KEY FACTORS AFFECTING MODE CHOICE DECISIONS BETWEEN AC AND NON-AC BUS SERVICES IN DHAKA-CUMILLA ROUTE

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ABSTRACT

Dhaka as the capital of Bangladesh attracts trips from different districts. Cumilla being situated close to Dhaka generates decent amount of traffic, majority of which is carried through bus services. The buses on Dhaka-Cumilla route can be categorized into AC and Non-AC buses, provided by a few established companies. This study aims to look at the passengers of these buses and understand their choice decisions based on factors affecting their choices. A group of 1088 individuals has been surveyed via an online questionnaire. Their socio-economic characteristics and trip related information were collected to be used in this study. Collected data revealed a disparity between the choices made between buses (93%) and other modes (7%) combined. Further separation of data showed a higher number of people choosing AC bus over non-AC bus. A logistic regression model was developed to predict between these two choices and to see which factors and how they affect most of these choices. Maximum likelihood estimation was used to calculate model parameters. The major finding of the model indicates travel time, travel cost, household income per capita and time of trips has the most significant impact on decision making. Although, different attitude other than traditional toward cost was seen when choosing Ac bus service initially, but later latent factors such as comfort and safety were identified to weigh this perception. However, individuals make their choice regarding non-AC bus in a way which is pertinent to traditional models. The study sheds light on latent variables which should be investigated more to identify observable variables associated with them. The proposed approaches have immense potential to better understanding the travel choice behavior of intercity trip makers not only for the study area but also for other intercity routes, where people face a similar choice-making situation.

Keywords: *MNL, Utility, Mode-choice, Comfort, safety*

1. INTRODUCTION

Urban transportation systems, vital for the mobility and economic development of cities, significantly impact urbanization patterns. Dhaka, the capital of Bangladesh, exemplifies these impacts. It's one of the world's most densely populated cities, attracting vast numbers from suburban and rural areas. This migration, driven by the search for better livelihoods and amenities, has resulted in a staggering increase in Dhaka's population, from 3 million in 1980 to over 19 million in 2018 (Rama, 2017). This rapid growth has led to unplanned and haphazard urban developments, profoundly affecting commuting patterns and transportation needs, particularly evident in the Dhaka-Cumilla N1 highway segment.

The N1 highway, part of the larger Asian Highway Network, is a critical economic corridor in Bangladesh, linking Dhaka and Chittagong and facilitating a significant portion of the country's trade and garment industry transportation. The research focuses on the Dhaka to Cumilla segment of the N1, a 97-kilometer stretch experiencing significant traffic demand and undergoing upgrades to improve service levels. The expected increase in vehicle usage on this route highlights the need for effective transportation planning and policy.

Mode choice can be modelled by discrete choice theory. It has been developed by Mcfadden (1947a, 1974b, 1975 and 1976). Binary mode choice model is the initial application of this theory (Warner, 1962; Lisco, 1967; Stopher, 1969; McGillivray, 1972; Talvitie, 1972; Wigner, 1973; Watson, 1964). Later multinomial logit model (MNL) was developed by Mcfadden (1974b). MNL is an excellent tool for modelling decision making. It has been used in several studies to understand mode choice decisions (Enam, 2011; Rahman, 2018; Islam, 2020). It creates utility functions associating different factors with utility and disutility and finally deriving probability of choosing a preference based on utility from that choice.

Understanding factors impacting mode choice behaviour tremendously help planners and policymakers to take appropriate decisions. Some studies have already explored these factors. Trip purpose, time and income level seems to affect mode choice decisions (Rahman et al, 2020). Feroz (2022) has found similar factors as well as gender, age, occupation waiting time and cost to have significant influence in mode choice decision in N1 highway.

This study aims to develop a mode choice model for the Dhaka-Cumilla N1 route using advanced discrete choice modelling techniques. The objectives include developing a model with revealed preference (RP) data, service quality attributes for bus services, identifying factors influencing transport mode choice. This model will aid in understanding the dynamics of mode choice decisions influenced by socio-economic factors, alternative specific factors, and varying travel utility components such as in-vehicle time, safety, and comfort.

The outcomes of this research are expected to significantly contribute to transportation policy and planning, providing insights for multimodal public transport system improvements. These include fare adjustments, service enhancements, and travel time reductions, aiming to decrease automobile dependency and increase public transport use. This research will offer a strategic framework for future transportation demand predictions and policymaking, ensuring a safe and affordable transport system for commuters in and around Dhaka.

