Analysis of Mode Choice Preferences Under Changes in Travel and Socio-economic Environments in Yangon City based on Stated Preference Survey*

by Akimasa FUJIWARA**, Junyi ZHANG**, Toshiyuki OKAMURA** and Soe THEIN***

1. Introduction

In recent years, the sub-urbanization of cities has been accelerating gradually in developing countries and has consequently increased in daily commuting trips between downtown area and suburban area. Travel behavior in developing countries is becoming complicated with increasing mobility and intense vehicle usage. Increasing mobility is strongly supported by rapid economic development and as a result private vehicle usages become popular among urban travelers. Despite of that, insufficient supply and inferior quality of public transportation also encourage travelers to use vehicles. Introduction of proper new transit system (NTS), which makes the alternatives to car use more attractive, for instance, light rail transit or mass rapid transit, will be a crucial solution to alleviate the mobility crisis in developing countries.

Travel users' revealed preferences (RP) for actual travel behavior are very useful in analyzing the travel demand for existing modes. However, forecasting the travel demand of new transport modes is always accompanied with travelers' stated preference (SP) since the actual travel data (RP) for such modes are not available. This study aims to apply a combined SP/RP model to analyze the future travel demand for a new transit system (NTS) in Yangon City.

2. Study Area

Yangon City, the capital of Myanmar, has grown rapidly in recent years and its population reaches up to 5 million now. Currently, car, bus, railway and taxi are the main transport alternatives. Especially bus system dominates travel modes in the city and railway only occupies a small portion because of its inconvenience. Buses, equipped with various old and second-hand vehicles, are over-crowded irrespective of the time of a day, and characterized by uncomfortable, inconvenient and unpunctual services.

Travel demand and transport supply is seriously unbalanced. Furthermore, increase of private car ownership and many kinds of buses will worsen the environment and cause much heavier traffic congestion at the city center in the future. As indicated in figure 1, the downtown area is located at the southern part of Yangon City, which has totally 33 townships and is 612 square kilometers wide. We selected a survey area, named Insein Township, which is 23 kilometer north from the downtown area, considering population, trip generation rate and regional development of social and economic sector.

