DOES DEPARTURE TIME FLEXIBILITY AFFECT THE WAY PEOPLE TRAVEL BETWEEN CITIES? EVIDENCE FROM THE SYLHET-DHAKA CORRIDOR

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ABSTRACT

Departure time flexibility is an important factor in the intercity travel decision-making, because this aspect changes the comparative appeal of the available modes. This research paper assesses the effect of the different degrees of flexibility, such as no flexibility, partial flexibility, and full flexibility, on the departure time to mode selection of the Sylhet-Dhaka corridor. Data in the form of a survey were gathered using a combined Revealed Preference (RP) and Stated Preference (SP) methodology in major transport terminals of Sylhet, such as bus terminals, railway stations, and Osmani International Airport. The Multinomial Logit (MNL) model was used to analyze the data to obtain differences in behaviors across the conditions of flexibility. The findings indicate that, as the flexibility increases, one can demonstrate the clear modal changes compared to the situation where there is no flexibility, with 23.61% of travelers transferring to rail and 7.36% and 16.25% of their shares lost by bus and air, respectively, in the conditions of full flexibility. The most interesting is the paradoxical augmentation of modal inertia with partial flexibility that is manifested with the significant increase in the train inertia coefficient ($\beta_{inertia\_ta}$ = -5.17 to -6.15, t-test = -24.68 to -26.93), which indicates that travel habits are not shattered but bolstered by schedule liberty. The MNL model is a good model to explain the determinants of mode choice, but it suffers from the assumption of homogeneous preferences. So it does not explicitly model how one shifts their behavior among flexibility conditions. This research can be further extended by future studies to come up with mode-shifting models that quantify the transition probability between modes and use more advanced models like the Mixed Multinomial Logit (MMNL) model to address random heterogeneity in the tastes that offer a more realistic depiction of the traveler behavior and better policy implications on sustainable intercity mobility.

Keywords: *Departure time, Multinomial Logit (MNL), Mixed Multinomial Logit (MMNL)*, Partial flexibility*, No flexibility.*

1. INTRODUCTION

A proper and sustainable transport system is critical in terms of facilitating economic growth and promoting mobility in developing societies such as Bangladesh, where car users choose their means and time of travel depending on the cost, traveling time, comfort, and other socio-demographic factors such as age, income, and vehicle possession. Together with mode choice, departure time flexibility is an important factor that determines the level of congestion and efficiency of transport in general, as the time, cost, and convenience balance are adjusted by the travelers. One of the most densely populated countries in Asia with a population of over 140 million and with only 56931 square miles (BBS, 2011), Bangladesh is highly strained economically in and around its transportation systems, especially in urban centres that are rapidly expanding like Sylhet with a population of about 0.9 million people and a population density rate of 32400 people per square mile and a growth rate of 2.1 percent (BBS, 2011). Although there has been a gradual improvement in socio-economic development, there has been no adequate growth in the transportation network to meet the demand, and as a result, there has been consistent congestion, causing poor travel efficiency. The Sylhet-Dhaka (245 km) route is one of the key intercity routes with bus, rail, and air service between a large variety of passenger requirements, which in most cases are limited in terms of the flexibility of schedule and the quality of services. The research proposes to determine the mode choice behavior of the travelers on this corridor with the help of the Multinomial Logit (MNL) model, which has been developed on the basis of the socio-demographic and travel-related factors impacting the choice of the mode under varying degrees of flexibility of the departure time. The results should be useful to policymakers and transport planners to enhance the quality of their services, reduce congestion, and improve intercity movement in Bangladesh and other developing countries.

2. LITERATURE REVIEW

Joint mode and departure time choice modeling takes its theoretical underpinning in discrete choice theory and the Random Utility Model (McFadden, 1974), and in initial research, mode and departure time were modeled independently because of computational limitations (Ben-Akiva and Lerman, 1985). One of the key developments was that Bhat (1998) came up with a detailed logit-probit model that models the dependency between these decisions, which has been extended to incorporate copula-based models (Bhat and Eluru, 2009), latent class models to model population heterogeneity (Hossain, 2021), and machine learning hybrids to make better predictions (Zhao et al., 2023).

