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Theory of Planned Behavior to Understand Commuter's Perception towards Mass Rapid Transit in Dhaka City, Bangladesh

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Abstract: The Dhaka Metro Rail (DMR) has been constructed as part of the Dhaka Transport Coordination Authority's 20-year Strategic Transport Plan to reduce traffic congestion in Dhaka, the capital city of Bangladesh. The DMR is the first urban rail transit system in Bangladesh and has the potential to change the existing modal share. Commuters have mixed responses about the daily commuting on the DMR and mode choice behavior. This study analyses the commuters' perception of a modal shift towards the DMR by applying the theory of planned behavior (TPB). The structural equation model (SEM) used environmental concern and socio-demographic factors as additional explanatory variables to improve the explanatory capability of the TPB. A questionnaire survey was administrated using an online survey and validated via an in-person interview to collect the commuters' responses. The results reveal that environmental concern is the most significant contributor to commuters' perceptions of a modal shift towards the DMR in Dhaka City, followed by the attitude and perceived behavioral control of the respondents. The findings offer valuable insights for the DMR and other mass rapid transit service operators for policy-making in Dhaka and other cities with similar socio-economic demographics in the world.

Keywords: MRT; theory of planned behavior; questionnaire survey; structural equation modeling; commuter's intention; mode shift

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1. Introduction

A transportation system that includes effective and service-friendly public transit ensures accessibility and improves the living standards of a community. Cities in developing nations are implementing rail-based transit systems as a solution to the challenges of urban traffic congestion and rapidly expanding travel demands [1]. Following the lead of initiatives in Hong Kong and Singapore, Dhaka, the capital city of Bangladesh, has constructed the Dhaka Metro Rail (DMR) to accommodate the region's growing transport demands [2].

Dhaka is one of the world's most densely inhabited cities and has a high population growth rate [3]. The city is struggling with traffic congestion due to the unregulated growth of private vehicles, inadequate traffic signaling systems, the road infrastructure, and drivers' propensity for risk-taking behavior. Long-term traffic congestion significantly reduces available working hours and has a detrimental impact on the economy. The traffic congestion also worsens the city's general environmental predicament causing air and noise pollution [4]. A mass rapid transit (MRT) system is a sustainable solution to minimize

traffic congestion, improve vehicle mobility efficiency, and reduce air pollution. The MRT system, a low-noise and -vibration electric mechanical system, runs on renewable energy, making it an environmentally benign, sustainable, and efficient transportation system.

The DMR was constructed as part of the Dhaka Transport Coordination Authority's 20-year Strategic Transport Plan to reduce traffic congestion in the city center of Dhaka, where six rail lines are planned for the total network [5]. Line 6 was recently inaugurated to operate from Uttara to Agargaon. The MRT system is crucial to securing long-term advancements and stabilizing the modal share of commuters for maintaining an affordable transport system within a transit-friendly city [6]. The MRT system is new for the residents of Dhaka, and there are mixed responses about the daily ridership and mode choice behavior. In addition, insignificant attention was given to studying the modal preferences, the willingness to switch to the MRT for daily commuting, and the supportive circumstances for the potential users [7]. The voice of the daily commuters and their travel preferences about a new transport system are often neglected. The perception of commuters portrays the quality of transportation services that support the service providers to set up the development goals and priority areas required for improvement within the budget constraints. The improvement of the MRT system improves its performance and services resulting in higher MRT ridership. Extensive research is necessary to properly apprehend the travel behavior of the modal shift for daily commuting. To shed light on this context, this study focuses on analyzing factors influencing the modal shift in the traveling behavior of commuters in Dhaka City for constructing the DMR.

Several studies were conducted on the modal shift in behavior in response to the new MRT [1,8–12]. This study, for the first time, applies behavioral theories to explore the factors affecting commuters' choice towards the MRT over the existing mode of transport. To bridge this research gap in the literature, the objective of this study is to synthesize the theoretical insights from the popular psychological theory, the theory of planned behavior (TPB), in order to identify the factors influencing the behavioral intention for the modal shift towards MRT for daily commuting. The TPB considers individuals' attitudes (ATD), subjective norms (SN), and perceived behavioral control (PBC) that govern the behavioral intention for the modal shift. However, multiple studies claim that behaviors and intentions are also connected to the beliefs about environmental issues and the demographic backgrounds of the people [13,14]. Hence, the research novelty of this study is the integration of not only the TPB but also the inclusion of socio-demographic factors and environmental concerns (EC) as predictor variables to improve the explanatory capability of the TPB. This study aims to develop a new model for a better understanding of how these factors influence MRT travel behavior that would lead to designing more effective commuting behavior, increasing MRT ridership among the residents in Dhaka city. It is anticipated that new information obtained via this strategy would provide MRT operators and authorities with access to information that might assist them in better grasping the views of potential consumers and enable new decisions to satisfy their expectations for the new service.

2. Literature Review

This study aims at investigating the commuters' intentions to shift to the newly constructed DMR in Dhaka, Bangladesh, by applying an extended version of the TPB. Therefore, in order to have a comprehension and background knowledge of the DMR and the TPB, the literature review has been divided into three sub-sections. The first sub-section highlights the background of DMR Line 6, followed by a comprehensive review of the studies on the preferred mode shift towards MRT. The final sub-section discusses the conceptual background of the TPB.

2.1. Background on Dhaka MRT Line 6

Dhaka Metro Rail is a public transport project carried out by the Dhaka Mass Transit Company Limited (DMTCL) under the Department of Road Transport and Highway division. It is built by the state-owned DMTCL and funded by JICA (Japan International Co-

operation Agency, Tokyo, Japan). The design was approved under a fast-tracked procedure at the Executive Commission of the National Economic Council (ECNEC) on 18 December 2012, and the construction was initiated on 26 June 2016. The DMR network will have a total of 104 stations, including 53 underground stations and 51 elevated stations. The Metro Rail carriages are outfitted with top-of-the-line amenities such as information displays, enhanced seating arrangements, wheelchair availability, and air exertion. The vibration and noise are reduced using cutting-edge technology. Due to the reduced travel time, it is expected to carry around 1.6 million passengers per day after the completion of the entire project. This will significantly reduce traffic congestion, air pollution, and journey times in Dhaka City.

A total of six routes were defined for the project, and in the first phase of the design, two metro lines will be constructed: Line 6 (Uttara North–South Line) and Line 1 (Airport–Gulistan Line). The first route, called "MRT Line 6", is now operational. MRT Line 6 is 20.1 km long with 16 stations and runs from Uttara in the north to Kamalapur in the south, with a 3.5 km long underground section and a 16.6 km long elevated section. However, in the present timeline, the first route to commence is the Uttara-to-Agargaon section. Its length is 21.26 km. MRT Line 6 can carry 60,000 passengers per hour. A six-auto train each way can carry up to 2308 passengers. Our study is primarily focused on the effect of the introduction of the first route of MRT Line 6.

