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EXPLORATION OF MODE CHOICE BEHAVIOR FOR REGULAR AND SHORT DISTANCE TRAVEL IN A DEVELOPING COUNTRY

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ABSTRACT

The study of mode choice behaviour is receiving a considerable interest in Bangladesh like in other developing countries. Hence, a questionnaire survey of 514 citizens in Chittagong city was conducted to explore mode choice behaviour for short distance and regular travel. Multinomial Logit Model (MNL) was used to assess the factors involved for various mode choices. Gender, age, profession, education, level of income, household type, vehicle ownership, and distance to a stopping spot all seem to be factors that have been found to be important for short-distance and regular travel using the MNL model according to a utility function. The major findings indicates that the majority of the people prefer the bus both for short and regular distance travel, whereas high earners choose the cars for regular travel.

Keywords: *Mode choice, Short distance travel, Multinomial logit model, Regular travel.*

1. INTRODUCTION

The travel mode choice behavior can be defined as the process by which travelers select their mode of transportation, with travel decisions commonly modeled to understand and predict these choices (Al Momin et al., 2022, Hadiuzzaman et al., 2019). In a developing country like Bangladesh, there are different modes in the transportation available for passengers. People are going out for their various works and they use different modes while traveling from one place to another place. The primary goal of mode choice behavior study is to asses the attribuiting factors involved for various mode. However, it is important to define the reasons for choosing one mode of transportation over another for understanding travel mode choice behavior in every area (Senikidou et al., 2022).

At the present time transport is a major issue in Bangladesh's big cities and the transportation systems have a greatest impact on mobility, economic progress, environmental quality, government financing, and quality of life. For this reason, it's need to determine which mode the passengers can use more easily or conveniently. To keep the financial activities constant, a well and sustainable plan is needed to increase transport infrastructure and services at a fair cost with little environmental impact. However, several studies in the literature show that it is essential to analyze daily travel by taking into account not only citizens (Arman et al., 2018) but also commuters (Ababio-Donkor et al., 2020). In Chittagong city, people travel their space of interest for other purposes like business, working, purchases, and so on. From this perspective, it is need to identify which mode is convenient for travellers for short distance travel of regular travel.

In a developing country, improving regular and short-distance travel is quite difficult compared to a developed country. Bangladesh has a high rate of population and high rate of road accidents due to inadequate transportation and management systems. Mode choice of people of transportation in Bangladesh vary depending on their age, gender, income, travel reasons, distance and time. Travel mode choice is the most important part of implementing regular and short-distance travel. The unclear road makes it difficult to know what route to take to get to the pedestrian's destination safely. Recent studies highlighted the need to support commuting by defining a customized route planner, in which soft measures are practical to influence the plans for each person's travel habits (Esztergár-Kiss et al., 2021).

Since Chittagong is the second biggest region of Bangladesh, there are traveller attribute, destination accessibility as well as psychological boundaries acts as attributing factors of mode choice which make the study more difficult. Overall, in order to reflect user preferences, a utility function that takes into account four different modes of

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transportation—walking, biking, taking public transportation, and driving—was developed and connected to four different characteristics: travel time, transport costs, impact on the environment, and health impact. In order to find a viable solution, it is important to understand how modes are defined. One of the main reason to choose Chittagong as a study region because Chittagong is a second biggest region of Bangladesh and the country's busiest seaport, as well as a business centre (Moeckel et al., 2014). In São Carlos (SP, Brazil) for travel mode choice used Kriging Geostatistical Method (Ordinary Kriging and Indicator Kriging) for determining travel mode choice on personal motor vehicles and other vehicles. Since Bangladesh is developing country, in most cases the transportation system in Bangladesh subsumes both motorized and non-motorized vehicles. Various kinds of transportation, including as rickshaws, auto-rickshaws (known as CNGs, which abbreviated in Natural Compressed Gas), normal taxicabs, easy cycles, bus, automobile, tempo, and people carrier, operate within and beyond Chittagong city (Ahmed et al., 2023). Which greatly differ from developed and other developing countries. Over the past several years, a substantial share of people's mode choice has evolved for an urban area, with a concentration on short-distance and regular travel. Short-distance traveling seems to be more common among people. The short-distance travel formed when people are often going to work, office, markets, and so on. Short-distance use of transit is dominated by commuters. The mode choice of the people for regular travel discord on theirs distance and household income(Hossain et al., 2021b).

Since mode is a mobile element of transportation, as a result, examining mode choice selections in large cities like Chittagong could be a viable transportation planning option.

The contributions of the paper are:

- Exploring the mode choice behaviour in an industrial zone of a developing country.
- Compare the mode choice behaviour considering regular and short distance travel using statistical models.
- Exploring the effect of demographic and trip characteristics on different mode choice behaviour.

2. LITERATURE REVIEW

Analytical approaches used to study mode choice behaviour have been many and varied, in acknowledgement of the multi-faceted aspects of transportation decisions. The (Zenina and Borisov, 2012) used the learning trees discriminant analysis, and the MNL models to examine the choice mode where (Shen, 2009) contrasted the LCM and the MLM models and found that the LCM models provided an overall better fit in terms of time savings, direct choice elasticity and the choice probability. Asian case studies provide further insights: Several studies, including the one conducted by (Chee and Fernandez, 2013) on Beijing, revealed that factors that influence short distance travel include age, household income and car ownership. In Chittagong, Bangladesh, use of paratransit is relatively common among the population (Ahmed et al., 2023), and for the similar population in Dhaka, vehicle ownership, financial capital and licenses for operating a motor vehicle are significant factors (Hanif et al., 2019). (Liu et al., 2019) realized that age was the key factor influencing the use of the mode through the nest logit model. Similarly, (Bhaduri et al., 2020) also researched the mode choice in India by employing the method called extreme value discrete choice model (MDCEV) and there were changes observed in the pre-COVID period and early COVID time. All the above-mentioned papers together draw attention towards different socioeconomic, demography and contextual factors influencing mode choice behaviour.

