Analyses on the Users' Impressions of Railway Stations and Their Effects on the Shopping Behavior

Cheng Li[1], Toshiyuki Yamamoto[2], Nobuhiro Sanko[1] and Takayuki Morikawa[1]
[1] *Graduate School of Environmental Studies, Nagoya University, Japan.*
[2] *Department of Civil Engineering, Nagoya University, Japan.*

Abstract

This paper aims to refine the cognitive structure of users' impressions of stations, quantify the influences of retail facilities of different types of stores on the cognitive structure, and clarify the effects of passengers' impressions of stations on their shopping behavior. The dataset used is a questionnaire survey recording feelings towards large railway terminals in Tokyo metropolitan area. Factor analysis is carried out to extract respondents' impressions of the stations firstly. Then the structural equation model (SEM) approach is introduced to understand how the extracted impressions affect the passengers' shopping activity. Simultaneously, the influences of surrounding retail premises on users' impression of stations as well as the differences in user's socio-economic characteristics are quantified through the SEM constructed here. The results suggested that the railway users have three kinds of impressions to stations: "convenience", based on attributes of interest when a station is mainly considered a transport facility; "pleasure", based on attributes when a station is mainly considered a place of communication or leisure; "crowded", based on attributes relating to the layout and atmosphere of the space. The analysis also showed that the effects of these three latent variables on passengers' shopping destination choice behavior vary across the purchased items. For the daily items, "convenience" and "crowded" play leading roles in the shopping destination choice, whereas for the non-daily items, the impression of "pleasure" is the most important. Different types of stores showed different effects. For example, clothing stores enhance all of the extracted impressions, stores selling furniture enhance the impressions of pleasure and crowded, but not of convenience, whereas the automobile dealers seem to be unsuitable for railway stations.

Keywords: urban renascence, railway stations, cognitive structure of impression, adjunct retail facilities, shopping behavior

1 Introduction

Urban sprawl is a serious problem in metropolises in Japan and other developed countries, and it will occur in other countries developing rapidly in the near future. One of the possible schemes for urban renascence is to reduce the traffic jam and lessen the air pollution in the central area, then to enhance the attractiveness of the central area as a comfortable and pleasant place for shopping and other leisure activities. More visitors will improve the business condition of commercial stores in the central area, and induce the accumulation of retail shops and leisure spots, then attract more visitors and form a good circle. Due to the spatial and financial limitation, it is impossible to build more roads and parking spaces in the central area in order to meet the concentrated travel demand by the visitors. To increase the ridership of mass transit systems appears to be the only feasible approach. In Japan, the conventional policies of railway promotion, such as the reduction in fare or the increase in the frequency, have showed little effect on the mode choice, and are difficult to be implemented due to the privatized rail business systems these days (e.g., Morikawa et al. (2004) [1]). On the other hand, offering multiple functions to users in railway

stations shows considerable potential to improve the overall impressions of mass transit systems, thereby attracting more users. Thus, analysis of transit users' shopping behavior, which can be affected by their impressions of stations, is important for the urban revitalization. Nishii and Kondo (1992) [2] had analyzed the behavior of rail commuters who make non-work stop during their commute route, but they focused on the time-space constrains instead of the impressions or level of service (LOS) of stations. Moreover, from the view of travel demand management (TDM), stations offering multiple functions have potential to reduce the car use by railway commuters in their non-work purpose trips, and also reduce the frequency of non-work trips themselves. Attractive stations in their commute route will be considered a sound alternative of their shopping or leisure destination choice before, during, or after the work schedule. Thus the inherent car-use trips after work will be replaced by the transit mode, and the frequency of trip will be reduced. Chatman (2003) [3] had analyzed the effect of mixed land use and the commute mode choice on personal commercial purposes trip. The decision-makings in shopping, such as mode or destination choices, are considered correlating with their commute and other activities in Chatman, which is consistent with our study. Though, the focus of Chatman's study is not on a station but on a workplace, and land use is represented just by the share of retail employment without the consideration of store types. In Japan, services provided in stations generally include stores, restaurants, and other leisure facilities. Various types of stores surround stations, some of which are not suitable to be located there intuitively. A research regarding the relationship of railway stations to the retail store distribution by Sadahiro (1994) [4] and a case study on complex function of railway station by Usui and Kamiura, (1999) [5] focused on how the stations had attracted the retail stores in Japan. However, there are few researches analyzing the opposite direct effect, that is, the concentrated stores to the station, especially how the stores surrounding stations change the impressions of a station. Incorporating the ideas mentioned above, this paper aims to refine the cognitive structure of users' impressions of stations, quantify the influences of retail facilities of different types of stores on the cognitive structure, clarify the effects of passengers' impressions of stations on their shopping behavior, and offer some fundamental insights into the policy implementation and promotion strategies of the adjunct stores. Tokyo metropolitan area is used for an empirical analysis, since it has the most advanced mass railway network as well as the adjunct functions of stations in Japan. The analysis of current Tokyo can be quite useful for the other areas in Japan and other countries, which will add adjunct functions to their stations.