2.2. Studies on Mode Shift to Metro

Although metro systems are becoming popular worldwide as an efficient resource to alleviate congestion and pollution [15], the willingness of prospective consumers to switch to the metro as their primary mode of transport is frequently ignored in feasibility assessments for new MRT projects [7]. This may cause the demand for metro services to be overestimated. A study [9] of possible metro customers in the vicinity of a proposed metro line was carried out in the Red Line project in Thailand using a sample of 667 respondents (staff and students situated at a nearby university campus). A total of 90% of the respondents were willing to switch to the metro for an upcoming 20 km trip between Salaya and Bangkok.

Some studies were conducted on the pre-launch views about MRT services in both industrialized [16] and underdeveloped [1,9] nations. Fraszczyk and Mulley [16] studied Sydney's new autonomous metro trains and how the public felt about this innovative form of transportation. A study in Copenhagen [17] on the transport effects of a harbor corridor metro was based on traffic counts, panel discussions, and model projections. According to the traffic data in the Copenhagen study, bus riders accounted for 70–72% of the modal shift to the metro, whereas automobile users made up just 8–14%. The Copenhagen passenger travel demand model is a state-of-the-art model that incorporates business, commuter, educational, and leisure groups. The metro's appeal as a brand-new form of transportation is estimated using stated preference (SP) data and a tour-based model. It was proposed that the planned metro infrastructure development might be utilized as a tool for policy to assure ideal traffic conditions in and out of the city.

Yuanqing Wang et al. [12] examined the mode-shifting behavior in response to the opening of the metro system in Xian City, China. An SP study was conducted along the metro route before starting the metro service. The SP model and the revealed preference (RP) survey, which was carried out after the metro's launch, were contrasted. A logistic regression model for both work-related and leisure travel was created. The lack of modal incorporation into various cities resulted in an 8 to 19% decline in the number of travelers choosing the metro. Besides this, Ling Ding et al. [18] investigated the impact of multiple transit priority methods on passengers' modal change in China. A comparison of the impact of single and multiple strategies on modal shifts was conducted by applying the logit model to SP and RP datasets.

To determine the likelihood of non-metro commuters switching to the Delhi metro, Chauhan [8] evaluated the effectiveness of a multivariate statistical modeling strategy and

also examined the causes of this departure from buses and private motor vehicles (PMVs). A survey database of 500 commuters on different metro lines was used by Chauhan [8]. Binary logistic regression was applied to determine the proportion of modal shift among bus passengers and PMV riders towards the Delhi Metro. Chauhan [8] identified that 57% of metro customers switched from buses, and 28.8% switched from PMVs. Since most metro commuters no longer utilize buses, there has not been much growth in the public transportation sector. By conducting two surveys—an RP survey (actual behavior) with a sample of 153 respondents and an SP survey (hypothetical situations) with a sample of 169 respondents—Sohoni et al. [1] studied the mode change behavior of commuters in Mumbai. According to the RP survey's findings, most participants (almost 80%) had previously used public transportation before switching to a new metro line. Additionally, more than half of the respondents (about 60%) who commuted by private vehicle in the SP questionnaire indicated a readiness to switch to the planned metro line. Selvakumar et al. [19] studied the increasing competition across PT modalities due to Chennai's recently installed metro rail system. Express bus passengers were the subjects of an SP survey to investigate the impact of metro rail on the bus mode. A modal shift model was created using the SP data to anticipate the likely transition from bus to metro rail. The findings showed that fare difference, age, and wealth have a significant impact on shift behavior. Selvakumar et al. [11] investigated the ridership of the proposed metro extension corridor in Chennai, India, by analyzing the inter-rail modal shift behavior of suburban train passengers. Using a stated preference questionnaire, a sample of 272 suburban rail customers traveling for employment, school, and other purposes was questioned for this inter-rail competition study. Six scenarios were considered for the assessments, including the time saved by taking the metro and the cost difference between commuting by metro and bus. The survey revealed that suburban rail travelers were less interested in journey time savings and instead prioritized travel costs regardless of the objective of their trips. In the context of India, this demonstrates the distinctive metro choice behavior of suburban train travelers.

The pre-launch impressions of a new metro service in Jakarta, which was to be the first metro system in Indonesia, were investigated by Dahlan et al. [9]. They divided the 516 respondents into two groups based on where they lived: those who lived along the new metro passageway and those who lived outside of it in other parts of the city. They found a few notable differences between the two groups. Fewer people who owned private cars belonged to the metro passageway category than the other group, and they were more inclined to use the metro as a substitute for other forms of transportation.

The literature review on the metro lines shows that a handful of studies have been conducted on people's readiness to switch from their present mode of transport to the new metro. The findings of these case studies are paramount in order to inform the new metro stakeholders and decision-makers about potential users' views regarding the new system and the significance of elements that may aid the future transfer to the metro, especially in the context of developing countries. Our comprehensive review of the literature also clearly shows that there is a gap in the critical understanding of the root of such willingness and behavioral intention to shift to MRTs and the lack of application of a solid psychological theorem to explain it. To close this research bridge, this study aims to investigate the factors influencing the willingness to shift to MRT in a megacity of a developing nation using an extended version of the TPB. This is the first study of its kind to add socio-demographic data (SDI) and environmental concerns (EC) as additional predictor variables to enhance the predictive value of the TPB on metro-shifting behavioral intention. This study was conducted to identify the variables impacting metro use from passengers' perspectives using a structural equation model (SEM) based on a questionnaire survey in Dhaka, Bangladesh.

2.3. Conceptual Background

The TPB offers a key conceptual framework for addressing the intricacies of human social behavior. According to the TPB, the personal judgment of a behavior (attitude),

socially anticipated style of behavior (subjective norm), and self-efficacy concerning an activity (perceived behavioral control) are the prime variables in social and behavioral research [20]. A positive attitude and a norm that is supportive of the action offer the desire to engage in it, but a definite intention to do so is only created when perceived control over the conduct is strong enough.

Attitude, the first component of the model, is considered to be a consequence of easily available beliefs, particularly behavioral beliefs, which are an individual's subjective likelihood that engaging in an activity would result in a certain experience or outcome. These behavioral beliefs collectively result in either a favorable or unfavorable attitude toward the behavior [21]. Although the strength of the relationship between attitude and behavior has occasionally been disappointing, the results have typically confirmed the hypothesized relationship between salient beliefs and attitudes [20].

