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Article

Travel Mode Choices in connection to Metro Station by Multinomial Logit Model: A Case Study in Dhaka, Bangladesh

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Abstract: The interdependence of feeder modes plays a crucial role in an efficient transit system, yet limited research has explored this aspect in developing countries like Bangladesh. This study investigates the mode choice preferences for accessing and egressing metro stations in Dhaka, analyzing the impact of socio-economic factors and trip attributes. Using a multinomial logit model, the study identifies significant determinants, including age, income, gender, trip distance, vehicle waiting time, in-vehicle time, cost, availability, and comfort. The findings reveal that while private automobiles are unpopular, rickshaws and buses dominate as the preferred feeder modes due to their affordability and accessibility. Additionally, motorcycles emerge as a competitive option for last-mile connectivity. The study underscores the need for improved first and last mile connectivity to enhance metro usage in densely populated cities. The results provide valuable insights for policymakers to design sustainable transit strategies, encouraging multimodal integration and reducing dependency on private vehicles. Future research could explore land-use characteristics and station-area accessibility to further optimize feeder mode selection.

Keywords: access; egress; para-transit; feeder modes; multinomial logit model

1. Introduction

Transportation is essential to urban development and social and economic growth (Suzuki, Cervero and Iuchi, 2013). Transit systems use roads or railroads to provide direct services to the public (Rahman, Akther and Recker, 2022). The first- and last-mile links—access and egress—of a transit journey greatly impact its overall performance (Winston and Shirley, 2010). These neighbourhoods are often the weakest links in the multimodal public transportation system, hindering transit accessibility (Handy, 2002). Even when the core transportation infrastructure is excellent, the first and last mile hinders public transportation use. This is especially important for long interstate and suburban trips (Rahman, 2007). Access to metro or any rail-based transportation system, particularly speedy elevated and underground travel, has become a major concern as big city communities try to shape the future through mass transit (Ali et al., 2023). To boost metro accessibility, municipal planning and urban transportation legislation must promote alternative means of transit and limit car use (Tiwari, Jain and Rao, 2016). Despite being one of the world's most populous cities, Dhaka has received little transportation planning research (Boarnet et al., 2017). Thus, the city's transportation system is poorly designed and built (Yin, Islam and Ju, 2021). Dhaka is one of the few megacities without an MRT system and a well-organized, regularly scheduled public transit system. The Dhaka metro was built to meet rising transport demand and reduce traffic. In cities like Dhaka, people arrive to metro stations by car, bus, auto rickshaw, rickshaw, bike, walking, and metro feeder bus (Das and Mandal, 2021; Kisla, Tuba and Yildiz, 2016). Each mode is effective only at a certain distance. Metro commuters use a range of modes, but walking and non-motorized modes dominate city transport (Liu, Qu and Ma, 2021).

This study examines Dhaka metro riders from adjacent areas. Bangladesh's capital, Dhaka, has 24 million people, making it one of the world's densest metropolitan areas (Yin, Islam and Ju, 2021). Only

5% of Dhaka's excursions are made in private vehicles, despite the city's predicted growth in car ownership (Tiwari, Jain and Rao, 2016). NMT modes including walking and rickshaws, para-transit modes like human-haulers, shared auto-rickshaws, and legunas, CNG, and buses affect Dhaka's transportation system (Tiwari, Jain and Rao, 2016). Rickshaws account for 32% of modal share (Ali et al., 2023). Due to underreported journeys, the amount may be much higher. Paratransit is shared by many users and available on demand (Rahman, 2007). Despite following predetermined routes, these cars can pick up and drop off people at any area. As in other poor nations, paratransit modes in Dhaka are essential for connecting the first and last mile of transportation because there is no coordinated feeder service and standard public transportation is inadequate (Tiwari, Jain and Rao, 2016).

Cost, journey duration, convenience, safety, and demographics influence metro station transit choices (Shen, Chen and Pan, 2016; St-Louis et al., 2014; Lavieri and Bhat, 2019). Higher-income people may seek more luxurious, time-saving, and congestion-free options, while others may value cost-effectiveness. The travel goal, weather, and safe walking and cycling infrastructure also matter (Ahmed, Nahiduzzaman and Hasan, 2018). Understanding these factors might help transport planners and policymakers improve metro utilization and reduce vehicle dependence (Alam, 2010). In Dhaka, paratransit modes such legunas, shared auto-rickshaws, and rickshaws dominate the transportation environment, making mode choice behaviour critical (Sobhani et al., 2020). These shared forms of transportation have fixed routes but can stop at any time, making them ideal for short-distance travel (Niger, 2019; Nasrin and Bunker, 2021), but not for long-distance travel in Dhaka (Rahman, Islam and Hadiuzzaman, 2023; Rahman, 2020). Paratransit modalities provide first- and last-mile connectivity when there is no feeder system and few public transportation options, making metro access easier (LaBelle and Frève, 2016; Costa, Cunha and Arbex, 2021). Congested neighbourhoods, tiny streets, and a lack of bike and pedestrian infrastructure make metro access harder (Weinreich et al., 2020; Asadi-Shekari, Moeinaddini and Zaly Shah, 2013).

Dhaka, with its high population density, compact settlements, limited roadways, and absence of bicycle and pedestrian infrastructure, lacks adequate entry and egress transit alternatives (Rahman, Akther and Recker, 2022; Tiwari, Jain and Rao, 2016). Public transit efficacy and appeal depend on the ease of access and departure from diverse modes of transportation to metro rail services (Rahman, Akther and Recker, 2022). Bike sharing and bike lanes make metro access sustainable. Feeder bus and shuttle bus services are also great for metro accessibility. Taxis, CNG, leguna, and ride sharing offer direct metro access (Chowdhury, 2014). Park and ride facilities allow commuters to drive to a metro station, park, and ride the metro. MRT ingress and egress transit is not supported by policies or initiatives. This field lacks research too. Few researches have examined Dhaka metro station entry and egress mode choice. Thus, the first and last mile connections of public transit and access-egress mode choices are poorly understood, thus the government cannot provide metro rail access and egress mode services. This study sought to fill this information gap by identifying metro rail mode selection criteria.

This article is structured to provide a comprehensive analysis of metro access and egress mode choices in Dhaka. Following the introduction, Section 2 presents a review of relevant literature on urban transit systems, with a particular focus on first- and last-mile connectivity. Section 3 outlines the research methodology, describing the study area, data collection procedures, and survey design. Section 4 details the multinomial logit model employed to analyze mode choice behavior. The key findings are presented in Section 5, highlighting the influence of socio-economic and trip-related factors on the selection of feeder modes. Section 6 discusses the broader implications of the results, particularly in the context of urban mobility planning and policy formulation. Finally, Section 7 concludes the study by summarizing the key insights, offering policy recommendations, and suggesting directions for future research.

2. Literature Review

A "transit trip" necessarily encompasses forms of transportation other than merely transit. In order to utilize public transportation, an individual must initially go from their starting point to the designated transit stop, then subsequently from the transit stop to their intended destination (Van Nes and Bovy, 2004). "First mile" and "last mile" travels are the terms used to describe the trips to and from transit stops, albeit they may vary in terms of distance and mode of transportation (Figure 1). Since sufficient accessibility to and from transit stops is necessary for transit to function effectively, first and last mile journeys must be included in transport design (Kumar and Khani, 2021).

