Modeling performance of waterway

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Abstract— **In this paper, a Binary Logit model has been developed to evaluate the prospect of waterway in Sylhet city. Data has been collected from the commuters of Tuker Bazar to Bandar Bazar route. Stated Preference (SP) survey method was used and in hypothetical scenarios, river boat with different level of service in terms of boat size, security system, travel time, travel cost etc. was presented to the commuters keeping roadway same as now. Model output shows that travel cost, travel time, boat frequency, comfort, safety, boat capacity and stoppage number control the choice of waterway as well as respondents socio-economic characteristics have great influence on their travel route choice. The developed models provide useful insights and helpful for the policy makers that can lead to minimize traffic congestion by motiving people to waterway.**

Keywords— route choice model, binary logit, SP survey, BIOGEME.

I. Introduction

Traffic congestion is a very far-famed problem in Bangladesh which becomes grievous in the capital city Dhaka leading to other major cities in Bangladesh like Sylhet. Sylhet is the fifth populous city of the country with a population more than 0.9 million and an area of only 26.5 km2, whereas the population growth rate is the highest (2.1%) in the Bangladesh [3].

Without any proper plan, development activities are going on leaving insufficient road network. Unauthorized on road and road side activities, motorized and non-motorized vehicle mixture, low capacity intersections, lack of transportation management etc. creates huge traffic congestion in major roads of Sylhet city nowadays. Tuker Bazar to Bandar Bazar route is one of the busiest and congested roads in this city [12]. It becomes almost impossible to further widening the road network to increase the roadway capacity due to roadside activities as well as considering physical scenario and cost efficiency, infrastructure like fly over, expressway is also tough considering. So, using Surma River, waterway can be an alternative and effective route to minimize travel demand of the existing roadway to travel from Bandar Bazar to Tuker Bazar and vice versa..

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II. Literature Review

Reference [2] developed a binary logit model to estimate respondents' choice to accept or reject an ATIS advice. Reference [8] specified a route choice model featuring a modification of the MNL model, which penalizes the utility function in the standard MNL by a commonality factor. Reference [1] estimated two route choice models; first, five hypothetical binary choice sets were used collected by a computer-aided telephone interview to determine how travel time variation affects route choice and second, three binary route choice SP scenarios were used collected by a mail survey to investigate the potential effect of advanced traveler information systems on route choice.

Commuters' diversion and return behavior varied with their personal characteristics [14]-[22] and user knowledge of the network and the available paths [19]. It was established from the literature that, socio-economic characteristics [10]-[16]-[18]-[20], numbers of stops [11]-[15]-[19], traffic incident and congestion information [9]-[17]-[19]-[20] are the most important in influencing subjects' in route decisions. Travel time [6]-[9]-[11]-[13]-[18]-[17]-[19] was the best factor in explaining route choices, followed by travel speed, distance [19]. Safety [16]-[17]-[19] and environmental characteristics have a good influence on route choice decisions. Travel cost [4]-[5]-[7]-[16]-[17], frequency [7]-[11], degree of uncertainty [17]-[21] had found as influential in decision making. Crime level, Traffic conditions on the road or availability of traffic mode [20], Roadway capacity or road width [9] or road quality [19], number of intersections or traffic-light regulated intersections [19], traffic lights, accident probability, signal etc. may have influence in route choice

III. Methodology

Modeling performance of the waterway in hypothetical scenario has been assessed by using route choice attributes for Tuker Bazar to Bandar Bazar route considering waterway as SP choice which has three link roads that are used mainly to travel which are via Police line road, Medical road and Amberkhana (Figure 1). Firstly, an initial survey was conducted in order to identify the variables that are playing major role in the choice of route. Profiles of all choice attributes identified from initial survey have been generated using partial factorial design by statistical software SPSS (Statistical Package for the Social Science). Three SP scenarios on route choice have been presented to each respondent and choice set has been generated randomly to ensure the distinct profile in each scenario. The respondents have been asked about their socio economic characteristics, current traveling route, their choice of mode and choice of route behind these SP scenarios. Data have been collected from the general people, local residents and people of various professions who frequently use this route. With the help of