Research on mode choice behaviour for short-distance (2-5 km) and regular-distance (over 5 km) travel reveals distinct influencing factors for each travel type (Hossain et al., 2021). Whereas, the aspects like convenience, affordability of transport, and the accessibility of transportation are integral when traveling short distances like business, shopping, school, or work (Ahmed et al., 2024). It is shown that mode choice is dependent on age, income, and car ownership; and therefore, the findings suggest that those who have a higher income and are older are more likely to use cars, while younger persons and those with less income are likely to adopt walking, cycling, and public transport (Tahsin, 2018). The existing place setting and physical facilities, including walk and cycle ways also help to enhance active transport. Furthermore, it includes psychological factors known as perceived control safety and environmental factors. Such, there are paratransit, a highly used transport means in Chittagong city of Bangladesh, clearly pointing to the various Asian short-distance travel characters (Siraj et al., 2021). On the other hand, business-distance travel relates to the travel done for business purposes and is more focused on finding the shortest time and the costs required and more focused on the quality of the public transportation and the owning of vehicles (Cheng et al., 2019). Research has also revealed that ready and inexpensive populace transport reinforces its application characteristically for longer distances; additionally, employer-provided encouragement also plays an influential role in modality selection (Sheikh et al., 2006).

Several studies have also highlighted that before and during the pandemic there were important variations in travel intention, mode of transport, distance travelled and recurrence (Abdullah et al., 2020, Anwari et al., 2021, Zubair et al., 2022, Meister et al., 2021, Hensher and Beck, 2023, Aderibigbe and Gumbo, 2022).

Observing a series of works of literature in the Asian world it is possible to highlight that

- The effect of COVID-19 on the shopping habits of consumers in Bangladesh and India, two neighbouring countries with underdeveloped economies. The house relies on the provision of essential online services by the district administration. But this was not the case in Bangladesh (Zannat et al., 2021).
- In the Khon Kaen City, Thailand determined the effect of psychological characteristics on mode choice behaviour and stressing that people who have their own private vehicles are less likely to use bus rapid transit (BRT). This study shows how social influence, and also service attribution factors such as travel time and cost, can influence mode choice behaviours (Vrtic et al., 2010).
- In Khulna City, Bangladesh (Habib, 2016) identified factors influencing mode choices for low-income people using a multinomial logistic model. The results identified that age, gender, distance, cost of travel, etc. are those variables that influenced their choices of modalities (Huda and Ahsan, 2019). Elements that have a significant impact on transportation mode selection include: travel time, age, income, travel distance, weather, vehicle ownership, etc. (Almasri and Alraee, 2013).
- Two scenarios of stated preference (SP) and multimodal traveller information have a significant effect on the mode decision. Age, gender, education level, and income are socioeconomic characteristics that have a considerable effect on modality choice (Meng et al., 2018). However, travel mode choice is greatly impact by income statement of individuals. For people's choice of mode, it has been found that middle- and high-income people choose rickshaw and easy bike for their regular trips and both middle- and low-income people choose van for their regular trips. Another study was performed by using the regression model to analyze the impact on travel (Ahasan and Mudasser, 2018).
- A study conducted on border transport between Saudi Arabia and Bahrain and based on logit models has shown that the car and the plane are the most useful for traveling on this route. The result revealed ferry service is more attractive than car service for a single traveller (Ratrout and Gazder, 2014).
- Another study conducted at Saudi Arabia and Bahrain examined that age, occupation, frequency of travel, solo travel and cost of travel were important factors in the choice of mode (Ratrout and Gazder, 2014).

Over the past decade, several studies have analysed the principal variables influencing modal choices and applied different type of logit models (Hossain et al., 2021b, Zenina and Borisov, 2012, Siraj et al., 2021)

Considering the Asian context, a number of studies have emphasised the importance of correlations between short-distance travel variables such as safety, comfort and cost of service (Liu et al., 2019, Madhuwanthi et al., 2016, Bhaduri et al., 2020) and socio-demographic variables such as age, household income or car ownership (Chee and Fernandez, 2013, Shen, 2009) and driving licence (Hanif et al., 2019, Ahmed et al., 2023). Study focusing on the period 2020-2023 have also considered a comparison between the pre- and post-COVID-19 periods (Abdullah et al., 2020, Anwari et al., 2021, Zubair et al., 2022, Meister et al., 2021, Hensher and Beck, 2023).

Analysing the use of the different logit models and considering the residential or industrial vocation of some Asian cities, a summary can be observed in Table 1. Authors have found, there was no work done before in Chittagong city by using MNL model according to a utility function for regular and short travel distance. To accomplish the study in the Chittagong city the MNL model is used because it offers very comprehensible coefficients that quantify the relationship between various attributes (age, gender, education, income level etc.) and different categories. Besides, MNL is simple to apply, comprehend, and analyse. It is also a common choice for travel mode choice modeling. Because of this, it's a good choice for researchers who wish to comprehend the variables affecting travellers' choices of modes of transportation and forecast how those choices may be influenced by improvements in those variables.

Summarizing the literatures (Table 1), very few research has been focused on regular and short distance model choice behaviour. Additionally, no study has been compared the two scenarios considering industrialized city. Hence, the purpose of this study is to analyze, modeling and comparison of regular and short distance travel behaviour of an industrialized zone. The study uses multinomial logit model (MNL) which offers very comprehensible coefficients that measure the correlation between characteristics and outcome variable is one of its key advantages. The ability to account for individual unobserved heterogeneity with regard to the intercepts is another benefit of the multinomial logit model (MNL) with fixed effects.

