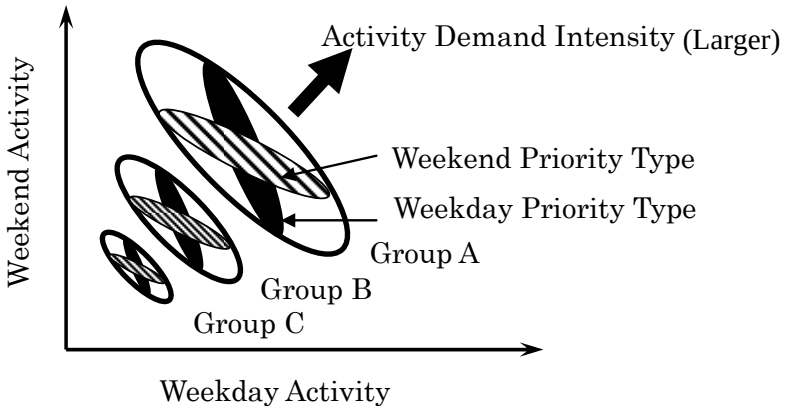

Figure 3. Concept of Discretionary Activity Demand

4. COVARIANCE STRUCTURAL MODELING

4.1 Model Specification

In this paper, in order to quantify the behavior of trip generation considering mutual relationship between week and weekend days and to understand the mechanism of individual travel behavior based on the above-mentioned hypothesis, a covariance structural model is developed with the individual as the unit of decision making to examine the hypothesis on trip generation and to explain the activity interaction. The application of covariance structural model for travel behavior research is conducted actively in recent years (e.g., Seto *et al.*, 1995) as well as a wide variety of applications was reviewed in Golob (2003). However, there is no attempt to analyze trip generation by taking into account the mutual relationship between week and weekend days, even though there are several approaches to model trip generation and to test for transferability in time and in space separately (e.g., Valentin *et al.*, 2003).

The model explaining the mechanism of trip generation in this research consists of measurement equations and structural equations which are described as follows:
The measurement equations are given by

$$x = \Lambda_x \xi + \delta \quad (1)$$

$$y = \Lambda_y \eta + \varepsilon \quad (2)$$

The structural equation is expressed as

$$\eta = \mathrm{B}\eta + \Gamma\xi + \zeta \quad (3)$$

where,

x : column vector of n exogenous variables,
y : column vector of m endogenous variables,
ξ : vector of exogenous latent variables,
η : vector of endogenous latent variables,
$\Lambda_x, \Lambda_y, \mathrm{B}, \Gamma$: coefficient matrices, and
$\delta, \varepsilon, \zeta$: vectors of error terms.

The model of the study contains individual attribute, traffic conditions, etc. as exogenous variables (observed exogenous variables) displayed in Table 4, and the number of discretionary trips on both weekdays and weekend days as endogenous variable (observed endogenous variable); however, in this model, age variables are represented as continuous categorical variables due to the difficulty in model estimation. Based on the above-mentioned hypothesis, additional 3 factors of exogenous latent variables, i.e. “factor affects specifically weekday travel behavior (=weekday specific factor)”, “factor affects specifically weekend travel behavior (=weekend specific factor)”, “factor affects commonly travel behavior regardless of weekday or weekend (=week and weekend common factor)” and 2 factors of endogenous latent variables, i.e. “weekday discretionary activity intensity”, “weekend discretionary activity intensity” are structured in the model (see Fig. 4). Furthermore, the mutual relationship between weekdays and weekend days is taken into consideration by setting up the bidirectional causal relation of endogenous latent variables.