BlOGEME (Bierlaire's Optimization Toolbox for GEV Model Estimation) software, a Binary Logit model has been developed with the significant attributes using maximum likelihood estimation (MLE) technique. Different model specifications are tested and the best model is selected based on statistical tests, probability values and overall goodness-of-fit measure.
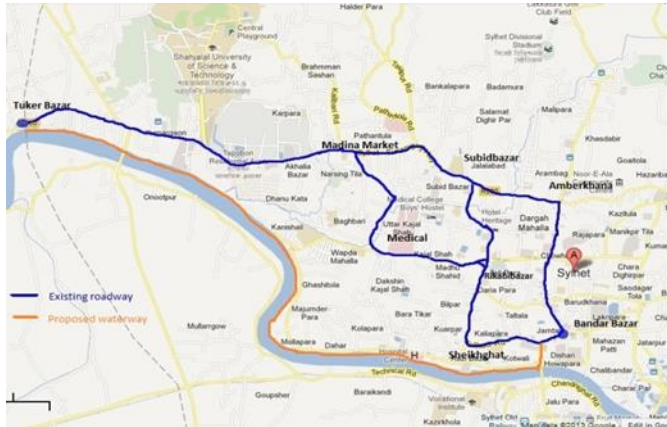

Figure 1. Study area (Source: http://maps.google.com/).

IV. Data Analysis

Preliminary survey shows that, Police line road is most preferable followed by Medical road and Amberkhana. The major causes leading the present choice of the respondents are summarized as Travel time, Travel cost, Congestion, Road width, Road condition, Comfort, Safety, Accident probability, Availability of modes, Number of intersections, Number of turns and Easy transportation of goods. Travel time and roadway condition are found as main effective parameters followed by travel cost, jam, comfort, safety, availability of modes etc.

It was found from final survey that 44% respondents choose waterway in hypothetical scenario (Figure 2). Around half of the respondents (54%) are between the age ranges 21 to 30 years. Figure 3 shows the age distribution and choice percentage with respect to age range. Male respondents are more likely to waterway (44%) than female (43%), shown in Figure 4. 53% respondents were found unmarried and 41% of them choose roadway in hypothetical scenario (Figure 5).
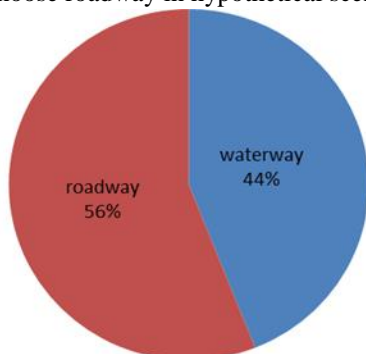

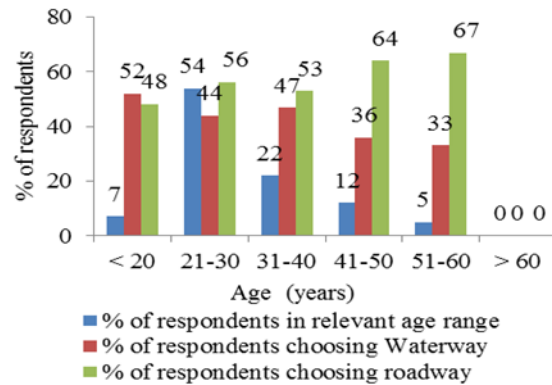Figure 2. Percentage of choosing route in SP scenario

Figure 3. Percentage behind choosing route with respect to age range of the respondents
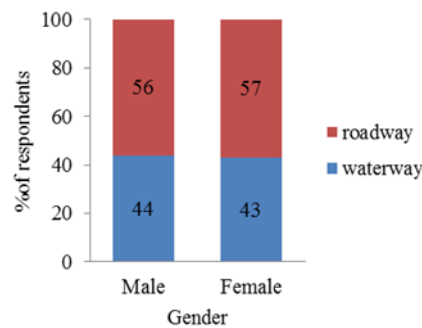

Figure 4. Percentage behind choosing route with respect to respondent's gender
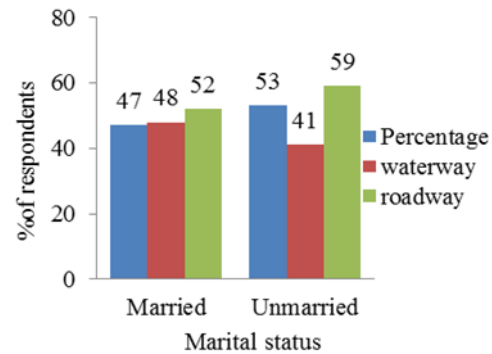

Figure 5. Percentage behind choosing route with respect to respondent's marital status

Police line road is found as the most dominant travel route (74%). Profession, car ownership, monthly income etc. are also important in commuters' route choice decision. 40% people choose waterway in hypothetical scenario though having private vehicles.

V. Estimation of Model

Waterway and roadway are considered as dependent variable and commuters socio-economic characteristics (age, gender, income, marital status, car ownership etc.), travel time, travel cost, frequency, comfort, mode capacity, stoppage, weather condition, safety are considered as independent variable in this model. The priori hypotheses regarding

different variables that may have significant impact on choice model are illustrated in Table 1.

