SOME ISSUES ON PUBLIC TRANSPORT DEMAND FORECASTING IN DEVELOPING CITIES*

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1. Introduction

Rapid urbanization and motorization have immensely contributed to the current transport situation in cities of developing countries. Such phenomena have been expressed in various literatures, which are generally considered as an outcome of economic growth[1]. To compliment such brisk development, public transportation (PT) plays a vital role in order to meet the ever-increasing travel demand in developing cities. Its efficiency contributes to the city's livability and eventual competitiveness over the long term. This has often placed developing cities in complex situations in providing the necessary transport infrastructures. With severe resource constraints facing them at current levels of urbanization, there is a wide gap between infrastructure demand and supply, which typifies developing countries. This study highlights key points regarding the difficulties associated with developing cities' PT system. The modal choice individuals make to fulfill mobility needs is very important. The complexities associated with analyzing travel demand, a key starting point in any transportation study, must be addressed. Sound theoretical foundations are needed because errors committed at the initial step propagate up to the end, especially the forecast benefits and policy impacts derived from any transport facility improvement. It then raises important issues such as reliability and time valuations, key elements in benefits calculation. Disparities and heterogeneities between individuals are crucial considerations for developing cities' PT system forecasting. Also, we touch on market characteristics in developing cities.

2. Some issues on PT forecasting

(1) Complicated PT chains in developing cities

With urbanization trend at the fringes of the region, away from the city core, alongside with the presence of numerous kinds of modes in developing cities like Metro Manila (MM), it is quite typical for a traveler to go thru a public transport chain, using different PT modes A very distinctive situation lies on the existence of para-transit in developing cities, unlike in developed cities that emphasize on the higher capacity and fixed route public transport, facilitating smooth and coordinated road-to-rail, or between-rail transfers. Figure 1 depicts example of PT chains. A single chain may be composed of different mode combinations of rail, jeepney, bus, tricycle, walk, or car (R, J, B, Tc, W, or C). An approach might be to define a representative mode (i.e. main mode based on distance or time) for every chain, which is shown as the shaded mode. However, analyzing PT using representative modes is a formidable task, which, for some mode combinations, is just difficult to resolve, and might end in oversimplification. Thus, the inherent complexity of the "overlapping modes" must be addressed to represent the reality of the choice situation. Such situation may be partly due to the presence of numerous modes, inexistent in developed cities. Table 1 presents the complexity of the situation. An example is to look at the R mode. Note that this mode belongs to at least five PT chains from Table 1. A modeling structure aside from the standard logit might be more suitable under such circumstance.

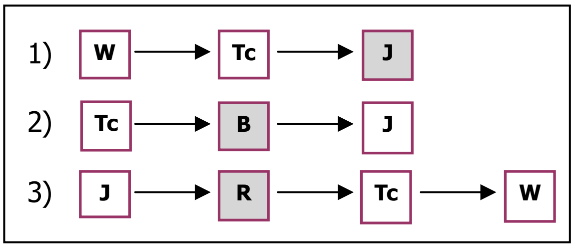

Figure 1 PT chain

In travel demand modeling, disaggregate approach is an appropriate tool that may be successfully adopted for describing the travel behavior. Model formulation using standard logit cannot address the choice situation, where alternative PT chains may both

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Table 1: PT chains dataset

No.	Md1	Md2	Md3	Md4	Freq.	%
1	W	R			402	4.03
2	W	J			3,897	39.05
3	W	B			122	1.23
4	W	J	R		1,432	14.35
5	W	B	R	J	58	0.58
6	W	J	B		270	2.72
7	W	J	R	Tc	531	5.32
8	W	Tc	R		211	2.12
9	W	Tc	J		1,243	12.46
10	W	Tc	B		87	0.87
11	C				1,513	15.16
12	W	B	R		98	0.98
13	W	J	B	Tc	111	1.11
Tot					9,975	100.0

contain any of the given modes. Standard logit formulation simply cannot handle correlations and similarities between alternatives. Another approach is to put alternatives into predefined nests or branching system, which is the nested logit (NL) approach. This partly alleviates the multinomial logit (MNL) problem but still face major difficulties. Identifying the nesting structure itself poses a difficult task for the researcher. Correlations in unobserved attributes are handled for alternatives belonging to the same nest, but alternatives belonging to different nests poses difficulty. It is therefore necessary to explore different model structures, to pursue travel demand analysis. It would be useful then to have a model in which the unobserved utility for an alternative could be correlated with another alternative, and in turn, with that of another alternative. Simply put, structure that allows a given alternative to belong to more than one nest is needed.