The second component of the model, normative belief, comprises two categories: injunctive and descriptive [22]. An anticipation or subjective probability that a particular referent individual or group approves or disapproves of engaging in the action in question is known as an injunctive normative view. On the other hand, descriptive normative beliefs are opinions about whether significant others engage in the behavior. The perceived total social pressure to follow the behavior or subjective standard is influenced by both sorts of views [21]. The chance that significant referent persons or groups approve or disapprove of engaging in a certain activity is what normative views are concerned with [20].

The third component of the model, perceived behavioral control, is predicated on accessible control beliefs, just as attitudes are predicated on accessible behavioral beliefs, and subjective norms on accessible normative beliefs [21]. According to TPB, a set of beliefs that ultimately decide intention and action has to do with whether or not necessary resources and opportunities are available. These control beliefs may be influenced by prior experience with the behavior, but they will typically also be influenced by hearsay about the behavior, interactions with acquaintances and friends, and other factors that either increase or decrease the perceived difficulty of engaging in the behavior in question [20]. A person's subjective likelihood that a certain facilitating or inhibiting factor would exist in the circumstance of interest is referred to as a control belief. Each control belief interacts with the factor's perceived ability to help or hinder the performance of the activity to influence perceived behavioral control. In the TPB, it is anticipated that real behavioral control would reduce the impact of intention on behavior as well as the influence of attitude and subjective norms on intention [21].

A vast body of research on the theory of planned conduct has convincingly proved that attitudes toward the conduct, subjective norms about the behavior, and perceived control over the behavior are all proven to accurately predict behavioral intentions. However, the hypothesis makes no mention of how these beliefs came to be [22,23]; it just draws attention to a wide range of potential background elements, including exposure to media and other sources of information, aspects of a personal nature like personality and general life values, and demographic factors like education, age, gender, and income. These factors are anticipated to have an impact on intentions and behavior through their impact on the theory's more immediate determinants. Most empirical studies only evaluate a few demographic factors when they are used as controls. Nonetheless, other studies concentrate on one or more background variables that are thought to be pertinent to the behavior being studied for intuitive or theoretical reasons [22].

3. Methodology

3.1. Research Framework

The TPB assumes that behavioral intentions are solely influenced by ATT, SN, and PBC. However, many of the studies contradict the statement that intentions and behaviors can be influenced by some additional factors which are not presented in the theory [23]. For example, some studies reveal that intentions and behavior are also affected by environmental aspects. Behavioral intention can be related to pro-environmental activism and moral

norms regarding the environment which are the additional identity factors of the TPB [24]. Environmental concerns play a major role in mode choice behavior [25]. Senikidou et al. asserted that the operation of sustainable transport systems should integrate all these personal concerns by emphasizing the contribution of low-carbon transport schemes to environmental protection and social well-being [26]. Socio-demographic factors, such as gender, age, etc., may affect people's opinions regarding any aspects [27], intentions [28], and behavior regarding travel mode choice [29–31]. However, the elements for modeling behavior with respect to the TPB must be carefully considered since they may have an impact on the underlying choice of whether to act in a particular way or not [13]. Likewise, based on the TPB, the theoretical framework of this study is presented in Figure 1, which consists of a network of eight hypotheses detailing the relationships among ATT, SN, PBC, EC, gender, age, net income, vehicle ownership, and behavioral intention (BI) to predict the behavioral intention of the commuters of Dhaka City to shift towards DMR.

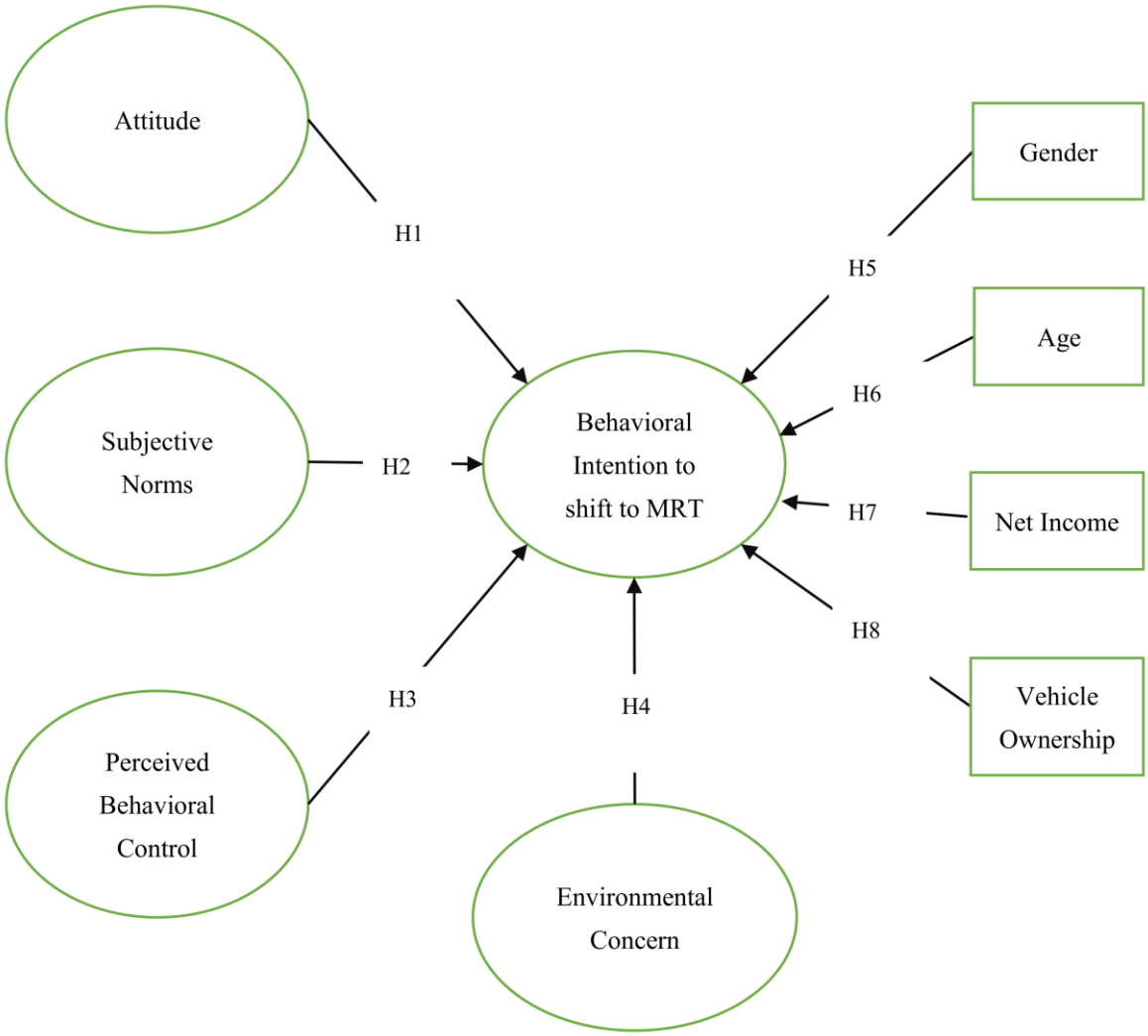

Figure 1. Theoretical Framework.