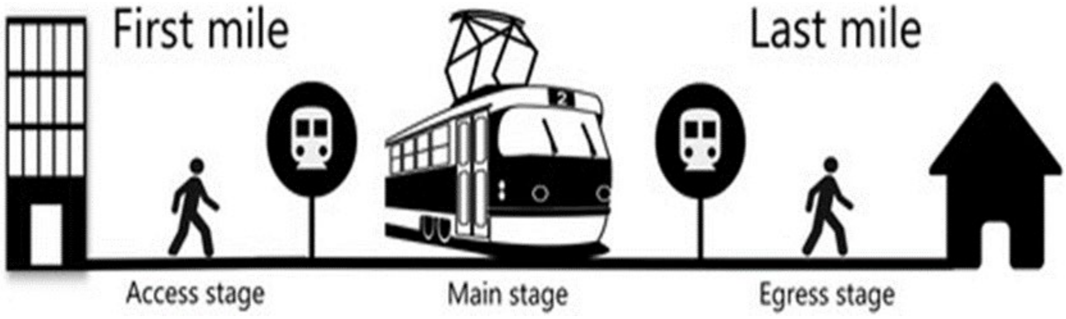

Figure 1. First Mile and Last Mile (FMLM).

Creative methods are used to prepare for better transportation access worldwide. Singapore's National Cycling Plan in Asia envisages bicycles as a first and last mile connection to Mass Rapid Transit (Tay, 2012). The Milton Keynes Council offered a more comprehensive mode aggregation strategy for UK first and last mile transport, combining fixed route transit with on-demand and emergent mobility (Franco et al., 2023). Cambridge train station established a mobility hub for transit station improvement by merging bicycles, taxis, and buses (Tay, 2012; Franco et al., 2023). The New South Wales transport authority is investigating on-demand mobility options to offer personalised services (Dolins, Wong and Nelson, 2021). Europe has formed Sustainable Urban Mobility Plans (SUMP) to help cities build policies to encourage sustainable transportation, focusing on public transportation (Tay, 2012). Multimodal integration at the neighbourhood level, where shared and sustainable modes are integrated, is also emerging (Van Nes and Bovy, 2004). However, the US is far behind in embracing creative multimodality and sustainable transportation initiatives. Despite Europe being ahead of the curve in auto access limitations, New York and San Francisco have started car-free zone projects by increasing transit and active transport access (Tay, 2012).

New mobility services like electric bike sharing, electric scooter sharing, and ride hailing have made first and last mile (FLM) travel a concern for transportation providers. Millennials travel differently than previous generations due to these advances (Mohiuddin, 2021). Recent studies have linked the expansion of bike-share programs and ride-hailing services like Uber to the reduction in public transportation usage. These services are replacing some public transit excursions. First-and-last-mile access is a hot topic in public transit research. This includes many researches on public transit service, station distances, pedestrian walkways, and bicycle infrastructure (Mohiuddin, 2021). Public transportation network multimodality is attracting scholarly interest (Nakshi and Debnath, 2021).

According to some research, socioeconomic characteristics of travellers also affect the route of access and egress they choose. The literature is limited, nevertheless, and presents conflicting results with relation to socioeconomic factors. The majority of earlier research on access/egress mode choice was carried out in China, the Netherlands, and the United States, and it concentrated on bicycle and car modes as well as systematic feeder mode services. Research on the developing nations of the Global South, where transportation supply characteristics differ and informal forms of transportation including rickshaws and paratransit modes are essential for many people's mobility, is quite limited. Furthermore, the majority of research has focused more on the choice of access option and has examined either the access or egress stage. However, both endpoints' connection determines the entire transit service. To the best of our knowledge, this is the first study to look at the first and last miles that people take to get to the metro in Dhaka.

3. Methodology

3.1. Study Area

Bangladesh's capital, Dhaka, covers 1463.60 square kilometres. Dhaka, with about 17 million residents, is one of the densest cities in the world. Population is expected to reach 35 million by 2035 (ESCAP, 2018). Due to the lack of an affordable, inclusive, efficient, and safe mobility solution, the city is suffering. Dhaka relies on road transit, which is a chaotic mix of cars, buses, auto-rickshaws, rickshaws, motorcycles, CNGs, bicycles, and more (Fahim and Miti, 2021). Meeting Dhaka's transportation needs has improved with the MRT system. Dhaka's MRT system has multiple lines. First built, MRT Line-6 is the most notable of these transit projects. The construction connects the city's north and south across 20 km (Chowdhury, Bari and Mukherjee, 2021) (Figure 2).