2. METHODOLOGY

2.1 Data Collection and Analysis

The study collected data through an online survey, targeting regular users of the Dhaka-Cumilla route. The questionnaire, distributed via social media groups and recorded in Microsoft Form, included socio-economic characteristics and travel-related information. The final dataset, comprising responses from 1,011 individuals, focused primarily on the choice between air-conditioned (AC) and non-air-conditioned (Non-AC) buses, the most commonly selected modes of transport.

2.2 Key Variables for the Model

The model development emphasized four main variables: cost, in-vehicle travel time, household income per capita, and time of travel. These factors were identified as significant influencers in the mode choice between AC and Non-AC buses. In the model, the variables of cost, in-vehicle travel time, household income per capita, and time of travel were identified as crucial. Cost refers to the monetary expense associated with using either AC or Non-AC buses, influencing the affordability and accessibility of these transport options. In-vehicle travel time denotes the duration spent inside the bus, affecting commuter convenience and overall travel experience. Household income represents the economic status of the commuters, playing a pivotal role in determining their transport mode choice, especially when deciding between cost and comfort. Lastly, the time of travel captures the specific hours or periods during which the commuters travel, which can reflect varying levels of service quality, bus availability, and travel urgency.

2.3 Modelling Technique

The study employed Discrete Choice Analysis to model the choice preferences of travellers. The Multinomial Logit Model was chosen as the primary tool, which allowed for a detailed examination of how the key variables impacted the choice between AC and Non-AC buses. The utility parameters within this model were estimated using Pandas Biogeme (Bierlaire, M., 2003). Furthermore, the study utilized maximum likelihood estimation techniques to estimate model parameters. The validity of these parameters was assessed using t-statistics, with a 95% confidence interval as the benchmark for including a parameter in the final model.

Confusion matrix was used to assess the prediction accuracy of the final model. Confusion matrix is a table that shows actual frequency of a certain class in each row and frequency of each class predicted by the model in each column. Accuracy can be easily calculated by dividing the number of corrected predictions (diagonal entry) by the total number of predictions of the model.

3. RESULTS

This section presents and analyses data to identify patterns and characteristics in mode choice behaviour. Various factors influencing travellers' mode preferences were examined using factor analysis, cross-tabulation, and visualizations in SPSS and MS Excel.

3.1 Mode Choices

A survey on the Dhaka-Cumilla highway revealed seven different mode preferences among 1088 respondents. Notably, 92.93% (1011 respondents) (Table 1) favoured AC or non-AC buses. Specifically, 62.2% (Figure 1) preferred AC buses. This significant preference for buses prompted a focused analysis on factors affecting bus service choices.

Table 1: Choices by percentage of respondents.

Mode	Percentage of choices made by respondents
AC Bus	57.81
Non- AC Bus	35.11
Private Car	3.49
Train	2.48
Motorcycle	0.64
Rented Car	0.38
Micro	0.09

3.2 Socio-demographics

After data refinement, 1088 valid responses were analysed, with 12.96% female and 87.04% male respondents (Table 2). Females showed a slightly higher preference for AC buses and less interest in non-AC buses, with only 31.9% choosing non-AC (Table 2).

The majority of commuters are aged 18-25 (57.47%) and 26-40 (37.29%). Only a small fraction is below 18 (2.67%), or over 40 (2.57%). Younger travellers under 18 predominantly use AC buses (74.07%), with the proportion of AC bus users increasing with age (Table 2).

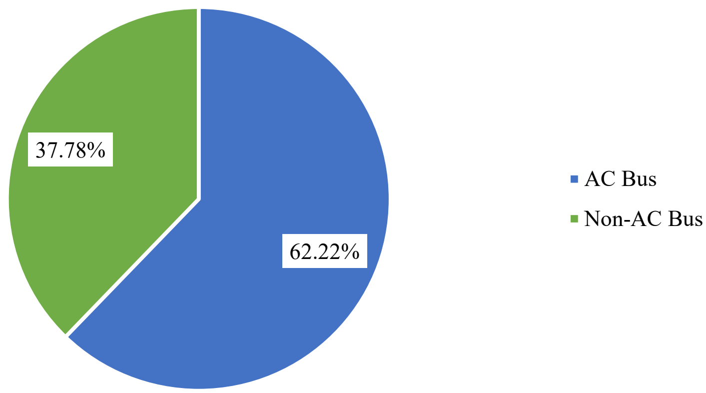

Figure 1: Choice split among people who uses bus services in Dhaka- Cumilla highway.