(2) Valuation of reliability and time

PT's primary role of congestion alleviation is crucial in developing cities, where road network usage is generally shared with private mode. A case study[2] was undertaken focusing on the unreliability issues in PT's actual departure/arrival times, from a multimodal (PT chains) perspective, applied to users. A transport chain was defined as an ordered sequence of trips where endpoint of each trip is the starting point of the subsequent trip in the chain. Unreliability problem becomes more significant when travelers move via chains, with different modes. Computational analysis was done to evaluate reliability enhancing schemes based on travelers' valuation of reliability, travel time and waiting time. It highlighted the attitude of risk aversion towards travel time (TT) among travelers, and concluded the importance of non-motorized transport (bicycle) as the most promising means in improving the overall utility of the chains. This unreliability problem is also of prime significance to developing cities, for it affects both public and private mode users. Using elasticities and regression techniques, relation between TT components and PT use was quantified using trip and trip chain levels. It highlights the importance of analysis on a trip chain level[3]. Here, trip chain is defined as combination of successive trips, starting at a place of reference, home or workplace, and ending at the same place. Another study[4] found the negative correlation between trip chain complexity and PT use. Indeed, there are relatively few researches in this area.

Given the PT travel demand complexities, the next question pertains to the issue of time valuation. As the city continues to expand, more infrastructures are needed to sustain, if not improve, the gains of progress. But will there be any benefit gained most especially from the societal perspective? Benefits from a transport facility project, new or improvement, accrue principally from the evaluation of travel time savings. For such projects, value of travel time savings (VTTS) is crucial because 50 to 70% of the total benefit is attributed to time savings[5]. In transport economics, VTTS is arguably the single most important number, which measures the user's willingness-to-pay (WTP) for TT reductions. It constitutes a sizeable share of the benefits in CBA of infrastructure projects and is a fundamental factor to evaluate transport policy measures related to travel time reduction.[6)-7] Since the 1970's, in developing countries, World Bank and other international development aid organizations have consistently applied cost-benefit analysis (CBA)[8]. The results form a major element among the feasibility criteria for support provision and investment prioritization. Scarcity of empirical evidence in developing cities, with limited funds but in dire need of infrastructure, is an alarming situation. The underlying fact is that unlike in developed cities, heterogeneity among travelers (in developing cities) might be more persistent, compounded by the existence of various PT modes, creating direct impact to studies in time valuations. Such variations may be attributed to the wider disparities in travelers' characteristics. Disaggregate approach is an appropriate tool that may be successfully adopted for time valuation studies. Standard logit formulation, or fixed-parameter logit, will always give a single average value that is true for the individuals in the entire population. Systematic variations over the population can be accounted by standard logit, but not the random taste variations. Moreover, this will fail to account for the wide disparities (e.g. socioeconomic) between travelers in developing cities, as compared to the relatively more homogeneous characteristics of travelers in developed cities. An example of such disparity may be largely due to the income distribution among the population. Such differences will produce significant impact on the marginal utilities of income. Eventually, it will affect the benefits derived from the travel time savings, brought about by improvements in the PT system. This is crucial for willingness-to-pay (WTP) studies, where heterogeneity around the mean parameter might be significant and thus, must be captured. Specifically, unobserved heterogeneity in the marginal utility of specific variables can be accommodated by the random parameter logit model formulation, through its coefficients' random parameters[9].

Using the dataset given in Table 1, model estimation was carried out using random-parameter logit known as Mixed-logit model (MXL). The cost coefficient in models is fixed across the population. Utility of an alternative is given by: $U_j = \boldsymbol{\beta}_p \boldsymbol{x}_{pj} + \boldsymbol{\beta}_t \boldsymbol{x}_{tj} + \Sigma \boldsymbol{\beta}_s \boldsymbol{x}_{sj} + \varepsilon_j$, where x_{pj} refers to the travel cost (TC) attribute for alternative j, x_{tj} the travel time (TT), x_{sj} represent the socioeconomic characteristics, β is the associated utility parameter, and ε_j is the unobservable random utility component that is IID extreme value. A VOT indicator, also viewed as the WTP for a unit reduction in travel time, can be computed from the ratio of the attribute coefficient to the cost coefficient. A standard MNL model is estimated first, with linear utility function for each alternative. Since tastes and perception varies for each individual, MXL models are likewise estimated, with mixing distributions, normal and lognormal density having mean b and standard deviation σ.

