Assessing Travelers' Characteristics and Trip Information Influencing the Boarding and Alighting Experience at Bus Stops in a Developing Urban City: A Simultaneous Bivariate Ordered Probit Approach

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APPROVAL

This is to certify that the dissertation entitled "**Assessing Travelers' Characteristics and Trip Information Influencing the Boarding and Alighting Experience at Bus Stops in a Developing Urban City: A Simultaneous Bivariate Ordered Probit Approach**", by K. B. M. Ibrahim, Tashdid Haque and Md. Fardeen Tanim has been approved fulfilling the requirements for the Bachelor of Science Degree in Civil Engineering.

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DECLARATION

We declare that the undergraduate research work reported in this thesis has been performed by us under the supervision of Professor Dr. Moinul Hossain. We have taken appropriate precautions to ensure that the work is original and has not been plagiarized. We can also make sure that the work has not been submitted for any other purpose (except for publication).

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DEDICATION

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ABSTRACT

Improved public transport accessibility for the catchment area is crucial towards achieving increased transit ridership. It is essential to determine how passengers commute to various bus stops, how their preferences differ depending on their individual characteristics and passenger's perception of prevailing commuting infrastructure to get to the bus stops to achieve optimal transit ridership. A simultaneous bivariate ordered probit model is performed utilizing data collected from a face-to-face survey at different bus stops in Dhaka, a developing urban city. Socio-economic characteristics, such as income, education level, etc., and trip characteristics, such as; frequency, purpose etc. were found to have significant impacts on boarding and alighting experience at bus stops. Furthermore, boarding experience was found connected with passenger's alighting experience. The findings of this study would enable the policy makers to identify and improve the underlying factors affecting ridership of public buses in a developing urban society.

Keywords: Bus stop, boarding, alighting, socioeconomic, trip characteristic, bivariate ordered probit model

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CHAPTER 1

INTRODUCTION

1.1.Importance of Public Transport in an Urban Area

Urban areas and regional centers are heavily populated areas that require safe and reliable transportation of people and goods (Iles, 2005). Mass transit is also said to be the cornerstone of urbanization (Paaswell and Saikia-Eapen, 2005). Elevated levels of activities enable and demand the use of high-capacity transit systems, such as bus, light rail or subway, because they are cheaper, more energy-efficient and require considerably less urban space than personal vehicles. In addition, public transit services are universally accessible, while private vehicles could only be used by some who own and can ride them. As a result, urban areas demand and flourish from public transit systems that provide high accessibility for the larger community. In fact, public transportation services are often required in densely populated areas to make high frequency trips, such as homes, corporate offices, parks, malls, etc., functionally feasible while keeping cities habitable and attractive to its residents. Rise in urban inhabitants with time have triggered surge in traffic causing congestion on road network and adverse environmental impacts; people are further attracted towards public transport compared to private transport (Benenson *et al*., 2011; Kawabata and Shen, 2006). This disparity in attraction is because of the large capacity of public transportation modes, adherence to scheduled time, low cost, high speed and its ease of mobility for travelers inside the congested city centers.

Enlarging urban populations needs greater access to financial activities, transportation, housing and recreation. The position of these facilities and the availability of suitable transport networks, such as freeways, rapid transit and parking spaces, are the foundation of urban planning. The transport infrastructure has a major effect on regional trends of growth, economic viability, environmental consequences and the maintenance of culturally acceptable standards of living standards. It is not unusual to see that substantial efforts are already being committed by government authorities on the preparation and implementation of more efficient transport networks. Although the journey from policy formulation to system implementation is not always transparent or strategic, it is crucial that procedures be developed and used to analyze and evaluate accomplishment of objectives.

1.2. Significance of Sustainable Transportation System

Efficient public transport (PT) networks are primary characteristics for well-operative and sustainable cities (Kujala *et al*., 2018). In order to shift from a private motorized vehicle to public transportation, walking and cycling can play a significant role to increase the sustainability of transportation and accordingly, improve the environment, economics and public health (Elias and Shiftan, 2012).

Sustainability implies satisfying current needs without undermining the future generation's potential to fulfill their own needs (World Commission on Environment and Development, 1987). By broadening this principle to the transportation sector means developing the transport infrastructure in such a way that it provides maximum efficiency in mobility without hampering with the needs of the future generation. A research conducted by Black (2010) sought to define a sustainable transportation system as one that utilizes clean fuels for transportation and connectivity and minimizes pollution that adversely impact the environment and human health and prevents fatality, injury and traffic disruption. This concept emphasizes on the fact that sustainable transport development would not only be environmentally responsible, but also fulfill its mobility, comfort and safety purpose. On another perspective, the European Union Transport Council indicates that a sustainable transportation infrastructure is one that cost efficient, provides equal service for all people, offers alternate modes of transport and promotes a dynamic market as well as a prosperous urban development.

Mass transit has an influence on the structure and living of people in urban region (Karim, 1998). Robust, effective public transit infrastructure promotes urban growth as well as provides sufficient connectivity, accessibility and ease of use of public transport for city residents. Mass transit could free capital expenditure from a region that can more constructively be allocated somewhere else as fixed capital investment (Karim, 1998). The lack of transport infrastructure is among the greatest obstacles in large cities' socio-economic growth and national integration (Mannan *et al.*, 2001). Hence, it can be deduced that a sustainable urban transit infrastructure helps to improve urban life both economically and socially.

Researchers have concluded that adequate transport planning is needed to support productivity growth. Transportation systems account for 20 to 25% of global energy utilization and carbon dioxide emissions and have major effects on the atmosphere (World Energy Council, 2007). Carbon emissions from transportation system are increasing faster than any other energy utilizing system (Ribeiro *et al.*, 2007). Social transportation cost include traffic collisions, noise and air pollution, congestion, lack of physical activity and time taken away while driving, fuel price risk etc. Traditional transit design is generally targeted towards improving mobility of vehicles, particularly for cars, and often does not consider the wider impacts of transportation system. Nevertheless, access to jobs, school, transporting of goods and services are the main aim of transportation and there are tested strategies to increase access while minimizing significant environmental and social effects and controlling traffic jams (Litman, 2003). Cities that are efficiently upgrading their transit network's sustainability are indeed being implemented as component of a bigger project to create lively, viable and prosperous communities.

The development and growth of metropolitan areas is critically influenced by transport planning. The aim of travel, time and space allocations of trips, modal splits of transport modes and cost of travel should be taken into consideration (Meyer and Miller, 1984). This will affect both existing and future facilities and the atmosphere of the region. From a wider perspective, the mobility of an efficient transportation system factors in the social, economic and environmental aspects of sustainability. Hence, transport networks are the basis for sustainable growth and the way to communicate within communities. An inefficient network of transportation and its corresponding social aspects would restrict economic opportunities. More specifically, the main impact on a region's sustainability is inferred from the energy and environmental impacts of unnecessary single vehicle transport. The associations among high fuel use and low urban density in Northern American and Australian cities as matched to higher density, more energy efficient European cities were detected in a study (Newman and Kenworthy, 1989). The effects of excessive utilization of non-renewable energy, congestion, noise and air quality degradation are results of urban transportation systems planned for passenger car travel only.

Transit planning is an essential element of regional stability and development that is closely linked with the development and execution of policies. In order to help instruct and comprehend transport policy and regulations, it is important that methods for measuring, assessment and modeling system functionality exist. In the United States, for instance, the Clean Air Act constitutes policies that seek to minimize the impacts of pollution on the atmosphere (Hanson, 1995). The persistent design and implementation of analytical methods and models to find and evaluate alternatives to mandatory reduction measures has been associated with this. Yet another explanation is the modelling framework for urban transport consisting of interconnected models to better forecast ridership demand (Meyer and Miller, 1984). This is vital in assessing the impacts of urban development and transformation on transport infrastructure and different modes of transport. This last example is the relationship between land use and transport, which is also being modelled (Paulley and Webster, 1991). Geographical information systems are one of the core components of evolving concepts and strategies to better understand transport mechanisms (GIS). GIS is appearing to be useful in developing transport frameworks for management and modelling of large strategic policies (Nyerges, 1995). Consequently, substantial investments have been made in improving strategies for transport planning as well as the related data to enable monitoring, assessment and modelling.

Sustainable development of transportation, environmental conditions of the city, urban welfare and financial conditions of people can be enhanced by transitioning from private transport to mass public transit, walking and cycling. (Elias and Shiftan, 2012). This transition to a more efficient use of urban land space shall be plausible when mass public transit systems are easily accessible and widely available for the use of general public.

1.3. Importance of Catchment Area

One of the most significant implications of the public transport system is accessibility. The provision of transportation systems is also an important aspect of social sustainability, and mass transit can be made more appealing by ensuring "Door to Door Mobility." In terms of usability and affordability, urban transport accessibility has become exceedingly important in the design and evaluation of transit systems. Other than the transportation infrastructure itself, the operational flexibility and accessibility of public transportation has a significant effect on life quality.

The key purpose for assessment of the public transport accessibility is to offer enhanced connectivity between people and mass transit in order to lessen the congestion on roads. Simply put, transportation by public transit offers an incentive to decrease inopportune impact of vehicle usages on ecological conditions and public health (Jackiva Yatskiv *et al*., 2017). A well-organized transportation system can increase the connectivity standard of a region. Accessibility for publicly funded transportation stations, integration of public transit with other modes and mobility of the network should also be taken into account to run an easy-to-use public transport infrastructure (Cheng and Chen. 2015).

The ability of using mass transit is regarded as having access to it. It could be perceived in terms of proximity to public bus stop catchment area and the expense of utilizing these services. An approach from a financial viewpoint has been undertaken previously (Jansson 1993). The concentration of this study is mostly on proximity-based public transportation access.

For setting relevant policy and legislation, assessing access to urban public transportation is of special concern. For example, high-density developments or public housing will benefit from a location that allows for easy access to public transportation. A potential way to determine access would be to define a specific distance (or travel time) around a bus stop. Therefore, all the areas within this threshold distance can be identified and the overall percentage of people in an area who have suitable accessibility can be estimated. This creates the necessity for a spatial linearization, since marginal coverage of geographical units is plausible. Another strategy is to compare the distance between a spatial reporting unit and its closest stop, which may be called a collection zone. Coverage is done if the gap is less than the limit. Both methods have the potential for mistakes. They are, however, opposing viewpoints that, when combined, offer a way of ensuring that accessibility figures are correct and consistent.

1.4.Paratransit Role in Dhaka

The capital city of Bangladesh, Dhaka, has a population of over 17 million, is amongst the top ten densely populated mega cities of the world and projected to increase to 35 million within 2035 (World Bank). An enormous growth in population has been observed in developing countries over the last two decades. (Buhaug and Urdal, 2013). This massive rise in population has an inherently domino effect on the travel demand of people residing in the area as more urban sprawls continue to develop further away from the city center. Therefore, if the transportation sector's structural frame work is not capable of keeping up with all the travel demands, this eventually results in an increase of waiting time, bus dwelling time and congestion time (Samek Lodovici and Torchio, 2015).

As growth of urban development and increase in population is projected to continue rising in the near future, the existence of inadequate public transportation and policies, an intricate traffic combination constituting over-concentration of non-motorized vehicles i.e. paratransit has resulted in a significant deterioration of traffic and environmental problems in Dhaka. The absence of an effective public transit system and a lack of enforcement of traffic laws have resulted in a reduction in connectivity, quality of service, convenience, ridership and operating performance. Hence, this has led to increased costs, greater travel time, environmental damage and social stress, and continues to pose a significant threat to the future prosperity of the Dhaka. Bartone et.al (1994) asserted that approximately 80% of GDP growth in developing countries is likely to be generated from urban metropolitan areas or cities. A study conducted by Firdous (1984) also emphasized on several problems relating to bus operation in Dhaka Metropolitan Area. Another research work led by Ahan (1990) inspected the existing condition of Public Transportation System in Dhaka. Specific consideration was provided to the requirement of mass public transit systems that are both highly efficient and affordable for general population. Dhaka has lately faced significant mobility issues for its residents. Ineffective use of the old busses which are mostly malfunctioned and other paratransit feeder services can't keep up with the demand of such a large number of communities and hence triggers many cases of congestion, collisions and environmental pollution. Regrettably, the city of Dhaka has mostly grown without any organized transit system. (Hossain, 2006). Typically, rapid development, less pay and serious disparities among societal groups are among the basic reasons for transportation problems in Dhaka City. The environmental impacts of congestion are also highly significant. Air Quality Index (a measure of pollutant concentration in air) measured at various checkpoints inside the city reveal that most of the readings from the urban road network generally tend to exceed 200, whereas the acceptable standard for clean and minimally polluted air is 50 (Alam *et al*, 2000) and (WHO). The fact that the real life cases of air pollution far exceeds the international limit set by WHO poses a great health risk for the residents of Dhaka City.