Table 4. Definition of Exogenous Variables

Typology of variables	Name	Definition
Socio-economic	SEX	Sex (dummy variable: 1 = man; 0 = woman)
	AGE	Age (dummy variable in 6 points scale: 1 = ≤ 25 years; 2 = 26-35; 3 = 36-45; 4 = 46-55; 5 = 56-65; 6 = ≥66)
	WRK	Working Status (dummy variable: 1 = worker; 0 = non-worker)
	CA	Car availability (1 = car availability; 0 = car not availability)
Individual-family relationships	VHC	Number of cars owned by family
	MBR	Number of family members
	INL	Family total income level (dummy variable: 1 = ≤2 millions Yen; 2 = 2-3.99; 3 = 4-5.99; 4 = 6-7.99; 5 = 8-9.99; 6 = 10-11.99; 7 = 12-14.99; 8 = ≥15)
Time availability	WCTRIP	Number of constrained trips made by the person on weekdays
	HCTRIP	Number of constrained trips made by the person on weekend days
Transportation environment or location	TTC	Travel time by car
	TTPT	Travel time by public tranport

The correspondent relationship with respect to the hypothesis stated in section 3 is that: "week and weekend common factor" is equivalent to activity demand intensity, "weekday specific factor" and "weekend specific factor" is related to "weekday priority type" and "weekend priority type", which is demonstrating the portion that cannot be explained solely by "week and weekend common factor". The bidirectional causal relationship between endogenous latent variables is responded to a substitutional or complementary relation between weekdays and weekend days.

In addition, as for factors related to travel behavior constraints, this model contains the individual car availability and transportation environment (car and public transport travel time). Besides, it has included in exogenous variable set the "number of constrained trips" on weekdays and weekend days in the form of proxy variables for demonstrating the influence of other activities except discretionary activities. However, because a huge number of discretionary trips are performed within the city, travel times to outside of the city are not taken into account in this analysis. Thus travel time is defined as weighted mean travel time ($\bar{t}_i$) given by the following equation:

$$\bar{t}_i = \sum_{j=1}^{n} p_j t_{ij} / \sum_{j=1}^{n} p_j \qquad (4)$$

where p is population and t_{ij} is mean perceived travel time between zone i and j; n is the total number of zones in the study area. Furthermore, constrained trips are defined as trips made by the person for other purposes except discretionary trips, i.e. work trip, school trip, business trip and home trip.

Moreover, as displayed in Fig. 4, the relationship between each endogenous variable and its corresponding endogenous latent variable is set to be 1.00 based on the assumption that endogenous latent variables, i.e. weekday discretionary activity intensity and weekend discretionary activity intensity, are measured without errors through their corresponding endogenous variables. Thus in model estimation, the variance of error term is fixed to be zero. Furthermore, in order to make interpretation of the estimated parameters easier, the variance of latent variables are standardized to 1 and then model solution is calculated. Hence, the estimated parameters can be represented as causal effects.

4.2 Model Results

In this analysis, AMOS (Arbuckle, 1999) is used to estimate the model parameters. The goodness-of-fit index (GFI) of this model (model A) is shown in Table 5. In this table, while

model B and C deals separately for weekdays and weekend respectively, model D deals simultaneously for week and weekend days but does not consider the mutual relationship between weekday and weekend discretionary activities, the goodness-of-fit index of model B, C and D are also shown for comparison. From these results it indicates that the fitness of model A in this analysis, which considers the mutual relationship between weekday and weekend, seems to be the best. It means that, by taking into account the mutual relationship between week and weekend days, the model explanation can be improved.

Table 5. Comparison of Fitness among the Models

	Year 1991					Year 2001			
	Model A	Model B	Model C	Model D		Model A	Model B	Model C	Model D
GFI	0.930	0.792	0.808	0.933	GFI	0.950	0.768	0.779	0.950
AGFI	0.860	0.695	0.718	0.861	AGFI	0.890	0.660	0.675	0.900
RMSEA	0.097	0.167	0.160	0.096	RMSEA	0.087	0.177	0.173	0.086
AIC	416.6	954.5	885.9	421.8	AIC	416.3	1328.0	1272.5	420.3