3.2. Hypothesis Development

Eight hypotheses were considered in this study to perform the SEM. The SEM has been used in several studies as a hypothesis-testing approach to the multivariate analysis of a structural theory bearing on some phenomenon [14,32,33]. SEM allows us to incorporate several observed variables (indicators) and unobserved (latent) variables in a single model, making it advantageous compared to conventional regression analysis. In this study, the SEM analysis was conducted using AMOS 28 of the IBM SPSS package in which

measurement models are developed initially and correlations between observed and latent variables are confirmed. Finally, the measurement models were combined to develop a structural model. A structural model is a path diagram that elaborates the measurement and structural equations. In this study, the structural model was constructed to test the following hypothesis:

Hypothesis 1 (H1). *The favorable attitude has a positive effect on respondents' intentions to use metro rail.*

Hypothesis 2 (H2). *The subjective norms of users have an influence on their intentions to shift metro rail.*

Hypothesis 3 (H3). *High perceived behavioral control of respondents has a positive effect on the intentions to ride metro rail to commute.*

Hypothesis 4 (H4). *The beliefs on environmental values and concerns of people have a positive effect on their intentions to use metro rail as daily commute mode.*

Hypothesis 5 (H5). *Gender of the users has an influence on the intentions to use metro rail.*

Hypothesis 6 (H6). *Age of the respondents positively affects the intentions to ride metro rail to commute.*

Hypothesis 7 (H7). *Net income of the respondents has an influence on the intentions to ride metro rail to commute.*

Hypothesis 8 (H8). *Vehicle ownership has an influence on the intentions to shift to metro rail.*

3.3. Data Collection and Survey Design

Both face-to-face and online questionnaire surveys were conducted to extract data regarding socio-demographic background and opinions related to MRT ridership among residents in Dhaka City. The face-to-face survey was conducted at the Agargaon, Mirpur-10, Pallabi, and Uttara North metro stations among the commuters. On the other hand, the web link of the questionnaire survey was distributed on social media platforms and through emails. In this study, the minimum sample size was determined based on the following equation:

$$n \geqslant N\left[1 + \frac{N-1}{P(1-P)}\left(\frac{d}{z_{\frac{\alpha}{2}}}\right)^2\right]^{-1} \quad (1)$$

where n is the minimum sample size to be considered, N is the population of the city, P is the quality characteristics (for neutral cases or where no previous experience exists then the value of P is taken as 0.5), and d is the margin of error, which is taken as 5% and $z_{\frac{\alpha}{2}} = 1.96$ for the 95% confidence interval. The metro area population of Dhaka for the year 2022 was approximately 22,478,000 [34]. Hence, the value of the minimum sample size calculated from the formula was 378. The surveys were carried out from January 2023 to April 2023 among a total of 764 responses. A total of 740 out of 764 respondents were filtered due to incomplete questionnaire surveys.

The questionnaire was formulated based on previous literature, transportation experts' insights, and initial opinions from the respondents. The questionnaire was divided into two parts. The first segment collected data on socio-demographic characteristics, namely, gender, age, occupation, monthly income, vehicle ownership, area of residence, and current transport mode. The summary statistics of the socio-demographic characteristics of the respondents are shown in Table 1. The second section asked respondents to express their

opinion on the measurement items of the proposed constructs based on the five-point Likert scale, where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. The literature suggests that a five-point scale appears to be less confusing and increases the response rate as respondents have choices without becoming overwhelmed [35].

Table 1. Socio-demographic characteristics of the respondents.

Characteristics	Category	Present Regular Users		Potential Regular Users	
		N = 154	%	*N* = 586	%
Gender	Male	89	57.8	313	53.4
	Female	65	42.2	273	46.6
Age	15–18	6	3.9	34	5.8
	19–25	61	39.6	222	37.9
	26–60	83	53.9	310	52.9
	60+	4	2.6	20	3.4
Profession	Student	28	18.2	169	28.8
	Job-holder	74	48.1	242	41.3
	Businessman	24	15.6	51	8.7
	Housewife	9	5.8	40	6.8
	Others	19	12.3	84	14.3
Net monthly income	0–40,000 BDT	105	68.2	422	72
	40,001–80,000 BDT	46	29.9	134	22.9
	80,000+ BDT	3	1.9	30	5.1
Vehicle ownership	Yes	32	20.8	139	23.7
	No	122	79.2	447	76.3

Note: BDT = Bangladesh Taka.

Since the respondents comprised commuters who ride the MRT on a regular basis and potential riders, two separate structural models were designed for separate focused groups. The present regular users were asked whether they were willing to continue commuting using the MRT. This is the only measurement item, namely, BIA, of the construct BI for model 1. For conducting SEM analysis, N = 100–150 is considered the minimum sample size [36]. Hence, for model 1, the sample size satisfies the minimum value. On the other hand, the potential MRT riders were asked about their willingness to commute by MRT regularly when all rail lines start operating successfully. This measure is counted as the BIB of the construct BI for model 2. Here, BIA and BIB are the individual observed endogenous variables of the two different structural models. Researchers have debated whether single-item measures can provide valid and reliable assessments of important psychological phenomena. However, numerous studies prove that a single-item measure is a sound approach to measuring psychological outcomes [37]. A study in 2007 found that there was no difference in predictive capability between multiple-item measures and single-item measures [38]. Similarly, a medical study observed that a single item can serve as a substitute for the full 20-item measure [39]. The measurement items of the six proposed constructs in the context of MRT ridership are listed in Table 2.

Table 2. Details of constructs and measurement items.