Table 1: Mode choice issue focused on previous literature

Author (Year)	Country	Population (Million)	Area of Study	Short Distance	Regular Mode Choice	Model
Shen and Junyi (2009)	Japan	125	I	No	No	Latent Class Model (LCM) and Mixed Logit Model (MLM)
Chee and Fernandez (2013)	Malaysia	33	I	No	No	Structured Questionnaire
Rahman et al. (2015)	Bangladesh	170	R	No	No	Trip generation model and gravity model
Meng et al. (2016)	Saudi Arabia and Bahrain	37.46	R	No	No	Logit Models
Madhuwanthi et al. (2016)	Sri Lanka	20.3	I	No	Yes	KMO & Bartltt's test
Hanif et al. (2019)	Bangladesh	170	I	No	Yes	Binary Logit Model
Liu et al. (2019)	China	1411	R	Yes	Yes	Nested Logit Model
Bhaduri et al. (2019)	India	1393.4	R	No	No	Discrete Choice Extreme Value (MDCEV) Models
Huda and Ahsan (2019)	Bangladesh	170	R	No	Yes	Multinomial Logistic Model
Bastarianto et al. (2019)	Indonesia	275	I	No	No	Multinomial Logit (MNL), Nested Logit (NL) and Cross-Nested Logit (CNL) Model
Zannat et al. (2019)	Bangladesh	170	I	No	Yes	Linear Regression Model
Hadiuzzaman et al. (2019)	Bangladesh	166	R	Yes	Yes	Structural Equation Modeling (SEM)
Wang et al., (2020)	China	1411	R	No	No	mixed behavioral equilibrium model
Siraj et al. (2021)	Bangladesh	170	I	Yes	Yes	Multinomial Probit (MNP) Model

Note: I=Industrial, R=Residential

3. METHODOLOGY

A manual survey using pen and paper was conducted for this investigation. Research was carried out in 17 of Chittagong's most prominent wards. A total of 514 people were questioned at the specified sites on weekdays and weekend (Figure 1). From among the survey sites, the respondents were picked at random.

Sample size for a population of infinity

$$S = \frac{(Z-Score)^2 \times Std.\ Dev \times (1-Std.\ Dev)}{(Confidence\ Interval)^2} = \frac{Z^2 \times \rho \times (1-\rho)}{M^2} = \frac{(1.960)^2 \times) 0.5 \times (1-0.5)}{(0.05)^2} = 384.16$$

$$\text{Adjusted sample Size} = \frac{S}{1+\left(\frac{(S-1)}{Total\ population\ of\ this\ city}\right)} = \frac{384.16}{1+\left(\frac{(384.16-1)}{45\times10^5}\right)} = 384.12 \approx 385$$

Here: S = Sample size for infinite population,
Z = Z- score (confidence level 95% = 1.960),
P = Population proportion (assumed to be 50% = 0.5),
M = Marginal error (5% = 0.05).

According to the given calculation, it was predicted that data would be collected from 385 people and the study actually conducted the data collection with 514 people. (Ahmed et al., 2023).

The general framework of the study approach used in this survey is shown in Figure 2. For the investigation of short-distance and regular travel mode selection behavior, a questionnaire survey was conducted. Gender, age, employment, education, income level, household type, vehicle ownership, and nearest stopping distance data were all reported on the questionnaire. In order to highlight the characteristics of the people planning the trips, information regarding the types of travel, such as short distance travel or frequent travel a questionnaire was conducted in the area of Chittagong's 17 busiest location like bus stand, Educational Institutes, Commercial area, EPZ area etc. Because it is one of the most extensively performed discrete choice model to examine travel behavior, the multinomial logit model (MNL) is used to mark a develop mode choice model for short distance and regular travel. Cars, buses, paratransit, walking, and motorcycles are the most common ways of transportation in Chittagong (Figure 2) (Siraj et al., 2021, Ahmed et al., 2023, Siraj et al., 2023, Hossain et al., 2021a, Rahman et al., 2015, Islam et al., 2022). The analysis for this Study was conducted using STATA software.