The transportation conditions in Dhaka don’t necessarily coincide with the existing infrastructure in other countries owing to the huge reliability of the public on paratransit modes. Paratransit modes are given their name because they do not adhere to any fixed route/schedule. As the road networks served by the public transportation are low compared to the total amount of roads, many people are highly dependent on these modes for door-to-door service. Conversely, these paratransit also contribute to public transit ridership as they act as feeder services carrying people from their origin to the bus stop. Therefore, this distinctive trait makes the existing public transportation policies of cities around the world ineffective in Dhaka.

1.5. Variables

One of the most essential traits of everyday trip/travel is the choice of mode of transportation from an array of various alternatives. Models integrating mode choice are perhaps as longstanding as discrete choice modeling theory itself (Domencich and McFadden, 1975).

Bus networks provide a flexible mode of public transit with ability to satisfy a range of access needs in the urban environment. The efficiency of transport systems would be reasonable when measured from the viewpoint of passengers, so it is important to recognize the impact of socioeconomic conditions and trip characteristics of passengers on the accessibility of bus service. The background of developing countries, however, varies considerably from circumstances elsewhere; variables impacting passenger experience vary from country to country. A study by Diana (2012) determines that the residents of major agglomerations are less content with their public transit systems than those who live in less densely populated areas. Such regional and cultural considerations, as well as disparities between public transport networks and technology, would also have an effect on the overall satisfaction of passengers of the service offered (Felleson and Friman, 2012).

It is to note that a majority of existing literature related to public bus transit analysed the impact on bus ridership experience whereas this paper intends to focus more on the accessibility to the catchment area and the passenger’s boarding and alighting experience at bus stops. Hence, the social demographic and trip characteristics data of passengers are important factors in determining how the accessibility impacts the boarding and alighting experiences. Although many variables like cost, travel time and waiting time associated with the feeder service used to access to and from bus stops, frequency of the trip made, pedestrian facility to walk up to bus stop, etc. might have an intrinsic effect on boarding and alighting experiences of passengers, they were not considered in previous studies.

1.6.Problem Statement

For quite a while, the customer experience is believed to be the customers' perception, evaluation, and interaction throughout cognitive, emotional, behavioral, sensorial, and social components about service provider (Lemon & Verhoef, 2016; Patrício *et al*., 2004; Verhoef *et al*., 2009). Service provider that improved their service reliability would be crucial toward enhancing passenger experience or travel experience (Leong *et al*., 2016). Majority of studies conducted in the transportation sector has concentrated on travel experience or factors influencing passenger experience more so than the quality of transport mode itself because recording customers' response would be a major competitive lead for transportation service providers (Carreira *et al*., 2014). Therefore, travel experience of passengers could be denoted as appealing customers' distinction for transportation service providers, policy makers and regulators comprising of both goods transportation and public transportation.

Research showed that urban-transportation sustainability can be greatly improved if there are significant modifications in urban structures and activities that can decline the growing use of private vehicles and is able to make public transit and alternate modes attractive and feasible (Sinha, 2003). In Asia, large-scale urbanization is complicating the development of required infrastructure, especially transportation infrastructure. Since megacities of developing countries are already rising, policymakers will not be able to identify a model that is directly replicable elsewhere to solve these problems. It is crucial to understand the city's potential scope and to take a long-term strategic view point in order to prepare transportation facilities appropriate for a city of such a magnitude (Morichi, 2005). Dhaka, as one of Asia's fastest expanding megacities, is facing the same rapid urbanization, high density, and lack of public transportation services as other Asian megacities. The purpose is to obtain a greater understanding of the prospects for improved transit accessibility in Dhaka, as well as to discuss the underlying factors related to accessibility experience. There is also a major gap between what consumers think their current demand is and what policymakers are aiming to implement with potential initiatives.

In the entire transportation industry, there are a variety of participants and factors on transit services and operations. As previously noted, the public is one of the major important stakeholders in public transit. The ridership of public transit significantly depends on how the experience of the passenger while accessing the catchment area and finally getting on the desired vehicle. A positive experience while accessing public transport services or during the journey would inevitably increase ridership, which would make more people consider the more sustainable mode of transportation. Second, it is important to get a better understanding of the public bus network's catchment area. The aim of public transportation in Dhaka is to provide dependable, regular, and safe service. Efficiency measures, according to Fielding (1985), describe the relationship between resource input and generated output. These include cost effectiveness, labor utilization, and vehicle utilization factors. On the other hand, effectiveness measures represent the capacity of transit operations to achieve certain objectives. These considerations include service utilization, service consistency, and service accessibility. Therefore, improvements in the last mentioned indicator would result in an increased transit ridership.

The transport industry in Dhaka City consists of a diverse variety of vehicles, including motorized vehicles such as buses, minibuses, private cars, taxis, and human haulers, as well as non-motorized vehicles (rickshaws). Since the city lacks a mass rapid transit system, residents rely on bus transportation for longer trips. While bus services can usually be run where demand from outlying points is adequate to support them, it is also more cost-effective to operate feeder services with smaller vehicles where demand is poor. Based on travel behavior, socioeconomic conditions, and trip profiles, several studies have suggested how paratransit could be a potential way to reach bus stations and how to improve its operation and reliability as an informal transportation service (Amrapala and Choocharukul, 2019). According to research, several mass transportation schemes in developing countries, such as Bus Rapid Transit (BRT), have struggled to meet their target passenger numbers due to weak connection with other modes, such as paratransit (Tangphaisankun, A. *et al*., 2009).

A regular feeder service will improve the accessibility of the bus network, resulting in increased ridership by displacing commuters from their personal vehicles. In the absence of a formal feeder mode, access and egress trips to and from the major transit system become critical. Dhaka has a plethora of feeder services available throughout the city, so if they could be effectively used as feeder services to connect to public bus networks, public bus accessibility and experience would improve.

1.7. Objective

The aim of our research is to find the most influential factors linked to socioeconomic conditions and trip characteristics that influence travelers' boarding and alighting experiences at bus stops. The outcome would help transport authorities to adjust their services to ensure the best possible experience for the users, hence, increasing public bus ridership. Moreover, another main focus of this research is aimed at determining the relationship between a commuter's boarding and alighting experience at bus stops.

CHAPTER 2

LITERATURE REVIEW

2.1. Overview

The major goal of public transport is to connect people with various activities. Poor experience while accessing public transport catchment area would result in decreased transit ridership and thus an inefficient transportation system. Accessibility is generally characterized in the transportation literature as the ability to interact with different activities. (Han sen, 1959). Access to catchment areas is largely determined by land use and demography, with little regard for individual preferences. However, some studies conclude that the number and variety of destinations, the socio-economic and trip characteristics, the travel efficiency to reach activities (time or cost), and the travel mode choice (passenger car, bus, bicycle, walking) would all influence the degree of accessibility (Cascetta, Carten, & Montanino, 2013; Handy & Niemeier, 1997).

This chapter looks at some of the literature on public bus catchment areas, feeder service integration, relevant current research in developing countries, boarding and alighting issues, and bus service quality and attributes. In this section, a few studies related to Dhaka are also discussed.

2.2. Catchment Area

The accessibility of bus stops will have a significant impact on the use of public transportation. According to Murray and Wu (2003), accessibility of transit service bus stops is a critical factor in public transit planning, and the more people who live near and/or work at bus terminals, the more likely the service will be used. An interconnection between different modes and travelers that is greatly influenced by the location and configuration of the transport network can be denoted as accessibility of a public transport catchment area as stated by Lee, K. *et al.* (2018). Public transport accessibility can be interpreted in terms of proximity to and the cost of using transport services. The latter has been approached from an economic perspective (Jansson, 1993). Accessibility of bus stops is pivotal in increasing both attractiveness and sustainability of public transport (Corazza and Favaretto, 2019). Public transport has become a popular alternative among travelers because of its social and economic importance with regard to its connectivity to different locations (Tyrinopoulos, 2020). In addition, the catchment area measures the accessibility of passengers at a public transit hub and ensures that passengers coming from the surrounding area are properly linked by different street networks and land use near the vicinity (Andersen and Landex, 2008; Flamm and Rivasplata, 2014). The boarding and alighting of passengers at a public transit center is thus a predictable occurrence.

2.3. Transit Ridership Factors

The factors affecting ridership can be classified into two categories; internal and external, as stated by Taylor and Fink (2003). External causes are those that influence ridership independent of bus companies' and administrators' decisions and policies. Studies identify and include a host of socio-economic factors to explain aggregate transit ridership levels. Transit use has long been thought to be more sensitive than private vehicles to changes in employment levels. Although transport operators have no direct control over these variables, they can adapt to them. Demographic and socio-economic developments, such as population, education, income and occupation are some examples of external influences. Pasha, M. *et al*. (2016), for example, found that a variety of socioeconomic and demographic factors linked to income, age, lifestyle and marginalized people are significant determinants of public transport use. Furthermore, potential transit users were not encouraged to use public transportation because of inefficient public transport services and high fares, according to Nasrudin, N. *et al*. (2014), but a spike in gasoline prices and toll collection would minimize their personal vehicle use and allow them to use public transportation more frequently.

Other researchers have assessed and used a number of socioeconomic factors in their assessments of overall transit ridership. Transit use has long been considered to be more susceptible to increases in work levels than private cars. In their regression analysis while evaluating transit ridership, Liu (1993) and Kain and Liu (1995, 1996) used regional employment levels and transitions as variables. Similarly, Gomez-Ibanez (1996) also found out that between 1970 and 1990, passenger numbers in Boston was primarily influenced by external forces outside the transit agency's authority, rather than internal factors such as price hikes. It was observed in his research that employment played a more critical part than per capita income. Income level and vehicle ownership are two of many socio-economic factors that are widely used in regression studies of public transit ridership. A few other studies have also shown that increasing the accessibility, frequency, and quality of public transportation would improve overall ridership (Pronello and Camusso, 2011; Jou and Chen, 2014; Farber *et al*., 2014; Kitamura *et al*., 1997; Yao, 2007).

2.4. Feeder Service

Transit operators are always actively trying to improve bus ridership; however, lack of accessibility to the bus transit stop also prohibits the use of the bus by significant parts of society. This concern is also seen as the lack of first/last mile transit connectivity to the transit stop. If integrated with feeder services, public transit buses could play a key role in improving accessibility in developing countries. Some studies have proposed how paratransit could be a possible way of accessing bus stations and how to enhance its functioning and efficiency as an informal transport service based on travel conduct, socioeconomic factors and trip profiles (Amrapala and Choocharukul, 2019). Studies also show how some public transport projects such as Bus Rapid Transit (BRT) in developing countries failed to reach their estimated passengers due to poor connectivity with other modes including paratransit (Tangphaisankun, A. *et al.*, 2009).

A large number of studies have also led to the advancement of literature by incorporating walking as another form of access to catchment areas for public transport. Some studies included how the perception of passengers in choosing routes to travel varies based on walking distance to a public transit hub when commuting to a bus stop (Chia, J. *et al.*, 2016), how the perception of passengers in choosing routes to travel varies depending on walking distance to a public transit hub (Sarker, R.I. *et al*. 2018); how side-walk pavement efficiency, pavement lighting, road surveillance minimize successful pedestrian activity towards bus terminal (Roy and Basu, 2020). Behrens *et al*. (2018) also examined the integration of minibus taxi service with a scheduled BRT trunk feeder network in South Africa that combines the quality and availability of daily service, travel characteristics, safety, comfort, accessibility to explore passenger satisfaction in the opinion that people are relatively satisfied with the integrated feeder service. Some research centered on the implementation of ride-sourcing as one of the modes of transfer from and to bus stops to the origin and destination of travel to assess whether it could boost mobility in the catchment area of public transit by using unused and unpopular routes to improve operational efficiency (Yan, X. *et al*., 2019). Very few studies have explored the perception of travelers on the feeder service that moves them to and from bus stops. Hiraide *et al*. (2019) conducted this kind of research where it was shown that car and motorcycle owners found little benefit in using feeder services.