Constructs	Indicators	Measurement Item	Reference
Attitude (ATT)	ATDA	If I commute to my place of work or study on MRT, I would enjoy the ride.	[40–43]
	ATDB	If I use MRT while commuting to my workplace or study center, I would have a safe travel.	
	ATDC	If I use MRT while commuting to my workplace or study center, I would have a secured travel against robbery.	
	ATDD	I would commute quickly to my work/study destination if I use MRT	
	ATDE	If I commute by MRT I would know how long it would take me to get to my destination	
	ATDF	I would have a comfortable journey If I were commuting to my place of work or study on MRT	

Table 2. *Cont.*

Constructs	Indicators	Measurement Item	Reference
Subjective Norms (SN)	SNA	I prefer to use MRT as it is recommended by my family.	[44–46]
	SNB	My friends and colleagues praise me if I commute to my workplace/study center by MRT	
	SNC	My neighbors motivate me to commute to my workplace/study by MRT	
Perceived Behavior Control (PBC)	PBCA	I believe that long waiting time in MRT stations makes it difficult to use it	[47–49]
	PBCB	I believe that a high fare would demotivate me to use MRT	
	PBCC	I think the existing frequency of service makes it difficult to use MRT	
	PBCD	I think relatively remote positions of the stations make it difficult for me to use MRT	
Environmental Concern (EC)	ECA	If I commute to my workplace or academic institute by MRT, I would contribute to less air pollution.	[13,49]
	ECB	I feel morally obliged to use MRT for preservation of the natural resources.	
Behavioral Intention (BI) to shift to MRT	BIA *	I am willing to continue commuting regularly using MRT in the future.	[13,14]
	BIB **	I plan to be a regular MRT user when all the lines start operating successfully	

Note: * item for model 1; ** item for model 2.

3.4. Socio-Demographics of Respondents

The summary of the socio-demographic profile of the respondents is illustrated in Table 1. Out of 740 respondents, a total of 154 were current riders, and 584 respondents were observed as potential MRT riders. The genders of the participants from both categories have nearly equal proportions among teenagers (15–18 years old), graduate students (18–25 years old), adults (26–60 years old), and senior citizens (60+ years old). The majority of respondents are university students and adults. The distribution of the sample in Table 1 also aligns with the population demographics of Bangladesh [50]. Almost half of the existing riders are job-holders (48.1%), followed by students (18.2%). Similar proportions can also be observed for the potential riders from Table 1. The net monthly income was classified into three groups such as low (0–40,000 BDT), middle (40,001–80,000 BDT), and high (80,000+ BDT) [51]. The monthly income distribution of respondents is highly skewed towards the low-income group in both categories (Table 1). This may indicate that people with high incomes are not interested in commuting by MRT as most of them own private vehicles. A similar conclusion can be drawn by observing the vehicle ownership distribution. Approximately, 80% of the respondents do not own any vehicles.

Respondents were also asked what their general mode of travel was irrespective of the trip purpose. The majority of the respondents (42%) commute via public transport such as buses or legunas. However, a decent 16% and 15% of the respondents commute via private vehicle and use on-demand vehicles, respectively. Such strong dependency on cars and on-demand vehicles does not imply a sustainable transportation system for Dhaka. In this context, MRT can be an effective solution for daily commuters (Figure 2).

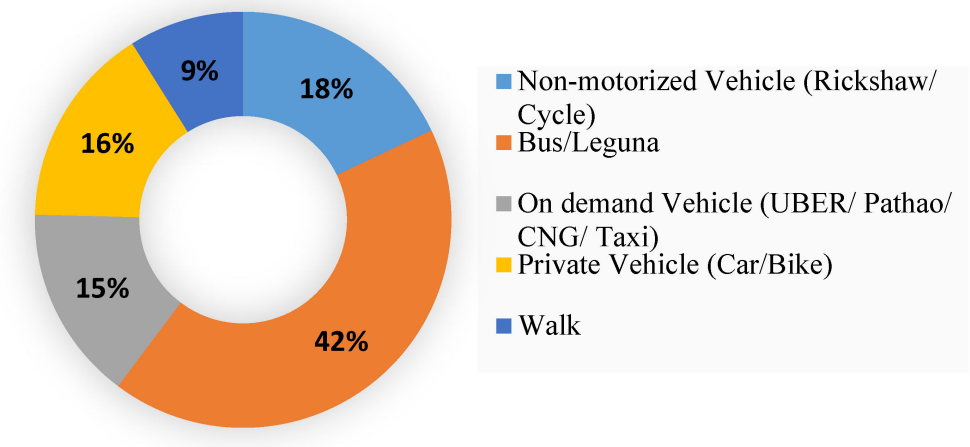

Figure 2. General mode of travel of respondents.

4. Results

4.1. Behavioral Intention Responses

An overall response of the behavioral intention to shift to MRT for daily commuting based on passengers' willingness is illustrated in Figure 3. BIA is the measurement item of BI in model 1 directed for existing riders. They were asked about their willingness to continue commuting via MRT in the future. More than half of the respondents strongly agreed, and nearly 38% agreed that they would commute via MRT in the future as well. This indicates that existing MRT riders are highly satisfied with the service quality and facilities of MRT. On the other hand, BIB is the measurement item of BI in model 2 directed for potential MRT riders. They were asked about their plan to be regular MRT riders when all the lines start operating successfully. While 32.3% of respondents agreed, only 9.9% strongly agreed that they were going to be regular MRT users when all the lines are operational. Moreover, nearly 30% of respondents were neutral to the question. This indicates that a large number of potential users are still not sure about their mode choice regarding MRT for daily commuting. Such responses might be due to the fact that their residences are very distant from any close metro stations. The MRT stations are all situated on the main arterial road and not within the residential area. Hence, the journey from home to the metro station can be an extra delay while commuting. In addition to that, for some people, the fare may be an issue. The government of Bangladesh has set the minimum fare at only 20 BDT, and after that, passengers will only be charged 5 BDT per kilometer onwards. Even though the rate is comparatively low, the fare rates of the present public transport of Dhaka like buses and legunas are cheaper than the fare rate for the MRT. This may create a lack of interest for some low-income commuters.

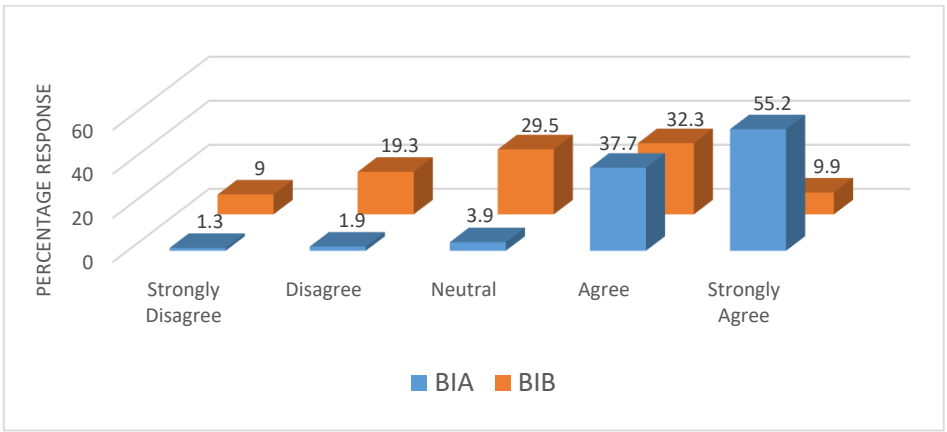

Figure 3. Overall behavioral intention to shift to MRT.