Two MXL models[10] are shown and compared with the MNL model. The estimation result is presented in Table 2. The explanatory variables can be grouped as: alternative specific constants (ASC), socio-demographics, and main (TC, TT) variables. The referent alternative is C alternative. Socio-demographic characteristics (SDC) do not vary across choices. They can enter the model if they are specified in ways that create differences in utility over alternatives. In general, it means that the only parameters that can be estimated (e.g. are identified) are those that capture differences across alternatives. The variables are described below. TC and TT variables are specified as generic variables. The coefficients are shown with the expected sign and are significant. It confirms the disutility associated with time and cost increases. Among the SDC, HHsize, specific to C alternative, and Age, specific to rail chains, proved to be significant. Other socioeconomic variables proved to be insignificant and were left out. Also, the MXL models improve the LL and LL ratio index. TT coefficient is specified to be normally (MXL-*N*) and lognormally (MXL-*L*) distributed. Both models reject the MNL at high significance level. Note that standard deviation (TT_s) for both models is significantly different from zero, heterogeneity that standard logit cannot capture. Overall, the parameter estimates of these 2 (MXL) models shown are somewhat similar. The key difference between them, with density distributions as aforementioned, lies in the value of its "spread" as given by TT_s. This value has an important meaning for VTTS. Heterogeneity is revealed looking at the significant t-test value. This is the gain in using MXL formulations, over fixed parameter approach.

It is of primary interest to see the VTTS (PhP/min) defined as WTP for TT reductions. We now turn to TC and TT coefficients. Significant differences can be seen from the result. MXL models treat TT as random parameter. Two values are given: mean and standard deviation (TT_s). Different number of (Halton) draws (i.e. from 25 to 1000) was performed and the parameter values were observed to stabilize at about 200 draws. Table 3 summarizes the VTTS data output, with calculated TT savings. MXL models reveal that total TT savings falls within 18% to 23% more than MNL estimates. These are significant increases that are difficult to ignore. Kernel density estimates (smoothened histograms) for MXL models are shown in Figure 3, based on the population moments of the estimation sample. Looking at *MXL-N*, positive values of the MU of time account for less than 5% of the sample. More than 60% of the travelers have WTP more than the fixed-parameter model. Likewise, *MXL-L* model estimates this at 50% more, as shown in the third column of Table 3, where N is the number of travelers. The last column presents TT savings valuation, which reveals the highest value, being the *MXL-L* model. Respective strengths and weaknesses of various distributions are discussed in detail by Hensher/Train/Bierlaire, to name a few. The message here is clear: heterogeneity must be accounted for in time valuation studies in developing cities. Ignoring this would risk getting lower estimates of WTP as revealed.

(3) Competition in the market

Given the PT system characteristics and some issues quite unique for each developing city, it is therefore crucial to consider these intricacies. The situation is such that infrastructure development (e.g. road expansion) simply just cannot cope with the trend in urbanization. Now, with the governments' plan to build new PT systems (e.g. rail) along major links, in direct competition with the current system, how would the existing modes interact with the new systems? It is believed that developing cities, having limited options and resources as to placement and timing of PT system provision, will eventually have to face such predicament sooner or later. Developed cities, in the first place, never had to contend with such numerous PT modes upon implementation of their new PT system.

Table 2: Model Estimation result

Var	*MNL* Par. Est	T-stat	*MXL-N* Par. Est.	T-stat	*MXL-L* Par. Est.	T-stat
ASC						
R	-3.696	-20.5	-3.908	-19.5	-4.070	-18.94
J	-1.956	-11.8	-1.989	-11.1	-1.987	-10.75
B	-3.206	-17.2	-3.317	-16.6	-3.371	-16.50
JR	-2.263	-13.2	-2.388	-12.8	-2.449	-12.77
BRJ	-1.412	-5.77	-1.539	-5.91	-1.587	-6.01
JB	-1.829	-10.0	-1.914	-9.75	-1.937	-9.68
JRTc	-1.284	-6.76	-1.380	-6.72	-1.407	-6.74
TcR	-2.521	-13.5	-2.656	-13.2	-2.707	-13.18
TcJ	-2.536	-15.4	-2.594	-14.6	-2.610	-14.30
TcB	-1.768	-8.09	-1.940	-8.19	-2.021	-8.41
BR	-0.876	-3.76	-1.078	-4.25	-1.182	-4.55
JBTc	-0.982	-4.40	-1.110	-4.58	-1.151	-4.70
SDC						
HHsize	-0.273	8.66	-0.299	-8.63	-0.311	-8.63
Age	-0.013	6.74	-0.013	-6.54	-0.013	-6.39
TC	-0.0492	-10.5	-0.0461	-8.88	-0.0443	-8.43
TT	-0.0591	-18.4	-0.0650	-16.8	-0.0652	-39.00
TT_s		--	0.0322	6.30	0.0346	3.88
VTTS	1.201		1.414		1.471	
LL(0)	-11,870		-11,870		-11,870	
LL(β)	-10,189		-10,180		-10,174	
N	9,581		9,581		9,581	
chi^2,DF	--		(18,1)		(30,1)	
ρ^2	0.1417		0.1424		0.1429	