2.5.Service Attributes

In previous literature, most of the boarding-alighting studies at the bus stops focused on the level of service, activity management, travel time, etc. Applicability of a social force model for boarding and alighting behavior of the passengers (Fan, Y. *et al.*, 2017), boarding and alighting count on transit line (De Oña, J. *et al.*, 2014) are some of the studies that have been done related to boarding and alighting at the bus terminal; serviceability of public transit considering dwelling time and headway (Mahdavilayen, M. *et al.*, 2020), optimizing bus frequency (Mo, S. *et al.* 2020), operational cost models (Mehran, B. *et al.*, 2020), impact of the built environment surrounding the catchment area (Zhao, L. *et al.*, 2020), integration of land use and transport (Nigro, A. *et al.*, 2019), etc. are some research conducted that are relevant to accessibility of public transit. Only a few studies considered the travelers' experience while boarding and alighting at a bus stop.

2.6.Boarding and Alighting Issues

As explained by Hossain (2018) in his study regarding the problems of public transport system in Dhaka city, boarding and alighting from public buses can be a daunting task due to inadequate facilities at bus stoppages, the use of the same door for passenger entry and exit, the vertical height of the door step not being at the same level as the floor of the bus (resulting in longer boarding and alighting times), narrow doors, and the availability of only one bus conductor to check and collect tickets.

2.7. Studies in Developed Countries

Some studies have been found to be part of this form of study in the developed world, but such a line of research is difficult to find in the context of developing countries. For example, in order for travelers to choose from public transit stations which were dramatically influenced by access points, alternate routes, walking time, travel time and number of stations, discrete option models were developed (Nassir, N. *et al.*, 2015). The study by Advani and Tiwari (2016) examined the use of bicycles as feeder mode to and from bus stops, including the effectiveness of bicycles as a means of access. Walking and biking to transit stops could possibly increase mobility and address the issue of first/last mile connectivity. However, walking or using a bike to access a bus stop is only useful when the built environment assists these modes (Chandra, S. *et al.*, 2013). More related studies were conducted using bicycles as a feeder mode for accessibility to the catchment area of public transport (Balya and Kumar, 2017) and the effect of passengers' socio-economic and demographic characteristics when using bicycles as a preferred mode of access (Plano, C. *et al.*, 2019). Also, there are studies that have considered accessibility to bus stops which is influenced by trip generation, road density and population (Ahsan, 2014). The availability of bus-based transit services where access to a bus stop is assumed to be accomplished primarily by walking was interpreted by Foda and Osman (2010).

2.8. Service Quality of Buses

In Dhaka, most studies regarding public transport are based on the service quality of buses. Quddus *et al.* (2019) conducted a study on determining the factors influencing the bus service quality. The findings revealed that variables like comfort level and driver skills were the most significant contributors to ‘‘bad" and ‘‘very poor" service quality perceptions. Punctuality, safety, entry and exit procedures, waiting times, and vehicle quality were also contributing factors. The current service and the users' opinion on the service level of public buses operating within the city were also stated by other relevant works in Dhaka city. However, the study by Ahsan (2014) illustrates the methods for evaluating the accessibility of bus stops by considering determinants such as trip generation, population served and road density, which seeks to explain the influence it has on the accessibility conditions for bus stops in Dhaka.

As a result, while several research on boarding and alighting experiences at bus stops have been conducted, little attempt has been made to extract travelers' experiences during their access into a public transportation catchment area, as shown by the above-mentioned sources. Furthermore, a bivariate ordered probit approach has never been carried out taking into account the socioeconomic conditions and trip characteristics of a person in a major city of developing country such as Dhaka.

CHAPTER 3

METHODOLOGY

3.1.Study Area

Public transport system (PTS) plays an important role by providing shared/mass transportation services that are vital to general public. PTS has become extremely crucial for Dhaka, a developing urban city in South Asia to the growing urban population demand which is more challenging now than ever before. Having a population density of 122,700 per square mile in 2018, the capital of Bangladesh, Dhaka, is one of the most heavily inhabited and extremely congested cities in the world (Demographia, 2018). Thus, eventually, Dhaka's bus transport system has become unstable due to inadequate and inefficient service hence struggles to deal with her large population's heterogeneous mobility demand. It is, however, the primary mode of transport for the middle and lower income people of the city. If not the only one, Dhaka is one of the very few mega cities without a well-organized, well-planned bus system or any sort of rapid transit system. For such a big city with a massive need for commuting, rapid transit is a necessity for the transport infrastructure. The present allocation of public transit is just 31 percent of passenger journeys, while mass transit is expected to share 80 percent of overall journeys in order to have an efficient transport system (Katz and Rahman, 2010).

Three types of bus stops are usually served on a daily basis in Dhaka, such as intercity, suburban and local. Any of these stops can be accessed by different modes; rickshaw, taxi, other paratransit, etc. (Abdullah and Sajol, 2018). Alam (2018) stated that 152 bus routes and

237 bus stops are located in the Dhaka Metropolitan Area in a study on the Sustainable Urban Transport Index (SUTI) for Dhaka. There are almost 400 km of pedestrian paths available. Through city bus, rickshaw, motorcycle, other paratransit etc. all the bus stops are linked to various destinations that are readily accessible.

Since almost half of the population of Dhaka is rated as "poor" (Strategic Transport Plan Dhaka, 2005), the majority of the people are captive riders' for buses and thus public transportation sustains mobility of those classes who can't afford private vehicles. Consequently, in the formation of a viable bus transport system for Dhaka and in the implementation of relevant policies and regulations, evaluating the efficiency of bus transportation systems from the perspective of these travelers is critical.

3.2.Method

In this study, a complete trip made was considered into three stages: from origin to a bus stop for boarding, the bus journey itself and from alighting bus stop to the destination.

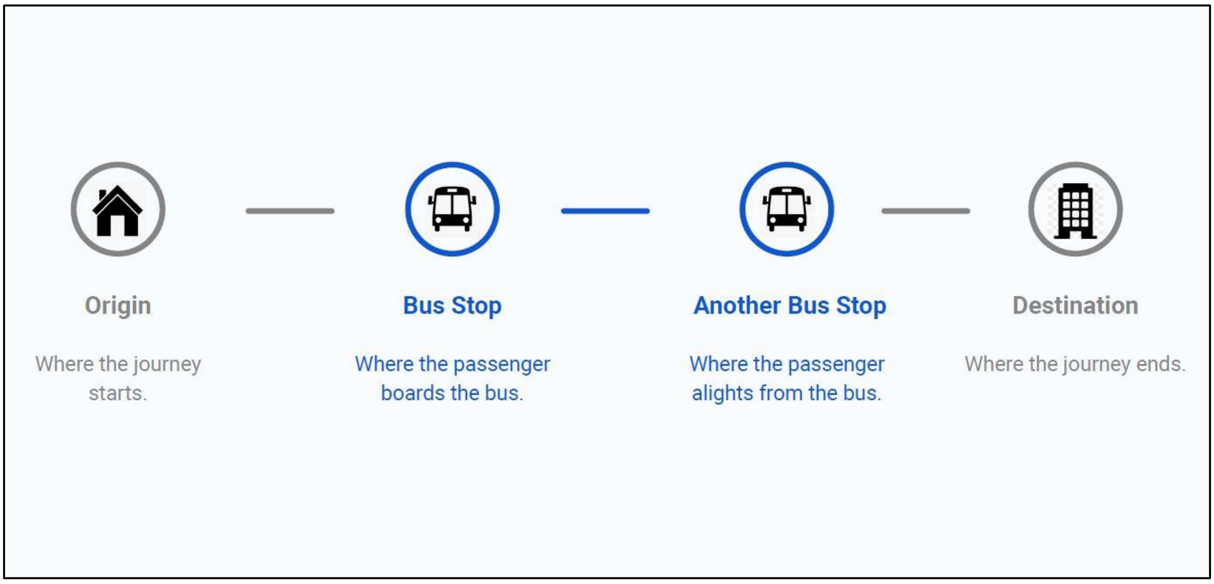

Figure 1: **Stages of a Journey**

Bus stop features can be primarily linked to the assumption that all bus stops in Dhaka City exhibit homogeneous characteristics. One of the main focuses of this research is aimed at determining the relationship between a commuter's boarding and alighting experience at bus stops in Dhaka.

A series of activities has been executed to complete the research and meet the stated objectives. Figure 1 shows the overall workflow of our methodology –

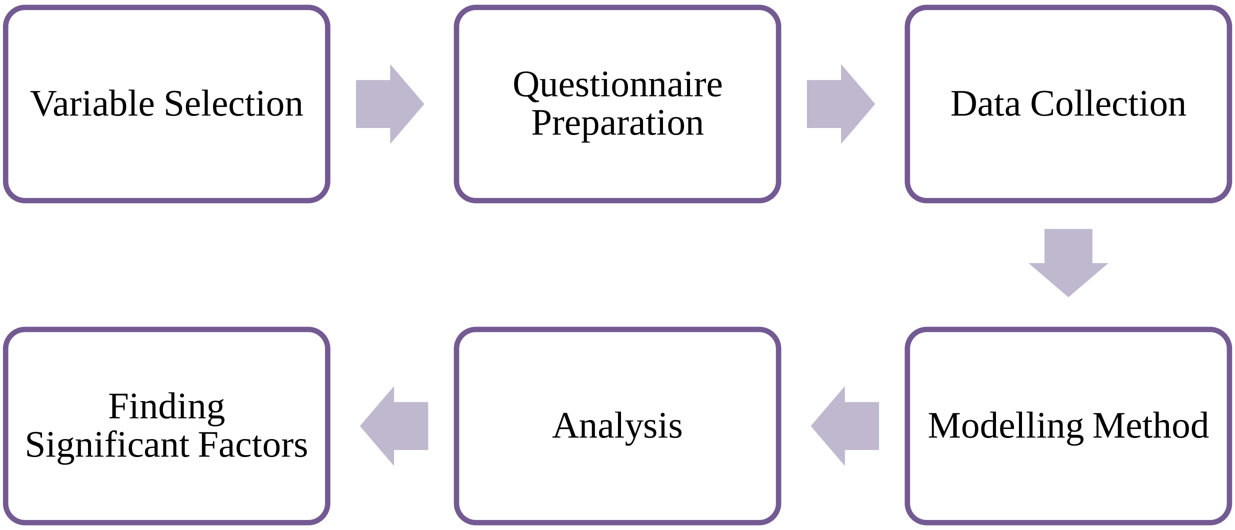

Figure 2: Workflow of Methodology

3.2.1. Variable Selection

The selection of variables for the questionnaire was done in three steps. Firstly, factors relating to accessibility in the catchment area of public transport, passenger boarding and alighting experience, trip information, socio-economic and demographic factors have been identified from previous studies; (Kim and Chung, 2017; Abenoza, R.F. *et al*., 2017).

Secondly, a pilot study was also carried out to connect it with the variables used in the literature in the local context of the passengers when accessing bus stops. Finally, following the previous steps, a questionnaire was prepared based on the engineering judgments of the authors.

