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ANALYSIS OF BEHAVIOURAL VALUE OF TRAVEL ATTRIBUTES AND THEIR IMPLICATIONS ON URBAN TRANSPORT POLICIES

Md. Jobair Bin Alam [1], Masum Ahmed Jaigirdar [2] and M. Habibur Rahman[1]

ABSTRACT: For the planning and development of a new transportation system, it is important to know users' willingness to pay (or behavioural values) to get benefits of various travel attributes. This paper focuses on estimating behavioural values of travel time savings, reduction of in-vehicle congestion and introduction of in-vehicle air-condition facility which are the main features of newly introduced improved bus services like Premium Bus Service and BRTC City Service. This paper also deals with the values of these attributes for different socio-economic groups. The results of this study can be used for developing urban transport policies and for providing new transport systems as well as for making pricing decisions for these services.

KEYWORDS: Behavioural Value, Travel Attributes, Logit model.

INTRODUCTION

The transport problem of Dhaka City has already become very acute and expected to deteriorate in future. Severe congestion on urban roads and over-crowding of urban bus services during peak hours have become very common phenomena. Realising the severity of the problem, the Government of Bangladesh has taken several steps that include introduction of improved bus service in the city. Although introduced in a small number, the new service has become very popular. Usually, the pricing and other financial decisions, like tax benefits provided to this kind of public facility, of these services are determined from supply side in Bangladesh. As the government is trying to privatise public transportation, it is essential to determine the prices from demand side also. To do so, it is required to know the behavioural value of different travel attributes such as time, in-vehicle congestion, in-vehicle air-conditioning etc. The behavioural values of these attributes provide information about the users' willingness to pay to get these benefits. Using this information, decision-makers can make policies regarding facilities to be provided. It also helps the decision-makers to make pricing decisions, analyse the impact of different pricing policies on the

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[1] Department of Civil Engineering, BUET, Dhaka-1000, Bangladesh.

[2] Department of Environmental Engineering and Pollution Control, Shahjalal University of Science & Technology, Sylhet, Bangladesh.

demand of these services, take decisions on tax benefits required for making these services operational and perform cost benefit analysis as well as sensitivity analysis.

Value of time (VOT) is a key concept in transport planning in terms of mode choice decisions of the users, economic evaluation of travel time savings and relative importance of time in transportation models. It can provide information on expected return of the introduction of faster services. Although time savings constitute a major portion of the benefits of transportation projects in developed countries, it is usually overlooked in developing countries (Thomas, 1977). Howe (1976) argues that there is no reason to do so and suggests that evaluation of time savings should be included in all aspects of transportation planning in these countries.

In-vehicle congestion or overcrowding in urban buses is very severe in Dhaka City. Usually, this congested situation discourages people (especially old people, female, children and higher-middle class people) to use the bus services. People may like to pay increased fare for the services with guaranteed seat. Also, it is argued that the introduction of air-conditioned bus service may become highly popular even in countries like Bangladesh. For making decisions in these aspects, it is essential to assess users' willingness to pay for the services with reduced congestion and air-condition facilities.

The paper deals with the evaluation of these travel attributes and their variations among different socio-economic groups. The paper also presents the implication of these values on urban transport policies of Dhaka City.

METHODOLOGY

A standard procedure for deriving behavioural values of different travel attributes is to use the trade off ratio implied by the coefficients of cost and other variables estimated in mode choice models. Such a model usually assumes that the trade-off ratio remains constant for all the members of the population. To overcome the problem, market segmentation approach can be used by categorising the population among various segments depending on socio-economic variables (Ortuzar and Willumsen, 1990). Ben-Akiva and Lerman (1985) suggests that the problem of heterogeneity can be overcome by allowing the trade-off ratio to vary along various observed dimensions such as income and age. These approaches have been widely used to evaluate value of time in various countries (Bureau of Transport Economics, 1982). In this study the first approach is used because of its usefulness in the applications of developing policies for different groups. The same approach can be extended to evaluate travel attributes like in-vehicle congestion and air-conditioning with appropriate specification.