The estimated results of structural parameters are shown in Fig. 4 and 5. Since, there are some parameters which have small *t* value, the model structure or variable set may technically need to be adjusted. Nonetheless, the results can be explained as follow: from Fig. 4 and 5, by examining each causal effect, if “week and weekend common factor” becomes larger, then both weekday and weekend discretionary activity intensity will become active which complies with the hypothesis of the research. That is, each individual has his/her own activity demand intensity in making discretionary trips regardless of weekday or weekend. Moreover, if the value of “weekday specific factor” becomes larger, then the “weekday discretionary activity intensity” will become less active, and it is the same for the case of “weekend specific factor”. This means that even though individual has the same discretionary “activity demand intensity”, individual has to distribute and carry out discretionary activities on either weekdays or weekend according to his/her discretionary activity behavior such as “weekday priority type” or “weekend priority type”. On the average, in making either weekday or weekend discretionary trip it is relatively dependent on common factor rather than on specific factor; however, *t* values of some factors are small which are statistically insignificant. During those ten years, individual had been becoming less dependent on common factor which complies with “activity demand intensity” in making discretionary activity that would have been caused by the development of information society, service industry, etc.

On the other hand, concerning the bidirectional causal effect between weekdays and weekend days, if a substitution relation is strong, the coefficient will be negative. In contrast, if a complementary relation is strong, then the effect is positive. According to Fig. 4 and 5, the estimated result indicates that there is a complementary relation from weekday to weekend and a substitution relation is vice versa. It means that individual (type) who frequently performs discretionary trips on weekdays will do the same on weekend. In contrast, individual (type) who frequently performs discretionary trips on weekend will do lesser on weekdays. However, this substitution relation or complementary relation is a consistent relative effect between weekday and weekend so that care is needed at the level of the absolute activity demand intensity which is regulated by week and weekend common factor. During those ten years, the mutual influence of making discretionary trips between weekday and weekend had been becoming weaker, noticeably the individual (type) who frequently performed trips on weekend, did often on weekdays.

In conclusion, in those 10 years, the effect of all causal parameters except “weekend specific

factor" on "weekend discretionary activity intensity" had been decreasing. It means that, during that period, "weekend discretionary trip" had been affected by "weekend specific factor" more strongly whereas "weekday discretionary trip" seemingly, had been consistently regulated by the considered factors in the hypothesis with weaker activity demand intensity.

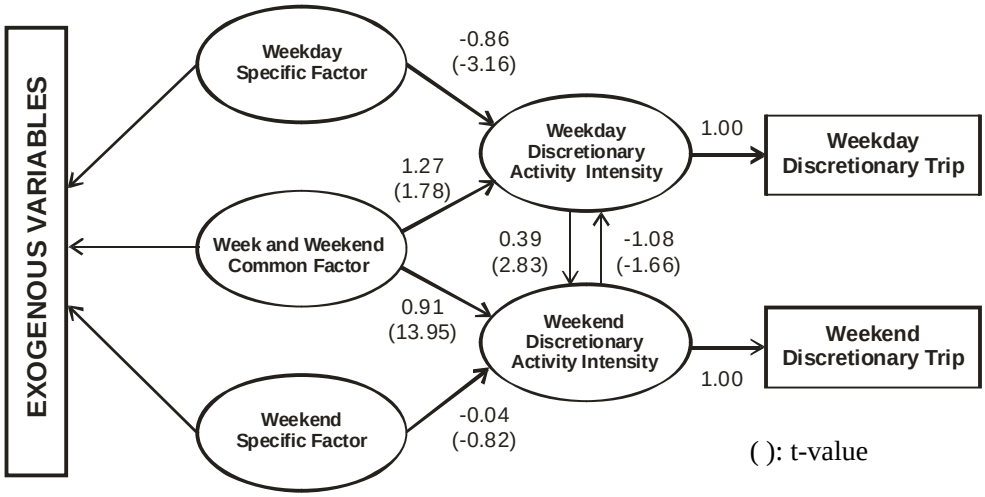

Figure 4. Structural Relations between Latent Variables and Endogenous Variables (1991)