Table 3: VTTS of models

Model	**VTTS** (mean)	**N > MNL est. (%)**	**Tot TT Sav.** (PhP/min)
MNL	1.201	--	11,506
MXL-N	1.414	62	13,647
MXL-L	1.471	50	14,081

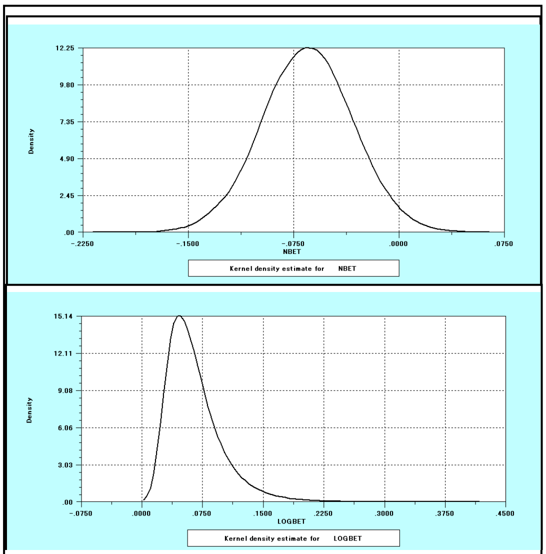

Figure 3: Normal/Lognormal density

Having said this, the next question might be raised: will it be right for governments to simply allow the competitive market to decide on the outcome, or some form of regulation and control must be put in place so that the government's interest will be protected? If such competitive market is allowed to take its natural course, or, on the other end, competition be eliminated in the sense that coordinated operation takes precedence, what are the benefits and costs from the perspective of various stakeholders? These are considered as important concerns which need further research. Developing cities, due mainly to financial constraints, have almost always been put in a position where motorization is rapidly increasing, prior to the development of the necessary PT system infrastructures. It becomes a vicious cycle wherein PT utilization eventually suffers from low ridership and poor cost recovery. Salient points and characteristics have been raised in forecasting PT system in developing cities. These are important considerations that must be accounted for, in one way or another, to improve analysis and forecasts reliability.

References

1) Morichi, S.: Long-term Strategy for Transport System in Asian Megacities, Journal of EASTS, Vol. 6, pp. 1-22, 2005.

2) Rietveld, P., et al.: Coping with unreliability in PT chains: A case study for Netherlands, Transportation Research A, vol. 35, pp. 539-559, 2001.

3) Walle, S., and Steenberghen, T.: Space and time related determinants of public transport use in trip chains, Transportation Research Part A, vol. 40, pp. 151-162, 2005.

4) Hensher, D., Reyes, A.: Trip chaining as a barrier to the propensity to use public transport, Transportation, Vol. 27, 341-361, 2000.

5) Vickerman, R.: Evaluation methodologies for transport projects in the UK, Transport Policy 7, pp. 7-16, 2000.

6) Fosgerau, M.: Investigating the Distribution of the Value of Travel Time Savings, Transport Policy B, Vol. 7, pp. 688-707, 2006.

7) Blayac, T. and Causse, A.: Value of travel time: a theoretical legitimization of some nonlinear representative utility in discrete choice models, Transportation Research B, Vol.35, pp.391-400, 2001

8) Nakamura, H.: The Economic Evaluation of Transport Infrastructure: Needs for International Comparisons, Transport Policy 7, pp. 3-6, 2000.

9) Train, K.: Discrete Choice Methods with Simulation, Cambridge University Press, Cambridge, U.K., 2003.