Model Structure

In disaggregate method for estimating travel choice model, it is assumed that for a given individual each of the alternative has a utility and the individual chooses the alternative from which he gets maximum utility. The utility function can be expressed in the following linear form,

$$U_i = V_i + \varepsilon_i = \alpha c_i + \beta t_i + \gamma' X_i + \varepsilon_i \tag{1}$$

Here, V_i is called indirect utility of i-th alternative and expressed as,

$$V_i = \alpha c_i + \beta t_i + \gamma' X_i$$

Assuming that ε is logistically distributed, the resulting probability of choosing alternative i is given by following expression (Ben-Akiva and Lerman, 1985).

$$\Pr(i) = \frac{\exp(\mu V_i)}{\sum_{k=1}^{m} \exp(\mu V_k)} \tag{2}$$

This model is known as Logit model that is widely used in transportation planning for its flexibility and scope. Here m is the number of alternatives available to the individual and μ is the scale parameter. Both the scale parameter and the parameters of the utility function can not be determined simultaneously from the model. Usually, it is assumed that the value of μ is 1 and this assumption does not change the relative importance of the parameters of the utility function.

The values of the parameters of the utility function can be calibrated by using 'Maximum Likelihood Method'.

Variables and Their Measurement

The variables considered in the model include fare (c), time (t), in-vehicle congestion (LF) and existence of air-condition in the vehicle (AC). The fare and time considered in the analysis included access cost and time. In the Stated Preference experiments the values of the variables were kept similar to the values experienced by the respondents in their daily trips. In-vehicle congestion was measured by load-factor (that is, number of passenger in the vehicle divided by the number of seats). Existence of air-conditions in the vehicle was included in the model in the form of dummy variable. If air-condition facility exists, the value of the dummy variable become 1, otherwise it is 0. The indirect utility function becomes,

$$V_i = \alpha c_i + \beta t_i + \gamma_{lf} LF + \gamma_{ac} AC \tag{3}$$

Estimation of the Value of Time and Other Attributes

From the calibrated coefficients of the utility function the value of time (VOT) and other attributes can be determined as the ratio of the coefficients of the variables. The average value of time for the population for which the model has been estimated is given by,

$$VOT\,, \quad V^{*} = \frac{\beta}{\alpha} \tag{4}$$

Equation (4) provides a point estimate of the value of time. As both α and β is assumed to be randomly distributed (which is assumed to be normal), the VOT will also be randomly distributed. Together with the point estimate given by equation (4) it may be useful to know the confidence interval of VOT for a given level of significance (Garrido and Ortuzar, 1993). This would allow specifying lower and upper bounds of VOT for the sensitivity analysis of costs and benefits of infrastructure projects.

The confidence interval can be built on the basis of *t*-statistics for the estimated VOT. The *t*-statistics for the estimated value of time is given below.

$$t = \frac{\beta - V\alpha}{\sqrt{Var\,(\beta - V\alpha)}} \tag{5}$$

Equation (5) can be rearranged to give the following expression,

$$V = V^{*}\left(\frac{t_c}{t_t}\right)\frac{1}{t^2 - t_c^2}\left[(\rho t^2 - t_t t_c) \pm \sqrt{(\rho t^2 - t_t t_c)^2 - (t^2 - t_c^2)(t^2 - t_t^2)}\right] \tag{6}$$

Where, t is the standard normal value for the required significance level, t_t and t_c are the *t*-statistics of time and cost variables, and ρ is the correlation coefficient. Using Equation (6) the upper and lower bounds of VOT at a given level of significance can be estimated.

Evaluation of in-vehicle congestion effect can be done similarly. The in-vehicle congestion can be measured by load factor. The willingness to pay for reducing in-vehicle congestion (or reducing load factor) can be estimated as follows,

The value of changing load factor by 1%, $$V_{LF} = \frac{\gamma_{lf}}{100\alpha} \tag{7}$$

The behavioural value of introducing air conditioning can be estimated as follows,

The value of providing air-condition in the vehicle, $$V_{AC} = \frac{\gamma_{ac}}{\alpha} \tag{8}$$

The upper and lower bounds of these values can be estimated in the same way as determined for the value of time.

DATA COLLECTION

The data used in the analysis had been collected for the study on environmental and socio-economic benefits of introducing improved bus service in Dhaka City. In the survey, 750 questionnaires were distributed and the response rate was 54.66 percent. The sample composed of 410 individuals who use various transport services for different trip purposes in the city. Each respondent gave a detailed account of his or her socio-economic condition as well as description of journey attributes including travel cost, travel time, trip purpose etc. The respondents were then asked to make a choice out of three options comprising different levels of the variables considered. Each respondent was asked to answer four such questions. The Stated Preference (SP) questionnaires were designed to measure the relative importance of four travel attributes: fare, travel time, in-vehicle congestion and air-conditioning. The basic statistics of the data is summarised in Table 1.