In Bangladesh, mode choice models first re-adjusted Western models on local conditions where paratransit use is high, and adjusted the traditional four-step models to incorporate rickshaws and auto-rickshaws with regard to travel time, cost, and socio-demographics, including income and vehicle ownership (Hasan and Hoque, 2008; Enam, 2010). Corridor studies, such as those between Dhaka and Chittagong, have studied mode switching thresholds, such as Bus Rapid Transit adoption (Anam, 2011), but the departure time is treated exogenously, introducing mode-time analysis gaps.

The case of the Sylhet Dhaka corridor, which has a tri-modal competition between bus, train, and air, over a distance of 245 km is a different situation, where previous models have underestimated the mode share of rail transportation by 22% with service quality excluded (Haque et al., 2013), and only 35% of the travelers have fixed departure times, with the flexibility being variable by the purpose of a trip (Rahman, 2022). None of the research has been able to model the various degrees of departure time flexibility (no, partial, full) on all modes, which is a critical research gap. This paper fills these gaps by using the joint choice framework by Bhat (1998) for the corridor and comes up with a three-level classification of flexibility. It is the model that represents these socio-demographic and travel-related factors that have an impact on the mode choice at different levels of flexibility based on the Multinomial Logit (MNL) model (McFadden, 1974; Hossain, 2021). The policy implications of the findings are evident, such as quantification of possible modal changes between air and rail, dynamic toll pricing, and inter-modal schedule coordination that are needed in the development of integrated transport policies in Bangladesh (MoRTB, 2023). Although there has been improvement, the previous studies are still limited and they tend to use the models of high-income countries, which is binary in flexibility, there is under-exploration of multimodal and paratransit interaction, and there is no methodological advancement that is specific to the context (Bhat, 1998; Rahman, 2022; Haque et al., 2013; Enam, 2010; Hossain, 2021). This study addresses these gaps by examining joint mode and departure time decisions in the Sylhet-Dhaka corridor to provide gains in methodology and actionable information to intercity transport planning in Bangladesh.

3. STUDY AREA, MOTIVATION, AND SCOPE

One of the most important and commonly used intercity paths in Bangladesh, which has a length of about 245 km, is the Sylhet-Dhaka corridor that links the northeast city of Sylhet and the capital. The route is a tri-modal transport system with bus, train, and air services, with their own trade-offs in terms of cost, comfort, and travel time. The reason behind the choice of this corridor is that the corridor experiences increasing travel pressure, high rates of urbanization, and continuous congestion, which has exerted enormous pressure on the existing infrastructure. Even with the current developments like the expansion of the four-lane highway and advancement of the rail and air transportation, the issues of inefficiencies in coordination, as well as the lack of flexibility in scheduling, are paramount problems. In this research paper, the authors examine the mode choice behavior of travelers in the presence of different levels of flexibility of departure time and varying cost, time, frequency, and comfort associated with socio-demographic factors and travel-related factors. The results, though geographically limited to the Sylhet to Dhaka route, are likely to provide useful information on the need to improve the intercity transport planning and policy in Bangladesh and other developing areas with the same mobility characteristics.

4. SURVEY DESIGN AND DEVELOPMENT OF THE SP SURVEY

4.1 *Preliminary survey*

The survey was carried out by using a preliminary questionnaire survey at the city transport hubs in Sylhet. These were bus terminals, railway stations, and the airport where real decision-making is done concerning mode and schedule to be followed by the travellers. Random selections were done under the preliminary questionnaire survey to obtain unbiased information on their current mode of travel, their travel time, travel cost, and socio-economic characteristics, etc. The primary aim of the survey was to determine the most significant attributes and their degree in the final survey.

4.2 *Choosing attributes and their levels*

Five attributes have been chosen from the preliminary survey work, and different levels of each attribute have been formed. Table 1 has explanations for each attribute, whereas Table 2 discusses the levels of each attribute.

Table 1: Description of Attributes

Attributes	Description
Travel Cost	Amount of fare charged per trip. In the hypothetical circumstances, the information provided is in the form of a percentile increase/decrease.
Travel Time	Amount of travel time in motion per trip. In the hypothetical circumstances, the information provided is in the form of a percentile increase/decrease.
Frequency	The number of trips per day for each mode was varied across scenarios. For trains, frequency was presented as trips per day, while for bus and air travel were presented as daily flight schedules in hypothetical scenarios.