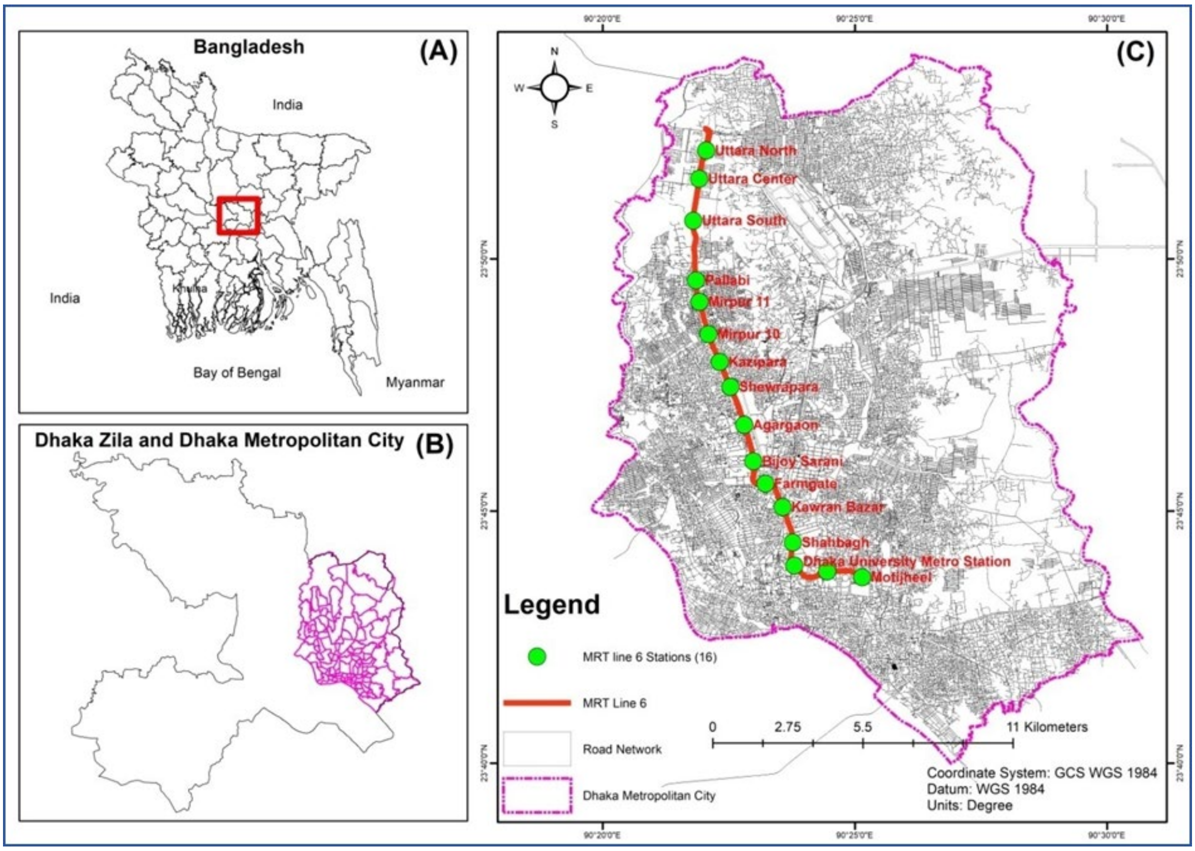

Figure 2. Dhaka City and Study area map.

3.2. Research Type

This study is quantitative and explanatory in nature. It employs a cross-sectional survey to collect data from metro users in Dhaka and uses statistical modeling (multinomial logit regression) to explain the determinants of mode choice. The research is also descriptive, as it provides a detailed analysis of transportation patterns, and analytical, as it applies statistical techniques to test relationships between variables and draw conclusions.

3.3. Research Strategy

This study employs a quantitative research strategy to investigate the factors influencing access and egress mode choices for metro users in Dhaka. A cross-sectional survey design was used to collect data from metro passengers, capturing their travel behavior, socio-economic characteristics, and trip-related attributes. We devised a questionnaire survey to gather data pertaining to the commuting trips of metro passengers. The questionnaire included information on trip time, which was broken down into in-vehicle time and waiting time, as well as travel cost and the locations of origin, destination, and boarding and alighting stations. To enhance precision, the map was used to depict the locations of the starting points and destinations, and the distances for each leg of the journey were measured accordingly. The questionnaire includes three distinct categories of variables: 1) Socioeconomic characteristics include age, gender, education level, occupation, and income. 2) Mode-specific details for the trip 3) Details regarding metro transportation.

3.4. Data Collection Methods and Techniques

We conducted intercept and on-board surveys to gain insight into the travel patterns of metro users, specifically focusing on their access and egress behaviours. A field investigation was conducted in January 2024 at Metro Rail Line - 6 stations and on board at both high-demand and low-demand periods on weekdays and weekends in Dhaka. Due to the unavailability of a population of public transit riders, the convenience purposive sampling technique was employed to gather data. Passengers were given the option to partake in the survey. If they agreed, they were directed to fill out a questionnaire using a pencil and paper while being supervised by the data collectors. A total of 400 questionnaires were issued, out of which 382 were deemed usable. The confidence level of the sample size is 95%. After excluding those with incomplete responses, the effective response rate was calculated to be 95.5%.

3.5. Data Analysis Techniques

This study utilizes discrete choice models to analyze the behaviour of public transit riders while choosing their access and egress modes. Based on this modelling approach, a commuter is expected to choose the access/egress mode that maximizes their personal satisfaction when presented with different options. The Multinomial Logit (MNL) model was employed to choose the final model that most accurately captures the observed behaviour.

3.6. Methodological Limitations

While this study provides valuable insights into metro access and egress mode choices in Dhaka, several methodological limitations should be acknowledged. First, the study relies on self-reported survey data, which may introduce response bias, as participants might not accurately recall their travel behavior or may provide socially desirable responses. Second, the sampling method used was convenience purposive sampling, which, although practical for data collection, may limit the generalizability of the findings to the broader population. Third, the study primarily focuses on quantitative analysis using a multinomial logit model, which, while effective in identifying statistical relationships, does not capture the qualitative aspects of commuter experiences, such as personal perceptions of safety, comfort, or reliability. Additionally, the study does not account for seasonal variations in travel behavior, meaning the results might differ during extreme weather conditions or special events. Lastly, while the research identifies key determinants of mode choice, policy and infrastructural constraints that may also influence commuter decisions are not extensively explored. Future research could address these limitations by incorporating longitudinal data collection, mixed-method approaches, and broader sampling techniques to enhance the robustness of findings.

4. Data Analysis

4.1. Respondents of the Study

The proportion of male respondents was higher compared to female respondents. A 72.8% male and 27.2% female sample was used. The majority of respondents (51.1%) are 21-30 years old. The representation diminishes with age, suggesting a younger audience. A considerable percentage of respondents (44.5%) have a bachelor's degree or higher (31.4%), indicating a very educated sample. Few (1.8%) have less than a secondary education. The largest occupational group (39.8%) is students, reflecting their youthful age (Table 1). Office (31.7%), education (19.1%), recreation (16.5%), and visiting friends and family (14.1%) are the main trip purposes. This shows that respondents prioritized job, education, and social activities. Females prefer rickshaws for access and egress, whereas males choose buses. Those with less education use rickshaws more, whereas those with more education use CNGs and walking. Students walk or ride buses, while businesspeople and private workers take rickshaws and shared CNGs. Higher-income groups prefer expensive options like CNG and motorcycles, whereas lower-income people walk and take buses. Office journeys use buses, whereas vacation and study trips involve walking and rickshaws. Younger commuters walk or use shared modes due to cost sensitivity and convenience.

4.2. Access and Egress Travel Condition

Figure 3 shows people's entrance and egress transportation modes. At 34.81%, walking is the most prevalent egress mode after using another means of transport. Its 21.72% access mode popularity shows its value at both ends of a journey. Buses are the second most common means of public transportation, with 23.56% utilizing them for access and 25.13% for egress. Rickshaws and Legunas are important access modalities with 20.41% and 17.80%, respectively. Motorcycles are utilized more for access (9.16%) than egress (5.50%), while CNG vehicles are rarely used (Figure 3).

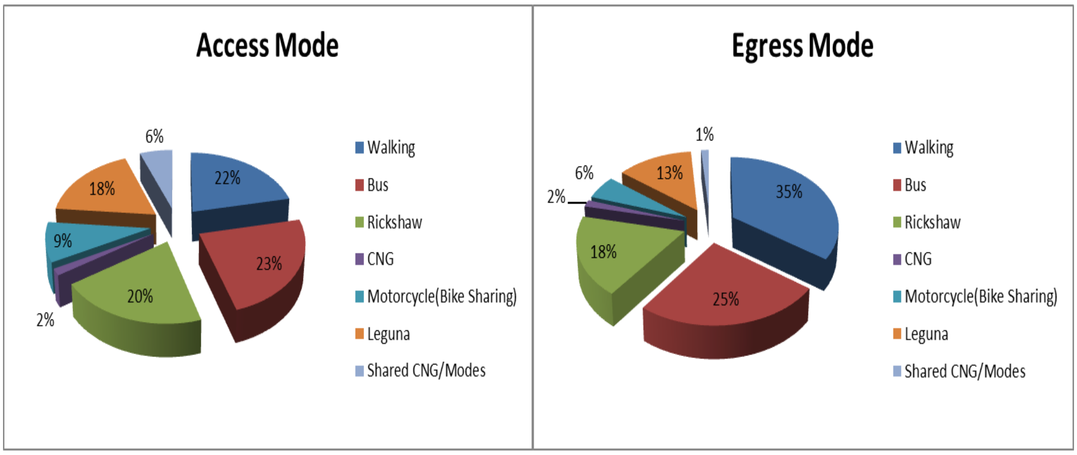

Figure 3. Access and Egress Mode Condition.