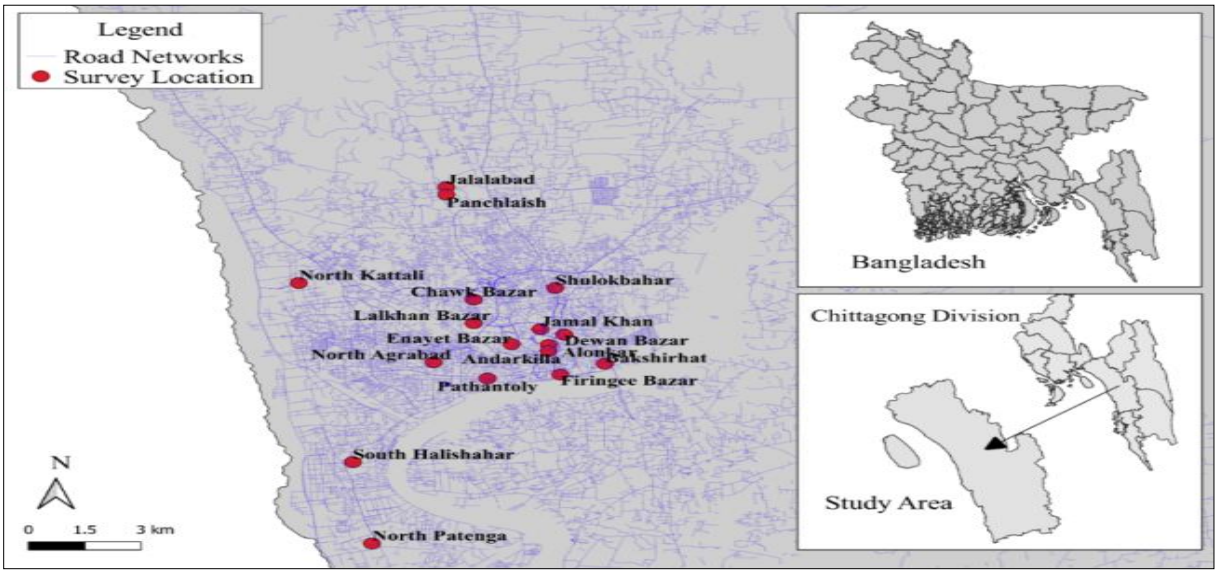

Figure 1: Major mode choice classification for this study

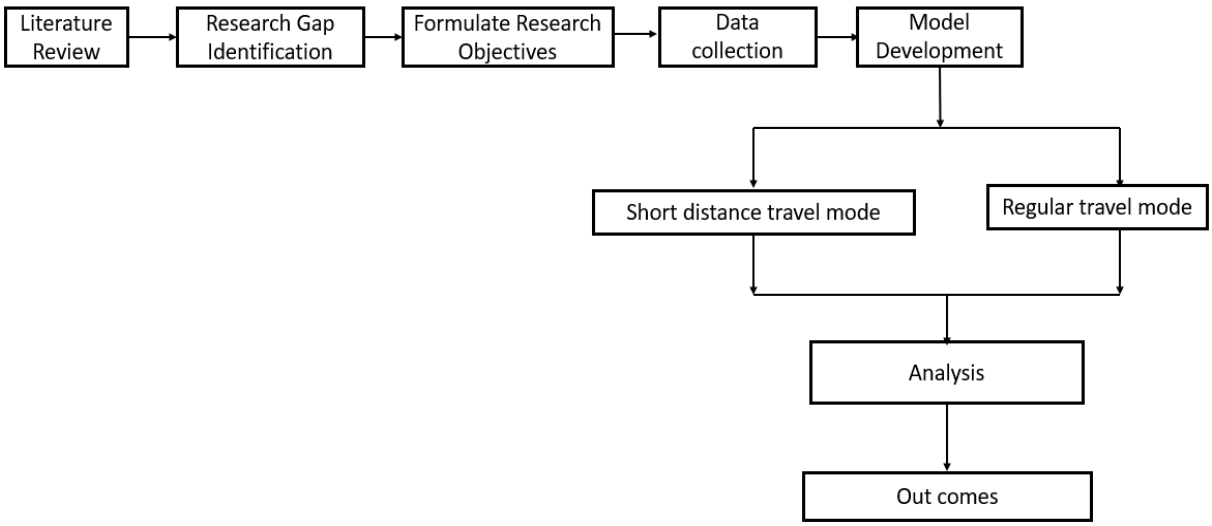

Figure 2: General framework of the study methodology

4. DESCRIPTIVE ANALYSIS

It is important to note the descriptive statistics of the variables which are shown in the Table 2 below. The first column mentions the attributes and the second column identifies the respective categories that have been assigned while the third column mentions the amounts in terms of percentage. From the data which has been collected, it shows that majority of the respondents are male accounting 79.53% and majority of them are aged between 14-

30 years. Based on this age group most of the respondents are males with a percentage of 61.67% as indicated in the table below. Regarding occupation, the groups with the highest percentage of respondents are those of service providers (about 27.84%), students (about 26.66%), and daily labourers (about 22.20%). This indicates that a large proportion of the respondents are employed or students who utilize various modes of transportation on a regular basis. In terms of education and monthly income, the majority of respondents (about 30.35%) are graduates with income ranging from 15000 to 25,000 BDT. It demonstrates that the large bulk of participants are middle class (Hossain et al., 2021) and have a college or university education. About 93.39% of respondents had a multi-story home, indicating that the majority of respondents are financially secure.

Table 2: Descriptive statistics of the responses

Attribute	Category	N (%)
Gender	Male	408(79.53)
	Female	106(20.47)
Age (Year)	14-30	317(61.67)
	31-40	125(24.32)
	41-50	51(9.92)
	>50	21(4.09)
Occupation	Service holder	143(27.84)
	Student	137(26.66)
	Daily labour	114(22.18)
	Housewife	56(10.87)
	Businessman	36(7.00)
	Others	28(5.45)
Education	Uneducated	38(7.39)
	Primary Educated (class 1-5)	108(21.01)
	Secondary Educated (class 6-10)	89(17.32)
	Higher Secondary Educated (class 11-12)	123(23.93)
	Higher Educated (graduate)	156(30.35)
Income level	0-8000 BDT	96(18.68)
	8001-15000 BDT	135(26.26)
	15001-25000 BDT	156(30.35)
	25001-40000 BDT	84(16.34)
	>40000 BDT	43(8.37)
Household type	One storied house	34(6.61)
	Multi-storeyed house	480(93.39)
Vehicle ownership	No	412(80.16)
	Yes	102(19.84)
Short distance travel mode (2-5 km)	Walking	216(42.02)
	Paratransit	128(24.85)
	Bus	77(14.98)
	Motorcycle	57(11.09)
	Car	36(7.00)
Nearest stoppage distance	0-150 m	136(25.46)
	151-350 m	165(32.10)
	351-500 m	115(22.37)
	501-1000 m	30(6.84)
	>1000 m	68(13.23)
Regular travel distance	0-2 km	105(20.43)
	2-5 km	256(49.81)
	5-10 km	115(22.37)
	>10 km	38(7.39)
Regular travel mode	Bus	246(47.86)
	Paratransit	120(23.35)
	Motorcycle	60(11.67)
	Car	47(9.14)
	Walking	41(7.98)

According to the survey, 80.16% of respondents do not have their own private vehicles. It suggests that they are extremely dependent on various modes of transportation. For short distances (2–5 km), walking is preferred by 42.02%, and the nearest station (like bus, CNG, Rickshaw stop) is within 150–350 m (32.10%). This might imply

that they prefer to stroll for short distances. In terms of regular travel distance, 49.81% travelled 2-5 km on a regular basis, and the majority of them choose to use the bus (47.86%). It implies that they choose the bus for long-distance travel on a regular basis. Variables are also quantitatively coded for statistical modeling.