Availability of Tickets	The ease of obtaining travel tickets. In the hypothetical scenarios, this has been provided as to whether the ticket is available or not for different types of modes.
Comfort	Comfort reflects the perceived quality of seating, crowding, and ride smoothness. In the hypothetical scenarios, this attribute has been categorized as an AC and a non-AC environment.

Table 2: Levels of attributes

Attributes	*Bus*	*Train*	*Air*
Travel cost	10% less than now 5% less than now Same as now 5% more than now 10% more than now	10% less than now 5% less than now Same as now 5% more than now 10% more than now	10% less than now 5% less than now Same as now 5% more than now 10% more than now
Travel time	20% less than now 10% less than now Same as now 10% more than now 20% more than now	20% less than now 10% less than now Same as now 10% more than now 20% more than now	Same as now (Overall 2.5hrs)
Frequency	Every 30 minutes Every 1.00 hours Every 2.00 hours	Every 2.5 hours (6 trains per day) Every 4 hours (4 trains per day) Every 7 hours (2 trains per day)	Every 1.5 hours Every 2 hours Every 2.5 hours
Comfort	AC NON-AC	AC NON-AC	Same as now
Availability of Tickets	Available Unavailable	Available Unavailable	Available Unavailable

4.3 *Generation of choice set and scenario*

Bus, Train, and Air transport profiles have been created individually using the statistical program, SPSS (Statistical Program for Social Sciences), since a partial factorial design was applied. Because of the many attribute levels full factorial design results in a tremendous number of profiles, consequently resulting in unequal distribution of choice sets. Profile best/worst all levels have been eliminated. Four SP scenarios have been demonstrated by all the respondents. Choice sets have been randomly chosen. Randomly conducted scores of combinations of profiles have been made, too. The questions posed to the respondents have been in the form of socio-demographic attributes, their current mode of transport, and the future mode of transport with the SPs.

4.4 *Main survey*

The questions that are generated in the questionnaire are questions about the socio-demographic status of the respondent to have a better understanding of his or her decision. The general survey has some socio-demographic questions with four SP situations.

5. DATA ANALYSIS

This study was conducted using a detailed questionnaire survey on 381 travelers who traveled along the Sylhet-Dhaka route as the main source of the data. All the respondents rated four different scenarios and thus gave 1,524 responses. The survey was narrowed down to the behavior of traveling, mode of transportation choice, preferences in departure time, and the important socio-demographic factors, which comprised gender, age, marital status, occupation, education, income, and schedule flexibility. They sampled the major transport hubs, such as bus and railway stations and airports, in a random manner to allow diversity in terms of travel purpose and socio-economic status.

Table 3: Socio-demographic characteristics of respondents

Characteristics	Categories	Percentage (%)
Gender	Male	74.80
	Female	25.20
Age (Year)	<20	4.32
	21-30	44.54
	31-40	24.20
	41-50	14.69
	51-60	9.05
	>60	3.20
Marital Status	Married	57.60
	Unmarried	42.39
Occupation	Student	22
	Jobholder	35
	Businessman	17
	Housewife	8
	Retired	3
	Others	15
Departure Time Flexibility	Flexible Schedule	65.22
	Fixed Schedule	34.78
Transportation Inertia	Bus	51
	Train	36
	Air	12
	Others	1
Income (k = thousands in BDT)	<30k	32
	30-50k	31.50
	50-70k	21.5
	70-100k	9
	>100k	6

The final survey results found that a majority of the surveyed individuals were male (74.8%), and a majority of the surveyed individuals fell within the 21 to 30 age bracket (44.54%). A more significant portion favored a flexible schedule (65.22%), and bus transit (51%) became the most popular, train (36%), and air (12%) came next in preference. With regards to occupation, jobholders (35%), students (22%), and businessmen (17%) dominate over other occupations.

To achieve the representativeness of the gathered data, a Chi-square goodness-of-fit test was conducted based on the census data of the Bangladesh Bureau of Statistics (BBS, 2022). In cases where considerable deviations were discovered, sampling weights were created under raking and weight trimming under the package survey in R according to the standard procedures (Kalton and Flores-Cervantes, 2003; Izrael et al., 2009). These were necessary in correcting the biases and to make sure that the final weighted data was a true representation of the target population to be used in further modeling and analysis.