4.3. Access and Egress Mode: Demographic Pattern

Walking is the mode with the most gender equality, with 21.2% of access and 35.3% of egress cases being male and 23.1% and 33.7% female. The overall mode share percentage for men and women is shown here. Males walk more for egress and females more for entrance. The distribution is reversed for bus transportation: males 23.7% access and 25.2% egress, females 23.1% and 25.0%. A gender bias in bus usage is suggested. A gender bias exists in rickshaw use. Women use them more than men—21.2% for access and 19.2% for egress vs. 20.1% and 18.0%. Motorcycle use is gendered, as men dominate (9.7% for access and 6.5% for egress for male and 7.7% and 2.9% for female). Legunas have male 18.0% and female 17.3% access and female 11.9% and 16.3% egress dominance. However, female dominance is found in shared CNG for access (5.4% and 6.7%) and egress (1.1% and 1.9%).

Walking is the most popular access option, with 37.3% of trips starting on foot and sometimes switching to Rickshaw (13.3%) or Bus (25.3%) for egress. Buses are also a major mode of transit, with 28.9% using them to get to the metro and 26.7% using them afterward. Rickshaws account for 38.5% of trips that transition into various egress modes, primarily Walking (38.5%) and Bus (24.4%), highlighting their importance in first-mile connection. CNG customers move to Leguna (33.3%) and Rickshaw (33.3%) after entering the metro, an unusually equal distribution. Motorcycle access is 40%, with large transfers to Rickshaw (20%) and Walking (40%) for egress. Shared CNG egress has the highest Bus changeover at 40.9%. (Figure 4, left).

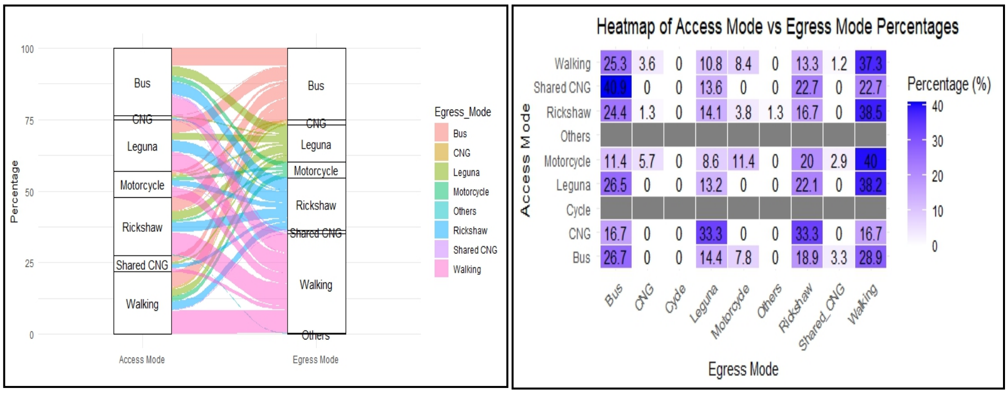

Figure 4. Access mode and egress mode distribution (**left**) and heat map of access mode vs egress mode (**right**).

Travel Time on the x-axis displays metro station access time by mode, while the y-axis shows trip density. Colour-coded lines represent Access Modes (Bus, Rickshaw, Walking, etc.). Walking (in pink) exhibits a high-density peak for shorter transit periods, indicating that many metro station walks are short. Some excursions take longer than others, as Rickshaw (green) and Bus (orange) have wider peaks. Motorcycle and Leguna have lower density, suggesting fewer journeys or more scattered travel times (Figure 5, left).

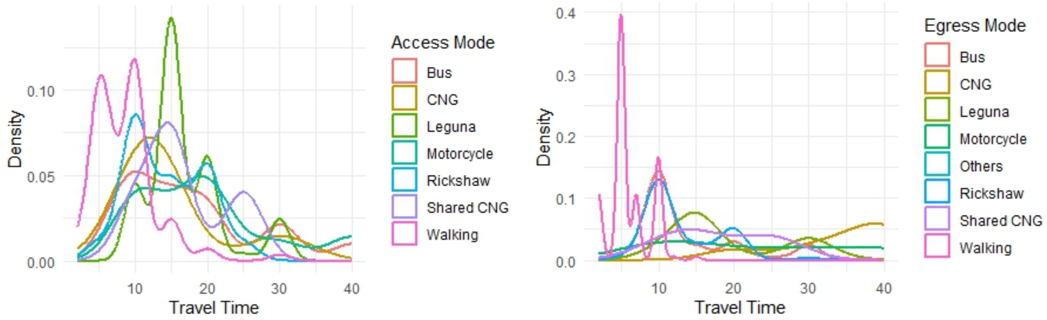

Figure 5. Access (**left**) and egress (**right**) mode travel time density.

The Egress Mode Density Plot shows journey times from the metro station using different Egress Modes. High-density peaks at reduced journey durations show walking is a widespread and effective egress route. Rickshaw and bus journey durations vary, however density fluctuations may indicate distinct trip characteristics for egress vs. access. CNG and Shared CNG have lower density, suggesting they are less used for egress or have more distributed transit durations (Figure 5, right).

4.4. Summary Analysis of Variables

Data was collected and compiled on multiple characteristics, such as the age of users, availability, comfort, access time, waiting time, distance, and cost, in order to analyze the different transportation options in Bangladesh. Rickshaws serve a younger clientele; averaging 27.9 years (Table 1). They are reasonably available and comfortable, scoring 3.39 and 2.39 on a Likert scale of 1 to 5. Vehicles take 14.58 minutes to reach rickshaws, while passengers wait 5.12 minutes. Rickshaws average 3186.44 meters and 37.46 Bangladeshi Taka. Walkers average 30.36 years old, as expected.

Table 1. Summary Analysis of Variables.