4.2. Measurement Model

The SEM analysis consists of two-step modeling—(i) measurement modeling, and (ii) structural modeling. For a valid and reliable measurement model, the factor loadings of items, items' communality, convergent validity, and discriminant validity are examined for both models. In order to obtain a reliable and convergent valid model, the following criteria [28,32] of these parameters need to be fulfilled:

1. The factor loading of each item should be larger than 0.5;
2. Communality is the proportion of each variable's variance that can be explained by the factors, which is defined as the sum of the squared factor loadings for the variables. The greater the value of communality, the more variability of a measurement item would be captured by its latent construct;
3. The convergent reliability is measured through the constructs' Cronbach's alpha, composite reliability, and average variance extracted (AVE). Cronbach's alpha (α) of each element should be larger than 0.6;
4. The composite reliability (Dillon–Goldstein's rho) of each element should be larger than 0.7;
5. AVE is the mean variance extracted for the factor loadings on a construct. The AVE of each element should be larger than 0.5.

The results of the item reliability and convergent validity denote that all elements employed for model 1 adequately achieved convergent validity for the measurement model, and a high internal consistency reliability within the items in the constructs was observed (Table 3). In the case of model 1, the construct BI has only one measurement item BIA; hence, no reliability nor validity is required for the item. In addition to the reliability data, the mean and SD (standard deviation) of each item of model 1 are presented in Table 3.

Table 3. Results of the item reliability and convergent validity of model 1.

Constructs	Items	Mean	SD	Factor Loadings	Communality	Cronbach Alpha	Composite Reliability	AVE
ATT	ATTA	4.26	0.807	0.879	0.905	0.937	0.939	0.720
	ATTB	4.29	0.738	0.867	0.819			
	ATTC	4.3	0.768	0.857	0.775			
	ATTD	4.31	0.708	0.808	0.89			
	ATTE	4.32	0.747	0.829	0.839			
	ATTF	4.32	0.72	0.849	0.915			
SN	SNA	3.69	1.094	0.81	0.9	0.955	0.917	0.788
	SNB	3.44	1.303	0.924	0.949			
	SNC	3.34	1.465	0.924	0.912			
PBC	PBCA	4.13	0.764	0.728	0.798	0.869	0.872	0.632
	PBCB	4.49	0.826	0.803	0.844			
	PBCC	4.04	0.914	0.888	0.891			
	PBCD	4.44	0.99	0.751	0.764			
EC	ECA	4.22	0.707	0.741	0.906	0.875	0.799	0.667
	ECB	4.28	0.719	0.886	0.832			

Note: ATT = attitude, SN = subjective norms, PBC = perceived behavioral control, EC = environmental concerns.

The measurement items of model 1 are then assessed for discriminant validities based on the AVE (along the main diagonal) and correlation (below the main diagonal) of the constructs as shown in Table 4. Discriminant validity is the degree to which the measures of different traits are unrelated. The Fornell–Larcker criterion has been applied in this study as it is recommended by most researchers [32]. According to the criteria, the calculated square root value of AVE should be higher than each of the inter-contracts' correlation scores [31]. From the results in Table 4, it can be observed that model 1 supports the discriminant validity as the values of AVE are greater than the correlations.

Table 4. Discriminant validity of model 1.

Constructs	ATT	SN	PBC	EC
ATT	**0.849**			
SN	0.506	**0.888**		
PBC	0.596	0.060	**0.795**	
EC	0.811	0.590	0.662	**0.817**

Note: ATT = attitude, SN = subjective norms, PBC = perceived behavioral control, EC = environmental concerns.

The results of the item reliability and convergent validity for model 2 in Table 5 denote that all elements considered achieved convergent validity for the measurement model, and a high internal consistency reliability within the items in the constructs was also found. The mean and SD of each item of model 2 are also presented in Table 5.

Table 5. Results of the item reliability and convergent validity of model 2.

Constructs	Items	Mean	SD	Factor Loadings	Communality	Cronbach Alpha	Composite Reliability	AVE
ATT	ATTA	3.56	1.11	0.815	0.893	0.955	0.920	0.657
	ATTB	3.6	1.048	0.832	0.895			
	ATTC	3.55	0.998	0.835	0.846			
	ATTD	3.62	1.059	0.784	0.893			
	ATTE	3.64	1.077	0.832	0.906			
	ATTF	3.65	1.033	0.763	0.907			
SN	SNA	2.85	0.966	0.834	0.866	0.913	0.923	0.800
	SNB	2.7	1.083	0.934	0.92			
	SNC	2.56	1.191	0.913	0.915			
PBC	PBCA	3.55	1.019	0.842	0.859	0.905	0.912	0.723
	PBCB	3.87	1.261	0.828	0.871			
	PBCC	3.44	1.023	0.854	0.875			
	PBCD	3.86	1.303	0.876	0.888			
EC	ECA	3.63	1.018	0.881	0.863	0.886	0.867	0.766
	ECB	3.57	1.029	0.869	0.819			

Note: ATT = attitude, SN = subjective norms, PBC = perceived behavioral control, EC = environmental concerns.

Similarly, the measurement items of model 2 are also then assessed for discriminant validities as presented in Table 6, and it can be observed that model 2 also supports the discriminant validity as the values of AVE are greater than the correlations.

Table 6. Discriminant validity of model 2.

Constructs	ATT	SN	PBC	EC
ATT	**0.811**			
SN	0.408	**0.895**		
PBC	0.801	0.264	**0.850**	
EC	0.716	0.454	0.842	**0.875**

Note: ATT = attitude, SN = subjective norms, PBC = perceived behavioral control, EC = environmental concerns.

4.3. Structural Modeling

Table 7 represents the results of the path value from latent to observed variables calculated using the maximum likelihood (ML) method for both model 1 and model 2. The estimated value expresses the effect of a given observed variable on the respective latent variable, and an attribute is considered statistically significant at a 95% confidence interval when the p-value < 0.05 for that estimate value (Table 7).

Table 8 represents the results of the assessment of the statistical significance of the hypothesized relationships specified in the three research models. It can be seen that in model 1, the behavioral intention to shift to MRT can be explained by two of the standard predictors of the TPB: attitude ($\beta = 0.869$, $p < 0.001$) and perceived behavioral control

(β = −0.171, $p < 0.001$). Therefore, the model supports H1 and H3. However, the impact of perceived behavioral control is less influential. On the contrary, for subjective norms, the $p > 0.05$, so H2 is rejected for model 1. This implies, for daily commuters, subjective norms do not affect their behavioral intention to continue commuting to MRT. Nevertheless, the extended predictor, environmental concern, is the most significant factor (β = 0.921, $p < 0.001$) of behavioral intention for regular users. On the other hand, none of the socio-demographic factors are significant except net income (β = 0.207, $p < 0.013$) with a low coefficient for model 1. Hence, H4 and H7 are supported, and H5, H6, and H8 are rejected for model 1.