5. MODEL RESULTS

A multinomial logit model was employed in this investigation to see which model predicted better for short-distance trip and regular travel mode choice. Except for short distance travel mode and regular travel mode, all variables (Bus, Paratransit, Motorcycle, Car and walking) are utilized as dependent variables. The coefficient value in a model reflects whether the variable have a positive or negative relationship with the dependent variable.

5.1 Utility theory

An alternative's utility is an objective function of the decision-traits maker's and the attribute vectors, which can be expressed as:

$$U(Z_i, S_t) \quad (1)$$

Here,
U() = Utility function.
Z_i= qualities that describe the alternative i as vectors.
S_t= Socio-economic decision-maker t.
The appeal of an alternative for a particular journey is commonly referred to as the utility of a travel mode and the decision-maker typically selects the option with the highest utility. As an alternative, it might be said that $'i'$ will be chosen if its utility value is greater than or equal to the utility of all other options. The entire utility made operational by dividing it into deterministic (observable) and random (error) components, according to $'j'$ (Sekhar, 2014) who described this. Equation (2) represents the utility function for the chosen alternative *i*,

$$U_i = V_i + \varepsilon_i \quad (2)$$

Here,
U_i =utility function for alternative 'i'.
V_i= visible component of the analyst's projected utility.
ε_i = mistake or the part of the utility that the analyser is unaware.

The general utility may be defined as a function of V, since ε is the error element of the utility. A new vector X_n can be defined by combining the vectors Z_n and S_n. As a result, V_{in} can be expressed as V_{xin}. The linear form of the function is used to assess how the factors in x affect the utility and to quickly estimate the function's parameter (Wittink et al., 2011).

The utility function of the alternative 'i'defined by the vectors of k parameters $\beta = [\beta_1, \beta_2, \ldots\ldots, \beta_k]$ may be expressed as follows:

$$V_{in} = \beta_1 x_{in1} + \beta_2 x_{in2} + \cdots + \beta_k x_{ink} \quad (3)$$

5.2 Model development

The utility function technique, which is used in travel behavior analysis to determine travel mode choice, uses the multinomial logit model (MNL), which is typically one of the best structures for modeling mode choices. Models of mode selection statistically link each traveller's decision to the characteristics of the available alternatives. The MNL model makes the assumption that the utility components of the various sets of options are independent.
As a function of the systematic fraction of the utility of all the alternatives, the MNL mathematical framework provides the choice probabilities for each alternative. The following is the generic equation for the likelihood of selecting option 'i' (i = 1, 2, ..., j) from a set of j alternatives:

$$\Pr(i) = \frac{\exp(V_{in})}{\sum_{i=1}^{J} \exp(V_{in})} \quad (4)$$

Here,
$P_n(i)$= Probability of the traveler's mode choice (n) and alternate (i),
V_{in}= the systematic utility component for a mode choice n by the traveller selecting alternative i,
V_{jn} = The systematic element of the set alternative's usefulness (j). (Al-Salih and Esztergár-Kiss, 2021)

For the purpose of this study, any significance level of $p \leq 0.05$ is taken to have a statistically significant value.

5.3 Short distance travel mode choice

Table 3 shows multinomial logit model results for short distance travel mode choice. Analysis shows that p values of monthly income (0.018), household type (0.022) and vehicle ownership (0.002) are statistically significant and positively correlated with cars. This suggests that since they have access to a car, wealthy individuals and their families prefer using a car for short distance trips over other modes of transportation. On the other hand, gender (0.049) and nearest stoppage distance (0.410) are statistically substantial unfavourable correlations (negatively) with cars. Bus statistically significant and has a favourable relationship with gender (0.023) and nearest stoppage distance (0.020) and negatively related with occupation (0.002) and vehicle ownership (0.001). This indicates that choosing a bus for a short distance trip may be done by either a man or a woman, but wealthy persons are avoid using this mode of transportation. Gender (0.010) and vehicle ownership (0.000) are positively correlated with motorcycles, both of which are statistically significant. This suggests that motorbike owners who are wealthy prefer to use this mode of transport for short distances. Although statistically significant, paratransit has a negatively relationship with age (0.048), gender (0.024) and vehicle ownership (0.003). This suggests that wealthy, elderly women do not find paratransit to be a comfortable mode of transport. Occupation (0.000) is statistically significant and positively related with walking. On the other hand, monthly income (0.009) and vehicle ownership (0.000) are statistically significant but negatively related with walking. This means that low-income people do prefer walking as they do not have the ability to use other mode daily but rich people do not prefer this mode.

Model fit results of short distance mode choice are acceptable and presented in Table 3. For short distance travel mode choice, log likelihood of MNL model is -261.089. Wald chi^2 value is significant (0.000) and the value is 139.72. Pseudo R^2 value for short distance travel mode choice is 0.32.

Table 3: Multinomial logit Model for Short Distance Travel

Description	Car	Bus	Motorcycle	Paratransit	Walking
	Coefficient (p value)	Coefficient (p value)	Coefficient (p value)	Coefficient (p value)	Coefficient (p value)
Constant	-6.240 (0.022)	-9.657 (0.997)	-7.753 (0.022)	0.133 (0.955)	-2.120 (0.192)
Gender	-0.933 (0.049)	0.933 (0.023)	2.055 (0.010)	-0.569 (0.024)	0.104 (0.708)
Age	-0.561 (0.364)	-15.262 (0.981)	0.0921 (0.888)	-0.762 (0.048)	0.501 (0.188)
Education	0.175 (0.183)	-3.510 (0.116)	-8.569 (0.790)	2.015 (0.120)	0.129 (0.322)
Occupation	0.057 (0.914)	-3.313 (0.002)	-1.120 (0.052)	-0.634 (0.056)	1.634 (0.000)
Monthly Income	1.236 (0.018)	0.544 (0.115)	-0.066 (0.891)	0.308 (0.255)	-0.829 (0.009)
Household type	0.126 (0.022)	13.188 (0.993)	-1.196 (0.368)	0.849 (0.440)	1.109 (0.093)
Vehicle Ownership	2.487 (0.002)	-3.508 (0.001)	3.577 (0.000)	-0.948 (0.003)	-1.909 (0.000)
Nearest stoppage distance	-0.502 (0.410)	2.515 (0.020)	0.812 (0.224)	0.514 (0.170)	-0.669 (0.066)
Model Fit Results					
Log likelihood				-261.089	
Wald chi^2 (Prob > chi^2)				139.72 (0.000)	
Pseudo R^2				0.32	