Mode	Average Age (Years)	Average in Vehicle Time (Minutes)	Average Vehicle Waiting Time (Minutes)	Average Distance (Meters)	Average Cost (BDT)
Rickshaw	27.9	14.58	5.12	3186.44	37.46
Walking	30.36	8.47	0	670.45	0
Leguna	31.37	16.73	7.98	4288.46	21.83
Shared Vehicle	30.33	16.25	10	4583.33	35.83
Bus	30.07	17.19	7.74	4143.06	16.39
CNG	30.33	15	3.33	6666.67	66.67
Motorcycle	29.41	20.31	8.03	11281.25	145.63

Availability and comfort are 3.36 and 2.5. Walking averages 670.45 meters and is free. Transit riders in Leguna average 31.37 years. This transportation method, like rickshaws and walking, has 3.38 availability. All modes have their lowest comfort rates, 2.25. Latency and queueing are 16.73 and 7.98 minutes for Legunas. They average 4288.46 meters for 21.83 Bangladeshi Taka. Like walking, this mode's average user age is 30-33. The availability and comfort scores are 3.33 and 2.25. Costs 35.83 Bangladeshi Taka and is 4583.33 meters long. Bus riders are the youngest, averaging 30.07 years. This mode has limited availability and modest comfort at 3.26 and 2.35. The bus ride takes 17.19 minutes, including 7.74 minutes of waiting. For 16.39 Bangladeshi Taka, they traverse 4143.06 meters. Like shared CNG customers, CNG consumers average 30.33 years old. This choice has the lowest availability (3 and comfort 2). The longest mode is 6666.67 meters but the most expensive at 66.67 Bangladeshi Taka. Average motorcycle rider age is 29.41. They are more comfy (2.75) and accessible (3.31). Motorcycles last 20.31 minutes and wait 8.03. The longest average distance is 11281.25 meters for 145.63 Bangladeshi Taka.

4.5. Applying Multinomial Logit (MNL) Regression

MNL regression uses a dependent variable category as the reference. All model parameters are understood in respect to it. Other response categories naturally compare to the standard/reference category. The coefficients are calculated iteratively using maximum likelihood. The odds ratios are calculated for all independent factors in each dependent variable category except the reference category. The odds ratio measures the difference in probabilities of being in the dependent variable category relative to the reference category when the independent variable changes by one unit.

Table 2 shows the likelihood ratio tests that illustrate each variable's contribution to the model. It is evident from Table 3 that several variables have significance levels below 0.05. It can be inferred, then, that the four variables in the model significantly contribute to the prediction of the mode choice in relation to metro rail. The three most important ones are discovered to be access time, waiting time, distance, and cost.

Table 2. Model Fitting Information.

Parameter	Model – Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept	285.190	.000	0	.
Age	286.288	1.097	6	.000
Availability	289.277	4.087	6	.000
Comfortability	292.023	6.832	6	.001
Gender	287.939	2.748	6	.840
Education	284.013	5.678	24	.740
Income	288.792	3.601	24	.004
Pattern	288.513	3.323	6	.031
Occupation	294.747	9.557	42	1.000
Access time required	328.222	43.032	18	.001
Waiting time	326.310	41.120	12	.019
Distance	6962.240	6677.050	12	.002
Access Cost	529.040	243.850	18	.000

Table 3 compares intercept-only and final models statistically. The "intercept" model predicts the output variable by fitting an intercept and deleting predictor variables. Finally, an iterative model maximizes output variable log likelihood using provided predictor variables. Add predictor variables and improve log likelihood of data outcomes to improve intercept-only model.

Table 3. Likelihood Ratio.

Model	Model – Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	781.119			
Final	285.190	495.929	180	.000

A likelihood ratio test indicates each variable's model contribution. Both models' statistical testing shows this. The final model had pseudo R^2 values of 0.885, 0.921, and 0.668 from Cox and Shell, Negelkerke, and McFadden tests. The pseudo R^2 value, which can reach 1, indicates how much variation predictors explain the response variable. The model can describe more variation with bigger pseudo R^2 statistics. Thus, pseudo R^2 values show that this study's model explains 66–92% of variance. The model is significant statistically.

Table 4 presents the prediction accuracy of the multinomial logit model used to analyze metro access and egress mode choices in Dhaka. The table compares observed mode choices (actual commuter decisions) with the predicted mode choices (model estimations) to evaluate how well the model classifies different transportation modes.

Table 4. Prediction Accuracies.

Observed	Predicted							
	Walking	Bus	Rickshaw	CNG	Motorcycle	Leguna	Shared CNG	Percent Correct
Walking	2	0	0	0	0	0	0	100.0%
Bus	0	47	3	1	0	26	2	59.5%
Rickshaw	0	3	35	3	8	2	2	66.0%
CNG	0	0	0	5	1	0	0	83.3%

Motorcycle	0	0	0	0	35	0	0	100.0%
Leguna	0	4	5	0	0	42	0	82.4%
Shared CNG	0	0	0	1	0	0	15	93.8%
Overall Percentage	0.8%	22.3%	17.8%	4.1%	18.2%	28.9%	7.9%	74.8%

The accuracy of prediction for walking is 100%. Similar analysis on Bus users gave a prediction accuracy of 59.5%, Rickshaw as 66%, CNG as 83.3%, Motorcycle as 100%, Leguna as 82.4% and Shared CNG as 93.8%. The model has an overall accuracy of 74.8%.

Each variable affecting user's walking preference for shared mode grows by one unit, according to the MNL model. Men are 1.53 times more likely than women to walk over shared means. MNL regression showed that money affects walking versus shared transportation. Low monthly incomes (less than BDT 15,000) and monthly incomes between BDT 300,001 and 500,000 increase the likelihood of walking over shared cars by 6.09 and 10.05 times, respectively. Individuals earning 15001-30000 prefer walking less than shared means. Walk 6.86 times more than shared modes for those earning 50001-80000. Regular metro users walk 1.01 times more across shared modes than irregulars. For preferring walking over shared modes, the multinomial logit for 'access time 0-10 minutes' is 3.66 units lower than 'above 30 minutes access time'. 'Access time 11-20 minutes' (coefficient = −.670) and 'access time 21-30 minutes' (coefficient = −1.147) have lower walking preferences than shared modes. Walking has an 8.22 times higher chance of use than shared modes and a 'waiting time of 0-5 minutes'. Metro passengers find 'waiting time of 6-10 minutes' unacceptable. They like shared modes.499 times more than walking. In this scenario, 'waiting time of 11-15 minutes' is meaningless. Since shared CNG are unavailable during peak times, walking is less comfortable for metro customers but more available than shared means to reach metro stations. Prefer walking over shared modes logit is -3.811. (Appendix Table A2)

User bus choice for shared modes is calculated using the MNL model. Men are roughly 1.45 times more likely than women to switch from shared to bus modes. Females find sharing modes unsafe and insecure. Bus is preferred over shared means by all socioeconomic groups in Dhaka. The coefficients for "Below BDT 15000 income group", "BDT 15001-30000 income", "BDT 30001-50000 income" and "BDT 50001-80000" are 1.421,.528, 2.314, and 1.903. Metro customers favour bus paratransit over shared options. Buses are less preferred by people who need 0–30 minutes to reach the station. Bus riders accept 0-10 minute waits. Distance increases the likelihood of transferring to bus from shared modes (2.887). Metro riders don't like to take buses for shorter distances (-.150 coefficient). Metro customers prefer buses over shared modes when the cost is between BDT 0-20 (coefficient = 2.632, 1.495). Cost rises reduce bus preference. Metro riders favour buses over shared options for availability and comfort. Preferring bus over shared modes has a logit of.117.