Table 1. Basic Statistics on the Collected Data

Variable	Group	Number of Respondent
Total respondent		410 (Male 322, Female 88)
Average age		33 Years
Average Income		7830 Taka per Month
Average Travel Time (per trip)		38.06 minutes
Average Travel Cost (per trip)		15.66 Taka
Income Groups	Less Than 3000/-	74
	3000-6000/-	115
	6000-10000/-	105
	More than 10000/-	116
Age	15-25 Years	76
	25-57 Years	322
	Above 57 Years	12

RESULTS OF THE ANALYSIS

The results of the analysis are presented in this section. Initially the results of the calibration procedure of the model are presented. Then, by using the estimated coefficients, the behavioural values of different attributes are presented.

Calibration of the Model

The 'Logit Model', described earlier, is calibrated using the collected data. Initially the model is calibrated with all the data pooled together. Using this model the average values of different travel attributes are estimated for the whole population. To estimate the same values for different socio-economic groups, market segmentation approach has been used. The calibration results of the model for whole population are presented in Table 2. It is observed that all the parameters of the model have expected sign and are acceptable at 5% level of significance. Also, the values of Likelihood Ratio Statistics (ρ^2) and Likelihood Index are highly significant. The results of the calibrated models for different socio-economic groups are used to calculate behavioral values of different travel attributes that have been mentioned earlier. For some of the groups, models could not be calibrated due to small sample size.

Table 2. Calibrated Coefficients of Logit Model

Variable	Estimated Coefficients	t- Statistics
Cost (c)	-0.1046	-13.06
Time (t)	-0.0386	-3.00
Load Factor (LF)	-3.8178	-11.38
Air-condition (AC)	0.8484	11.18
Number of Observer		410
Number of Valid Cases		1636
L(0)		-1797.33
L(β')		-1202.00
Percentage Correctly Predicted		61.92
Likelihood Ratio Statistics (ρ^2)		0.33
Likelihood Index [-2{L(0)- L(β')}]		1190.66 (df 4)

Value of Travel Attributes

The behavioral values of travel attributes can be calculated by using the estimated parameters shown in Table 2 and procedure described earlier. These values including their upper and lower limits calculated for 95% level of confidence are presented in Table 3. It is found that the average value of travel time savings for the population under study is Tk. 22.17 per hour. For 95% level of confidence, the upper and lower limits of VOT are Tk. 33.18 per hour and Tk. 8.68 per hour respectively. The VOT obtained in this study can be compared with the same obtained in DITS study that ranges between Tk. 3.60 to 17.70 per hour with an average of Tk. 7.02 per hour (DITS, 1993). The difference can be attributed to the characteristics of the population considered in the study. The present study deals with the people who use motorized vehicles for trip making rather than the whole population as dealt with in DITS study. For an average trip, the value of changing load factor by 1% is Tk. 0.365 (Tk. 0.041 per km) and the value of introducing air-condition in the vehicle is Tk. 8.11 (Tk. 0.91 per km).

Table 3. Value of Travel Attributes

Travel Attributes	Behavioural Value	Upper limit	Lower limit
Average Value of Time (Taka/hour)	22.17	33.18	8.68
Average Value of Changing Load Factor by 1% (Taka/km)	0.041	0.048	0.034
Average Value of Introducing Air-condition in the Vehicle (Taka/km)	0.91	1.14	0.72

Value of Travel Attributes for Different Socio-Economic Groups

This section presents behavioral values of the travel attributes described above for different socio-economic groups using market segmentation approach. For this purpose, the samples are categorized into different groups and the Logit model, using the utility function shown in Equation 3, is calibrated for each of the groups separately. The values of various attributes for different groups are presented in Table 3. It shows that value of travel time savings for female passenger is significantly higher than that of male passenger. VOT ranges between 60% of hourly income for low income people to 35% of the same for high-income people.