5.4 Regular travel mode choice

Table 4 indicates the relation of different types of mode with age, gender, occupation, monthly income, vehicle ownership, nearest stoppage distance, and household type. In logit model, vehicle ownership is statistically significant with all modes except walking. In addition, vehicle ownership is positively related with car and motorcycle but negatively related with bus and paratransit. This means that rich people use personal vehicle for

regular travel as they have the ability. Nearest stoppage distance is statistically significant and positively related with car and paratransit but negatively related with walking. This indicates that regular walking is not possible for a person and they have to use car or paratransit according to their ability. Age and gender are statistically significant with paratransit and motorcycle respectively. Age is negatively related with paratransit and gender is positively related with motorcycle. This implies that all age group are not preferred paratransit. But now-a-days, a man either male or female can use motorcycle as their regular mode of travel specially motorcycle ridesharing is highly popular in Chittagong city. Walking and monthly income have statistically significant and beneficial relationships. Those scenarios indicate that, all income range of people preferred walking based on shortest distance regular travel like grocery activities.

For regular travel mode choice, MNL model fitness are acceptable as shown as Table 4. The fitness value of the MNP model in terms of three criteria are Log likelihood (-123.932), Wald chi^2 (79.54), and Pseudo R^2 (0.37).

Table 4: Multinomial logit Model for Regular Mode Choice for Regular Travel

Description	Car	Bus	Motorcycle	Paratransit	Walking
	Coefficient (p value)	Coefficient (p value)	Coefficient (p value)	Coefficient (p value)	Coefficient (p value)
Constant	-7.453704 (0.001)	3.156624 (0.021)	-8.386472 (0.012)	0.9226636 (0.626)	-4.953396 (0.026)
Gender	0.0862798 (0.856)	0.0886295 (0.709)	2.018135 (0.013)	-0.0928653 (0.723)	-0.6147312 (0.103)
Age	-.8576623 (0.115)	0.6568554 (0.053)	0.3888139 (0.565)	-1.13129 (0.004)	0.5778213 (0.326)
Education	-0.320418 (0.196)	1.7271962 (0.249)	5.1938340 (0.157)	-1.4252935 (0.281)	-6.1825439 (0.887)
Occupation	-0.6819677 (0.163)	0.233782 (0.412)	-0.5999558 (0.306)	-0.0640727 (0.847)	0.1172782 (0.797)
Monthly Income	0.8278701 (0.092)	-0.3283418 (0.193)	-0.0112748 (0.982)	-0.3091106 (0.281)	1.381052 (0.002)
Household type	-0.4255516 (0.594)	0.0123377 (0.981)	-1.2789 (0.317)	0.3774208 (0.647)	1.291137 (0.108)
Vehicle Ownership	2.646227 (0.000)	-2.806686 (0.000)	4.103924 (0.000)	-1.554512 (0.000)	-1.43142 (0.055)
Nearest stoppage distance	1.215599 (0.026)	-0.4248181 (0.183)	-0.0133712 (0.984)	0.7273497 (0.049)	-1.064874 (0.045)
Model Fit Results					
Log likelihood				-123.932	
Wald chi^2 (Prob > chi^2)				79.54 (0.000)	
Pseudo R^2				0.37	

5.5 Estimation of Utility Function for Short Distance Travel

In the Table 5, method of estimation gives parameter estimates for the mode choice based on utility function, which is based on the theory of random utility maximization choice. The day-to-day activity of traveling that was observed in traditional travel datasets is used to estimate the multinomial logit model with utility function as the goal function of mode choice. The selected set of alternatives in this study has been chosen after considering the observed travel behaviors of the dataset's participants.

For short travel distance 2-5km, based on the average utility value, it has been shown that males prefer to utilize motorcycles and paratransit when traveling. In contrast to males, women prefer buses and paratransit when traveling. Travelers in the 14–30 age range are more likely to utilize a bus, paratransit, and walk to get where they need to go. Additionally, paratransit, buses, and cars are useful for passengers in the age brackets of 31 to 40 and 41 to 50. In the meanwhile, it has been discovered that those over 50 make a higher proportion of journeys by car and paratransit. Except for the higher educated residents are preferred paratransit, buses and motorcycles. The higher educated are use paratransit, buses, motorcycles and cars for their short distance travel.

For service holders favourite travel vehicles are car, paratransit, car and motorcycle. Students are use paratransit and bus for travel distance while businessmen are used motorcycle and car. Novelty showed that in Chittagong city, people of low economic status primarily depend on buses and paratransit because of its relatively cheaper fare than other mode of transportation. People with high income also majorly rely on car and motorcycle, which

are considered as a personal and private transport means. A majority of city residents live in multiplex housing, and the main transportation means embraced by individuals in cities include buses, paratransit, motorcycles, and walking. This is also true for other models that consider buses and paratransit as priorities. Most of the respondents who own automobiles in addition to buses use motorcycles and cars to mitigate the inconveniences of bus use. Again, for the majority of residents, the bus stop with about one kilometre is the nearest bus stop.