2 Data

In order to investigate the impressions of stations held by people living in the Tokyo metropolitan area and confirm whether the impressions affect the passengers' activities, a questionnaire survey was carried out. The questionnaire included two sections for recording 1) feelings towards 23 of large railway terminals in Tokyo metropolitan area and 2) the shopping activities during one week. The dataset was supplied by the East Japan Marketing & Communications, Inc., a major railway-business marketing company in the JR (Japan Railways) group. The questionnaire was implemented in 2001 and involved 3047 mail-in responses from residents in the Tokyo metropolitan area. Figure 1 shows the locations of the 23 terminals. Feelings towards each terminal are asked by 16 concrete binomial-choice questions from different aspects, such as "Is it lively?", "Is it convenient?", and so on. The one week shopping log recorded all the shopping activities with the purchased items and the name of the station if the trip is made by train. Using GIS software, these 23 stations were plotted on a map, and areas within a radius of 500 meters of each station were defined. Taking information from commercial statistics available on a 500 meter mesh, commercial facility information of these 23 terminals is calculated in the level of store type, such as the number of clothing stores, furniture stores and automobile dealers.

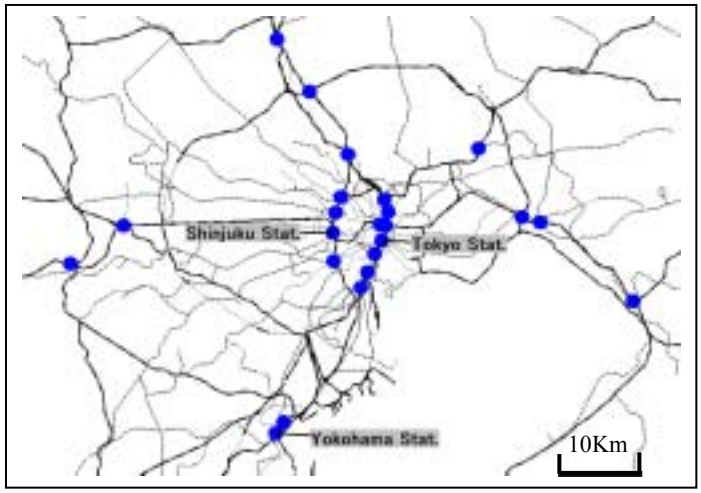

Figure 1: Locations of the 23 terminals

Only the answers to the stations where respondents had accessed in the past year are used. The impression to a place where each respondent has never been to will show little confidence and be not influenced by the surrounding facilities, thus, is excluded from the analysis. 16957 observations are obtained according to this rule. Table 1 shows the 16 concrete binomial-choice questions and their basic statistics.