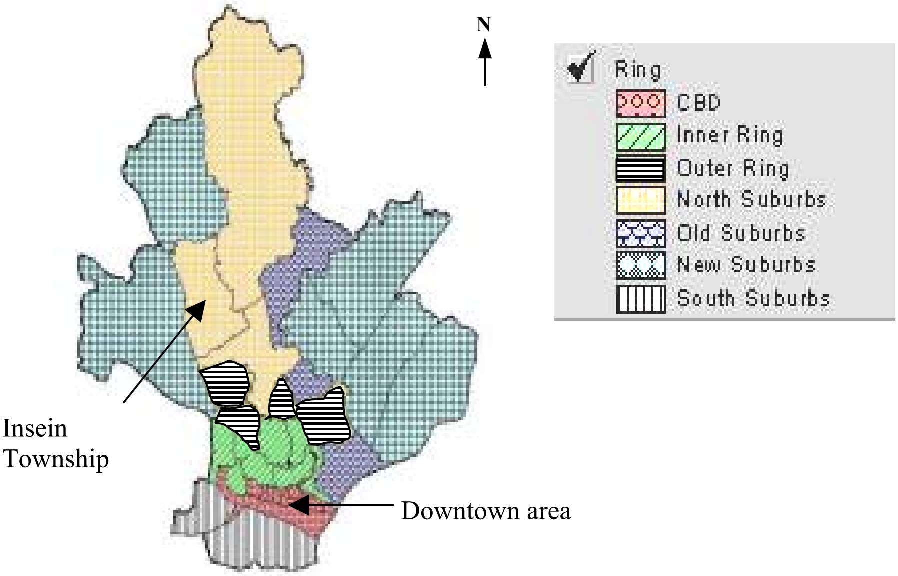

Fig 1. Map of Yangon city and survey area

3. Survey Structure And Data

To investigate individuals' socio-economic attributes and current travel behavior between suburban and downtown area, RP questions are first asked at the survey questionnaire, while people's preferences for the selected travel modes are then stated for several hypothetical situations with different levels of services including travel cost, travel time, waiting time and punctuality. The SP responses are answered conditional on the assumed income level in the future. In the RP questions, respondents are asked to report their actual chosen travel modes, e.g., bus, railway, taxi and private car for daily trips from suburban area to downtown area. Even many kinds of buses are operating to serve the over-crowded passengers on the fixed routes and competitive passengers are waiting at their bus stops in peak hours. Such a saturated situation of bus services implies the unbalanced travel demand and supply. Therefore a new transit system (NTS) is assumed in SP as one alternative with the following attributes, (a) Travel cost of NTS > Travel cost of bus & railway services, (b) Travel cost of NTS < Travel

---

*Keywords: travel mode choice, travel behavior analysis, SP, developing country
**Member of JSCE, Dr. Eng., Graduate School for International Development and Cooperation, Hiroshima University,
*** Non-Member of JSCE, B. Sc., Graduate School for International Development and Cooperation, Hiroshima University,

cost of taxi, (c) Travel time of NTS < Travel time of bus & railway services, (c) Access and egress time in NTS < = Access and egress time in bus & railway services, (d) Capacity per vehicle in NTS > Capacity per vehicle in bus.

In our SP experiment, we deal with the future income level as one of attributes affecting mode choice behavior as well as the level-of-service. The assumed alternatives are passenger car, bus, railway and NTS. The level-of-service attributes include travel time and cost for all the alternatives, and waiting time, punctuality for public transit. Based on orthogonal fractional SP design method, totally 27 profiles were set up with respect to the combinations of the assumed income and the level-of-service with three-levels respectively. After excluding the unrealistic profiles, 24 profiles are used in the experiment. We randomly selected 500 residents from a residential area and conducted the SP survey for various trip purposes in March 2003 in Yangon city. To author's knowledge, this is the first attempt of SP survey in Myanmar. Owing to the cooperation of township officers and residents' interest in the survey, 402 valid questionnaires were successfully returned with a high response rate. In the survey questionnaire, to reduce respondents' burden, the 24 profiles were grouped into 3 balanced blocks. Each respondent received only one block of 8 profiles and was asked to choose one alternative from the four predefined travel modes with hypothetical changing levels in both level-of-service and income.

Each respondent also reported his/her socio-economic attributes, trip frequency to the city center, main travel mode, trip purpose, current level-of-service including travel time, access time to and egress time from the nearest bus stop and railway station etc (See fig 2). Most of trip purpose is for work trip (46%) and 48% of respondents are daily trip to downtown. It is shown that actual modal shares are 2.86% for car, 84.94% for bus, 5.97% for railway, 4.68% for taxi and 1.55% for other modes (See fig 4), while the shares in the SP survey are 6.25% for car, 36.08% for bus, 9.24% for railway and 48.43% for NTS, respectively (See fig 5). It is observed that 42.82% of respondents would use the cars if their future income levels were increased enough to afford the cars. 87.77% of respondents feel that the bus services are not convenient. This might be the main reason why 50.36% of bus users reported to shift to the NTS. In contrast, 31.07% of railway users are satisfied with the present level-of-service and consequently 71.74% reported not to shift to the NTS. It is also clear that 56.59% of future car users comes from the present bus users. On the other hand, even though the total car share is only 6.25% in the SP survey, 54.55% of car users chose the NTS. This suggests that better public transport services may contribute to the reduction of car users. Totally, 84.62% of NTS users come from the present bus users and high preference to the NTS is observed irrespective of individual attributes and trip purposes.