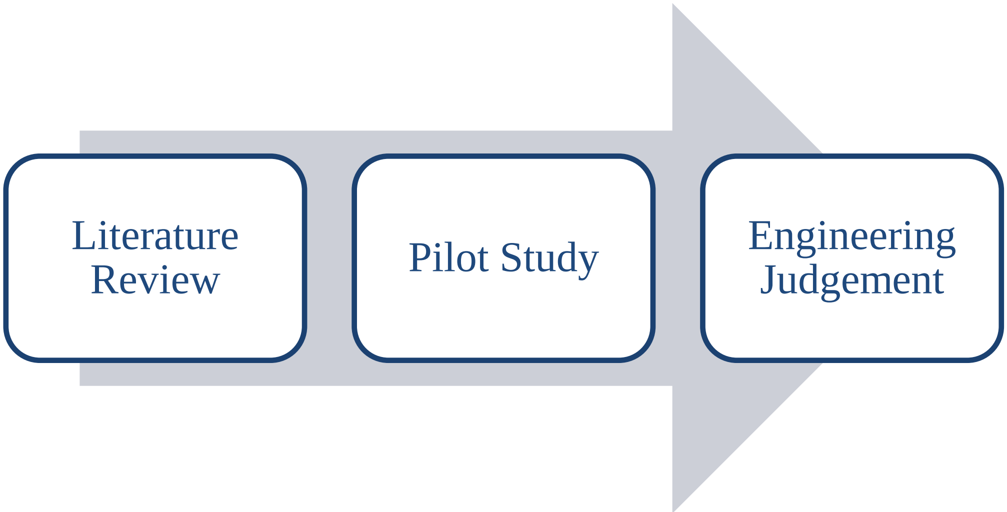

Figure 3: Workflow of Variable Selection

3.2.2. Questionnaire Preparation

A questionnaire consisting of 19 questions was prepared. The questions were grouped into three categories: passenger's personal information including age, gender, income, occupation, education level, accessibility to various modes of transport; trip characteristics such as the choice of mode for accessibility to boarding area and from alighting area to destination and associated cost, travel time and waiting time, frequency of the trip made, payer for the trip, presence of other bus stops in the immediate vicinity of boarding station as perceived by the commuter; trip component rating on a five-point Likert scale which ranged from 0 to 4 (where 0 indicated "very poor" and 4 indicated "excellent"). Participants were asked to rate their trip component ratings during boarding at bus stops. The distance travelled from the origin to the bus stop, availability of buses, pedestrian facility to walk up to the bus stop and availability of feeder service comprised the trip component factors, which accounts only for trip components of boarding. All of these ratings were judged based upon the individual perception of the interviewees. The participants also provided their ratings on the overall accessibility experience of both boarding and alighting which accounted for our outcome variables.

3.2.3. Data Collection

To collect the data of the commuters, a face-to-face survey among bus passengers was taken at all the major bus stops in Dhaka city. The survey was conducted in September, 2019. At each bus stop, at least 10-15 passengers were chosen for the survey. In addition to that, the survey was not only taken on weekdays (81.12%) but on weekends (18.88%) as well. During the weekdays, about 60% of the interviews were taken during peak hour (AM and PM peaks), about 30% of the interviews were taken during inter-peak hours and finally the rest 10% of the data was collected in off-peak periods (early morning and night). No specific groups were targeted while conducting the survey and a random sampling method was used to collect the data. Even though 3600 interviews were recorded, the final data contained 2532 observations owing to data cleaning.

3.2.4. Modelling Method

This study aims to examine those factors that affect boarding and alighting experiences of a passenger at bus stops in Dhaka city. For alighting to take place, boarding has to occur beforehand, which indicates that boarding and alighting at bus stops are not entirely independent, i.e. they must be correlative to each other. As narrated earlier, the effect of boarding on alighting experience is statistically significant. The experience of a passenger while boarding tends to leave a footprint on the overall experience of the trip, consequently affecting the alighting experience as well.

Thus, from an analytical perspective, two univariate probit models are not fitting to explain both boarding and alighting, because the standard single equation probit model does not quite take into consideration the correlation between dependent variables. The correlation between the deviations would be overlooked if two independent univariate probit models were established for each dependent variable, resulting in ineffectiveness in model estimation (Greene, 2007).

To resolve this issue, the bivariate probit model is derived, which can account for the correlation between residual error terms and accommodate the boarding and alighting experience expressed by possibly correlated explanatory variables. The bivariate ordered probit model is a specialization of the univariate ordered probit model and is intended to model ordinal dependent variables that can be calculated simultaneously. (Greene, 2003).

The univariate ordered probit model presumes that the alighting experience of the bus is independent of the boarding experience of the same journey. If the alighting experience is endogenous then the conditional independence is breached. Hence, a biased approximation would be provided by the aforementioned strategy. In order to fix the probable endogeneity of alighting experience, we used a simultaneous bivariate ordered probit model to attain our outcomes. Consider a system of Equation (1) and (2), which associates the latent boarding experience ($y^*_{i,j=1}$) and latent alighting experience ($y^*_{i,j=2}$) to individual traits of the travelers (X_i).

$$y^*_{i,j=1} = \beta_1 X_{i1} + \alpha Z_i + \varepsilon_{1i},\ \ y_{i,j=1} = k\ if\ a_{k-1} < y_{i,j=1} < a_k\ where\ k = 0\ to\ K_1 \quad (1)$$

$$y^*_{i,j=2} = \beta_2 X_{i2} + \delta y^*_{i,j=1} + \varepsilon_{2i},\ \ y_{i,j=2} = k\ if\ b_{k-1} < y_{i,j=2} < b_k\ where\ k = 0\ to\ K_2 \quad (2)$$

$$\mathrm{Cov}(\varepsilon_{1i}, \varepsilon_{2i}) = \rho$$

Where Z_i represents vectors of instrumental variables which are correlated with $y^*_{i,j=1}$, α represents the vector of its coefficient. β_1, and β_2 are vectors of slope of the parameter estimates for boarding and alighting experience, respectively. X_{i1} *and* X_{i2} are respectively the vectors of explanatory variables that have an impact on travelers' experience during boarding and alighting; and δ refers to the coefficient of interest that is associated with the latent variable - boarding experience. ε_{1i} and ε_{2i} are the error terms for boarding and alighting experience. ρ is referred to as the correlation between the two residual error terms. This method can be asserted as a simultaneous bivariate ordered probit model when ρ is not zero. Conversely, if ρ is found to be zero, the univariate probit model would be more fitting to the observed data (Sajaia, 2008). a and b are the threshold parameters that define ($y^*_{i,j=1}$) and ($y^*_{i,j=2}$) respectively in k-ordered scale.

Here, the experience of the passengers with the accessibility encountered while boarding and alighting, y_i for each of the trip makers, is regarded to be the realization of the perception of latent accessibility, y^*_i.The ordered relationship between various categories (i.e. from very poor to excellent) can be expressed in the form:

$$y_{ij} = \begin{cases} 0, (if & y_{ij}^* \leq \mu_0) \\ 1, (if & \mu_0 < y_{ij}^* \leq \mu_1) \\ 2, (if & \mu_1 < y_{ij}^* \leq \mu_2) \\ 3, (if & \mu_2 < y_{ij}^* \leq \mu_3) \\ 4, (if & \mu_3 > y_{ij}^*) \end{cases} \quad (3)$$

Here, $\mu_k = \{a_k, b_k\}$ are the cut off points where, k = {0, 1, 2, 3} and j = {1, 2}. The residuals ε_{i1} and ε_{i2} are assumed to follow a normal distribution with mean vector 0 and correlation matrix with components being variances 1 and correlation coefficient as shown below:

$$\begin{pmatrix} \varepsilon_{i1} \\ \varepsilon_{i2} \end{pmatrix} \sim Normal \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \right] \quad (4)$$

Where, ρ = correlation coefficient of the error terms.

The signs of the coefficients, β_1 and β_2 are used to explain the impact of explanatory variables. For example, if the coefficients show a positive sign, it is suggesting an improvement in the likelihood of having a better experience and if the sign is negative, it can be perceived as increasing probability of the commuter having a worse boarding and alighting experience.

The exogeneity condition is asserted in terms of the error correlation coefficient ρ. When ρ = 0, $y_{i,j=1}^*$ and $y_{i,j=2}^*$ are uncorrelated and $y_{i,j=1}^*$ is exogenous for the second equation. Conversely, ρ ≠ 0 infers that $y_{i,j=1}^*$ is correlated with $y_{i,j=2}^*$ and therefore endogenous. This has culminated in the formulation of the following system of theories, the review of which is one of the objectives of our study:

$$H_0 : \rho = 0$$
$$H_1 : \rho \neq 0$$

Subsequently the null hypothesis H_0 can also be termed as the exogeneity hypothesis. It is to note that, for the case H_0 the log likelihood value equals the sum of the log likelihood functions of two univariate probit, as shown below:

$$l_0(\beta) = l_1(\beta_1) + l_2(\beta_2) \quad (5)$$

Here, $l_0(\beta)$ is the log-likelihood value of the bivariate probit model and $l_1(\beta_1)$ and $l_2(\beta_2)$ are the log-likelihood values of the two univariate probit models (Fabbri, D. *et al*. 2004). If the value obtained of ρ is significantly different from zero, the two random parameters of the model are correlated. In the contrary, if the value of the rho is not substantially different from zero, the bivariate probit is reduced to two independent probit models.

3.2.5. Analysis

The entire statistical analysis was carried out using STATA Version 13. The analysis was conducted with full-information maximum likelihood estimation (Sajaia, 2008).

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Overview

This study focuses on how passengers concurrently assess their experience while boarding and alighting at bus stops. Assumptions were made that all bus stops in the study area exhibit homogenous condition. A major significance of this analysis is the implementation of a bivariate approach which permits the measured parameters of the model to differ through the inferences and hence to provide less skewed empirical results that are more consistent and reliable. The bivariate model in this study establishes two equations to describe boarding and alighting experiences of passengers and proposed a model to demonstrate correlation in unobserved factors for the case of boarding and alighting. This chapter explains the research findings that include the descriptive statistics and the significant factors that influence the boarding and alighting experience of the commuters.

4.2. Descriptive Statistics

This section unravel socio-demographic attributes of the respondents, their trip information, statistics associated with their accessing mode while boarding to public buses from origin and finally reaching their destination from alighting site. Their commuting facility rating statistics along with their overall boarding and alighting rating is also summarized in this section.

4.2.1. Socio-demographic Characteristics of Respondents

The socio-economic attributes of the respondents in **Table 1** includes the percentage values and frequency of the sample which makes it easier to compare the variables.

Table 1 Travelers' Characteristics

Variable		Percentage	Frequency
Age			
	<18	4.27%	108
	18-25	37.01%	937
	25-40	47.51%	1203
	>40	11.22%	284
Gender			
	Male	69.71%	1765
	Female	29.94%	758
	Others	0.36%	9
Occupation			
	Service holder	33.89%	858
	Student	31.64%	801
	Businessman	16.63%	421
	Others	17.85%	452
Highest education			
	Post graduate	25.59%	648
	Undergraduate	33.49%	848
	HSC/SSC/Technical education	25.51%	646
	Others	15.40%	390
Income per month (in Taka)			
	<10000	41.94%	1062
	10000-25000	27.61%	699
	25000-40000	24.01%	608
	40000	6.44%	163

Variable	Percentage	Frequency
Vehicle Ownership/access		
Car/microbus	3.40%	86
Motorcycle	8.73%	221
CNG	0.20%	5
Others (e.g., bicycle, rickshaw etc.)	87.68%	2220
If one has access to vehicles then it is -		
He/she owns it	8.10%	205
His/her family owns it	5.21%	132
Given by office	0.43%	11
Others	86.26%	2184

Among the participants 84.52% are aged between 18 to 40 years, 69.55% have income less than 25,000 Taka per month, Only 25.59% have education level over undergraduate and Only 3.40% have access to cars or microbuses.. All of these clearly suggest that the middle class people of Dhaka are the prevalent consumers of the public bus services.

4.2.2. Trip Information

Trip information which includes the purpose of the trips made, frequency of the particular trip made per week, trip occurring day within the week, cost bearer of the trips and presence of other bus stops nearby is summarized in **Table 2**. Of all the trips made, 73.78% trips are made either for work or education which concludes majority of the trips conducted by public buses are mandatory trips. About 68.44% of the trips recorded occurs at least once per week, which indicates that discretionary trips are not dominant.

Table 2 Trip Information

Variable	Percentage	Frequency
Purpose		
Work	61.49%	1557
Education	12.28%	311
Shopping	4.15%	105
Recreation	4.98%	126
Others	17.10%	433
Trip Frequency		
5 times or more	39.69%	1005
At least once	28.75%	728
Less than that	15.84%	401
Seldom	15.72%	398
Trip time		
Weekday	81.12%	2054
Weekend	18.88%	478
Cost bearer		
Him/Herself	87.95%	2227
Office	1.58%	40
Others	10.47%	265
Any bus stop nearby		
Yes	53.59%	1357
No	46.41%	1175

4.2.3. Accessibility from Origin to Bus Stop and from Bus Stop to Destination

To access to a bus stop for boarding from origin and to destination from alighting bus stop a commuter has to use a mode such as walking, using rickshaw, another bus or other permitted paratransit. The means and standard deviations of cost and travel times using such modes and waiting time for the modes are tabulated in **Table 3**.