5.1 Current mode preferences by socio-demographic factors

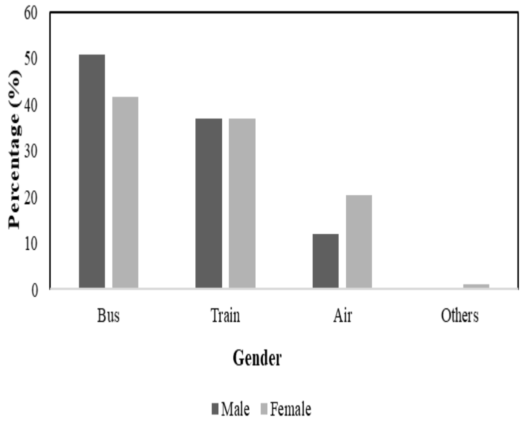

Figure 1: Mode of transport based on gender distribution

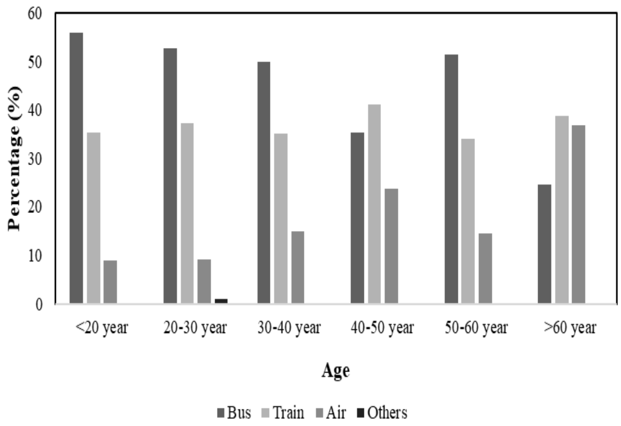

Figure 2: Mode of transport based on age distribution

In Figure 1, the mode distribution of transportation according to gender is given. It shows that Men predominantly travel by buses (50.9%), trains (36.9%), but air travel (11.9%) is minimal, and the rest of the transportation methods are negligible. The women use bus less (41.6%), however, the same number of women use trains (36.9%), and more women prefer air travel (20.4%) and other alternatives (1.1%). All in all, both genders use buses and trains as the primary mode of transportation, but women are more likely to use air and alternative transportation options. Figure 2 shows the distribution of the transport mode according to age. The younger respondents (below 20 years) take buses as their primary mode of transport (55.9%) based on price and availability, although the usage of buses reduces with age, with the highest usage being 24.5% among persons over 60 years. The use of trains is not differentiated by age (approximately 35 to 41 percent), as it is a compromise for everyone. The prevalence of air travel increases drastically with age, with only 8.8% of the youngest group showing this tendency and 36.7% of seniors being more inclined towards faster, long-distance, as well as leisure-related travel. Generally, the youths prefer buses, middle-aged aged use buses and trains, and the older ones are shifting towards flying.

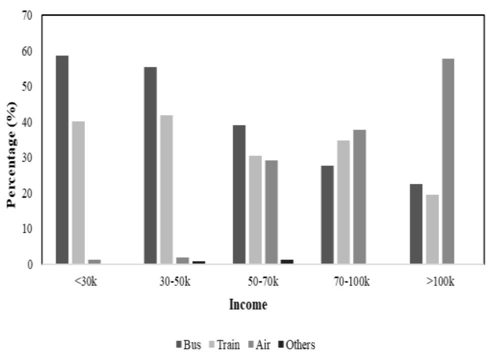

Figure 3: Mode of transport based on income distribution (where k = thousands in BDT)