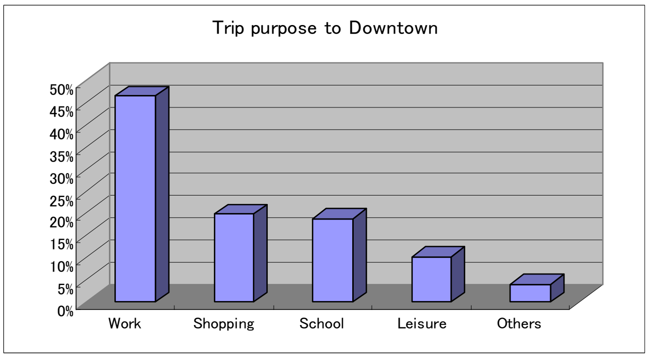

Fig 2. Trip purposes to downtown area

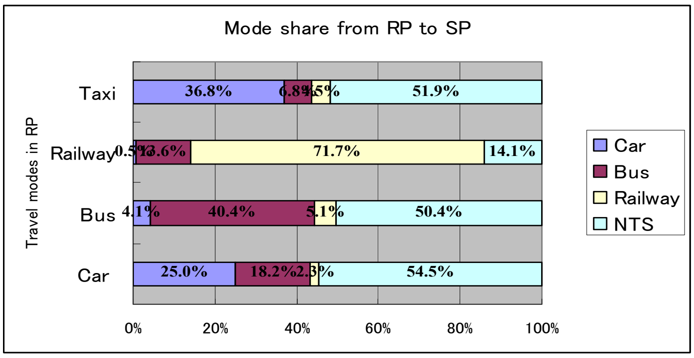

Fig 3. Changes of mode shares from RP to SP

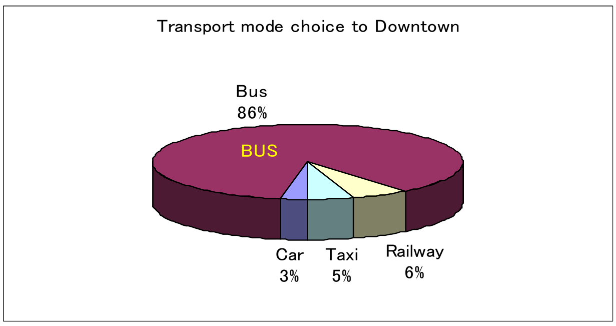

Fig 4. Mode shares in RP data

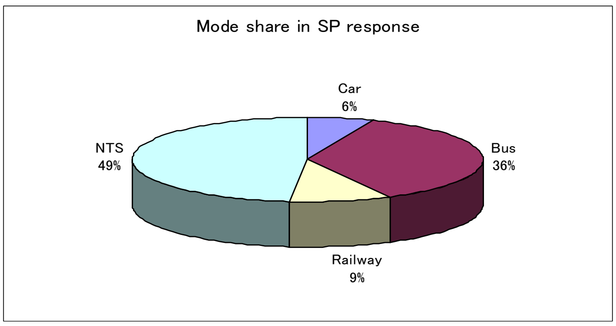

Fig 5. Mode shares in SP data

4. Model Estimation with Combined SP/RP Model

To model people's choice behavior based on SP data, we apply the logit-type SP model as well as SP/RP combined model. The latter is especially used to correct SP reporting biases by introducing the revealed preference (RP) information. The SP approach contains more biases than the RP approach because biases can arise at any stage and any situation during the course of survey. For instance, respondents cannot answer the questions properly when the purpose of the survey is not clear. They may feel very confused to give answers due to bad wording and ordering of the questions. They may also lose their patience when answering too many questions. On the other hand, SP-based prediction models tend to overestimate the future demand of new alternatives (Ben-Akiva and Morikawa, 1990; Zhang et al., 2001). This paper therefore proposes a model for the people mode choice preferences based on the assumed income level under changes of hypothetical travel attributes and socio-economic environments by using a SP/RP combined logit model.