Table 1: Impressions of station

	Question	Mean	Standard deviation
Q1	Lively	0.239	0.427
Q2	Information-rich	0.249	0.433
Q3	Interesting	0.182	0.386
Q4	Convenient	0.406	0.491
Q5	Fashionable	0.185	0.388
Q6	Bright	0.172	0.378
Q7	With delightful advertisements	0.091	0.288
Q8	Large-scale	0.356	0.479
Q9	Functional	0.175	0.380
Q10	Modern	0.151	0.358
Q11	Unclean	0.254	0.435
Q12	Crowded	0.420	0.494
Q13	Easy to get lost	0.203	0.402
Q14	Friendly	0.030	0.171
Q15	Abound in event	0.146	0.353
Q16	Noisy	0.385	0.487

Sample size: 16957

3 Analysis

3.1 Factor analysis

Firstly, to extract respondents' overall impressions of the stations a factor analysis is carried out. When introducing all 16 items of the questionnaire into the factor analysis, two variables, "Easy to get lost" and "Friendly" showed small value of communality; they were 0.106 and 0.033 respectively. This suggests that both of them have little relation with other variables. The evaluation of "Easy to get lost" might be determined solely by whether the direction boards and other information provision are set

sufficiently; and “Friendly” by whether the designers considered the barrier-free or global enough. Removing these two variables, factor analysis with 14 variables has been done. The factor loading matrix resorted by the factor loading are shown in Table 2.

Table 2: Factor Pattern Matrix

KMO=0.818; Varimax Rotation: 4 iterations

	Factor 1	Factor 2	Factor 3
Lively	0.631	-0.025	0.034
Interesting	0.460	0.209	0.093
Fashionable	0.666	0.094	0.095
Bright	0.427	0.263	-0.145
With delightful advertisements	0.376	0.226	0.125
Modern	0.342	0.332	-0.100
Abound in event	0.335	0.310	0.116
Information-rich	0.482	0.342	0.186
Convenient	0.077	0.458	-0.060
Large-scale	0.164	0.415	0.107
Functional	0.087	0.447	-0.098
Unclean	-0.032	-0.127	0.425
Crowded	0.072	-0.020	0.662
Noisy	0.176	0.122	0.522

Three common factors are extracted and look comprehensible. The result implies that the impressions of stations held by citizens should be considered from three major points of view: the first common factor relates to the variables regarding the pleasure, such as *Lively*, *Interesting*, *Fashionable*, that is, a station is mainly considered a place of communication or leisure rather than just a transport facility; the second common factor relates to the variables regarding the convenience, that is, a station is considered a transport facility; the third factor relates to the other three variables, *Unclean*, *Crowded* and *Noisy*, in other word, the layout and atmosphere of the station. Thus, we named the three factors “pleasure”, “convenience”, and “crowded” respectively. Compared with the positive impressions of “pleasure” and “convenience”, the third factor, “crowded”, looks like a negative one. It is necessary to point out that the attitude to the layout and atmosphere of a station is supposed to vary according to the trip purposes or the items to purchase. For example, people might not mind a place full with people when they buy clothes since popular stores are often crowded.

Factor analysis helped us extract the view points of the impressions held by citizens of a station, but the exogenous variables affecting the impression, such as the number of facilities and social-economic characteristics, can not be introduced in the analysis. More importantly, the presumable relations of impressions to shopping behavior could not be confirmed and quantified here. To clarify how these impressions of stations enhance the purchases and visits is highly beneficial for policy-study aiming to station enlivenment. Thus, the structural equation model (SEM) approach is introduced.

3.2 Structural Equation Model

SEM is an extremely flexible modeling technique for handling multiple endogenous and exogenous variables, as well as latent variables (Golob, 2003) [6]. This approach is introduced here to confirm the cognitive structure of impressions refined in above factor analysis, understand how retail premises effect users’ impressions of stations in store type level, and quantify the effect of these impressions on the real shopping behavior.