TABLE I. ASSUMPTIONS OF THE ATTRIBUTES FOR MODEL

Attributes	relationship and assumptions
Age	Peoples less than or equal to 40 years are more likely to choose waterway for the cost and time facilities. Respondents of age range above 40 years may have strong affinity to travel in roadway for the easy travel, safety and being over aged.
Profession	This variable is supposed to be somewhat correlated with monthly income, and highly educated white-collar employees and high level businessman are likely to have higher propensities of having choice sets with individual modes in roadway.
Gender	Due to social norms and culture female passengers do not feel free to share transit vehicles especially in congested situation and also try to avoid waterway, as well as public transit due to safety concerns.
Marital status	Married people prefer private transport (e.g. CNG, Rickshaw) in roadway, when they travel with their spouses. Therefore waterway public transport may be ignored by them.
Monthly income	Due to considerable disparity in monthly income, monthly income is supposed to play a vital role in the determination of the choice set of the individual, the propensity of having choice sets with waterway increasing with income and with roadway decreasing with income.
Car/ motor cycle ownership	Respondents having cars or motor cycles are more likely to travel with roadway. One of the reasons might be their flexibility to use private vehicle to go to anywhere.
Travel time	People's sensitivity to travel time is supposed to play an important role in passengers' route choice and may vary in different routes. Increase in travel time may create disutility to waterway.
Travel cost	Fare sensitivity is supposed to play also a vital role. Decrease in travel cost may enhance the utility of waterway route choice.
Frequency	Frequency of travel mode in waterway may be highly influential with the choice set of trip makers. Increase in frequency of travel mode in waterway may have positive impact for the waterway route choice.
Boat capacity	People may have a strong affinity to use small boats for more comfort and privacy; at the same time people may have a strong affinity to travel in big boats too for safety consideration.
Comfort	People are more likely to use waterway because of being smooth and congestion free than roadway.
Stoppage	Peoples may have strong affinity to use the waterway route from wharf to wharf.
Weather condition	Bad weather or rainy season may have negative effect for choosing waterway by the peoples to travel.
Safety	Boat without life jacket may reduce the utility of waterway, because people, who don't know swimming, may have repulsion for choosing waterway.

Assuming waterway as base, alternate specific constant (ASC) of waterway and roadway are measured. The model is estimated with generic travel time and travel cost at the beginning. Then frequency of mode is added as additional variables. Stoppage, comfort, capacity, safety, weather condition and socio-economic characteristics are also added as dummy variables and remain or rejected from the model by specifications test. In addition, the Revealed Preferences (RP) for route choices are included as dummy variables and found to be significantly increasing the goodness of fit. Explanations of dummy variables are given in Table 2.

TABLE II. EXPLANATION OF DUMMY VARIABLES

Variable		Description
stoppage_dummy	1	having two stoppage at least
	0	having no stoppage
safety_dummy	1	including full life support
	0	without life support
comfort_dummy	1	more comfortable than roadway
	0	same as now
capacity_dummy	1	for small (20 passengers) and big (40 passengers) boat
	0	for all other boats
age_dummy	1	for the respondents less than or equal to 40 years of old
	0	for the respondents more than 40 years of old
sex_dummy	1	for male respondents
	0	for female respondents
pcar_dummy	1	respondents having private car or motorcycle
	0	respondents do not have any private car or motor cycle
income_dummy	1	respondents monthly income less than 30,000 taka
	0	respondents monthly income over than 30,000 taka
weather_dummy	1	sunny day or summer season
	0	rainy day or rainy season
mstatus_dummy	1	for married respondents
	0	for unmarried respondents

The general forms of utility functions are presented below:

$V_{waterway} = \beta_{tt\_waterway} * w\_tt + \beta_{tc\_waterway} * w\_tc + \beta_{frequency\_waterway} * w\_freq + \beta_{stoppage\_waterway} * stoppage\_dummy + \beta_{safety\_waterway} * safety\_dummy + \beta_{comfort\_waterway} * comfort\_dummy + \beta_{capacity\_waterway} * capacity\_dummy + \beta_{age} * age\_dummy$

$V_{roadway} = ASC_{roadway} * one + \beta_{tt\_roadway} * tb\_ttime + \beta_{tc\_roadway} * tb\_tcost + \beta_{sex} * sex\_dummy + \beta_{mstatus} * mstatus\_dummy$

The betas (β) refer to the sensitivity associated with each variable. The subscripts of betas (β) refer to corresponding variables where tt and tc indicates travel time and travel cost respectively. In variables, tb means Tuker Bazar to Bandar Bazar road.