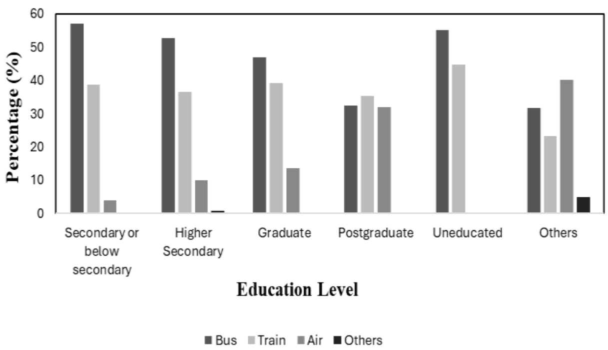

Figure 4: Mode of transport based on educational level

Figure 3 represents the division of the transport mode based on income, depending on the monthly distribution of the income. The bar chart indicates the preference of transportation according to income groups in five categories of income (<30k, 30-50k, 50-70k, 70-100k, and >100k). The bus mass observation is rather widespread among those whose income is lower (<30k: 58.67%, 30-50k: 55.37%), and this situation declines sharply with the rise of the level of income (>100k: 22.55%). The usage of trains is relatively low at the lower-middle end (30-50k: 41.94%, 50-70k: 30.48%) and is growing lower but decreasing in higher income groups. The least income group (<30k: 1.21%), on the other hand, is the least fond of flying, with the highest income group (100k+: 57.84%) being the most fond of air transportation because the preference is significantly associated with income. Figure 4 reveals that the less-educated groups (Secondary or below, Uneducated) predominantly use buses and trains, and air travel is not common. Students in the Higher Secondary and Graduates continue to rely on buses and trains to some extent, although they use air travel a little more. There is a significant shift in the mode of transport of those in the postgraduates and the Others group toward air transport, unlike the dominance of bus in the lower education groups.

6. MODEL DEVELOPMENT

The mode choice models of transportation were created by using the R software for the travellers of the Sylhet-Dhaka corridor. The model included attributes (travel time, travel cost, etc.) as the independent variables and socioeconomic characteristics of the respondents as the dummy variables. Three options (Bus, Train, and Air) had been taken into consideration, and specifications tests were performed to obtain the optimal model. Model outputs were verified on the sign and magnitude of the coefficients being expected. They were also judged by statistical parameters (e.g., Final log likelihood, McFadden's Pseudo R^2, t-statistics, etc.).

6.1 *Model hypothesis*

The model for the selection of transportation modes was constructed utilizing discrete choice analysis methodologies. Factors pertaining to socio-demographics and attributes specific to alternatives were incorporated into the model framework. Three alternative modes were evaluated, specifically including bus, train, and air transportation options. The outcomes were employed to evaluate both the signs and magnitudes of the anticipated coefficients' values. The efficacy of the model was further scrutinized through an array of statistical metrics, such as the final log-likelihood, McFadden's Pseudo R, and t-statistics. Concurrently, Table 3 delineates hypotheses concerning variables that may exert significant influences on the selection of transport modes. The bus was employed as a benchmark for the measurement of alternative-specific constants (ASCs) in relation to the train and air transport modes. Continuous variables, such as travel cost, travel time, and travel frequency, were utilized for model estimation, while monthly income and inertia were incorporated in the form of dummy variables.

Table 4: Hypothesis of Mode Choice Variables

Variables	Hypothesis
Travel Cost	Depending on the mode characteristics, travel cost sensitivity may vary. An increase in travel costs for a particular type of vehicle may reduce the mode's utility.
Travel Time	Travel time can be different for different modes of transport. An increase in the travel time is likely to decrease the utility of that specific mode.
Frequency	The frequency of the service depicts the number of times that one specific mode takes over a given time, but in this study, frequency is represented by the average headway, which is the number of hours

	separating one departure from another. So the more significant the headway, the greater the wait and the less frequent the services; therefore, the perceived value of a given mode will also decrease with the increasing headway.
Inertia	Passengers may resist switching from their habitual transport mode due to inertia, even if alternatives offer better travel time or cost. However, excessive inconvenience (e.g., unreliability or increased travel time) may eventually overcome this resistance, reducing the utility of the habitual mode.
Monthly income	Passengers with higher monthly incomes may be less sensitive to travel costs and more likely to choose faster or more convenient transport modes, while those with lower incomes may prioritize affordability, increasing their sensitivity to price changes.
Departure time flexibility	Individuals with greater schedule flexibility may prioritize transport modes with lower costs or higher comfort over strict timeliness, while those with rigid schedules may favor modes with guaranteed punctuality, even at higher costs.

6.2 Description of dummy variables that are used in the mode choice models

The regressor variables are those that are posited to be of a quantitative nature. However, in numerous circumstances, variables cannot be effectively positioned on a definitive scale and are more accurately classified as qualitative. In this context, the monthly income and inertia considered in the analysis are qualitative in nature. Artificial constructs are employed to quantify such variables through the assignment of numerical values such as 0, 1, 2, etc. These variables are organized into mutually exclusive sets, commonly referred to as dummy variables. A dummy variable is initialized with a value of 0 as its baseline. Table 4 presents the dummy variables.

