ANALYSIS OF URBAN TRAVEL DEMAND FOR DEVELOPING COUNTRIES BY INTEGRATING RP AND SP DATA*

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1.0 INTRODUCTION

Most of the developing countries are suffering from serious transportation problems, congestion and environmental pollution for instance, with increase in travel demand. Therefore, competent implementation of new modes such as subway, LRT, MRT or even zero-emission vehicles are essentially required for a remarkable change in the level of service.

In general, disaggregate demand modeling is widely applied in transport planning by using the method of discrete choice analysis which is based on the principle of utility maximization (Ben-Akiva and Lerman 1985). Although estimation of discrete choice models are basically relied on revealed preference (RP) data for actual travel behaviour, there is also a substantial interest on stated preference (SP) data which is related to hypothesized travel scenarios. SP techniques have been widely spreaded within the market research and some considerable attention was made on RP and SP combining technique in recent years. It is rather rational forestep towards the reality by improving the accuracy of parameter estimates while exploiting the advantages of both RP and SP data sources (Morikawa 1989).

This study focuses on estimation with SP data and combined estimation with RP and SP data, upon the introduction of a new mode into the system. The developed SP model is verified using the data regarding the future MRT project in Bangkok.

Since the mode choice and car ownership are inextricably linked, development of integrated model is important for future investigations on travel demand. Therefore, the factors influencing on car ownership under rising economic conditions are also discussed.

2.0 MODEL ESTIMATION USING SP DATA

2.1 Data Description

The research group of Infrastructure and Transportation Planning laboratory at the Nagoya University conducted a SP survey during 1996 to obtain information on user intention towards future MRT that is scheduled to be opened in 2010 in the metropolitan area of Bangkok in Thailand (Anurakamonkul 1997).

The SP questionnaire was prepared to achieve explicit coverage of requirements, where the collected information is successfully applied for modeling of user travel demand.

2.2 Modeling Approach

Upon the introduction of the new mode, MRT, into the prevailing transportation system in Bangkok, the universal set of alternatives consists of four elements: MRT, bus, car, and motor cycle. According to the collected data, it is clarified that the choice tendencies are mainly directed to MRT, bus, and car regardless of motor cycle. For the formulation of utility functions for each mode, attributes that are highly influential are identified by considering SP responses regarding the most important and the second most important factors which are incorporated to make decisions on choice. Therefore, the travel time and the travel cost are considered as the dominant system attributes where the transport users are assumed to maximize utility with respect to their travel time and travel cost corresponding to the income.

By applying discrete choice modeling, the utility functions for MRT, bus, and car mode choices are formulated as follows:

$$U_{mrt} = \alpha_1 + \beta_1(ttime_{mrt}) + \beta_2\left(\frac{tcost_{mrt}}{inc}\right) + \varepsilon_{mrt} \quad (1)$$

$$U_{bus} = \alpha_1 + \beta_1(ttime_{bus}) + \beta_2\left(\frac{tcost_{bus}}{inc}\right) + \varepsilon_{bus} \quad (2)$$

$$U_{car} = \beta_1(ttime_{car}) + \beta_2\left(\frac{tcost_{car}}{inc}\right) + \varepsilon_{car} \quad (3)$$

where ttime, tcost, and inc are the travel time, the travel cost, and user income, respectively.

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2.3 Results and Discussion

The model is estimated for each user category depending on their:

(1) current mode, and
(2) income class.

(1) Current Mode

Estimated results as shown in table 1 are consistent with theoretical expectations: MRT constants for instance, are significantly positive coefficients for the models of ordinary bus, AC bus, and motor cycle indicating the user intention to switch to future MRT.

For car users, the negative signs on the estimated MRT and bus constants describe their willingness to use car over MRT and bus because of the availability of vehicle and convenience of travel.

Almost all user types have significantly negative coefficients for both the travel time and the travel cost as expected.

(2) Income Class

Parameter estimation results as shown in table 2 are also consistent in the sense of behavioural analysis of transport users where MRT constant is significantly positive coefficients for low income class indicating that their intention to switch to future MRT.

For transport users belong to high income class has significantly negative coefficients for MRT and bus constants by expressing their negative tendency to use those modes.

Almost all income classes have significantly negative coefficients for both the travel time and the travel cost which describe their willingness to receive maximum utility with contributing less time and cost. Therefore, some trading off between time and cost is expected to select the best choice.