3.2.1 Hypothesis

In this study, the impressions of stations extracted by factor analysis and the attractiveness of stations measured by the frequencies of shopping occurred in stations are defined as latent variables. One merit of using SEM approach is that the relationships of latent variables can be introduced in the structure, so the effect of impressions on behavior becomes computable. Since shopping destination choice behavior is considered to vary across items purchased, we categorized the items into daily items and non-daily items. Two latent variables, one for daily items and the other one for non-daily items, are defined to imply the attractiveness of stations. The daily items included newspapers, juices, cigarettes, and so on, and the non-daily items included clothes, souvenirs, groceries, etc. Finally, five latent variables are introduced, that is, 1) “pleasure”; 2) “convenience”; 3) “crowded”; 4) “daily shopping”; 5) “non-daily shopping”. The first three described the impressions of stations and the other two described the attractiveness of stations as a destination of shopping for non-daily items and daily items respectively.

We hypothesize that those who have a high evaluation of convenience would have a higher possibility to go there for shopping. This effect will be larger when they buy daily items. Those who have a high evaluation of pleasure would go there for shopping when they buy non-daily items. Further, those who feel crowded would be difficult to go there to buy daily items, though whether a place is crowded is presumably not a matter when they buy non-daily items since.

3.2.2 Model Structure

Besides the latent variables, the vector of measurement indicators and the vector of independent variables are required to be defined to construct the SEM. The model structure is shown in Figure 2.

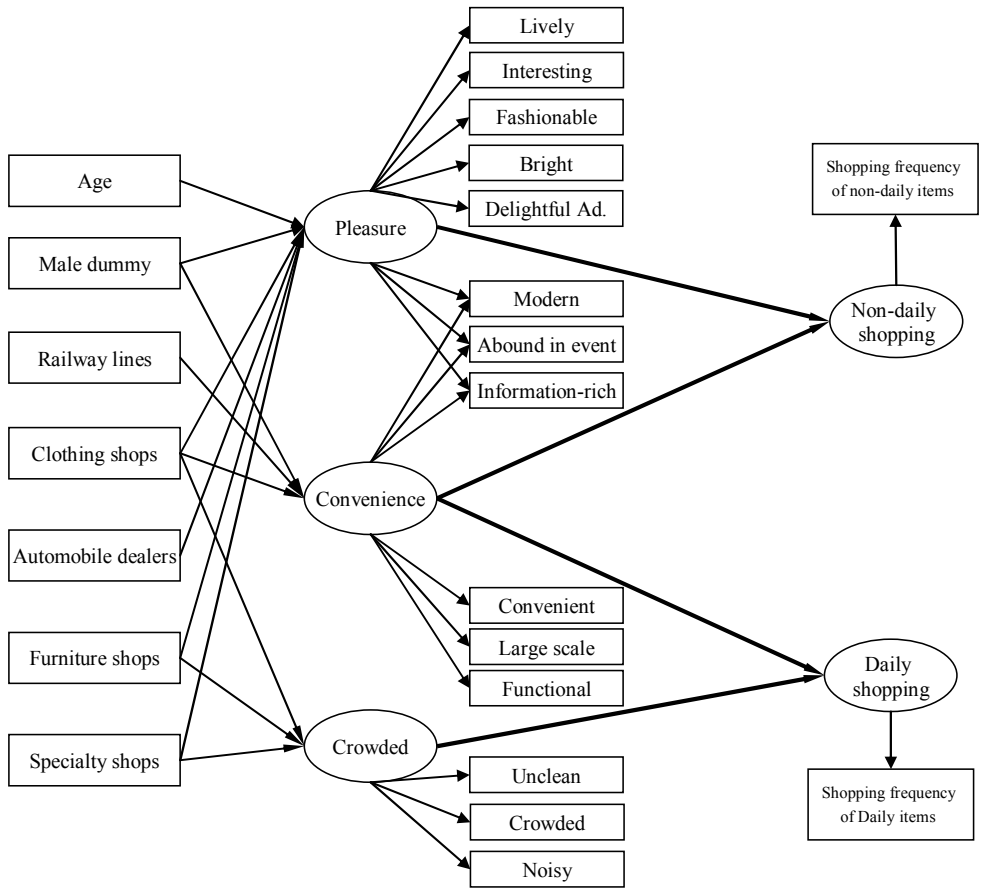

Figure 2: Path diagram of the hypothesized structure

14 variables in the above factor analysis are used as observed indicators in the measurement equations to measure the three latent variables about impressions and the factor pattern matrix is reflected directly. For each station, frequencies of shopping of daily and non-daily items are set as "daily shopping" and "non-daily shopping" respectively to measure the two latent variables about attractiveness. These 2 indicators are calculated from one week shopping log included in the data set.