Table 5: Dummy variables for the response model

Dummy Variables	Coded value	Description
Transportation inertia dummy	0	Passengers have inertia towards buses (habitually prefer buses despite alternatives).
	1	The passengers have inertia toward the train (habitually, they prefer trains despite alternatives).
	2	The passenger has inertia toward air (habitually prefers air travel despite alternatives).
Monthly income dummy	0	The monthly income is less than 30 thousand.
	1	Monthly income between 30-50 thousand.
	2	Monthly income is between 50-70 thousand.
	3	Monthly income is between 70-100 thousand.
	4	Monthly income is greater than or equal to 100 thousand.
Departure time flexibility dummy	0	Passengers with departure time flexibility.
	1	Passengers without departure time flexibility.

Three alternatives (Bus, Train, and Air) have been considered in their choice set, as stated above. The following are the utility functions of Bus, Train, and Air transportation users:

U_{Bus} = *ASC_{Bus} + β_{tc_b}* (Travel Cost of Bus) + β_{tt_b}* (Travel Time of Bus)*(No departure time flexibility)+ β_{freq_b}*(Frequency of Bus)+ $\beta_{inertia\_bt}$*(Train as a preferred mode of travel)+ $\beta_{inertia\_ba}$*(Air as a preferred mode of travel)+β_{inc_b1}* (Monthly income between 50-70 thousand BDT)+ β_{inc_b2}*(Monthly income greater or equal 85 thousands BDT)*

U_{Train}= *ASC_{Train} + β_{tc_t}* (Travel Cost of Train) + β_{tt_t}* (Travel Time of Train) + β_{freq_t}*(Frequency of Train)*(Monthly income greater or equal 85 thousands BDT) + $\beta_{inertia\_tb}$*(Bus as a preferred mode of travel)+ $\beta_{inertia\_ta}$*(Air as a preferred mode of travel) + β_{inc_t1}* (Monthly income between 50-70 thousand BDT) + β_{inc_t2}*(Monthly income greater or equal 85 thousands BDT)*

U_{Air} = *ASC_{Air} + β_{tc_a}*(Travel Cost of Air) + β_{freq_a}*(Frequency of Air) *(No departure time flexibility)*

6.3 Model estimation

Transportation mode choice models were constructed under three distinct conditions of departure time flexibility, namely: no flexibility, partial flexibility, and full flexibility, utilizing the R programming environment for the purpose of model estimation. In the no-flexibility scenario, travelers possessed no authority over their departure time, necessitating adherence to a predetermined day and specific hour, analogous to situations wherein students journey for examinations or employees participate in meetings with fixed schedules. The partial-flexibility scenario permitted travelers to embark at any time during a designated day, thereby affording a moderate degree of scheduling autonomy typically associated with business or familial engagements that must transpire within the confines of a single day. The full-flexibility scenario granted travelers the latitude to select any day and any time, epitomizing complete autonomy in trip planning, such as recreational excursions or visits to relatives that are devoid of temporal constraints. For each of the aforementioned conditions, a distinct Multinomial Logit (MNL) model was estimated to scrutinize mode choice among bus, train, and air transport options. The pivotal variables encompass travel duration, expenses, and frequency, in addition to socioeconomic factors such as income, gender, and occupation, represented as dummy variables. The models were assessed based on the signs of the coefficients, t-statistics, McFadden's Pseudo R^2, and log-likelihood metrics, elucidating how an increase in flexibility systematically influences traveler preferences and the perceived attractiveness of various modes along the Sylhet-Dhaka corridor.