The research found that male metro passengers are 1.21 times less likely to move to rickshaw from shared modes than females. Dhaka residents of all income levels prefer rickshaws. The coefficient values of "Below BDT 15000 income group", "BDT 15001-30000 income", "BDT 30001-50000 income" and "BDT 50001-80000" are 2.251,.520, 1.945 and 2.138. Poor people switch rickshaws 9.498 times more than shared modes. University students are a large income category below 15000 BDT. More chances to exchange rickshaws. Regular metro riders favour rickshaw. 1.207 times more likely than irregular metro riders to transfer rickshaws. Rickshaws are less preferred by people who need 0 to 30 minutes to reach the station. Rickshaws can wait less than 5 minutes (coefficient = 3.225). Waiting less than 5 minutes increases the risk of switching rickshaws from shared modes by 25 times. When waiting time rises, rickshaw use falls. Rickshaws may travel 501–3000 meters. Metro riders prefer rickshaws over shared rides. Rickshaws are convenient and private. Metro riders choose shared modes over rickshaws for cost. Rickshaws cost more than shared rides. Rickshaws are more comfortable for metro riders than shared transportation. Prefering bus over shared modes logit is -.995.

Males are 1.87 times less likely to transition to CNG from shared modes than females, according to multinomial analysis. Women prefer CNG over shared modes. Male-to-male multinomial logit is -.629. CNG is preferred by all income groups in Dhaka because to its safety and privacy. The coefficients for "Below BDT 15000 income group", "BDT 15001-30000 income", "BDT 30001-50000 income" and "BDT 50001-80000" are 5.703, 3.487, 7.648 and 5.653. It implies more people from all income levels can use CNG as metro paratransit. Regular metro riders won't use CNG paratransit. They like shared modes. Regular metro users have -1.186 logit. CNG paratransit is not preferred by users who need less time to reach the metro station. CNG has a lower preference than shared modes for 'time 0-10 minutes' (coefficient = -.3.481) and 'time 11-20 minutes' (coefficient = -.130). The multinomial logit for 'time 21-30 minutes' against 'above 30 minutestime' favours CNG over shared modes by 3.93 units. It's acceptable for CNG to wait less than 10 minutes (0-5 minutes = 4.621, 6-10 minutes =.072). Over 500 meters for CNG is fine. People like to drive great distances in CNG vehicles. Metro customers won't utilize CNG while shared modes are cheap. Metro customers choose CNG when shared mode charges rise. CNG carries roughly 3-4 people per journey, therefore consumers may pick it over shared vehicles to save money and time. Metro customers choose CNG over shared modes for availability and comfort. Prefering bus over shared modes logit is -10.414.

Men are 1.45 times more likely than women to move to motorcycles from shared modes, according to the model. Dhaka residents of all income levels prefer motorcycles. Metro riders dislike switching to motorcycles over shared transportation. Motorcycle preference is lower than shared modes for 'Access time 0-10 minutes' (coefficient = -2.997), 'Access time 11-20 minutes' (coefficient = -1.394), and 'Access time 21-30 minutes' (coefficient = -2.838). Motorcyclists can wait 0-5 minutes (coefficient =.302). Motorcycles can go above 500 meters. The coefficients for 'Distance 501-1000 meters' and 'Distance 1001-3000 meters' are 2.132 and 1.639. Metro riders prefer motorcycles over shared means for longer distances. The motorcycle's price is too high for metro riders.

Multinomial Logistic Regression showed that males chose Leguna 2.366 times more than females over shared CNG. MNL regression showed that money affects Leguna and shared mode preference. Leguna is popular with all income groups. For preferring Leguna over shared modes, the multinomial logit for 'access time 11-20 minutes' is 1.91 units higher than 'above 30 minutes'. Leguna prefers 'access time 0-10 minutes' (coefficient = -2.959) and 'access time 21-30 minutes' (coefficient = -.925) less than shared modes. Leguna accepts a "waiting time of 0-5 minutes" and has 3.69 times the chance of using than shared modes. The coefficients for 'Distance 501-1000 meters' and 'Distance 1001-3000 meters' are 3.361 and 2.796. Metro riders chose Leguna over shared modes for BDT 11-20 (coefficient = 1.984). Metro users can use Leguna, which is uncomfortable for formtrousers.

5. Discussion

This study on Dhaka metro users' mode choices for reaching and egressing stations sheds light on their transit behaviour. The important result that socio-economic factors, notably income and trip-related features, greatly influence entrance and egress modalities is consistent with the literature on constructing city transportation systems. Rahman et al. (2022) observed that income and access times influence suburban commuters' transit choices (Rahman, Akther and Recker, 2022). This study adds to our understanding by focusing on Dhaka's new metro train system. Despite pedestrian infrastructure shortcomings, notably in the first and last mile, people choose walking and rickshaws. Similar research from Delhi and Jakarta shows that walking and cycling are popular due to low prices but restricted by poor urban infrastructure (Kumar, Zimmerman and Agarwal, 2011). Singapore, for example, has improved cycling infrastructure to boost multimodal connectivity to metro stations (Zhao and Li, 2017). Lack of such amenities in Dhaka misses an opportunity to promote healthier, more sustainable commuting. Since they're cheap and fast, buses and motorcycles are popular feeder modes, according to the report. Public buses connect neighbourhoods and metro stations in Indian cities, according to Tiwari et al. (2016) (Goel and Tiwari, 2016; Chava, Newman and Tiwari, 2018; Tiwari, 2017). The intermittent availability of these services during peak hours and their low capacity in Dhaka make them less appealing to regular travellers. In contrast, Istanbul and London have well-organized bus services with real-time passenger information for better first- and last-mile connection. This study found that male commuters favour bus, leguna, and motorcycles, whereas female commuters chose safer options like CNGs and rickshaws. This pattern matches other developing cities where safety concerns cause gender-based transportation preferences. Due to safety concerns, Jakarta and Manila women prefer ride-hailing over public transport (Chalermpong et al., 2023; Fitri, 2024; Benita, 2023). This emphasizes the need for gender-sensitive transportation policy that addresses safety concerns and ensures fair public transportation access.

The study's Multinomial Logit Model shows that access and egress time, waiting time, distance, and cost strongly influence mode choice. This supports Van Nes and Bovy (2004)'s finding that multimodal transport design must prioritize time and cost efficiency to increase public transit use (Fiorenzo-Catalano, Van Nes and Bovy, 2004). In Dhaka, like in Cairo and Lagos, the lack of integrated price structures and coordinated schedules between metro services and feeder modes hinders smooth multimodal travel (Hussin, 2020; Venter, Mahendra and Hidalgo, 2019; Okanlawon, 2011; Benhlima, 2024). Finally, limited walking infrastructure around metro stations and low comfort levels for bus and rickshaw riders highlight the need for policy reforms to improve pedestrian facilities, introduce dedicated bus lanes, and improve shared modes of transportation. This supports urban mobility studies in Indian and Brazilian cities (Ho and Tirachini, 2024; Cervero, Guerra and Al, 2017), where first-and-last-mile connection has improved metro utilization and reduced private car dependency.