Table 1: Parameter Estimation results of mode-choice model based on Current Mode
(t-statistics in parenthesis; bold-faced figures are statistically significant at the 5% level)

Variables	User Category			
	ordinary bus	AC Bus	car	motor cycle
MRT constant	**2.11** (6.3)	**0.56** (2.7)	**-0.66** (-4.0)	**0.91** (2.6)
Bus constant	0.33 (0.5)	-0.10 (-0.2)	**-3.04** (-5.2)	1.85 (1.8)
Travel time (hrs)	0 (-0.1)	**-1.79** (-2.3)	**-1.41** (-2.0)	**-2.79** (-2.1)
Travel cost/income/10^3	**-0.65** (-3.7)	**-0.64** (-3.4)	**-0.47** (-2.1)	0 (-0.8)
SP observations	221	239	374	70
$L(O)$	-242.8	-262.6	-410.9	-76.9
$L(\hat{\beta})$	-158.2	-204.9	-277.0	-62.9
σ^2	0.348	0.220	0.326	0.182

Table 2: Parameter Estimation results of mode-choice model based on Income Class
(t-statistics in parenthesis; bold-faced figures are statistically significant at the 5% level)

Variables	Income Class		
	Low 0-30,000 baht	Middle 30,000-75,000 baht	High Over 75,000 baht
MRT constant	**1.29** (7.5)	0.24 (1.2)	**-0.70** (-3.0)
Bus constant	0.16 (0.4)	0 (0.1)	**-2.62** (-4.7)
Travel time (hrs)	0.47 (-0.9)	**-2.69** (-2.3)	**-2.09** (-2.3)
Travel cost/income/10^3	**-0.22** (-2.8)	**-0.64** (-2.2)	**-2.75** (-3.3)
SP observations	492	423	325
$L(O)$	-540.5	-464.7	-357.1
$L(\hat{\beta})$	-421.1	-355.3	-51.5
σ^2	0.221	0.236	0.296

3.0 COMBINED ESTIMATION OF CHOICE MODEL USING SP AND RP DATA

3.1 Basic Formulation

There exist some common attributes, which are equally applied for both RP and SP choice models. But, some of the attributes have close relationship with either RP response in the sense of actual market behaviour or SP response as biased factors. In RP and SP combined analysis, for instance Morikawa (1989) proposed a model that is successfully applied in demand analysis.

3.2 Specification of the Model

By applying discrete choice modeling, the utility functions for RP and SP combined model are formulated as follows:

(1) RP model

$$U_{bus} = k_1 + \beta_1(ttime_{bus}) + \beta_2\left(\frac{tcost_{bus}}{inc}\right) + \alpha_1(incclass) + \varepsilon_{bus} \quad (4)$$

$$U_{car} = \beta_1(ttime_{car}) + \beta_2\left(\frac{tcost_{car}}{inc}\right) + \alpha_2(carownship) + \varepsilon_{car} \quad (5)$$

(2) SP model

$$U_{bus} = k_2 + \beta_1(ttime_{bus}) + \beta_2\left(\frac{tcost_{bus}}{inc}\right) + \gamma_2(RPmode_{bus}) + \gamma_3(incclass) + v_{bus} \quad (6)$$

$$U_{car} = \beta_1(ttime_{car}) + \beta_2\left(\frac{tcost_{car}}{inc}\right) + \gamma_1(carownship) + \gamma_2(RPmode_{car}) + v_{car} \quad (7)$$

$$U_{mrt} = k_3 + \beta_1(ttime_{mrt}) + \beta_2\left(\frac{tcost_{mrt}}{inc}\right) + \gamma_1(carownship) + \gamma_3(incclass) + v_{mrt} \quad (8)$$

where *carownship* is 1, if car is available, and zero otherwise; *incclass* is 1, if the user belongs to high income class, and zero otherwise; $RPmode_{bus}$ is 1, if current mode is bus, and zero otherwise; and similarly, $RPmode_{car}$ is 1, if current mode is car, and zero otherwise.

4.0 FRAMEWORK OF DEMAND ANALYSIS FOR DEVELOPING COUNTRIES

4.1 Overview On Car Ownership Modeling

Increase in car ownership and usage is directly linked with rapid economic growth resulting in severe traffic congestion, which is highly influenced on decision making in the area of transportation planning. Therefore, it is rather important to develop some combined analysis by integrating car ownership and use, into the travel demand models.

Train (1980) mentioned that the factors such as the number of cars belonging to the household and number of workers using cars for commuting are very useful for the efficient analysis on transportation policies. Dargay and Gately (1999) developed a model to investigate the income effect on car and car ownership and found that the ownership grows twice as fast as income for the lowest and middle income levels and ownership saturation is approached for the highest income levels.

Though there has been some substantial improvement on car ownership modeling in recent years, the integrated analysis with car ownership and mode choice modeling is rarely found. Train (1980) also described that modeling with one of the choices, either car ownership or mode choice, does not simultaneously accommo-date the desires of the other model, and therefore, proposed a methodology to create the interaction between the models by eliminating the uncertainties associated with separate models.