Table 6: Model estimation results under each flexibility condition

Type of variables	Parameters	No Flexibility		Partial Flexibility		Full Flexibility	
		Estimated Values	T-statistics	Estimated Values	T-statistics	Estimated Values	T-statistics
Constants	ASC_{Bus}	Base	N/A	Base	N/A	Base	N/A
	ASC_{Train}	0.9911	2.81	2.4065	5.66	0.4962	1.32
	ASC_{Air}	1.3144	1.58	-1.7063	-1.56	-4.4660	-2.92
Bus	Travel time (β_{tt_b})	-0.0405	-3.36	-0.0440	-3.34	-0.0438	-4.29
	Travel cost (β_{tc_b})	-0.0001	-1.16	-0.0002	-1.47	0.0000	0.46
	Frequency (β_{freq_b})	-0.0010	-0.95	-0.0011	-0.94	-0.0007	-0.68
	Inertia_train to bus ($\beta_{inertia\_bt}$)	-0.9787	-7.66	-0.7828	-3.67	-2.1947	-9.21
	Inertia_air to bus ($\beta_{inertia\_ba}$)	-4.6268	-24.14	-4.3520	-21.89	-4.9553	-19.68

	Income (β_{inc_b1})	-0.9157	-6.35	-0.8833	-2.86	-0.6486	-2.96
	Income (β_{inc_b2})	-0.7119	-3.97	-1.7580	-4.05	-2.1934	-10.23
Train	Travel time (β_{tt_t})	-0.1839	-3.86	-0.2342	-4.32	-0.1190	-3.09
	Travel cost (β_{tc_t})	-0.0002	-0.94	0.0001	0.56	-0.0002	-1.20
	Frequency (β_{freq_t})	-0.0039	-4.00	-0.0027	-2.60	-0.0015	-1.74
	Inertia_bus to train ($\beta_{inertia\_tb}$)	-1.1753	-8.97	-2.3896	-10.86	-0.5518	-2.37
	Inertia_air to train ($\beta_{inertia\_ta}$)	-5.1701	-24.68	-6.1515	-26.93	-4.3020	-23.20
	Income (β_{inc_t1})	-1.5446	-10.21	-1.1130	-4.87	-0.6262	-2.91
	Income (β_{inc_t2})	0.3165	0.97	-1.3144	-3.56	-1.7546	-5.88
Air	Travel cost (β_{tc_a})	-0.0011	-5.28	-0.0007	-2.45	0.0001	0.10
	Frequency (β_{freq_a})	-0.0042	-3.87	-0.0043	-3.14	-0.0023	-2.03
Goodness of fit parameters							
No. of estimated parameters		18					
No. of observation		1524					
Initial loglikelihood		**-4286.243**		**-4286.243**		**-5489.704**	
Final log-likelihood		**-2577.656**		**-1974.123**		**-3052.455**	
McFadden's Pseudo R^2		**0.40**		**0.54**		**0.44**	

The three Multinomial Logit (MNL) models, estimated under conditions of no, partial, and full schedule flexibility, collectively elucidate the evolution of traveler preferences and the influencing factors associated with varying levels of temporal flexibility in the Sylhet-Dhaka corridor, in addition to demonstrating differences in overall model efficacy. Under the no-flexibility condition, the model exhibits a McFadden's Pseudo R^2 of 0.40, signifying a robust explanatory capability and accounting for approximately 40% of the variance in mode choice. The substantial enhancement in log-likelihood (from -4286.24 to -2577.66) corroborates a strong model fit. Key significant parameters encompass travel time for both bus (β_{tt_b} = -0.0405, t-test = -3.36) and train (β_{tt_t} = -0.1839, t-test = -3.86), underscoring a heightened sensitivity to travel duration, while the frequency of trains (β_{freq_t} = -0.0039, t-test = -4.00) also exerts a notable influence on mode selection. Pronounced and highly significant inertia effects (e.g., for previous train $\beta_{inertia\_bt}$ = -0.9787, t-test = -7.66; and air $\beta_{inertia\_ba}$ = -4.6268, t-test = -24.14) indicate a persistent loyalty to prior modes, whereas income effects reveal that middle- and high-income demographics tend to eschew bus transport, thereby confirming socio-economic disparities in transportation preferences. In the partial-flexibility model, the explanatory power markedly improves with an McFadden's Pseudo R^2 of 0.54, rendering it the most effective model among the three. This observation suggests that permitting a certain degree of schedule flexibility enhances the model's capacity to accurately capture real-world behavior. The train alternative is distinctly favored (ASC_{train} = 2.4065), with significant parameters including train travel time (β_{tt_t} = -0.2342), frequency (β_{freq_t} = -0.0027), and air travel frequency (β_{freq_a} = -0.0043), while air travel cost (β_{tc_a} = -0.0007) continues to serve as a significant deterrent. The strongly negative inertia effects across all prior mode choices further emphasize the limited propensity for switching, while pronounced income effects indicate a disutility associated with public transport modes among higher-income travelers. Collectively, the model posits that moderate flexibility facilitates travelers in optimizing their schedules, thereby enhancing the explanatory capacity of determinants influencing mode choice. Under the full-flexibility scenario, the model attains a Pseudo R^2 of 0.44, indicating a reasonable yet slightly diminished performance in comparison to partial flexibility. In this context, the air alternative is markedly disfavored (ASC_{air} = -4.4660), while the train constant (ASC_{train} = 0.4962) is both small and statistically insignificant. Travel time persists as a significant deterrent for both bus (β_{tt_b} = -0.0438) and train (β_{tt_t} = -0.1190), although cost loses its significance across all modes, suggesting that with complete schedule control, travelers prioritize convenience and temporal factors over pricing considerations. Frequency influences only air travel (β_{freq_a} = -0.0023), and inertia effects remain powerfully negative (e.g., $\beta_{inertia\_ba}$ = -4.9553 for bus, $\beta_{inertia\_ta}$ = -4.3020 for train), highlighting enduring modal loyalty despite the availability of maximum flexibility. Comparatively, the partial-flexibility model exhibits superior performance (McFadden's Pseudo R^2 = 0.54), implying that travelers' decision-making processes are most responsive and predictable when they possess some, albeit not complete, control over departure timings. The no-flexibility model follows, indicating that even inflexible schedules capture considerable behavioral variation due to sensitivity to time and frequency, while the full-flexibility model, despite its strength, suggests that excessive flexibility diminishes the significance of cost and subsequently reduces the overall predictive capacity of the model. Collectively, these findings demonstrate that moderate schedule flexibility offers the most authentic representation of intercity travel behavior, balancing structural constraints with behavioral adaptability.