6. Research Limitations

While this study provides valuable insights into metro access and egress mode choices in Dhaka, several limitations should be acknowledged. First, the study employs a cross-sectional survey design, which captures commuter behavior at a single point in time. As a result, it does not account for potential variations in travel behavior due to seasonal changes, economic shifts, or evolving transport policies. A longitudinal approach could offer deeper insights into trends and changes over time.

Second, the study relies on self-reported survey data, which may introduce recall bias or social desirability bias, as respondents might not always accurately report their travel patterns, costs, or waiting times. Additionally, the use of convenience purposive sampling may limit the generalizability of the findings, as the sample might not be fully representative of the entire population of metro users in Dhaka. Future research could employ randomized or stratified sampling to enhance representativeness.

Third, while the multinomial logit model (MNL) effectively identifies statistical relationships between independent variables (e.g., income, travel cost, waiting time) and mode choice, it does not account for qualitative factors such as commuter perceptions of safety, convenience, or service reliability. A mixed-methods approach, incorporating interviews or focus groups, could provide a more comprehensive understanding of commuter preferences.

7. Conclusion

This study aimed to examine the factors influencing metro access and egress mode choices in Dhaka, with a particular focus on socio-economic characteristics and trip-related attributes. By employing a multinomial logit model, the study identified key determinants affecting commuters' travel decisions, including age, income, gender, travel distance, waiting time, in-vehicle time, availability, comfort, and travel cost. The findings indicate that while private automobiles are rarely used, rickshaws and buses are the most preferred feeder modes due to their affordability and accessibility. Additionally, motorcycles have emerged as a viable option for last-mile connectivity, particularly among younger commuters.

The model showed that metro users' should not walk because there is no walking infrastructure near the station. Metro riders who walk to stations feel uneasy. Few people with 30000–50000 incomes walk to metro stations. Metro riders may find buses a good way to connect to metro rail. If buses are available with reduced wait time, metro customers will take them to connect. Young men 25–40 are willing to use the bus. Rickshaws are another nice metro alternative. It's sometimes unavailable during busy hours. Lower-income people use rickshaws to get to metro. Rickshaw riders wait little. People use rickshaws to go to metro stations. This model predicts less CNG metro train connecting mode use. CNG is preferred for long distances in Dhaka city by families. CNG is more popular among BDT 30000-50000 earners. This model shows that motorcycles are the most preferred means of metro rail connectivity. Metro customers connect to stations short- and long-distance using this model. Due to its availability and shorter metro ride, this mode appeals to all income levels. Metro customers dislike leguna owing to its unreliability and insecurity. Finally, motorcycles and buses are the most preferred travel modes, followed by leguna, rickshaw, and walking among metro passengers. That analysis suggests which transit modalities can be enhanced to make metro travel easier. Different land use and built environment characteristics around the station will be researched. The effects of density, land use, walkability, and station area qualities on metro users' trip characteristics and mode choice will be examined.

From a policy perspective, the results highlight the need for improved first and last mile connectivity to enhance metro utilization. Investments in integrated feeder services, such as dedicated bus routes, bicycle-sharing systems, and pedestrian-friendly infrastructure, could significantly improve metro access. Moreover, gender-specific concerns regarding safety and convenience should be addressed by ensuring well-lit walkways, designated waiting areas, and improved security measures. Additionally, fare integration between metro services and feeder modes could enhance affordability and encourage greater public transport usage.

For future research, a longitudinal approach could provide insights into how metro access behavior evolves over time, particularly as infrastructure improvements and policy changes take effect. Further studies could incorporate spatial analysis to assess the impact of land-use characteristics on mode choice. Additionally, a mixed-methods approach, combining qualitative interviews with quantitative modeling, could offer a more comprehensive understanding of commuter preferences and challenges. By addressing these areas, future research can contribute to the development of a more sustainable and inclusive urban transport system in Dhaka and other rapidly growing cities.

Conflicts of Interest

The authors declare no conflict of interest.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Appendix A

Table A1. Sample description and access and egress mode sharing.

Variables	Sub Class of Variables	Access and Egress Mode															
				Walking		Bus		Rickshaw		CNG		Motorcycle		Leguna		Shared CNG	
		N	(%)	Access (%)	Egress (%)	Access (%)	Egress (%)	Access (%)	Egress (%)	Access (%)	Egress (%)	Access (%)	Egress (%)	Access (%)	Egress (%)	Access (%)	Egress (%)
Gender	Male	278	72.8%	21%	35%	24%	25%	20%	18%	2%	2%	10%	6%	18%	12%	5%	1%
	Female	104	27.2%	23%	34%	23%	25%	21%	19%	1%	1%	8%	3%	17%	16%	7%	2%
Education	Below SSC	7	1.8%	14%	29%	14%	0%	29%	43%	0%	0%	0%	14%	14%	14%	29%	0%
	SSC	26	6.8%	31%	46%	23%	19%	19%	12%	4%	0%	4%	8%	19%	15%	0%	0%
	HSC	59	15.4%	29%	37%	24%	24%	19%	15%	2%	5%	5%	5%	20%	12%	2%	2%
	Bachelor	170	44.5%	20%	36%	21%	26%	24%	17%	2%	1%	10%	5%	16%	15%	7%	0%
	Above Graduate	120	31.4%	19%	30%	28%	27%	16%	22%	1%	1%	12%	6%	18%	11%	6%	3%
Occupation	Government Job	27	7.1%	26%	41%	22%	30%	19%	15%	0%	4%	15%	0%	15%	11%	4%	0%
	Private Job	117	30.6%	25%	39%	21%	25%	19%	15%	3%	2%	9%	4%	20%	13%	5%	3%
	Business	31	8.1%	26%	29%	23%	13%	10%	19%	0%	3%	16%	16%	23%	13%	3%	3%
	Driver	0	0.0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Teacher	23	6.0%	17%	48%	30%	9%	9%	22%	0%	0%	9%	9%	30%	13%	4%	0%
	Student	152	39.8%	18%	31%	23%	28%	27%	20%	2%	1%	8%	6%	14%	13%	8%	1%
	Others	17	4.5%	35%	41%	18%	12%	12%	24%	0%	0%	6%	0%	24%	24%	6%	0%
	Day Labourer	9	2.4%	11%	11%	56%	67%	22%	11%	0%	0%	0%	0%	11%	11%	0%	0%
	No Employment	6	1.6%	17%	17%	50%	33%	17%	33%	0%	0%	17%	0%	0%	17%	0%	0%
Income	Below 15000	183	48.2%	19%	35%	24%	27%	25%	19%	2%	1%	8%	5%	15%	12%	7%	1%
	15001-30000	78	20.5%	27%	37%	23%	15%	14%	19%	0%	3%	13%	5%	17%	19%	6%	1%
	30001-50000	96	25.3%	20%	33%	23%	32%	18%	15%	3%	2%	8%	6%	25%	11%	3%	0%
	50001-80000	20	5.3%	35%	35%	20%	10%	15%	25%	0%	0%	10%	5%	15%	5%	5%	15%
	Above 80000	3	0.8%	0%	33%	33%	33%	33%	33%	0%	0%	0%	0%	0%	0%	33%	0%
Pattern	Regular User	161	42.1%	21%	34%	20%	27%	20%	20%	1%	2%	9%	5%	22%	11%	5%	1%
	Irregular User	221	57.9%	22%	36%	26%	24%	20%	17%	2%	1%	9%	6%	14%	14%	6%	1%
Purpose of Trip	Office	121	31.7%	20%	36%	19%	24%	20%	17%	1%	2%	12%	6%	24%	15%	4%	1%
	Business	25	6.5%	20%	40%	24%	12%	16%	12%	0%	4%	24%	12%	12%	12%	4%	4%
	Study	44	11.5%	20%	27%	23%	23%	25%	25%	0%	2%	2%	7%	16%	16%	14%	0%
	Recreation	63	16.5%	24%	35%	17%	27%	27%	17%	5%	2%	8%	3%	17%	16%	2%	0%
	Exam	1	0.3%	0%	100%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	School	13	3.4%	38%	54%	15%	8%	23%	8%	0%	0%	0%	23%	15%	8%	8%	0%
	College	3	0.8%	67%	67%	33%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%
	University	12	3.1%	17%	50%	17%	17%	25%	25%	0%	0%	33%	8%	0%	0%	8%	0%