Table 3 Accessibility from origin to bus stop and from bus stop to destination

Accessibility to bus stop from origin		
Variable	**Mean**	**Standard deviation**
Cost (BDT)		
Walking	-	-
Rickshaw	21.025	8.390
Bus	7.303	6.780
Permitted Paratransit	3.201	3.160
Travel time (minutes)		
Walking	4.853	4.031
Rickshaw	5.664	5.002
Bus	6.373	8.469
Permitted Paratransit	6.763	7.788
Waiting time (minutes)		
Walking	-	-
Rickshaw	0.779	1.572
Bus	4.935	1.459
Permitted Paratransit	1.099	2.299
Accessibility to destination from bus stop		
Variable	**Mean**	**Standard deviation**
Cost (BDT)		
Walking	-	-
Rickshaw	19.784	6.519
Bus	6.137	6.200
Permitted Paratransit	3.291	3.736
Travel time (minutes)		
Walking	4.729	5.011
Rickshaw	4.581	4.682
Bus	6.000	7.718
Permitted Paratransit	6.817	7.828
Waiting time (minutes)		
Walking	-	-
Rickshaw	0.743	1.472
Bus	4.429	1.785
Permitted Paratransit	0.915	1.899

4.2.4. Trip Component Rating

Efforts were given to capture the commuting experience of the traveler while reaching a bus stop for boarding as represented in **Table 4**, where the commuter could rate his/her experience as very poor, poor, alright, good or excellent.

Table 4 Commuting facility rating while boarding

Variable	Percentage	Frequency
Experience of distance traveled from origin to bus stop		
Very poor	1.70%	43
Poor	15.76%	399
Alright	46.41%	1175
Good	27.61%	699
Excellent	8.53%	216
Experience of availability of buses at the bus stop		
Very poor	3.12%	79
Poor	20.18%	511
Alright	48.18%	1220
Good	22.55%	571
Excellent	5.96%	151
Experience of pedestrian facility to walk up to bus stop		
Very poor	6.36%	161
Poor	30.61%	775
Alright	45.85%	1161
Good	14.06%	356
Excellent	3.12%	79
Experience of feeder service		
Very poor	15.64%	396
Poor	27.88%	706
Alright	39.85%	1009
Good	10.94%	277
Excellent	5.69%	144

User's perception towards overall boarding and alighting experience was also recorded. Table 5 cross-matches the experience of users while boarding vs while alighting. The null hypothesis is the absence of any relationship between boarding and alighting experience. For the Pearson Chi-square test, here the p-value is less than significance level (0.05). This is an indication of the presence of sufficient evidence to reject the null hypothesis and conclude that there is a relationship between the boarding and alighting experience.

Table 5 Cross Tabulation of Boarding and Alighting Ratings

Boarding	**Alighting**					**Total**
	Very Poor	Poor	Alright	Good	Excellent	
Very Poor	65	31	7	3	0	106
Poor	59	555	266	2	1	883
Alright	40	218	983	68	0	1309
Good	0	9	78	111	3	201
Excellent	0	0	4	8	21	33
Total	164	813	1338	192	25	**2532**
Pearson chi2(16) = 3239.6				**Pr = 0.000**		

As demonstrated in Table 5, only 33 passengers (1.3%) have rated their boarding experience as "excellent", while 25 passengers (0.99%) have rated the same for alighting. 201 participants (7.94%) and 192 participants (7.58%) have rated their boarding and alighting experience respectively as "good". While most respondents categorized their experience as "Alright" (51.70% for boarding and 52.84% for alighting), a significant portion have rated them as "Bad" or "Very Bad" (39.06% for boarding and 38.59% for alighting).

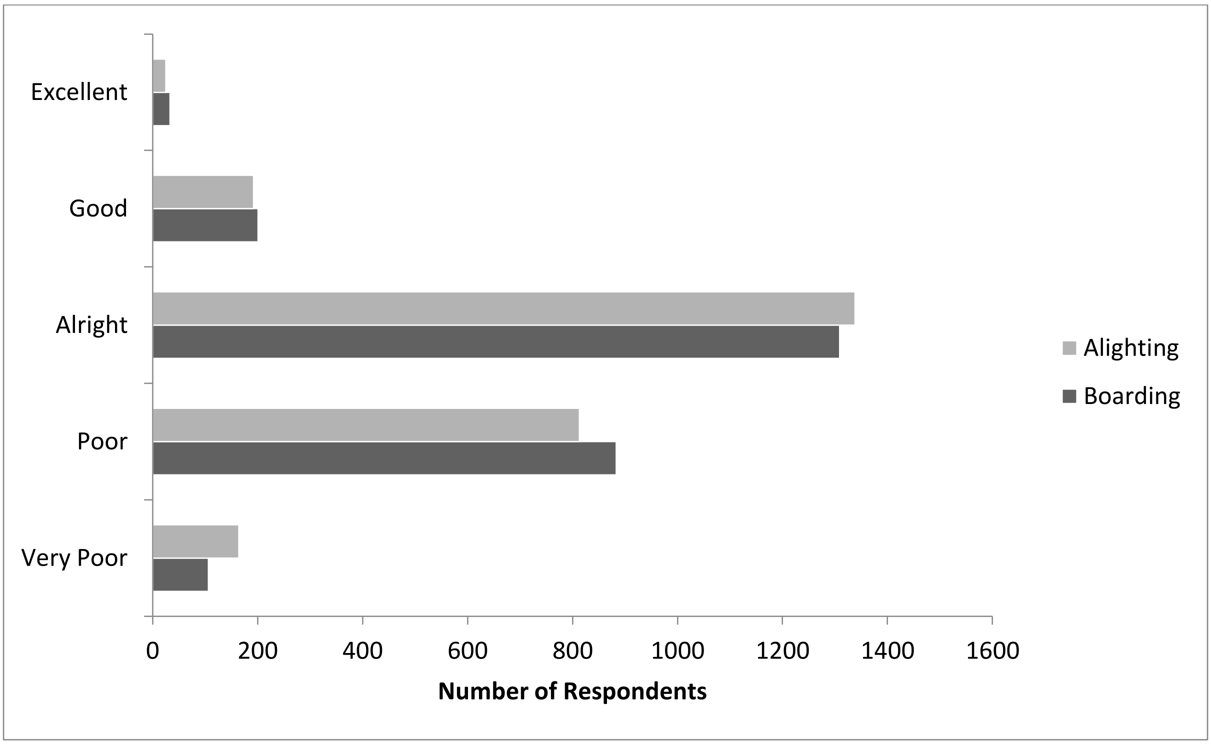

Figure 4: Overview of Overall Boarding and Alighting Ratings

From this, a conclusion can be drawn that the accessibility to bus stops has a huge gap to overcome to meet the expectations of the users.

4.3.Result Interpretation

The final simultaneous bivariate ordered probit model includes a total of 16 parameters for boarding, 7 parameters for alighting and 6 parameters for both boarding and alighting; each statistically significant at 95% confidence level. The explanatory variables found to have statistically significant impact on both boarding and alighting experience of the passengers were travel day, occupation, highest education level, purpose of the trip, cost bearer of the trip and accessibility modes. **Table 6** represents the results of the bivariate analysis comprising of all statistically significant variables at 1%, 5%, and 10% significance level.

4.3.1. Traveler's Characteristics

External factors that are not in control of the authorities in public transport companies are normally age, occupation, income level, etc. These factors have a significant impact on the boarding and alighting experience thus affecting ridership.

4.3.1.1. Age

For the case of age, people aged less than 40 years (i.e. less than 18, 18 to 25 and 25 to 40 years) were likely to have worse experience while boarding at bus stops. This might be because of the social view towards elderly people as they are generally given more priority and receive better facility than their younger counterpart while boarding.

Table 6 Estimation of simultaneous bivariate ordered probit model

Description of variables	Boarding Experience				Alighting Experience			
	Coeff.	SE	z-value	p-value	Coeff.	SE	z-value	p-value
Traveler's Characteristics								
Age (Base: >40 years)								
<18	-0.30782	0.152066	-2.02	0.043**	-			
18 to 25	-0.22862	0.097234	-2.35	0.019**	-			
25 to 40	-0.17214	0.083185	-2.07	0.039**	-			
Occupation (Base: Others)								
Service holder	-0.16469	0.09149	-1.8	0.072*	-0.20652	0.091494	-2.26	0.024**
Student	-0.25822	0.100534	-2.57	0.01***	-			
Income/month (Base:10,000 to 25,000 BDT)								
25,000-40,000	-0.22637	0.069579	-3.25	0.001***	-			
>40,000	-0.23886	0.113288	-2.11	0.035**	-			
Highest education level (Base: HSC/SSC/ Technical Education)								
Postgraduate	-0.15243	0.07792	-1.96	0.05**	0.159041	0.076715	2.07	0.038**
Undergraduate	-				0.154886	0.065116	2.38	0.017**
Others	-0.19344	0.080426	-2.41	0.016**	-			
Vehicle Ownership/ Access (Base: Car/Microbus)								
Motorcycle	-0.40361	0.160348	-2.52	0.012**	-			
If you have access to vehicle then it is (Base: Others)								
You own it	0.403975	0.162515	2.49	0.013**	-			
Given by office	-0.86416	0.388834	-2.22	0.026**	-			

Description of variables	**Boarding Experience**				**Alighting Experience**			
	Coeff.	SE	z-value	p-value	Coeff.	SE	z-value	p-value
Trip Information								
Travel day (Base: Weekday)								
Weekend	-0.19428	0.063349	-3.07	0.002***	0.202213	0.061869	3.27	0.001***
Trip Frequency (Base: 5 times or more)								
At least once	-0.16041	0.060479	-2.65	0.008***	-			
Seldom	-0.18212	0.08186	-2.22	0.026**	-			
Purpose (Base: Work)								
Education	0.280806	0.090927	3.09	0.002***	-			
Recreation					-0.34807	0.11375	-3.06	0.002***
Others	0.211019	0.072798	2.9	0.004***	-0.20012	0.071342	-2.81	0.005***
Any other bus stop nearby (Base: No)								
Yes	-0.11188	0.048933	-2.29	0.022**	-			
Cost bearer of the trip (Base: Myself)								
Office	-0.39955	0.189114	-2.11	0.035**	-			
Others	0.145443	0.081495	1.78	0.074*	-0.20454	0.080084	-2.55	0.011**
Boarding Experience	-				2.017869	0.235553	8.57	0.000***
Accessibility to bus stop from origin								
Walking								
Travel Time	-0.01515	0.006379	-2.38	0.018**	N/A			
Waiting Time	0.030264	0.01466	2.06	0.039**	N/A			

Description of variables	Boarding Experience				Alighting Experience			
	Coeff.	SE	z-value	p-value	Coeff.	SE	z-value	p-value
Accessibility to destination from bus stop								
Rickshaw								
Cost	N/A				0.014873	0.008928	1.67	0.096*
Bus								
Travel Time	N/A				-0.04589	0.016381	-2.8	0.005***
Community facility rating while boarding								
Experience of distance traveled from origin to bus stop (Base: Excellent)								
Very Poor	-0.7138	0.187921	-3.80	0.000***	N/A			
Poor	-0.40079	0.106198	-3.77	0.000***	N/A			
Experience of availability of buses at bus stop (Base: Excellent)								
Very Poor	-0.66237	0.155556	-4.26	0.000***	N/A			
Poor	-0.72711	0.114303	-6.36	0.000***	N/A			
Experience of pedestrian facility to walk up to bus stop (Base: Excellent)								
Very Poor	-1.52410	0.169309	-9.00	0.000***	N/A			
Poor	-1.23680	0.141594	-8.73	0.000***	N/A			
Alright	-0.72028	0.130846	-5.50	0.000***	N/A			
Good	-0.36453	0.128883	-2.83	0.005***	N/A			
Experience of feeder service (Base: Excellent)								
Very Poor	-1.52656	0.123131	12.40	0.000***	N/A			
Poor	-1.37537	0.111209	12.37	0.000***	N/A			
Alright	-0.90954	0.103681	-8.77	0.000***	N/A			
Good	-0.47368	0.110156	-4.30	0.000***	N/A			

Description of variables	Boarding Experience				Alighting Experience			
	Coeff.	SE	z-value	p-value	Coeff.	SE	z-value	p-value
Threshold values								
cut 11 and 21	-5.42513	0.295506			3.811456	0.986268		
cut 12 and 22	-3.42149	0.285177			5.350535	1.001468		
cut 13 and 23	-1.31775	0.279106			7.472728	1.030719		
cut 14 and 24	-0.16964	0.279699			8.930316	1.05584		
Sample size, n	2532							
Log-likelihood (univariate)	-2151.6333				-2773.7052			
Log-likelihood (bivariate)	-4181.4243							
Wald-chi2	1036.39, Prob > chi2 = 0.000***							
Correlation								
Error	**ρ**		**SE**		**z-value**		**p-value**	
Boarding and Alighting Experience	-0.63893		0.042611		-10.5000		0.000***	
LR test of independent eqns.	chi2 (1) = 31.39				Prob > chi2 = 0.000***			

Note: *** Significance at the 1% level; ** Significance at the 5% level; * Significance at the 10% level.