Table 7. Results of path value from latent to observed variables of model 1 and model 2.

Latent Variable	Observed Variable	Model 1		Model 2	
		Estimate	*p*-Value	Estimate	*p*-Value
ATT	ATTA	0.781	***	0.881	***
	ATTB	0.879	***	0.935	***
	ATTC	0.755	***	0.912	***
	ATTD	0.984	***	1	
	ATTE	0.866	***	0.963	***
	ATTF	1		0.987	***
PBC	PBCA	0.539	***	0.694	***
	PBCB	0.889	***	1	
	PBCC	0.795	***	0.766	***
	PBCD	1		0.974	***
SN	SNA	0.727	***	0.721	***
	SNB	0.965	***	0.978	***
	SNC	1		1	
EC	ECA	0.771	***	1	
	ECB	1		0.968	***

Note: *** $p < 0.001$; ATT = attitude, SN = subjective norms, PBC = perceived behavioral control, EC = environmental concerns.

Table 8. Path Analysis.

Path			β	*p*-Value
Model 1				
ATT	→	BIA	0.869	***
SN	→	BIA	0.037	0.238
PBC	→	BIA	−0.171	***
EC	→	BIA	0.921	***
Gender	→	BIA	0.052	0.547
Age	→	BIA	−0.084	0.231
Net Income	→	BIA	0.207	0.013
Vehicle Ownership	→	BIA	0.063	0.554
Model 2				
ATT	→	BIB	0.706	***
SN	→	BIB	0.459	***
PBC	→	BIB	−0.447	***
EC	→	BIB	0.983	***
Gender	→	BIB	−0.098	0.152
Age	→	BIB	−0.091	0.077
Net Income	→	BIB	0.201	***
Vehicle Ownership	→	BIB	0.595	***

Note: *** $p < 0.001$; ATT = attitude, SN = subjective norms, PBC = perceived behavioral control, EC = environmental concerns.

For model 2, the behavioral intention to shift to MRT can be explained by all three standard TPB predictors: attitude (β = 0.706, $p < 0.001$), subjective norms (β = 0.459,

$p < 0.001$), and perceived behavioral control (β = −0.447, $p < 0.001$) supporting H1, H2, and H3. Similar to that of model 1, environmental concern is also the most significant predictor (β = 0.983, $p < 0.001$) of behavioral intention for potential users and supports H4. Unlike model 1, vehicle ownership (β = 0.595, $p < 0.001$) is a significant predictor in addition to net income (β = 0.201, $p < 0.001$). Hence, H5 and H6 are rejected and H7 and H8 are supported for model 2. Figure 4 illustrates the development of model 1 and model 2.

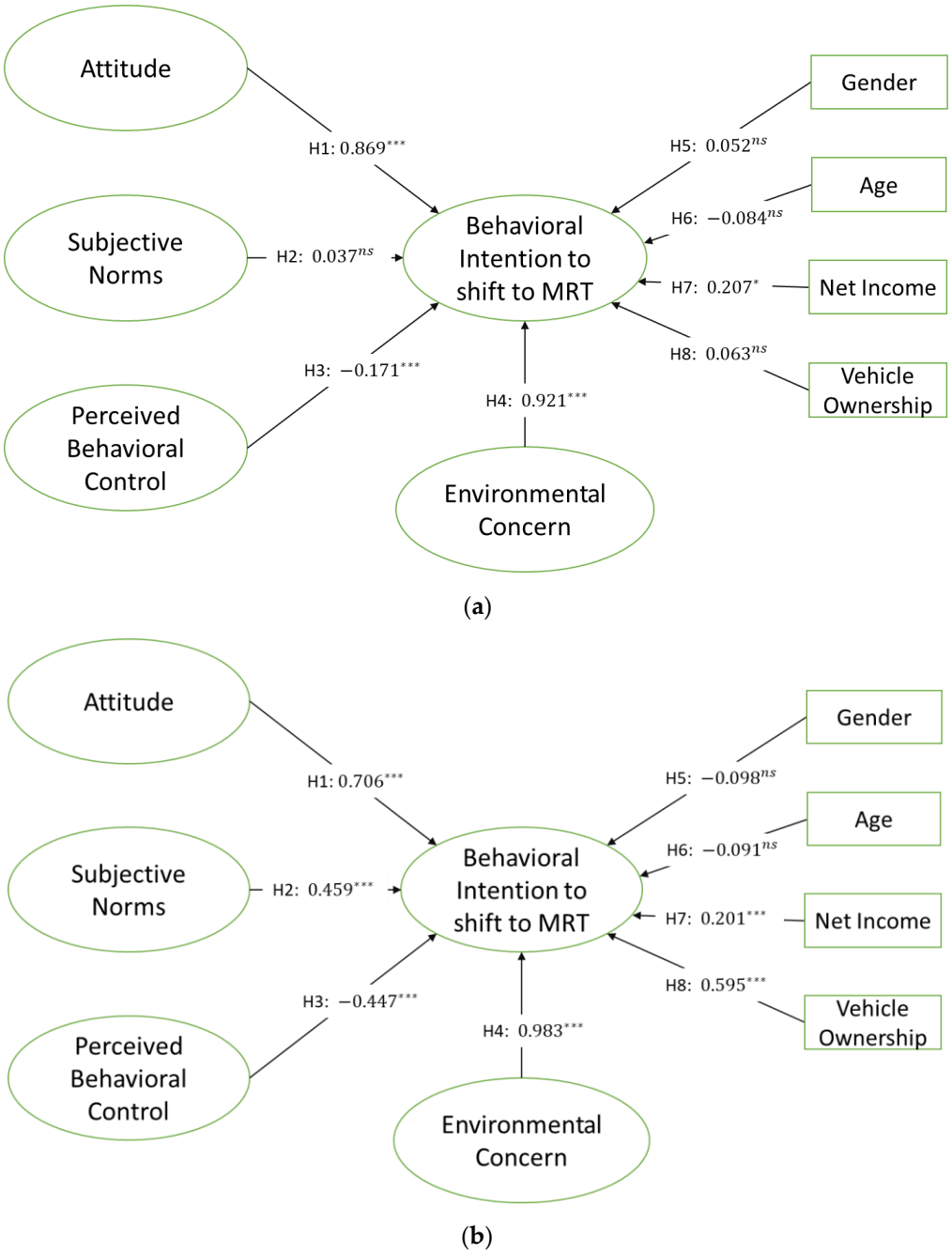

Figure 4. (**a**,**b**) Model 1 and model 2 SEM results. Note: ^{ns} $p > 0.05$, * $p < 0.05$, *** $p < 0.001$.