Structural equations contain two types of explanatory variables: one includes attributes about station, such as the number of railway lines crossing that station, number of clothing stores, and so on; the other one includes personal attributes, such as gender and age.

Finally, the measurement equations are given as

$$Y = \mathbf{\Lambda}\eta + \varepsilon \qquad (1)$$

where, Y is the vector of 16 observed indicators, η is the vector of unobserved 5 latent variables, $\mathbf{\Lambda}$ is a coefficient matrix, and ε is a vector of measurement disturbances.

Similarly, the structural equations are given as

$$\eta = \mathbf{B}\eta + \mathbf{\Gamma}\xi + \zeta \qquad (2)$$

where ξ is the vector of exogenous variables including the number of retail premises in level of store types, the number of railway lines, and two social-economic characters. $\mathbf{B}$ is a coefficient matrix of latent variables, $\mathbf{\Gamma}$is a 5 by 16 coefficient matrix, and ζ is the vector of disturbances.

3.2.3 Estimation Results

The software package LISREL (Jöreskog & Sörbom, 1996) [7] is used here to make estimates of the model. In order to minimize the possible biases resulting from the ordered variables, asymptotically distribution free weighted least squares (ADF-WLS) estimator is used in this study.

Table 3: Goodness-of-Fit Statistics of the Model

Statistic	
RMSEA	0.107
CFI	0.694
RMR	0.115
Standardized RMR	0.115
GFI	0.926
AGFI	0.896

The goodness-of-fit statistics of the model are summarized in Table 3. A slightly large discrepancy per degree of freedom suggested by the root mean square error of approximation (RMSEA) implies that the model is not perfect. However, this statistic based on chi-square should be used as a measure of fit, not as a test statistic (Jöreskog and Sörbom, 1996) [7], and the model should not necessarily undergo a major restructuring due to the slightly high values of the RMSEA. The root mean square residual (RMR), the standardized RMR and the CFI also suggest that the fit of the model is not bad. On the other hand, the goodness-of-fit index (GFI) and the adjusted goodness-of-fit index (AGFI), which adjusts GFI for the degrees of freedom in the model, have sufficiently high values, suggesting that the model represent the sample well.

The estimation results of the measurement model are presented in Table 4. All the indicators have statistically highly significant coefficient estimates and expected signs with the same pattern of factor analysis. The results suggest that the estimated three latent variables represent the hypothesized three unobserved factors extracted from the factor analysis.

Table 4: Estimation Results of the Measurement Model

	Pleasure		Convenience		Crowded		Non-daily shopping	Daily shopping
Indicator	Coef.	t-stat.	Coef.	t-stat.	Coef.	t-stat.	Coef.	Coef.
Lively	1*	--						
Interesting	0.632	74.8						
Fashionable	0.927	145						
Bright	0.594	79.3						
With delightful Advertisements	0.391	44.8						
Modern	0.680	89.6	0.287	10.7				
Abound in event	0.375	30.8	0.675	21.9				
Information-rich	0.708	74.9	0.518	18.2				
Convenient			1*	--				
Large scale			2.84	39.6				
Functional			0.209	10.5				
Unclean					1*	--		--
Crowded					2.55	28.6		
Noisy					3.40	28.0		
Shopping frequency of non-daily items						--	1*	--
Shopping frequency of daily items						--		1*

*: Coefficient is standardized as 1 for identification.