We adopt the framework developed by Ben-Akiva and Morikawa (1990). This framework postulates that the SP utility U_{ni}^{SP} has a different variance σ_{η}^{2} of error term η_{ni} from the one σ_{ε}^{2} of error term ε_{ni} in the RP utility U_{i}^{SP}, as shown in the following equation,

$$\sigma_{\eta}^{2} = \mu^{2}\sigma_{\varepsilon}^{2} \tag{1}$$

where, μ is an unknown *scale parameter.*

This leads to the following utility functions for alternative *i* of individual *n*.

$$U_{ni}^{RP} = \theta X_{ni}^{RP} + \alpha Y_{ni}^{RP} + \varepsilon_{ni} \tag{2}$$

$$U_{ni}^{SP} = \mu(\theta X_{ni}^{SP} + \phi Z_{ni}^{SP} + \eta_{ni}) \tag{3}$$

Where α, ϕ and θ are parameters to be estimated, X_{ni}^{RP} and X_{ni}^{SP} are the comment attributes of both alternatives and individuals in the RP and SP utility functions respectively. Y_{ni}^{RP} and Z_{ni}^{SP} are the RP-specific and SP-specific attributes respectively.

We would normally expect the SP data to have more biases than the RP data, suggesting that the scale parameter is usually less than unity. Assuming that both error terms follow a Gumbel distribution with zero mean but with different variances, the choice probabilities can be obtained as follows:

$$P_{ni}^{RP} = \frac{exp\left(\theta X_{ni}^{RP} + \alpha Y_{ni}^{RP}\right)}{\sum_{j} exp\left(\theta X_{nj}^{RP} + \alpha Y_{nj}^{RP}\right)} \tag{4}$$

$$P_{ni}^{SP} = \frac{exp\left[\mu\left(\theta X_{ni}^{SP} + \phi Z_{ni}^{SP}\right)\right]}{\sum_{j} exp\left[\mu\left(\theta X_{nj}^{SP} + \phi Z_{nj}^{SP}\right)\right]} \tag{5}$$

Then we can apply the conventional maximum likelihood method to the following logarithm likelihood function.

$$L(\theta,\mu,\alpha,\phi) = ln\left\{\left[\prod_{n}\prod_{i}\left(P_{ni}^{RP}\right)^{\delta_{ni}^{RP}}\right] * \left[\prod_{n}\prod_{j}\left(P_{nj}^{SP}\right)^{\delta_{nj}^{SP}}\right]\right\} \tag{6}$$

$$\begin{cases} \delta_{ni}^{RP} = 1, & if\ alternative\ i\ is\ chosen\ in\ RP, \quad otherwise, 0 \\ \delta_{nj}^{SP} = 1, & if\ alternative\ i\ is\ chosen\ in\ SP, \quad otherwise, 0 \end{cases} \tag{7}$$

5. Model Estimation Results and Discussions

We estimated two types of choice models for both SP model and SP/RP combined model: one is to ignore the heterogeneous influence of income while another is to incorporate the heterogeneous influence of income by segmenting the sample into three different groups: i.e., high, medium and low income. The estimation results are shown in Table 1.

It is shown that McFadden's Rho-squared of each SP/RP model is about twice higher than the one of the corresponding SP model for both types. All of the scale parameters are statistically significant. This suggests that SP/RP model can be used to properly represent people's stated preferences under hypothetical situations. All of the scale parameters are smaller than one, implying that SP data has a larger variation than the RP data. The scale parameter for low-income level group has the highest value while the one for high-income group has the lowest value. It might be interpreted that people with high income have a higher flexibility in the choice of travel mode than the people with low income and consequently, the latter has a higher confidence in answering the SP questions than the former.

Most of parameters are statistically significant with expected signs. Parameters for travel time, travel cost, waiting time, punctuality, access time and egress time are significantly negative, showing the excepted signs in SP/RP. This means that, improving level of service will increase the share of the corresponding travel mode and the increase of future income will increase the use of car and decrease the use of public transit systems. Except for punctuality, most of the parameters are relatively stable across different income levels. In contrast, the parameter of punctuality for high-income level has the lowest negative value among different income levels. This suggests that the people with high-income level are much more sensitive to the punctuality than others.