The goodness of model fitness has been checked using various fit indices illustrated in Table 9. The comparative fit index (CFI) was calculated, and values of 0.8806 (>0.7) for model BIA and 0.9362 (>0.7) for model B were obtained. The Tucker–Lewis Index (TLI) was also calculated as 0.8257 (>0.7) for BIA and 0.8885 (>0.7) for BIB. By obtaining the root mean square error of approximation (RMSEA) for both models, the RMSEA values for each

model were found to be 0.063 for model BIA and 0.066 for model BIB, both of which are below the suggested cutoff point of 0.08. Additionally, the Chi-square-to-DF (Chi/DF) ratio was calculated, and the results were 2.08 for model BIA and 2.17 for model BIB, values that are within the acceptable range of around 2 to 5. Overall, the Chi-square values, CFI, TLI, RMSEA, and Chi/DF suggested that both models, BIA and BIB, demonstrate an acceptable fit to the observed data.

Table 9. Goodness of model fitness.

BIA				**Chi/DF**
Chi-square	349.261	DF	168	2.07894
Probability level	0.0000			
CFI	0.8806			
TLI	0.8257			
RMSEA	0.063			
BIB				**Chi/DF**
Chi-square	363.992	DF	168	2.16662
Probability level	0.0000			
CFI	0.9362			
TLI	0.8885			
RMSEA	0.066			

5. Discussion and Policy Implications

This study investigated the influence of ATT, SN, PBC, EC, and the socio-demographic characteristics of commuters on their intention to shift to the newly introduced DMR. The results from Tables 7 and 8 reveal that environmental concern is the most significant contributor to BI to shift to MRT for both existing and potential riders. The ATT and PBC of both types of users also significantly affect BI, although to a lesser extent than EC does. Based on these results, some policy implications are suggested which can be used as interventions to promote the use of metro rail in Dhaka city.

Since environmental concern is the most significant predictor of behavioral intention, enhancing environmental norms and awareness related to environmental issues can strengthen the intentions of commuters to use the metro rail. The service operators and policy-makers can run campaigns to create more awareness about environmental concerns for the promotion of MRT and a reduction in private vehicle usage. In addition to that, government authorities can organize seminars, workshops, or symposiums for school students to spread knowledge on how metro rails can contribute to less air pollution relative to private cars and the adverse impact of private cars on the city's sustainability. The relationship of ATT is positive with the BI, indicating that the respondents have a positive attitude towards MRT service quality and facilities. Hence, the foremost thing which needs to be conducted for the service operators is to maintain the high service quality of metro rail trains such as cleanliness, Wi-Fi facilities, and other internal amenities according to the needs of the commuters for the promotion of its use. If commuters can simultaneously have a regular comfortable, enjoyable, safe, and secure ride to their workplace, they will develop the habit of using the MRT daily. A good serviceability rating will not only retain regular riders but will also bring new potential riders. The relationship of PBC is negative with the BI, meaning that under the present circumstances, the waiting time, fare rate, service frequency, and distant metro stations from the home make it difficult for commuters to use metro rail. Hence, reducing the travel fare and the waiting time and increasing the service frequency may provide a highly user-friendly MRT service system. However, Bangladesh is a developing country with widespread poverty amongst its population. Maintaining high-quality services would cost huge amounts of money for the government. So, in this regard, the government will either have to subsidize the MRT or may have to charge extra fares for such services, which would be undesirable for commuters. The question comes to mind as to where the subsidy would come from. The subsidy may come from the cost

savings made by the metro services from reduced congestion and air pollution in the first place. Besides that, policy-makers and service operators need to focus on re-strategizing the current service scheduling and feeder services of the metro system. Having a broad range of feeder services would make it easy and convenient for commuters who live farther away from stations or have limited mobility to complete the final leg of their journey, thereby discouraging the use of private vehicles. With the improvement of said measures, it is hoped that more commuters will have positive intentions to use the metro rail.

6. Conclusions

This study investigates commuters' intentions to shift to the newly introduced DMR in Dhaka, Bangladesh, applying an extended version of the TPB. The novelty of this study is the integration of the TPB, the socio-demographic characteristics of the commuters, and environmental concerns (EC) to improve the explanatory capability of the TPB in the context of MRT riders' behavior in a developing country. A questionnaire survey was conducted both online and face-to-face to collect 740 valid responses of Dhaka City residents regarding their socio-demographic information, attitudes, subjective norms, perceived behavioral control, environmental concern, and behavioral intention to shift to MRT for regular commuting. Two models were developed for present regular users and potential regular users, applying SEM to determine the influence of the predictor variables on their behavioral intention to use the metro for daily commuting. More than half of the respondents (55.2%) strongly agreed that they would continue to choose the MRT as their regular daily mode for commuting in the future as well. On the other hand, a significant number of potential MRT riders (32.3%) agreed that they were planning to shift to MRT from their existing mode of transport when all the DMR lines are in operation. From the modeling analysis, it was observed that for both types of commuters, environmental concern is the most significant contributor to behavioral intention to shift to MRT, followed by their attitude and perceived behavioral control. The results of the study can help service operators in promoting rail usage. Moreover, the survey methodology and questionnaire can act as guidelines for policymakers to assess people's perceptions of mass rapid transit systems in the future.

The analyses of this study are solely based on the stated preferences survey from the respondents. Combining a revealed preference survey with a stated preference survey would be useful in obtaining realistic user perceptions through actual travel information provided by respondents [1]. The duration of the survey is shorter in the context of the newly introduced MRT. This study suggests future research insights. First, there is a need for the continued estimation of the perception of users considering more exclusive factors that will enable researchers to measure how mode choice behavior changes in a broader way over time. Secondly, follow-up research is necessary on the serviceability evaluation of the metro rail along with the metro stations. In addition to the classical SEM approach, a Bayesian SEM approach can be used in similar studies to compare results between the two methods. Such an attempt or experimentation regarding the extended version of the TPB is encouraged to be applied in future studies also conducted by surrounding nations. Moreover, it is recommended to compare results obtained in future studies in regions close to Bangladesh with similar socio-demographics for the purpose of having a comprehensive understanding of the behavioral intention of the people. Furthermore, the service operators and transport planners of those countries where MRT services are yet to initiate can provide insights into what the general public wants and how its behavior influences when it comes to using MRTs for daily commuting.

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