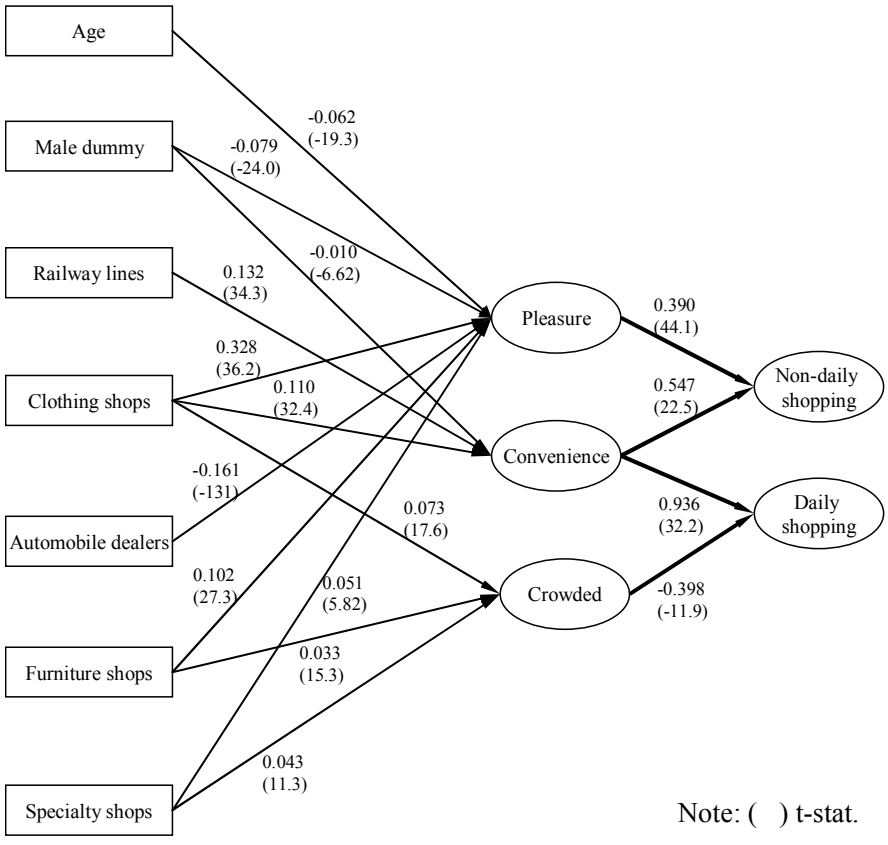

Figure 3: Estimation Results of the structure equations

Figure 3 shows the estimated parameters among latent variables, B. The estimates of the relationship among latent variables are statistically significant and have expected signs. The results support for our hypothesis developed in this study. Impression of convenience showed a significant effect on shopping destination choice for both item categories. Additionally, the enhancement effect on daily items, 0.936, is much larger than that on non-daily items, 0.547. This implies the convenience is a more important factor when purchasing daily items. The impression of pleasure only significantly affects the attractiveness of Non-daily items. This suggests the interesting and fashionable places are preferred by those who buy clothes, souvenirs, groceries and other non-daily items. Model appended with the effect of pleasure on daily items is also estimated on trial, as we thought, this relation was found to have a small coefficient estimate and an insufficient t-statistic. The impression of crowded showed a negative effect on daily items suggests those who buy newspaper, juice, tobacco or other daily items would not prefer to select a crowded place. However, they may not mind whether it is crowded when buying non-daily items. These results not only offer proofs for our hypothesis but also imply that analyzing the impression to stations held by transit users is a worthwhile work and can be utilized in concrete behavior predictions directly.