Table 5: Estimation of Utility Function for Short Distance Travel

Variables		Travel Mode (Short Distance Travel)				
		Utility of Car	Utility of Bus	Utility of Motorcycle	Utility of Paratransit	Utility of Walking
Gender	Male	2.80	5.10	7.50	13.43	4.39
	Female	1.20	5.45	2.32	14.00	3.32
Age	14-30	1.30	7.76	4.63	13.65	8.50
	31-40	2.12	4.45	7.72	12.89	5.00
	41-50	3.80	6.54	3.30	9.25	2.23
	>50	4.58	2.43	0.96	6.95	3.72
Education	Uneducated	0.00	12.54	1.80	11.75	10.00
	Primary Educated (class 1-5)	0.00	2.65	1.10	12.20	5.76
	Secondary Educated (class 6-10)	0.62	2.50	2.69	13.00	8.45
	Higher Secondary Educated (class 11-12)	1.13	11.32	7.23	13.50	7.80
	Higher Educated (graduate)	4.14	9.60	7.00	11.00	4.00
Occupation	Service holder	7.89	3.63	4.05	6.65	0.55
	Student	0.00	9.34	4.93	14.05	3.09
	Daily labour	0.00	7.90	0.54	2.84	12.00
	Housewife	1.04	2.90	2.83	13.00	0.43
	Businessman	6.40	3.00	7.76	4.56	0.65
	Others	1.30	9.00	4.65	13.54	5.70
Monthly Income	0-8000 BDT	0.00	3.20	0.21	10.33	14.32
	8001-15000 BDT	0.00	13.96	3.47	12.52	8.34
	15001-25000 BDT	0.00	16.71	6.92	2.31	2.12
	25001-40000 BDT	1.39	8.22	9.85	4.66	1.01
	>40000 BDT	3.54	9.23	6.54	3.89	0.19
Household type	One storied house	0.00	18.20	1.71	10.26	3.08
	Multi-storeyed house	1.24	19.91	5.76	5.25	3.09
Vehicle Ownership	No	0.00	13.61	1.29	9.21	2.60
	Yes	3.20	2.30	8.77	6.82	2.11
Nearest stoppage distance	0-150 m	0.20	0.49	1.72	2.31	2.97
	151-350 m	0.91	0.21	1.51	3.82	5.32
	351-500 m	0.63	5.69	1.11	2.22	4.88
	501-1000 m	1.86	2.77	1.47	3.74	0.27
	>1000 m	0.23	1.89	1.99	3.26	0.67

5.6 Estimation of Utility Function for Regular Mode Choice for Regular Travel

Table. 6 quantities of a few key variables with utility function to observe the mode choice of travel in regular distance. Based on the utility function the multinomial Logit model is used to find the travel activity. Male residents are more likely than female to utilize buses as their mode of transportation since it is suitable to travel for regular distance (more than 5km). Whereas, the uses of bus for female passengers have decreased marginally. Additionally, it is seen that female tourists are more likely to utilize paratransit for their regular travelling. The utility function for choosing the mode has been demonstrated to be influenced by the traveller's age which is depicted in the Table 6. It has been noticed that passengers aged 14 to 30, 31 to 40, and 41 to 50 prefer buses to make their regular travels. Like as, all the groups are found unhabituated to walk for complete their activity. Meantime, it has been discovered that users over the age of 50 make more car journeys than users of other ages.

Table 6: Estimation of Utility Function for Regular Mode Choice

Variables		Travel Mode (Regular Travel)				
		Utility of Car	Utility of Bus	Utility of Motorcycle	Utility of Paratransit	Utility of Walking
Gender	Male	3.75	10.00	6.43	8.34	0.21
	Female	4.55	6.98	2.32	11.53	0.00
Age	14-30	3.55	12.15	4.20	10.00	1.20
	31-40	6.00	11.00	3.89	7.13	0.90
	41-50	8.21	9.70	1.30	6.65	0.44
	>50	12.00	7.25	1.65	5.64	0.02
Education	Uneducated	0.00	13.32	3.30	8.80	2.20
	Primary Educated (class 1-5)	0.00	4.44	0.30	11.00	0.00
	Secondary Educated (class 6-10)	0.08	12.88	2.40	6.96	1.18
	Higher Secondary Educated (class 11-12)	1.81	11.00	2.00	9.56	1.00
	Higher Educated (graduate)	3.19	3.00	2.90	7.70	0.30
Occupation	Service holder	8.56	4.80	2.30	8.30	0.20
	Student	0.01	13.65	5.55	12.6	2.30
	Daily labour	0.00	12.12	2.21	9.60	5.90
	Housewife	0.32	3.20	1.32	13.20	0.20
	Businessman	5.14	6.84	5.76	10.55	0.32
	Others	3.22	12.32	6.00	11.00	1.65
Monthly Income	0-8000 BDT	0.00	15.26	0.23	9.16	1.20
	8001-15000 BDT	0.00	18.10	3.15	8.24	1.03
	15001-25000 BDT	0.00	15.68	7.89	1.98	1.23
	25001-40000 BDT	3.63	9.44	10.52	3.96	0.52
	>40000 BDT	6.10	10.94	8.12	5.66	0.05
Household type	One storied house	0.00	17.29	0.82	11.25	2.74
	Multi-storeyed house	1.78	20.02	6.18	5.31	1.22
Vehicle Ownership	No	0.00	16.97	1.88	11.41	1.80
	Yes	5.12	3.70	16.2	8.21	1.88
Nearest stoppage distance	0-150 m	0.19	0.77	1.68	3.73	4.23
	151-350 m	0.00	0.57	3.21	4.79	3.49
	351-500 m	1.00	6.37	2.16	3.85	3.55
	501-1000 m	2.10	2.69	3.58	1.33	2.12
	>1000 m	3.10	2.33	5.24	4.01	2.48

From Table 6, both educated and Illiterate people continue to make up their travel for regular distance. However, the proportion of the higher educated people make up their trip by car and it is sharply increased the students from secondary level and higher secondary level. According to the table, walking has a greater utility value for persons with little education. There is a definite growing tendency among service providers, housewives, and business people while there is little record of car use for everyday labour. For daily labour, buses are shown to have a greater utility value. It has been edified that the higher income family has highest probability of using private transport. Whereas, this probability sharply decreases for lower income people for making trips. In addition, the kind of household and vehicles ownership have a big impact on utility values related to transport mode selection.