4.3.1.2. Occupation

It can be ascertained from the analysis that when compared to people whose occupation is categorized as others (whose occupation is anything except service holder, businessman, student, i.e. homemaker, people out of work, etc.), service holders tend to experience worse while boarding and alighting while students have likelihood to experience worse while only boarding. This may be due to the fact that service holders and students are more aware about the quality of service of public buses.

4.3.1.3. Income Level

People who have income over 25,000 BDT (i.e. 25,000-40,000 BDT and over 40,000 BDT) had likelihood to experience worse during boarding compared to those having salary between 10,000 and 25,000 BDT. By crosschecking we find that 33.33% people having income between 10,000 and 25,000 BDT had rated their boarding experience as “poor” or “very poor”. The percentage of dissatisfaction rises with income (43.42% for people who have income between 25,000-40,000 BDT, further rising to 50.31% for people with income over 40,000 BDT). Generally, individuals with better income want to be adequately served and tend to expect a higher level of service (1 BDT ≈ 0.012 US$, as exchange rate of February, 2021).

4.3.1.4. Education Qualification

Considering the educational qualification, travelers who have postgraduate degree and others (either below Secondary School Certificate level or illiterate) have propensity to experience worse compared to those who completed the SSC (Secondary School Certificate)/ HSC

(Higher Secondary School Certificate)/ Technical Education for boarding. While alighting however, travelers who have undergraduate and postgraduate degree tend to have better experience compared to SSC/HSC/Technical Education.

4.3.1.5. Vehicle Ownership and Access

Travelers who have access to vehicle provided by office are likely to have worse experience and travelers who have their own vehicle has a better experience during boarding compared to others, which include having access to vehicles through paratransit or ride sourcing. This might be because people who own vehicles are normally self-driven and various concerns (like lack of parking spots, auto theft, and minor damage to vehicle body) arise that are regular occurrences in Dhaka. Therefore, when they do take the bus, they are relieved from the aforementioned stresses.

On the other hand, the other group of people who has access to transport provided by office are accustomed to a certain level of comfort while travelling in official vehicles, so, whenever they have to board a public bus it normally results in them having a worse experience. Another finding of the analysis is that people who have access to motorcycles appear to have a worse experience while boarding compared to people having access to cars or microbuses.

4.3.2. Trip Information

It includes various information related to the trip, such as, the day on which the trips was taken (weekday or weekend), how often the trip is taken, purpose of the trip, etc. The impact of these variables on boarding and alighting experience is discussed below.

4.3.2.1. Travel Day

It is interesting to note that passengers travelling on weekends are likely to have worse experience while boarding, while having the opposite experience during alighting. This might be owing to the decreased number of buses plying on the roads on weekends causing greater headways. People have to wait longer times at the bus stops resulting in the negative perception towards boarding experience. On the other hand, as there are fewer passengers in the bus, it becomes easier to reach to the exit point while alighting. Therefore, the experience tends to be better compared to weekdays when there are plenty of people obstructing the way to the exit point within the bus, and the crowd waiting just at the gate waiting for boarding.

4.3.2.2. Trip Purpose

People who travel for educational and other purposes (visiting hospitals/appointments, running miscellaneous errands, etc.) tend to have better boarding experience compared to those having work purpose. This might be because the trips taken by people travelling for education and other purpose are scattered throughout the day (inter and off-peak periods), whereas, people going to work has to face more congestion and crowding at stops as most of them travel during similar peak periods (i.e. AM peak). Also, people who travel for recreational purpose have worse experience in alighting area. When people travel for recreational purpose, more often than not they travel with their family which in and of itself is a hassle considering the rush and crowd density. Adding to that the continuous insistent shouting from different paratransit drivers to rent out their vehicles further worsens the alighting experience.

4.3.2.3. Trip Frequency

Moreover, people who travel at least once or less than that have likelihood to have worse experience during boarding relative to those who travel more than 5 times a week. However, no statistically significant effect was found in the alighting area. People who make the same trips frequently tend to be more accustomed with the bus stops compared to the ones travelling less frequently. Hence, prompting them to have a better boarding experience.

4.3.2.4. Nearby Bus Stop

In addition, if there are any nearby bus stops in the immediate vicinity of the specific bus stop, travelers tend to have a worse experience while boarding. This might be because people tend to gather at the entry and exit point of the bus even before they reach their desired bus stop, therefore, boarding passengers need to push through the crowd to enter the bus.

4.3.2.5. Boarding Experience

The alighting experience equation estimates suggest that the boarding experience coefficient came out to be positive and statistically significant at the 0.1% level. Our results demonstrate that boarding experience has an important and relevant impact on alighting experience. We could have underestimated the positive impact of boarding experience on alighting experience if we approached with the estimates of the univariate ordered probit model for comparison.

4.3.3. Accessibility to bus stop from origin

In case of attributes (i.e., cost, travel time and waiting time) related to different modes used to access bus stops from origin and to approach the destination from alighting bus stop. The results showed that if walking travel time increases, the experience of the travelers skew to the worse case during boarding. People do not usually prefer walking for longer periods to get to the bus stop. Paratransit system in Bangladesh can be classified into two types; motorized (human hauler, tempo) and non-motorized (e.g., bicycle) as stated by Rahman (2016). Interestingly, with the increase of waiting time for paratransit, the likelihood of boarding experience getting better increases. According to local context, if waiting time for paratransit increases, the chances of getting a better seat increases resulting in a better accessing experience to boarding bus stop.

Another surprising finding is that as cost of using rickshaw as a mode to access destination from alighting bus stop increases, the experience tends to get better. It could be due to the local uneven fare distribution of rickshaws (comparatively high fare proportion for short distances). On the other hand, as bus travel time (as feeder service) increases while approaching destination from alighting bus station, naturally the experience gets worse.

4.3.4. Community facility rating while boarding

In case of boarding, the trip component ratings are directly associated with the boarding experience. A lower trip component rating normally suggests a worse boarding experience. For example, as the trip component rating of feeder service availability decreases, the overall boarding experiences also gets worse. This claim can be supported by the increasing negativity of the coefficients in Table 3. Such a case is true for other trip component ratings as well.

4.4. Goodness of Fit of Model

According to Equation (5), the combined log-likelihood of two univariate probit models is -4925.34, whereas, the simultaneous bivariate probit model results in a major improvement in log-likelihood (i.e., -4181.4243), which implies the statistical superiority of the bivariate model over the two separate univariate models. This indicates that it is necessary to encapsulate this correlation in model developing instead of heterogeneity in parameter effects only. The correlation parameter $\rho = -0.63893$ was found to be significant, A statistically significant and negative correlation between the error terms of boarding and alighting experience signifies that a number of shared unobserved aspects were captured by the error terms of the two latent variables. Based on the p-value (Prob > chi2 = 0.0000) of the likelihood ratio test, the fitted model was found to be suitable compared to the null model (model with constant term only). The p-value of the Wald chi2 test (Prob > chi2 = 0.000) indicates the significance of the bivariate probit model run as contrasted to univariate probit model for each independent variable.

CHAPTER 5

CONCLUSION AND POLICY IMPLICATION

5.1. Introduction

In recent years, for the sake of increasing the efficiency of bus services, a growing emphasis has been put on a greater understanding of the determinants that influence passenger experience and perception in both developed and developing countries. Accessibility for transport (communications) is deemed to be a significant determinant for the sustainable development of densely populated cities. It plays a key role in efficient land use and urban growth; because mass transportations like bus provide people with provision to financial and social benefits. The growth of Dhaka's bus transportation has been lagging behind due to lack of capital investment and poor policy development over the last few decades. Studies that incorporate socio-economic conditions of Dhaka inhabitants thus play a pivotal role in ensuring a more viable transport system. Because when a transportation infrastructure is well developed and operated, the productivity and standard of living of a city can be enhanced, and such urban growth simultaneously boosts the potential for more transport. Therefore, the first step toward achieving the previously mentioned goal of a sustainable mass transit system is to measure ridership and assess the determinants of public transportation accessibility. In this study, a random sample of 2532 people were surveyed to record their boarding and alighting experiences at bus stops, as well as to determine the socioeconomic factors and trip characteristics that influence the type of experience an individual has while boarding and alighting at a bus stop.

Overall, only 9.24% respondents of our survey had a positive perception ("excellent" or "good") towards their boarding experience, while 8.57% respondents had similar perception in case of alighting. Our study found that travel day, age, occupation, income, highest education level, vehicle access/ownership, trip frequency, trip purpose, cost bearer, presence of other bus stops nearby, attributes of feeder service, accessibility to and from bus stops, pedestrian facility, availability of feeder service, headway and distance from origin to bus stop had a significant impact either on boarding or alighting or in both the experiences.

5.2.Policy Implication

While very few researches have been published on boarding and alighting experiences to the best of our knowledge, an analysis carried out by Quddus *et.al*. (2019) studied factors influencing the bus passengers' satisfaction in Dhaka appears to agree with the outcomes of this paper. Variables such as trip purpose, accessibility to the public transport catchment area and waiting time of the passengers were found to be significantly impacting the overall customer satisfaction. Moreover, another finding of the study is consistent with previous work done by Cirillo *et.al.* (2011) which revealed that increasing walking travel time (longer the distance, higher the travel time) from the origin to the bus stop adversely affects the boarding experience. Aceves-González *et.al.* (2016), on the other hand, reported that elderly people were more vulnerable to poor passenger experience, which contradicted the findings of our research. Cultural views towards elderly people in local context of Bangladesh might be one reason for the contradiction. Another research, similar to ours, suggested that multimodal integration of paratransit and bus services will help to improve accessibility within bus stop catchment area (Tangphaisankun *et al*., 2009). In addition, upgrading pedestrian infrastructure (sidewalks, crosswalks, road surface quality, and street lighting) leading to the bus stop catchment area should be prioritized (Roy and Basu, 2020).

The only structured mass transit system currently accessible in Dhaka City is the Bus Service, which is why it is of utmost importance to efficiently enhance the overall traveler experience for this mode of transport. The outcome of our study could give an insight to service providers to recognize the detrimental factors contributing to worsen experience of the commuters using public bus services and thereby enabling the bus operators to adjust or improve their services accordingly.

5.3.Scope of Study

Qualitative analysis of our data suggests that a large proportion of the study constitutes of "captive" riders who either may not have an alternative mode or own a private vehicle. The findings of this research imply that the respondents are coherent in their perceptions, which may very well be the case for non-users. This is a quite lengthy procedure to transform the attributes of bus transport to increase sustainability.

Even though fairly large number of variables was considered in this study, some potentially vital data such as dwell time of bus, categories of bus, feeder service quality etc. has been neglected due to the lack of available data. In terms of the experience of passengers, a GIS-based optimized location model of bus stops may also be created. In addition, the machine learning algorithm could be used to cluster individuals with common backgrounds given their travel time and relevant factors (e.g. mode choice) that could have an effect on improved route planning and public transit scheduling. However, the product of this study can be utilized in some possible aspects like developing better service standards to enhance passengers' boarding and alighting experience and improve their overall satisfaction of bus ridership.