Table 4. Value of Travel Attributes for Different Groups

Market Segments	Behavioural Value of		
	Travel time savings (Taka/hour)	Changing load factor by 1% (Taka/km)	Introducing Air-condition in the vehicle (Taka/km)
Sex: Male	19.55	0.041	1.01
Female	30.94	0.040	0.61
Income:			
Less Than 3000/-	9.29	0.017	0.46
3000-6000/-	19.07	0.036	0.51
6000-10000/-	25.67	0.046	0.89
More than 10000/-	31.57	0.069	1.16
Age:			
15-25 Years	26.26	0.030	0.68
25-57 Years	24.42	0.042	0.95
Above 57 Years	12.29	0.046	0.46
Trip purpose:			
Commuting	24.77	0.036	0.77
Recreational	11.21	0.030	0.52
Business	29.07	0.104	2.45
Mode choice:			
Rickshaw	12.87	0.045	0.52
Babytaxi	36.11	0.094	0.77
Car	45.12	0.219	2.38
Ord. Bus/Minibus	18.76	0.010	0.14
Improved Bus	24.24	0.054	0.90

IMPLICATION OF THE RESULTS ON URBAN TRANSPORT POLICY

In view of the results presented in the earlier sections, several points need to be explained in detail. The implications of these points on urban transport policies are also very important. These are illustrated in this section.

(i) Value of time for female passengers (Table 4) are much higher than that of male passengers. This can be attributed to the fact that due to social and cultural reasons it is rather cumbersome for female passengers to use cheaper alternatives like ordinary bus or tempo. Whenever affordable they prefer to use costlier mode like babytaxi. It implies that for female passengers special services (like female only service) during peak hour may be economically feasible.

(ii) High behavioural value of travel time savings (Table 4) suggests that faster services like non-stop bus service and bus priority lane may be economically feasible. On the basis of the results presented above, it is estimated that for an increase in the average speed by 25% (assuming that present average speed is 14 km per hour during peak hour) the fare may increase by about 11% which is shown in Figure 1. The figure also illustrates that the user's willingness to pay increases linearly up to the average speed of 22 km/hr after which the rate of increase reduces significantly. It implies that an average speed of about 22 km/hr will satisfy most of the urban transport users. In this regard it is worthy to mention the importance of reducing access and waiting time. Usually the values of these are much higher than the value of in-vehicle travel time savings.

(iii) Availability of seat is very important and highly valued by the passengers. The value of Tk. 0.041 per km (Table 3) for changing load factor by 1% implies that an ordinary bus or minibus (in which load factor is about 1.4) can demand about Tk. 0.65 per passenger per km if it guarantees the availability of seat. For the users of babytaxi and cars, availability of seat is even more important and valued at much higher rate.

(iv) For in-vehicle air condition service, the average willingness to pay is Tk. 0.91 per km (Table 4) that is about 50% of the cost of providing the service. It suggests that this service for average passenger is not economically feasible. But, in the case of higher income people, business travellers and car users the provision of this service will pay off.

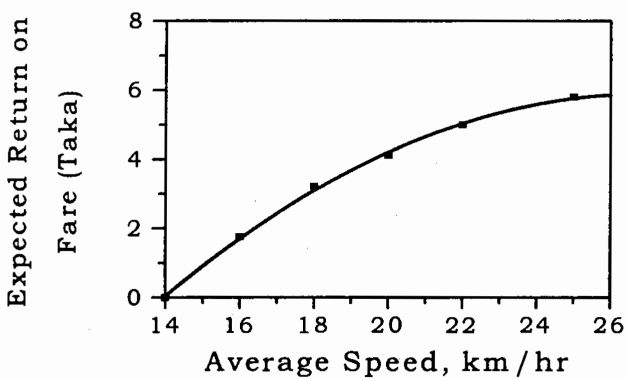

Fig 1. Effect of Network Speed on Bus Fare

CONCLUSION

Behavioural values of travel attributes are highly valuable for the planning and implementation of transport systems. Its importance increases further when transport services are provided by private agencies to make decisions on pricing and tax rebates. This paper deals with the behavioural values of travel time savings, in-vehicle congestion reduction and introduction of in-vehicle air-condition service. It is observed that faster mass transits and services with guaranteed availability of seats may be economically justifiable in Dhaka City. In-vehicle air-condition service may not be economically feasible for the average passengers. But, among the higher income people, business travellers and car users the provision this service is very popular and feasible.

The results of this study can be used in transportation demand forecasting, cost-benefit analysis of transportation investments and pricing decisions.

Although this study covers several important aspects, a couple of other issues are yet to be studied which include the effects of frequency of service as well as access and waiting time. Market segmentation approach may be extended further to include other socio-economic groups to have a better representation of the behaviour of the users.

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NOTATION

U_i	Utility of the *i*-th alternative
V_i	Utility of the systematic components
ε_i	Random error term
c_i	Cost of *i*-th alternative
t_i	Travel time of *i*-th alternative
X_i	Vector of attributes
α- γ	Parameters