Coefficients of the utility functions (β) have been estimated using maximum likelihood approach (MLE). Software BIOGEME (Bierlaire's Optimization Toolbox for GEV Model Estimation) is used in this regard. Model outputs with sign, magnitude, t-test and p-value in parenthesis are presented in Table 3.

TABLE III. MODEL RESULTS

Number of estimated parameters:	13	
Number of observations:	300	
Initial log-likelihood:	-207.944	
Final log-likelihood:	-163.530	
Adjusted rho-square:	0.151	
Utility parameters	**Value (t-test)**	**p-value**
ASC for roadway, $ASC_{roadway}$	-0.625 (-0.55)	0.58
Coefficient of travel cost in roadway, $\beta_{tc\_roadway}$	-0.0426 (-1.54)	0.12
Coefficient of travel cost in waterway, $\beta_{tc\_waterway}$	-0.162 (-6.14)	0.00
Coefficient of travel time in roadway, $\beta_{tt\_roadway}$	-0.0397 (-1.25)	0.21
Coefficient of travel time in waterway, $\beta_{tt\_waterway}$	-0.0446 (-1.89)	0.06
Coefficient of frequency in waterway,	-0.0639 (-2.53)	0.01

$\beta_{frequency\_waterway}$			
Coefficient of comfort in waterway, $\beta_{comfort\_waterway}$	1.41	(4.87)	0.00
Coefficient of mode capacity, $\beta_{capacity\_waterway}$	0.342	(1.04)	0.30
Coefficient of stoppage in waterway, $\beta_{stoppage\_waterway}$	0.523	(1.60)	0.11
Coefficient of safety in waterway, $\beta_{safety\_waterway}$	0.823	(2.58)	0.01
Coefficient of age dummy, β_{age}	0.624	(1.49)	0.14
Coefficient of gender dummy, β_{sex}	-0.681	(-1.56)	0.12
Coefficient of marital status, $\beta_{mstatus}$	0.492	(1.57)	0.12

.All the variables have given expected sign and found statistically significant. The results indicate that if all things remaining the same, the roadway have the smallest probability (negative ASC value) of being included in the choice set. Therefore waterway has the highest value of alternative specific constant (ASC) by assuming this fixed at the beginning of estimation.

Coefficients of frequency, travel cost, travel time for the waterway is very significant as hypothesized for public and the negative sign indicates that, the utility of waterway increases with the increase the mode frequency and reduction of fare and duration.

The dummy term comfort, safety indicates that people have significantly high likelihood to travel in waterway. The positive value implies the increase in utility with increased comfort and safety in waterway traveling. The sign and coefficient of mode capacity indicates that, the respondents have positive responses for small and large boat as hypothesized before. A positive coefficient of stoppage causes the increasing of utility in waterway when at least two stoppages are present as hypothesized. These variables are insignificant under t-statistics but fairly significant under p-value and strong hypotheses.

Socio-economic characteristics have amalgamated effect on the respondents' choice of route. Age dummy, gender dummy and marital status coefficient have found as insignificant variable under t-statistics but partially significant under p-value. These values do not impede the goodness of fit of the model and did not discarded for having strong hypotheses as described before. The gender dummy gives negative sign because of using in roadway utility equation that means the utility of roadway decreases with male respondent.

The weather condition dummy, monthly income dummy and car ownership dummy are insignificant for the model. They give wrong sign and make interruptions for the best fitted model. Therefore, these two variables discarded from the model.

VI. **Conclusion**

A route choice model between waterway and roadway in advanced discrete choice modeling techniques which was impossible to discern and the results can be a guideline for the decision maker to promote waterway use to reduce commute trip from roadway for the reduction of traffic congestion.

Binary Logit model was used for estimating the utility of roadway and waterway. The influential parameters and level of services for final Stated Preference (SP) survey which data are used to develop the model have been found from preliminary survey. It was observed from the model output that young aged people have strong affinity to travel in waterway. Male and unmarried people are more likely in waterway traveling. Reduced travel cost and travel time, safety, comfort and frequency are important factor for increasing people's utility in waterway.

Sample size has been considered very small as compared to target population due to the time and budge constrain. Difficulties have been faced during data collection due to the non-cooperative attitude of the respondents, which because, travelers cannot rely on prior experience and knowledge on future traffic conditions..

Data can be collected by more detailed survey in future study and model can be improved by combining RP choice with SP ones as well as A nested logit can be developed between existing roadways and waterway. A RP based route choice model can be also developed between existing routes.

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