Figure 3 also shows the estimated result of the effects of exogenous variables on latent variables, Γ. Commercial statistics used in this study include six categories of store type: shops with multiple items; food & beverage shops; clothing shops; automobile dealers; furniture shops; specialty shops (shops supplying special items not included in other categories). It was found that the last four types of store significantly affect the impressions of stations. Furthermore, it is obvious that the different types of store have different effect direction and strength on the impressions. The installation of clothing stores affects all the extracted impressions, especially the impression of pleasure largely, since 0.328 is the largest estimate in the table. Furniture stores and specialty stores will just enhance the impressions of pleasure and crowded, and not of convenience, whereas the automobile dealers negatively affect the impressions of pleasure, thus seem to be unsuitable for railway stations. Railway lines is an indicator representing how many lines are crossing the terminal (refer to Figure 1). As predicted, this variable enhances the impression of convenience. The result that gender and age have significant parameter estimates implies the cognitive pattern varies across individuals. The negative parameter estimate of age to pleasure may imply that seniors have less concern with pleasure to a station. The negative parameter estimates of male dummy to pleasure and convenience may imply that female feels these two factors more easily than male. An imaginable explanation of this tendency is that female has more possibility to use station avoiding the commute peak hours, so they will feel pleasure and convenience more easily.

4 Conclusion

This study clarified the structure of users' impression of stations, confirmed the effect of the impression on the shopping behavior, and quantified the influence of retail facilities to the impression of stations as well as the social-economic characters. The explicit declaration and scientific demonstration of the existence of the impression of the railway stations as communication and leisure spot, and the distinct proof of the effect of these impressions on shopping behavior will provide a theoretical underpinning for government to aid the installation of multiple functions to stations. Furthermore, the insights into the difference in effect among store types will prove useful to help the related public agencies to built facility siting policies more intelligently, such as to set a priority of installing stores which enhance overall impression of stations near the stations or set a restriction of setting up those kinds of stores in suburbs or other areas without mass transit service. The influences of social economic variables incorporated in this study would be used to make the promotion activity effective. To identify the appropriate target segments for campaign design or information provision will save the cost and increase the policy effectiveness.

Although this study has dealt with stations in Tokyo, insights obtained can be applied to local cities. However, maybe in local cities, it is more difficult to induce the stores concentration spontaneously due to the lack of incentives. For example, Li et al. (2004) [8] found both the level of store concentration and the business performance of concentrated stores in a smaller city are inferior to those in a bigger city. This suggests that the promotion polices at the initiative of government are more required in smaller cities. The future work aiming to induce effective concrete siting policies especially for local cities is expected here.

Acknowledgement

Authors are grateful that the data set used in this study was kindly provided by East Japan Marketing & Communications, Inc.

Reference

[1] Morikawa, T., Nagamatsu, Y., and Sanko, N., Post-Project Evaluation of the Demand Forecast for a New Transit System, *Transport Policy Studies' Review*, Institution for Transport Policy Studies of Japan, 2004, Vol.7 No.2, pp.002-011. (In Japanese)

[2] Nishii, K. and Kondo, K., Trip linkage of urban railway commuters under time-space constraints: some empirical observations, *Transportation Research Part B*, 1992, Vol. 26B, No.1, pp. 33-44.

[3] Chatman, D.G., The influence of workplace land use and commute mode choice on mileage traveled for personal commercial purposes, *Transportation Research Board 83rd Annual Meeting Compendium of Papers CD-ROM*, 2003.

[4] Sadahiro, Y., A statistical method for analyzing the relationship between the spatial distribution of retail stores and that of railway stations, *Papers on City Planning*, The City Planning Institute of Japan, 1994, Vol.29, pp.523-528. (In Japanese)

[5] Usui, Y. and Kamiura, M., Fundamental study on complex function of railway station and its transition --case study on Sapporo Station--, *Papers on City Planning*, The City Planning Institute of Japan, 1999,Vol.34, pp.595-600. (In Japanese)

[6] Golob, T.F., Structural equation modeling for travel behavior research, *Transportation Research Part B*, 2003, Vol.37, pp. 1-25.

[7] Jöreskog, K. and Sörbom, D., *LISREL 8: User's Reference Guide*, Scientific Software International Inc., Chicago, 1996.

[8] Li, C., Yamamoto, T., and Morikawa, T., The railway station as shopping destination, *Proceedings of The Fourth International Conference on Traffic and Transportation*, *Dalian, China*., 2004. (forthcoming)