CHAPTER 6

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APPENDIX A

QUESTIONNAIRE

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

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Declaration

Identifying an appropriate location for bus stops can bring many benefits to both the bus operators and the passengers. In order to do so, it is important to know how people travel to different bus stops, whether it varies depending on the connectivity of the bus stop to various para transit services, how these decisions vary based on the socio-economic condition of the passengers and demography of the bus stop location, etc. This study is part of an undergraduate research by the students of the Department of Civil and Environmental Engineering of Islamic University of Technology and the students are seeking the answers to the aforementioned questions through the following questions. Your inputs will have invaluable impact on the findings. We would like to confirm that data will be aggregated before analysis to ensure privacy of the participants. Therefore, thank you for your cooperation by participating.

Questionnaire

A. Basic Information

1. Date:	2. Time:	3. a. Weekday b. Weekend
4. Bus Stop Name:	5. Address:	

B. Personal Information Cell Phone:____________________

1. Age (year)	a. <18	b. 18-25	c. 25-40	c. 40+
2. Gender (year)	a. Female	b. Male	c. Others	
3. Occupation	a. Service holder	b. Student	c. Businessman	d. Others
4. Income/month (in Taka)	a. <10,000	b. 10,000 – 25,000	c. 25,000-40,000	d. 40,000+
5.Highest Education	a. Postgradaute	b. Undergraduate	c. HSC/ SSC/ Technical Education	d. Others
6.Vehicle Ownership/Access	a. Car/Microbus	b. Motorcycle	c. CNG	d. Others (e.g., bicycle/rickshaw)
7. If you have access to vehicle then it is:	a. You own it	b. Your family owns it	c. Given by office	d. Others

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B. Trip Information

1. Origin			2. Destination		
3. Origin Bus Stop			4. Destination Bus Stop		
5. Purpose	a. Work	b. Education	c. Shopping	d. Recreation	e. Others

6. How did you reach the boarding bus stop from your origin?			
a. Mode	b. Cost	c. Travel Time	d. Waiting Time
i. Walking			
ii. Rickshaw			
iii. Motorcycle			
iv. Bus			
v. Permitted paratransit			
vi. Others			

7. How did you reach the destination from the alighting bus stop?			
a. Mode	b. Cost	c. Travel Time	d. Waiting Time
i. Walking			
ii. Rickshaw			
iii. Motorcycle			
iv. Bus			
v. Permitted paratransit			
vi. Others			

8. How often do you take this trip?			
a. 5 times or more	b. At least once	c. Less than that	d. Seldom

9. Was there any other bus stop nearby from which you could have completed this trip? a. Yes b. No			
10. Who paid the cost of this trip?	a. Myself	b. Office	c. Others
11. How much do you spend per month on transportation?			

C. Trip Component Rating

1. How will you rate the accessibility of this bus stop? Rate in 1-5 scale where 5 = Excellent, 4 = Good, 3 = Alright, 2 = Poor and 1 = Very poor.					
a. Distance traveled from origin	i. 5	ii. 4	iii. 3	iv. 2	v. 1
b. Availability of buses from this stop	i. 5	ii. 4	iii. 3	iv. 2	v. 1
c. Pedestrian facility to walk up to bus stop	i. 5	ii. 4	iii. 3	iv. 2	v. 1
d. Feeder service	i. 5	ii. 4	iii. 3	iv. 2	v. 1

2. Rate the overall accessibility of the boarding bus stop.				
a. Excellent	b. Very Good	c. Alright	d. Bad	e. Very Bad
3. Rate the overall accessibility of the alighting bus stop.				
a. Excellent	b. Very Good	c. Alright	d. Bad	e. Very Bad

APPENDIX B

Simultaneous bivariate ordered probit model run in STATA 13

```
Simultaneous bivariate ordered probit regression  Number of obs   =       2532
                                                  Wald chi2(55)   =    1036.39
Log likelihood = -4181.4243                       Prob > chi2     =     0.0000
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
d2_boardingexperience						
a3_weekend	-.1942849	.0633485	-3.07	0.002	-.3184458	-.0701241
b1_agelessthan18	-.3078169	.1520664	-2.02	0.043	-.6058617	-.0097722
b1_between18and25	-.228616	.0972341	-2.35	0.019	-.4191913	-.0380406
b1_between25and40	-.1721394	.0831852	-2.07	0.039	-.3351793	-.0090994
b3_serviceholder	-.1646875	.0914896	-1.80	0.072	-.3440038	.0146288
b3_student	-.2582219	.1005338	-2.57	0.010	-.4552645	-.0611793
b3_business	-.1421508	.0969094	-1.47	0.142	-.3320898	.0477882
b4_incomelessthan10k	-.0575703	.0901333	-0.64	0.523	-.2342283	.1190877
b4_between25and40k	-.2263745	.0695784	-3.25	0.001	-.3627457	-.0900032
b4_over40k	-.2388611	.1132873	-2.11	0.035	-.4609002	-.016822
b5_postgraduate	-.1524319	.0779201	-1.96	0.050	-.3051524	.0002886
b5_undergraduate	-.0046816	.066134	-0.07	0.944	-.1343019	.1249387
b5_others	-.1934427	.0804262	-2.41	0.016	-.3510753	-.0358102
b6_motorcycle	-.4036122	.1603481	-2.52	0.012	-.7178886	-.0893357
b6_cng	.458003	.5739032	0.80	0.425	-.6668266	1.582833
b6_others	-.2891159	.2063513	-1.40	0.161	-.6935571	.1153253
b7_accesstypeown	.4039752	.1625151	2.49	0.013	.0854514	.722499
b7_family	.0774882	.1976888	0.39	0.695	-.3099748	.4649512
b7_office	-.8641608	.3888347	-2.22	0.026	-1.626263	-.1020587
c5_education	.2808062	.0909267	3.09	0.002	.1025931	.4590192
c5_shopping	.1407498	.1267756	1.11	0.267	-.1077258	.3892255
c5_recreation	.0741984	.1153508	0.64	0.520	-.1518849	.3002818
c5_others	.211019	.0727976	2.90	0.004	.0683385	.3536996
c6ci_walkingtraveltime	-.0151528	.0063794	-2.38	0.018	-.0276561	-.0026494
c6bii_rickshawcost	-.0040253	.0067739	-0.59	0.552	-.0173018	.0092512
c6cii_rickshawtraveltime	.0018061	.0195213	0.09	0.926	-.036455	.0400671
c6dii_rickshawwaitingtime	.0665245	.0611368	1.09	0.277	-.0533014	.1863504
c6biv Buscost	-.0141512	.0148578	-0.95	0.341	-.043272	.0149696

c6civ_Bustraveltime	-.0127918	.0143564	-0.89	0.373	-.0409298	.0153461
c6div_Buswaitingtime	.0067669	.0458358	0.15	0.883	-.0830697	.0966034
c6bv_Permittedparatransitcost	-.0050895	.0096093	-0.53	0.596	-.0239234	.0137445
c6cv_Permittedparatransittravel	-.0001734	.0039826	-0.04	0.965	-.0079792	.0076324
c6dv_Permittedparatransitwaitin	.0302644	.0146595	2.06	0.039	.0015324	.0589964
c8_atleastonce	-.1604081	.0604789	-2.65	0.008	-.2789446	-.0418717
c8_lessthanthat	-.0096825	.0768134	-0.13	0.900	-.160234	.140869
c8_seldom	-.182118	.08186	-2.22	0.026	-.3425607	-.0216752
c9_nearbystopyes	-.1118822	.0489331	-2.29	0.022	-.2077893	-.0159751
c10_office	-.399545	.1891136	-2.11	0.035	-.7702009	-.0288891
c10_others	.1454434	.0814946	1.78	0.074	-.014283	.3051699
d1a1_experienceofDistancetrave	-.7137989	.1879211	-3.80	0.000	-1.082117	-.3454803
d1a2_poor	-.4007861	.1061977	-3.77	0.000	-.6089296	-.1926425
d1a3_alright	.045372	.0921354	0.49	0.622	-.1352101	.225954
d1a4_good	-.085749	.0877104	-0.98	0.328	-.2576582	.0861603
d1b1_experienceofavailabilityo	-.6623716	.1555563	-4.26	0.000	-.9672563	-.3574869
d1b2_poor	-.7271117	.1143027	-6.36	0.000	-.9511409	-.5030824
d1b3_alright	-.0789452	.1025506	-0.77	0.441	-.2799407	.1220504
d1b4_good	-.0605343	.0992705	-0.61	0.542	-.2551008	.1340322
d1c1_experienceofpedestrianfac	-1.524104	.1693094	-9.00	0.000	-1.855945	-1.192264
d1c2_poor	-1.236803	.1415942	-8.73	0.000	-1.514322	-.959283
d1c3_alright	-.7202782	.1308458	-5.50	0.000	-.9767313	-.463825
d1c4_good	-.3645335	.1288831	-2.83	0.005	-.6171399	-.1119272
d1d19_experienceoffeederservic	-1.526555	.1231311	-12.40	0.000	-1.767887	-1.285222
d1d2_poor	-1.375371	.1112091	-12.37	0.000	-1.593337	-1.157406
d1d3_alright	-.9095412	.1036811	-8.77	0.000	-1.112752	-.70633
d1d4_good	-.47368	.1101559	-4.30	0.000	-.6895816	-.2577784
d3_alightingexperience						
d2_boardingexperience	2.017866	.2355517	8.57	0.000	1.556194	2.479539
a3_weekend	.202213	.0618693	3.27	0.001	.0809514	.3234746
b1_agelessthan18	.1699231	.1493897	1.14	0.255	-.1228753	.4627216
b1_between18and25	.0363132	.0950519	0.38	0.702	-.149985	.2226115
b1_between25and40	-.0600072	.081275	-0.74	0.460	-.2193032	.0992888
b3_serviceholder	-.2065204	.0914939	-2.26	0.024	-.3858451	-.0271957
b3_student	-.1008816	.0990515	-1.02	0.308	-.295019	.0932558
b3_business	-.0933495	.0965414	-0.97	0.334	-.2825672	.0958682
b4_incomelessthan10k	-.0034184	.0893456	-0.04	0.969	-.1785325	.1716957
b4_between25and40k	-.0417031	.0688864	-0.61	0.545	-.176718	.0933118
b4_over40k	.0297143	.1116259	0.27	0.790	-.1890684	.248497
b5_postgraduate	.1590413	.0767152	2.07	0.038	.0086823	.3094004
b5_undergraduate	.1548855	.0651157	2.38	0.017	.027261	.28251
b5_others	.1145103	.0788474	1.45	0.146	-.0400279	.2690484
b6_motorcycle	-.2313212	.1568118	-1.48	0.140	-.5386666	.0760242
b6_cng	-.8379801	.5278451	-1.59	0.112	-1.872537	.1965772
b6_others	-.0425377	.2049428	-0.21	0.836	-.4442183	.3591429
b7_accesstypeown	.1162184	.1595008	0.73	0.466	-.1963974	.4288342
b7_family	.2179441	.1939002	1.12	0.261	-.1620933	.5979816
b7_office	.3224956	.3784996	0.85	0.394	-.41935	1.064341

c5_education	-.1069089	.0887173	-1.21	0.228	-.2807915	.0669738
c5_shopping	-.0024585	.1237848	-0.02	0.984	-.2450721	.2401552
c5_recreation	-.3480707	.11375	-3.06	0.002	-.5710165	-.1251248
c5_others	-.2001174	.0713416	-2.81	0.005	-.3399443	-.0602905
c7ci_Walkingtraveltime	-.0007012	.0048378	-0.14	0.885	-.010183	.0087806
c7bii_rickshawcost	.014873	.0089276	1.67	0.096	-.0026248	.0323708
c7ciirickshawtraveltime	-.0212928	.0267106	-0.80	0.425	-.0736445	.0310589
c7dii_rickshawwaitingtime	.0640176	.0876294	0.73	0.465	-.1077329	.2357681
c7biv_Buscost	-.0035566	.0182389	-0.20	0.845	-.0393043	.032191
c7civ_Bustraveltime	-.0458947	.0163806	-2.80	0.005	-.078	-.0137894
c7div_Buswaitingtime	.0317381	.066317	0.48	0.632	-.0982407	.161717
c7bv_Permittedparatransitcost	-.0117239	.0085859	-1.37	0.172	-.028552	.0051043
c7cv_Permittedparatransittravel	.0068792	.0043715	1.57	0.116	-.0016888	.0154472
c7dv_Permittedparatransitwaitin	.0120784	.0203379	0.59	0.553	-.0277832	.05194
c8_atleastonce	.0819908	.0596963	1.37	0.170	-.0350117	.1989934
c8_lessthanthat	-.0135405	.0757742	-0.18	0.858	-.1620551	.1349742
c8_seldom	.0416654	.0805871	0.52	0.605	-.1162825	.1996133
c9_nearbystopyes	-.0070092	.0483604	-0.14	0.885	-.1017937	.0877754
c10_office	.2484996	.1877261	1.32	0.186	-.1194368	.616436
c10_others	-.204544	.0800837	-2.55	0.011	-.3615051	-.0475828

athrho						
_cons	-.7563628	.0720057	-10.50	0.000	-.8974914	-.6152343
gamma						
_cons	-.1347317	.1143177	-1.18	0.239	-.3587902	.0893268
/cut11	-5.425125	.2955033			-6.004301	-4.845949
/cut12	-3.42149	.2851751			-3.980423	-2.862558
/cut13	-1.317748	.2791052			-1.864784	-.7707122
/cut14	-.1696429	.2796994			-.7178436	.3785577
/cut21	3.811456	.9862685			1.878405	5.744506
/cut22	5.350535	1.001468			3.387693	7.313376
/cut23	7.472728	1.030719			5.452556	9.4929
/cut24	8.930316	1.05584			6.860907	10.99973
rho	-.6389296	.0426107			-.7150742	-.5478011

LR test of indep. eqns. : chi2(1) = 31.39 Prob > chi2 = 0.0000

APPENDIX C

Univariate ordered probit model run for boarding experience in STATA 13

Ordered probit regression	Number of obs	=	2532
	LR chi2(55)	=	1261.98
	Prob > chi2	=	0.0000
Log likelihood = -2151.6333	Pseudo R2	=	0.2268

d2_boardingexperience	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
a3_weekend	-.1824059	.0637631	-2.86	0.004	-.3073793	-.0574325
b1_agelessthan18	-.2977566	.1527919	-1.95	0.051	-.5972232	.0017101
b1_between18and25	-.2324693	.0976556	-2.38	0.017	-.4238709	-.0410678
b1_between25and40	-.1668869	.0834284	-2.00	0.045	-.3304036	-.0033703
b3_serviceholder	-.1860641	.0920463	-2.02	0.043	-.3664715	-.0056568
b3_student	-.2780986	.1010959	-2.75	0.006	-.4762429	-.0799544
b3_business	-.1548657	.0975755	-1.59	0.112	-.3461101	.0363788
b4_incomelessthan10k	-.0586713	.0906588	-0.65	0.518	-.2363593	.1190167
b4_between25and40k	-.2650937	.0697117	-3.80	0.000	-.4017262	-.1284613
b4_over40k	-.257257	.1138122	-2.26	0.024	-.4803249	-.0341891
b5_postgraduate	-.1547316	.0781894	-1.98	0.048	-.30798	-.0014832
b5_undergraduate	.0070382	.0663988	0.11	0.916	-.123101	.1371774
b5_others	-.2014599	.0808296	-2.49	0.013	-.3598829	-.0430369
b6_motorcycle	-.315604	.1624801	-1.94	0.052	-.6340591	.0028512
b6_cng	.4853371	.5454084	0.89	0.374	-.5836437	1.554318
b6_others	-.2734654	.2092656	-1.31	0.191	-.6836184	.1366875
b7_accesstypeown	.3300151	.164391	2.01	0.045	.0078147	.6522155
b7_family	.0588516	.1994544	0.30	0.768	-.3320718	.4497749
b7_office	-.7837695	.389585	-2.01	0.044	-1.547342	-.0201969
c5_education	.2517716	.0914789	2.75	0.006	.0724762	.431067
c5_shopping	.1137658	.1273003	0.89	0.371	-.1357381	.3632697
c5_recreation	.0421091	.1160199	0.36	0.717	-.1852858	.269504
c5_others	.1899991	.073103	2.60	0.009	.0467198	.3332785
c6ci_walkingtraveltime	-.0130002	.0070592	-1.84	0.066	-.0268359	.0008355

c6bii_rickshawcost	-.0069444	.0076615	-0.91	0.365	-.0219607	.0080718
c6cii_rickshawtraveltime	.013171	.0220109	0.60	0.550	-.0299696	.0563115
c6dii_rickshawwaitingtime	.0772851	.0681928	1.13	0.257	-.0563703	.2109405
c6biv_Buscost	-.0227339	.0166859	-1.36	0.173	-.0554376	.0099699
c6civ_Bustraveltime	-.0181734	.0159411	-1.14	0.254	-.0494174	.0130706
c6div_Buswaitingtime	.0286023	.0510237	0.56	0.575	-.0714023	.128607
c6bv_Permittedparatransitcost	-.0059173	.01074	-0.55	0.582	-.0269674	.0151327
c6cv_Permittedparatransittravel	.0003575	.0044659	0.08	0.936	-.0083954	.0091105
c6dv_Permittedparatransitwaitin	.0173018	.0165087	1.05	0.295	-.0150546	.0496583
c8_atleastonce	-.1626944	.0607991	-2.68	0.007	-.2818584	-.0435303
c8_lessthanthat	-.0035316	.0772954	-0.05	0.964	-.1550278	.1479647
c8_seldom	-.1967041	.0821875	-2.39	0.017	-.3577887	-.0356195
c9_nearbystopyes	-.1263763	.0492317	-2.57	0.010	-.2228687	-.0298838
c10_office	-.395201	.189885	-2.08	0.037	-.7673688	-.0230333
c10_others	.142292	.0824267	1.73	0.084	-.0192614	.3038455
d1a1_experienceofDistancetrave	-.8243763	.2122633	-3.88	0.000	-1.240405	-.4083479
d1a2_poor	-.4620209	.1193735	-3.87	0.000	-.6959888	-.2280531
d1a3_alright	-.002827	.10472	-0.03	0.978	-.2080744	.2024204
d1a4_good	-.0752973	.1000286	-0.75	0.452	-.2713498	.1207551
d1b1_experienceofavailabilityo	-.8353294	.175633	-4.76	0.000	-1.179564	-.491095
d1b2_poor	-.9883153	.1277147	-7.74	0.000	-1.238632	-.737999
d1b3_alright	-.2361858	.1172919	-2.01	0.044	-.4660736	-.0062979
d1b4_good	-.1265567	.1141699	-1.11	0.268	-.3503257	.0972122
d1c1_experienceofpedestrianfac	-1.46927	.1908655	-7.70	0.000	-1.84336	-1.095181
d1c2_poor	-1.163993	.1608555	-7.24	0.000	-1.479264	-.8487215
d1c3_alright	-.668183	.1496246	-4.47	0.000	-.9614417	-.3749243
d1c4_good	-.3129263	.1481528	-2.11	0.035	-.6033004	-.0225522
d1d19_experienceoffeederservic	-1.370439	.138916	-9.87	0.000	-1.64271	-1.098169
d1d2_poor	-1.326161	.1253452	-10.58	0.000	-1.571833	-1.080489
d1d3_alright	-.8993601	.1172609	-7.67	0.000	-1.129187	-.669533
d1d4_good	-.5228823	.1257519	-4.16	0.000	-.7693515	-.2764131
/cut1	-5.554137	.3046092			-6.15116	-4.957114
/cut2	-3.546783	.2955205			-4.125993	-2.967574
/cut3	-1.399622	.2897398			-1.967502	-.8317428
/cut4	-.1558874	.2911346			-.7265006	.4147259

APPENDIX D

Univariate ordered probit model run for alighting experience in STATA 13