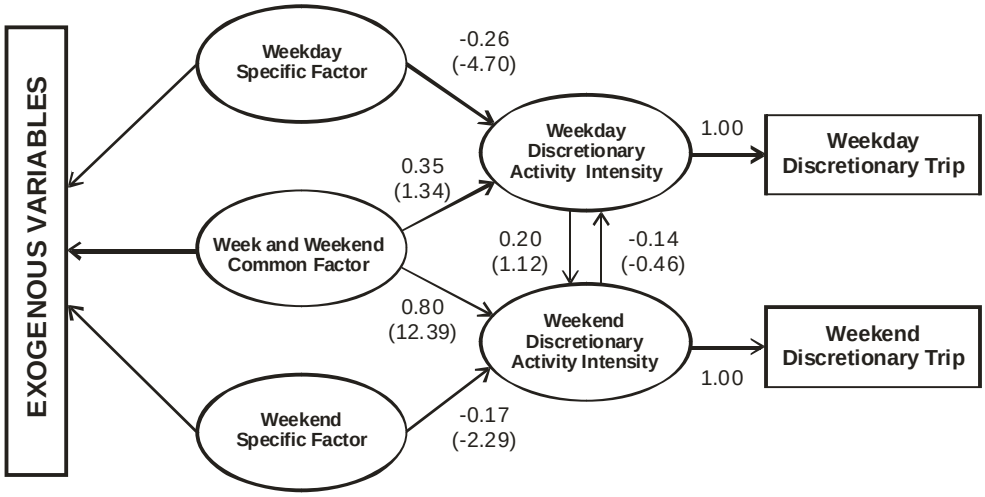

Figure 5. Structural Relations between Latent Variables and Endogenous Variables (2001)

Next, we examine the significant parameters of each exogenous latent variable. As given in Table 6 and 7, in "weekday specific factor" the total income and household car ownership are significant, whereas in "weekend specific factor" the family members, total income and car travel time are significant. In "week and weekend common factor", both weekend and weekday constrained trip and age are significant. From these results it can be said that the exogenous variables which regulate the three exogenous latent variables are mutually different; however, there are several factors which are related to activity constraints in "common factor" and to individual attributes in "specific factor". During those ten years, "common factor" had been regulating almost consistently by week and weekend constrained trips, and "weekend specific factor" had been showing nearly the same pattern where individual household variables and car travel time had been regulating strongly.

Table 6. Relations between Exogenous Variables and Exogenous Latent Variables (1991)

	Weekday specific factor		Week and weekend common factor		Weekend specific factor	
	Coefficient	*t* value	Coefficient	*t* value	Coefficient	*t* value
Sex	0.28	9.81	0.04	1.33	−0.07	−2.42
Age	−0.07	−1.01	−0.14	−2.30	−0.29	−4.75
Working Status	0.07	5.13	0.05	3.65	0.02	1.75
Car availability	0.15	7.70	0.08	4.12	0.11	5.51
Household car ownership	0.21	2.74	0.03	0.40	1.00	−
Family members	0.05	0.66	0.05	0.66	0.83	13.61
Total income	0.25	2.61	0.02	0.21	0.81	10.68
Weekday constrained trips	0.45	6.88	0.50	8.50		
Weekend constrained trips			0.53	12.17	0.00	−0.02
Car travel time	0.32	2.14	−0.17	−1.32	0.70	5.62
Public transport travel time	0.11	1.58	−0.03	−0.54	0.13	2.11
GFI	0.94					
AGFI	0.86					
Number of samples	694					

Table 7. Relations between Exogenous Variables and Exogenous Latent Variables (2001)

	Weekday specific factor		Week and weekend common factor		Weekend specific factor	
	Coefficient	*t* value	Coefficient	*t* value	Coefficient	*t* value
Sex	−0.04	−2.16	0.03	1.44	0.04	1.99
Age	−0.62	−8.49	−0.21	−3.21	0.03	0.41
Working Status	0.30	10.16	0.05	2.91	−0.07	−2.02
Car availability	0.11	6.55	0.11	6.25	0.08	4.82
Household car ownership	0.44	3.64	0.19	1.97	1.00	−
Family members	0.35	3.00	0.17	1.64	0.97	14.95
Total income	0.60	5.24	0.26	2.37	0.90	10.53
Weekday constrained trips	0.18	4.00	0.51	9.74		
Weekend constrained trips			0.58	14.20	−0.04	−0.61
Car travel time	0.29	2.67	0.03	0.25	0.62	6.39
Public transport travel time	0.15	1.91	−0.04	−0.37	−0.06	−0.71
GFI	0.95					
AGFI	0.89					
Number of samples	878					