Table 1. Model estimation results of SP and SP/RP models

Variable \ Model	SP All cases	SP High income	SP Medium-income	SP Low income	SP/RP All cases	SP/RP High income	SP/RP Medium-income	SP/RP Low income
Constant terms	3.4093 (9.242)**				10.8481 (17.715)**	10.9482 (10.642)**	11.1191 (11.187)**	10.3367 (8.784)**
Travel time	-0.0085 (9.621)**	0.0012 (0.638)	-0.0137 (9.075)**	-0.0107 (6.280)**	-0.0398 (7.435)**	-0.0416 (4.333)**	-0.0446 (5.43)**	-0.0312 (3.261)**
Travel cost	-0.0003 (2.732)**	-0.0007 (18.245)**	-0.0010 (18.593)**	-0.0014 (13.599)**	-0.0010 (1.963)*	-0.0012 (1.078)	-0.0012 (1.426)	-0.0014 (1.2564)
Waiting time	-0.0243 (12.909)**	-0.0377 (6.505)**	-0.0266 (8.517)**	-0.0242 (7.652)**	-0.0802 (9.719)**	-0.0784 (5.326)**	-0.0755 (5.904)**	-0.0799 (5.086)**
Punctuality	-0.0492 (8.949)**	-0.0419 (3.3105)**	-0.0358 (3.895)**	-0.0407 (4.159)**	-0.2894 (4.285)**	-0.5412 (2.552)*	-0.2564 (2.635)**	-0.1343 (1.916)
Access time					-0.1207 (11.58)**	-0.1209 (7.091)**	-0.1211 (7.133)**	-0.1227 (5.826)**
Egress time					-0.0588 (7.020)**	-0.0590 (4.301)**	-0.0594 (4.33)**	-0.0593 (3.557)**
Scale parameter					0.1970 (7.607)**	0.1370 (3.886)**	0.2200 (4.810)**	0.2900 (4.050)**
Value of time (Kyats/min)	32.7	-1.7	13.3	7.6	39.6	34.9	37.4	22.7
Initial Likelihood	-2663.82	-1534.63	-1556.81	-1035.56	-2663.82	-998.93	-998.93	-665.95
Converged Likelihood	-3210.7	-1250.26	-1188.89	-775.21	-1544.65	-601.55	-560.74	-364.69
McFadden Rho-square	0.2220	0.1853	0.2363	0.2514	0.4201	0.3978	0.4387	0.4524
Adjusted Rho square	0.2215	0.1843	0.2354	0.2501	0.4189	0.3943	0.4354	0.4476
Sample size	2977	1107	1123	747	1072	402	402	268

The value of time (VOT) from the SP models ranges from 7.6 to 32.73 (Kyats/min), except for the VOT from the SP model with high-income level, where the parameter of travel time is positive. On the other hand, the VOT from the SP/RP models ranges from 22.7 to 39.6 (Kyats/min). Obviously, the VOT from SP model has a larger variation than the one from the SP/RP models. This reflects the fact that that the parameters for travel time and travel cost in the SP/RP models are relatively stable across different income levels.

6. Conclusion

Focusing the role of a new transit system in relaxing traffic congestion and providing better public transport services, we analyzed people's preferences to the new transit system under changes in travel and social-economic environments in Yangon city based on a SP survey data. It is shown that there exists a high preference (modal share) to the new transit system, which is mainly observed in the present bus users. The value of travel time estimated from the SP model can be properly corrected by applying the SP/RP combined model, which also contributes to the improvement of model accuracy. However, it can be pointed out that the value of travel time might largely change with the increase of future income level in a long time situation. Therefore, it seems important how to predict people's long-term travel behavior and we leave it as a future research issue.

References

1) Ben-Akiva, M. and Morikawa, T.: Estimation of mode switching models from revealed preferences and stated intentions, Transportation Research A, Special Issue, Vol.24A, No.6, pp.485-495, 1990.
2) Zhang J., Sugie, Y. and Fujiwara, A.: A mode choice model separating taste variation and stated preference reporting bias, Journal of the Eastern Asia Society for Transportation Studies, Vol.4, No.3, pp.23-38, 2001.