```
Ordered probit regression                       Number of obs   =       2532
                                                LR chi2(39)     =     125.66
                                                Prob > chi2     =     0.0000
Log likelihood = -2773.7052                     Pseudo R2       =     0.0222
```

d3_alightingexperience	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
a3_weekend	.0914162	.0590017	1.55	0.121	-.024225	.2070574
b1_agelessthan18	-.0337355	.1423291	-0.24	0.813	-.3126954	.2452245
b1_between18and25	-.0882459	.0907375	-0.97	0.331	-.2660881	.0895963
b1_between25and40	-.1174862	.0775416	-1.52	0.130	-.2694649	.0344925
b3_serviceholder	-.4582487	.0861097	-5.32	0.000	-.6270206	-.2894769
b3_student	-.2898339	.0940107	-3.08	0.002	-.4740915	-.1055763
b3_business	-.3268831	.091483	-3.57	0.000	-.5061865	-.1475797
b4_incomelessthan10k	-.1866295	.0848188	-2.20	0.028	-.3528712	-.0203877
b4_between25and40k	-.2865359	.0653146	-4.39	0.000	-.4145502	-.1585215
b4_over40k	-.2801714	.1061309	-2.64	0.008	-.4881841	-.0721586
b5_postgraduate	.0691907	.0731056	0.95	0.344	-.0740937	.2124751
b5_undergraduate	.1566454	.0618401	2.53	0.011	.0354409	.2778498
b5_others	-.0608996	.075277	-0.81	0.419	-.2084398	.0866405
b6_motorcycle	-.0516403	.1508994	-0.34	0.732	-.3473977	.2441172
b6_cng	.0703368	.5166743	0.14	0.892	-.9423262	1.083
b6_others	-.1156694	.196347	-0.59	0.556	-.5005025	.2691637
b7_accesstypeown	.0611806	.1522134	0.40	0.688	-.2371521	.3595133
b7_family	-.1747598	.1855827	-0.94	0.346	-.5384951	.1889755
b7_office	-.1371187	.3674765	-0.37	0.709	-.8573595	.5831221
c5_education	.0239098	.0847563	0.28	0.778	-.1422094	.1900291
c5_shopping	.1060945	.1186564	0.89	0.371	-.1264678	.3386569
c5_recreation	-.3462994	.1081799	-3.20	0.001	-.5583281	-.1342707

c5_others	-.0546636	.0681722	-0.80	0.423	-.1882786	.0789515
c7ci_Walkingtraveltime	-.0070523	.0052081	-1.35	0.176	-.0172599	.0031553
c7bii_rickshawcost	-.0034354	.0095113	-0.36	0.718	-.0220772	.0152064
c7ciirickshawtraveltime	-.012175	.0288587	-0.42	0.673	-.0687371	.0443871
c7dii_rickshawwaitingtime	.059043	.0943504	0.63	0.531	-.1258804	.2439664
c7biv_Buscost	-.0136887	.0194642	-0.70	0.482	-.0518378	.0244605
c7civ_Bustraveltime	-.0244311	.0175256	-1.39	0.163	-.0587807	.0099186
c7div_Buswaitingtime	-.0612963	.071184	-0.86	0.389	-.2008144	.0782219
c7bv_Permittedparatransitcost	-.0235343	.0091258	-2.58	0.010	-.0414205	-.0056481
c7cv_Permittedparatransittravel	-.0021165	.0047037	-0.45	0.653	-.0113356	.0071025
c7dv_Permittedparatransitwaitin	.0273307	.0214909	1.27	0.203	-.0147907	.069452
c8_atleastonce	-.0188757	.0569961	-0.33	0.741	-.130586	.0928346
c8_lessthanthat	-.0865057	.0724828	-1.19	0.233	-.2285695	.055558
c8_seldom	-.213018	.0768032	-2.77	0.006	-.3635496	-.0624864
c9_nearbystopyes	-.1484159	.0459219	-3.23	0.001	-.2384211	-.0584107
c10_office	.1701362	.1787762	0.95	0.341	-.1802587	.5205311
c10_others	-.0590641	.0765023	-0.77	0.440	-.2090059	.0908778
/cut1	-2.358994	.2339842			-2.817594	-1.900393
/cut2	-1.092207	.2309194			-1.544801	-.6396131
/cut3	.6142348	.2305579			.1623496	1.06612
/cut4	1.585994	.2391745			1.11722	2.054767