The validity as well as the consent regarding the proposed policies in the previous approaches is rather low due to the limited number of explanatory variables introduced into the models. Furthermore, considerable attention is required on the family structure such as household size, the number of workers in the household, and the number of children for instance for better representation of the model.

4.2 Proposal of Modeling Framework

An extension of the concept on mode choice modeling is proposed to create overall decision making process related to travel demand analysis. Therefore, consideration is made on integrated analysis of car ownership with mode choice modeling, and the framework (Fig. 1) is proposed by observing all possible factors, which are closely related to the modeling approach.

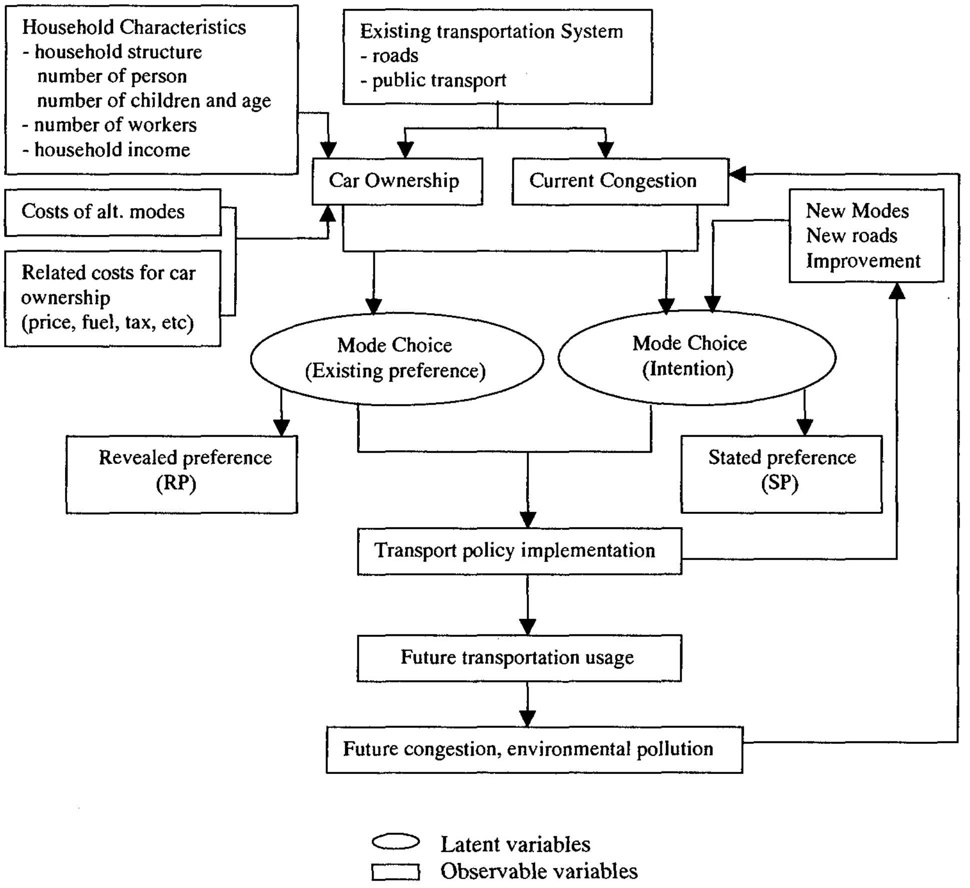

Figure 1: Proposed Framework for the Integrated Approach

5.0 CONCLUSIONS

This study proposes a methodology to analyze travel demand, incorporating SP and RP data upon the introduction of new transportation alternative into the system. The findings of this study provides further evidence that transport users' stated preferences on hypothetically created travel scenarios can be profoundly used as a accurate guide to represent the actual underlining preferences.

Further investigation on travel demand is proposed along with integrating car ownership model into the present approach.

REFERENCES

(1) Anurakamonkul, K. (1997), A Study on the Provision and Contribution of Mass Rapid Transit in Auto Dependent Metropolis: The case of Bangkok, Doctoral Dissertation, Department of Civil Engineering, Nagoya University.

(2) Ben-Akiva, M. and Lerman, S. (1985), Discrete Choice Analysis, MIT Press, Cambridge, Massachusetts.

(3) Dargay, J. and Gately, D. (1999), Income Effect on Car and Vehicle Ownership, Transportation Research, 33A, pp 107-138.

(4) Morikawa, T. (1989), Incorporating Stated Preference Data in Travel Demand Analysis, Doctoral Dissertation, Department of Civil Engineering, MIT.

(5) Train, K. (1980), A Structured Logit Model of Auto Ownership and Mode Choice, Review of Economic Studies, 47, pp 357-370.