This study was finished by factoring in the various utility modes. The data shown in the table 6 reveals that the stoppage distance or distance from the home frequently impacts the travel activity. By incorporating the concept of utility value, it proves that walking has higher utility value when used in short distance than a long distance when doing travel activities. Table 6 presents the utility values of different variables such as gender, age, education, occupation, monthly income, household type, vehicle ownership and nearest stoppage distance in relation to mode choice. The table 6 illustrates how utility values are strongly affected by multiple factors,

particularly the goal of an activity, meaning that the ultimate mode of transportation will vary depending on the priorities, which are represented in their utility function.

5.7 Policy Implications

Table 7 illustrates gest of the short distance and regular travel mode choice modeling results. The table represents only the common significant factors from MNL which is marked as gray colour. The positive and negative sign in the cell indicates different variables relation with different mode of transport. Common factors for short distance and regular travel mode choice are marked as '*'.

Table 7: Comparison of short distance and regular travel mode choice

Description	Short Distance Travel Mode Choice					Regular Travel Mode Choice				
	Car	Bus	Motorcycle	Paratransit	Walking	Car	Bus	Motorcycle	Paratransit	Walking
Gender		(+)	(+)	*(-)					*(+)	
Age										
Education										
Occupation		(-)			(+)			(+)		
Monthly Income	(+)				(-)					
Household type										
Vehicle Ownership	*(+)	*(-)	*(+)	*(-)	(-)	*(+)	*(-)	*(+)	*(-)	
Nearest stoppage distance		*(+)				*(+)				

Scenario 1: Vehicle ownership is significant for all modes except walking for short and regular mode choice. However, the relation is positive only for car and motorcycle. It indicates that, people drive their own vehicles for short and regular distance travel because it helps them to go their destination without any problem like it occurs for bus, paratransit and walking.

Scenario 2: People use bus based on the nearest stoppage distance (short distance and regular travel). Because bus travel is comparatively cheap and less time consuming for long distance travel.

Scenario 3: Monthly income has positively and negatively influence with car and walking respectively for short distance travel. Because, if the person monthly income gets increase, they use car, it can be personal or car riding service which will reduce their choice of walking for short distance travel. However, low-income people use walking as a mode for short distance travel.

Scenario 4: Occupation is negatively influence with bus and positively influence with walking for short distance travel. For regular travel motorcycle is positively influences with occupation. This indicates that, people like to use personal vehicle or riding service (UBER, Pathao etc.) for regular travel. However, in low-income categories people are preferring walking as a mode of travel for short distance travel.

Scenario 5: Gender negatively influences short-distance travel and positively influences regular travel for paratransit in Chittagong city. Paratransit services, which are less crowded than buses and accessible on all routes in the city, are often chosen for regular travel despite being time-consuming, especially by women. In contrast, buses and motorcycles are positively influenced by gender for short-distance travel.

6. CONCLUSIONS

The current study on the mode choice behavior of regular and short-distance travel is conducted in Chittagong city, and multiple significant factors that have a substantial influence on choice of transportation are examined as well. The multinomial logit model has been used to determine the contributing factors for the selection of various modes (Example. car, bus, motorcycle, paratransit and walking). This study is crucial for selecting MNL model for mode choice study.

From this study, the 17 attributing factors are determined using MNL model which have a significant impact on mode choice for regular and short-distance travel. Gender, monthly income, vehicle ownership, household type and nearest stoppage distance are important factors for cars; gender, occupation, vehicle ownership, and nearest stoppage distance are important for buses; gender and vehicle ownership are important for motorcycles; age,

gender, and vehicle ownership are important for paratransit; and occupation, monthly income, and vehicle ownership are important for walking.

The MNL model revealed that ten factors are relevant. Where vehicle ownership and nearest stoppage distance are important for cars; only vehicle ownership is important for buses; gender and vehicle ownership are important for motorcycles; age, vehicle ownership, and nearest stoppage distance are important for paratransit; and monthly income and nearest stoppage distance are important for walking.

The study found that if a personal vehicle (car, motorbike) is inexpensive, it is a common short-distance and regular means of transportation. Low-income people choose the bus or paratransit for both short and long-distance travel since it is more economical, especially who is not capable to buy their own vehicle. Many individuals utilize walking as a short-distance mode of travel; however, a significant number of them refrain from it due to time constraints, particularly when traveling to destinations such as workplaces, markets, or bazaars.

However, different types of variable modes have been determined by utility equation. Utility results suggested that rich peoples are used personal vehicles like car & motorcycle. Maximum low-income peoples choose bus, paratransit and walking as their travel mode for short and regular travel.

Most people mainly use walking for short distances, but they may use other means for transportation when they are in a hurry to go to places like workplaces, markets or bazaars. Therefore, to promote accessibility, communities of lesser income would be improved bus and paratransit facilities. Also, increasing the availability of pedestrian infrastructure for short distance trips would also increase accessibility. For details considerations of other transit alternatives, future research could investigate them comprehensively. Even though this study is set in Bangladesh, the method used for this research can be useful for both developed and the developing countries, and hence the results obtained from this study can be useful for other similar contexts of the developing countries.

This study has the following limitations. Firstly, the mode choice survey was carried out only in Chittagong city; it is wise to generalize Chittagong division. Besides, this study solely relied on the Multinomial Logit Model (MNL) as the type of discrete choice model. Future study should be conducted across a vast region utilizing all discrete choice models in order to discover the true one.

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