5. CONCLUSIONS

In this research, by taking into account the mutual relationship between weekday and weekend discretionary trips which are performed by the same individual, a covariance structural model is developed to estimate the structural parameters based on the hypothesis on trip generation mechanism by using the actual travel behavior data. The results in this analysis are summarized as follows:

- Each individual has his/her own “activity demand intensity” in making discretionary trips regardless of weekday or weekend, and has to distribute and carry out discretionary trips on either weekdays or weekend according to his/her discretionary activity behavior such as “weekday priority type” or “weekend priority type”.
- In making either weekday or weekend discretionary trip it is relatively dependent on common factor rather than on specific factor; and during those ten years, individual had been becoming less dependent on common factor which complies with “activity demand intensity” that would have been caused by the development of information society, service industry, etc.
- Discretionary activity is undertaken under substitution relation from weekend to weekday, and under complementary relation from weekday to weekend. During those ten years, the

mutual influence of making discretionary trips between week and weekend days had been becoming weaker.
- During those ten years, the "weekend discretionary trip" had been affected by "weekend specific factor" more strongly whereas "weekday discretionary trip" seemingly, had been consistently regulated by the considered factors in the hypothesis with weaker activity demand intensity.
- The estimate model which considers the mutual relationship between week and weekend days is the best model for prediction of discretionary trip generation.

Lastly, it is necessary to conduct additional analysis which can tackle all types of discretionary trips separately; and which should use not only one point in time of the actual travel data, but also a number of epochs in order to predict discretionary travel demand more appropriately by considering the mutual relationship between weekdays and weekend days.

REFERENCES

Arbuckle, J.L. (1999) **Amos 4.02** [Structural Equation Modeling Software]. SmallWaters Corporation, Chicago.

Golob, T.F. (2003) Structural equation modeling for travel behavior research, **Transportation Research Part B, Vol. 37**, 1-25.

Hirsh, M., Prashekea, J.N. and Ben-Akiva, M. (1986) Dynamic model of weekly activity pattern, **Transportation Science, Vol. 20, No. 1**, 24-36.

Isobe, T. and Kawakami, S. (1990) Travel behavior analyses on non-work days using activity-based approaches –Comparison with travel behavior in weekdays–, **Journal of the City Planning Institute of Japan, No. 25**, 49-54 (in Japanese).

Kitamura, R. and van der Hoorn, T. (1987) Regularity and irreversibility of weekly travel behavior, **Transportation, Vol. 14**, 227-251.

Kondou, K. (1987) **Travel behavior analysis**, Koyo shobo, Kyoto (in Japanese).

Seto, K., Kitamura, R. and Iida, K. (1995) An analysis of the causal relation between timing, duration, and mileage of activity suing structural equations, **Proceedings of Infrastructure Planning, Vol. 17**, 209-212 (in Japanese).

Tanimoto, S., Sugie, Y. and Fujiwara, A. (1996) Interdependence in shopping trip over a week and within a household, **Proceedings of Annual Conference of the Japan Society of Civil Engineers, Vol. 51**, 334-335 (in Japanese).

Valentin, C.A., Prashker, J.N. and Shiftan, Y. (2003) Analysis of trip generation characteristics in Israel for the years 1984,1996/7 and spatial & temporal transferability of trip generation demand models, **82nd Annual Meeting of the Transportation Research Board**, Washington, DC.

Yai, T. (1990) The latest change surrounding holiday traffic and development of analysis technique, Report paper in Traffic Engineering, **Japan Society of Traffic Engineers, Vol. 25 special issue**, 58-66 (in Japanese).