Based on the estimated utility equations, the predicted modal shares vary notably across flexibility conditions. Under the no-flexibility scenario, buses account for 56.16% of total trips, followed by trains at 32.96% and air travel at 10.88%. With partial flexibility, train usage rises significantly to 51.47%, while bus share declines to 45.89% and air travel drops to 2.64%. Finally, under full flexibility, the train mode further increases to 56.57%, whereas bus use falls to 39.91% and air travel slightly recovers to 3.52%, indicating that greater departure flexibility encourages a strong modal shift toward rail transport.

7. CONCLUSION

The analysis reveals that flexibility in departure time has a significant effect on mode choice on the Sylhet-Dhaka route. With flexibility, train ridership increases 32.96% to 56.57% and bus and air utilization reduce to 39.91% and 3.52% under complete flexibility, respectively. Travelers have no flexibility, and the utility of buses implies that travel time majorly affects their preference (β_{tt_b} = -0.0405, t-test = -3.36). In the partial-flexibility situation, there is further mode loyalty- particularly with the trains ($\beta_{inertia\_ta}$ = -6.1515, t-test = 26.93) and the travelers with much higher income will be likely to avoid buses (β_{inc_b2} = -1.7580, t-test = -4.05). In full flexibility, the level of inertia perk and the gap in incomes increase. The stronger preference of rich travelers is not only against trains (β_{inc_t2} = -1.7546) or buses (β_{inc_b2} = -2.1934), but the impact of costs and time is also weaker. This study defines flexibility as an important predictor of intercity mode choice and provides policy implications on the way to design, pricing, and infrastructure to accommodate levels of flexibility. Nevertheless, there are also such limitations as a survey bias on urban commuters, a small sample size (N = 1524), restricted options of mode (bus, train, air), and simplified service characteristics. In the future, mode choice needs to be combined with the other stages of demand concerning transport; other modes must be incorporated, and a mode-shift framework should be created to ensure that behavioral changes based on the levels of flexibility are better captured.

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Declaration of Use of AI

This paper has been written using Grammarly in order to improve the linguistic standard of the paper, namely grammar, comprehensibility, and readability. The research methodology design, data collection, statistical analyses, and the production of scientific interpretations were not designed with the use of artificial intelligence tools. A similarity test through Turnitin revealed a less than 20 per cent AI-assisted writing and an overall similarity index of less than 12 per cent, which effectively validates that the content of the rest of the work is original and human-made. Grammarly could therefore only do quality improvement of the manuscripts in order to make the research more comprehensible.

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