Variables	Sub Class of Variables	Access and Egress Mode															
				Walking		**Bus**		**Rickshaw**		**CNG**		**Motorcycle**		**Leguna**		**Shared CNG**	
		N	**(%)**	**Access (%)**	**Egress (%)**	**Access (%)**	**Egress (%)**	**Access (%)**	**Egress (%)**	**Access (%)**	**Egress (%)**	**Access (%)**	**Egress (%)**	**Access (%)**	**Egress (%)**	**Access (%)**	**Egress (%)**
	Home	22	5.8%	23%	41%	45%	41%	5%	14%	5%	0%	9%	5%	5%	0%	9%	0%
	Shopping	1	0.3%	0%	0%	0%	0%	0%	100%	0%	0%	100%	0%	0%	0%	0%	0%
	Visiting Relatives & Friends	54	14.1%	22%	28%	37%	35%	17%	17%	2%	0%	0%	2%	17%	13%	6%	6%
	Working	22	5.8%	14%	23%	23%	27%	23%	32%	0%	0%	5%	0%	27%	18%	9%	0%
	Others	1	0.3%	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Age	Mean = 30, Median = 28, Minimum = 16, Maximum = 72, SD = 9																

***Table** A2*. Parameter Estimation of Mode Choice.

Variables		Reference Category: Shared CNG/Modes					
		Walking	Bus	Rickshaw	CNG	Motorcycle	Leguna
Intercept		-3.811	.117	-995	-10.414	6.162	-.253
[Age = 10-25 years]	B	8.489	-7.67	7.509	-9.803	2.231	-5.893
	Exp (B)	.945	.995	.996	.987	.971	.324
[Age = 26-40 years]	B	-7.771	14.06	5.775	-4.541	-3.133	14.732
	Exp (B)	.999	.990	.995	.969	.356	.421
[Age = 41-50 years]	B	-25.312	-21.26	7.411	-9.882	-6.943	-9.312
	Exp (B)	.998	.991	.983	.992	2.652	2.301
[Age = Above 50 years]							
Availability	B	1.011	1.107	1.315	.655	.992	.919
	Exp(B)	2.749	3.026	3.725	1.926	2.698	2.507
Comfort ability	B	-.007	.132	.002	.506	.097	-.365
	Exp(B)	.993	1.141	1.002	1.659	1.101	.694
[Gender = Male]	B	.422	.374	-.208	-.629	.371	.861
	Exp(B)	1.525	1.454	1.231	1.875	1.449	2.366
[Gender = Female]							
[Income = Below BDT 15000]	B	1.807	1.421	2.251	5.703	1.897	1.989
	Exp(B)	6.092	4.143	9.498	299.886	6.667	7.309
[Income = BDT 15001-30000]	B	.745	1.696	.520	3.487	.864	1.143
	Exp(B)	2.106	10.115	1.682	32.682	2.373	3.135
[Income = BDT 30001-50000]	B	2.307	2.314	1.945	7.648	2.287	2.783
	Exp(B)	10.047	10.115	6.992	205.97	9.841	16.168
[Income = BDT 50001-80000]	B	1.925	1.903	2.138	5.653	1.491	2.203
	Exp(B)	6.857	6.706	8.482	285.10	4.441	9.048

Variables		Reference Category: Shared CNG/Modes					
		Walking	Bus	Rickshaw	CNG	Motorcycle	Leguna
[Income = Above BDT 80000]							
[Pattern=Regular]	B	.008	-.198	.189	-1.186	-.179	.408
	Exp(B)	1.008	.821	1.207	.306	.836	1.504
[Pattern=Irregular]							
[Access time required = 0-10 Minutes]	B	-3.657	-4.919	-4.009	-3.481	-2.997	-2.959
	Exp(B)	.026	.007	.018	.031	.050	.052
[Access time required = 11-20 Minutes]	B	-.670	-1.637	-.285	-.130	-1.394	.649
	Exp(B)	.512	.195	.752	.878	.248	1.914
[Access time required = 21-30 Minutes]	B	-1.147	-1.443	-.435	1.371	-2.838	-.925
	Exp(B)	.318	.236	.648	3.938	.059	.397
[Access time required = Above 30 Minutes]							
[Waiting time = 0-5 Minutes]	B	2.108	2.918	3.225	4.621	.302	1.297
	Exp(B)	8.229	18.502	25.146	101.57	1.352	3.658
[Waiting time = 6-10 Minutes]	B	-.695	.328	-.742	.072	-1.683	-1.861
	Exp(B)	.499	1.389	.476	1.074	.186	.155
[Waiting time = 11-15 Minutes]	B	NA	NA	NA	NA	NA	NA
	Exp(B)	NA	NA	NA	NA	NA	NA
[Waiting time = Above 16 Minutes]							
[Distance = 0-500 meters]	B	NA	NA	NA	NA	NA	NA
	Exp(B)	NA	NA	NA	NA	NA	NA
[Distance = 501-1000 meters]	B	123.325	-.150	4.094	2.037	2.132	3.361
	Exp(B)	6.70E+5	.861	59.992	7.665	8.431	28.827
[Distance = 1001-3000 meters]	B	NA	2.887	4.984	.968	1.639	2.796
	Exp(B)	NA	17.932	146.022	2.633	5.152	16.372
[Distance = 3000 meters]							
[Access Cost = BDT 0-10]	B	-.968	2.632	-3.420	-.469	-5.657	-1.143
	Exp(B)	.380	13.899	.033	.625	.003	.319
[Access Cost = BDT11-20]	B	.076	1.495	-.588	.742	-4.982	1.984
	Exp(B)	1.079	4.460	.555	2.099	.007	7.274
[Access Cost = BDT 21-30]	B	-4.251	-4.056	-3.180	.833	-8.838	-4.451
	Exp(B)	.014	.017	.042	2.301	.000	.012
[Access Cost = Above BDT30]							

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