Table 2: Summery of Socio-demographic data as percentage of total also as percentage of choice.

Groups	**Items**	**Percentage**	**Choices wise split**	
			AC Bus	**Non-AC bus**
Gender	Male	87.04%	61.4%	38.6%
	Female	12.96%	68.1%	31.9%
Age	<18	2.67%	74.07%	25.93%
	18-25	57.47%	56.97%	43.03%
	26-40	37.29%	68.70%	31.30%
	41-50	2.08%	71.43%	28.57%
	50+	0.49%	80.00%	20.00%
Education	Secondary	3.26%	69.70%	30.30%
	Higher Secondary	13.85%	65.00%	35.00%
	Undergraduate	58.75%	60.27%	39.73%
	Post-Graduate& above	24.13%	64.34%	35.66%
Monthly Household Income	<20 thousand	13.25%	44.78%	55.22%
	20-40 thousand	30.76%	54.98%	45.02%
	40-60 thousand	24.43%	62.75%	37.25%
	60-80 thousand	13.55%	70.80%	29.20%
	80-100 thousand	7.81%	84.81%	15.19%
	100-150 thousand	3.66%	70.27%	29.73%
	>150 thousand	6.53%	80.3%	19.70%
Number of Family members	1	0.89%	77.78%	22.22%
	2	2.77%	64.29%	35.71%
	3	12.86%	76.92%	23.08%
	4	31.75%	61.99%	38.01%
	5	27.30%	63.04%	36.96%
	6	14.05%	52.11%	47.89%
	7+	10.39%	54.29%	45.71%
Occupation	Students	56.48%	59.37%	40.63%

	Privat Service Holder	24.73%	64.80%	35.20%
	Govt. Service Holder	8.90%	66.67%	33.33%
	Businessman	4.75%	77.08%	22.92%
	Others	5.14%	59.62%	40.38%

Many respondents are graduates (58.75%), primarily students, followed by those with higher secondary (13.85%) and postgraduate (24.13%) qualifications. Only 3.26% have completed secondary education (Table 2).

Most respondents are students (56.48%), likely because the survey was conducted online on social media platforms frequented by students and young adults. Additionally, 24.73% are private sector employees, 8.90% government employees, 4.75% business owners, with the remainder categorized as 'others'. Occupation influences the preference between AC and non-AC buses (Table 2).

Income levels also play a role in mode choice. The largest group (30.76%) has a household income of 20-40 thousand taka per month, showing a trend towards AC buses as income increases. For instance, 44.78% of respondents with an average household income of 20 thousand choose AC buses, rising to 80.3% for those with incomes around 150 thousand. Higher income groups tend to prefer AC buses regardless of cost (Table 2). Family size impacts mode preference as well. Individuals from smaller families more frequently choose AC buses, while those from larger families tend to opt for non-AC buses as can be seen in Table 2.

3.3 Travel Characteristics

Travel costs are higher for AC buses, ranging from 250-350 Tk based on seat selection, compared to a consistent 200 Tk for non-AC buses. The average waiting times for AC and non-AC buses are similar, at 16.93 and 16.92 minutes, respectively (Table 3). While non-AC buses have a higher but irregular frequency, AC buses, despite being less frequent, run more regularly. The in-vehicle travel times for both AC and non-AC buses are almost identical, averaging 2.28 and 2.32 hours (Table 3), respectively. Both bus types follow the same route.

Table 3: Travel characteristics of the bus passengers.

Travel Characteristics	**Choices**	
	AC Bus	NON-AC Bus
Average Cost (Tk)	271.23	200.78
Average waiting time (minutes)	16.93	16.92
Average in-vehicle time (hr)	2.28	2.32

Contrary to the usual trend of frequent travellers preferring cheaper modes of transport, this study found no such pattern (as illustrated in Figure 2). Both groups, those traveling more than 12 times a year and those traveling 1-6 times annually, chose AC buses for an average of 62% of their trips. A similar trend is observed for individuals traveling 6-12 times a year.

Table 4: Summery of trip related data.

Groups	**Items**	**Percentage**
Trip Frequency	1-6 times a year	35.41%
	6-12 times a year	47.97%
	More than 12 times a year	16.62%
Trip Purpose	Business related.	1.78%
	Family related.	11.97%
	Treatment related.	2.18%
	Study related.	37.39%
	Tour related.	16.42%
	Work related.	29.77%
	Others.	0.49%
Number of travel companion	Alone	3.26%
	With 1 companion	13.85%

With 2 companions	58.75%
With more than 2 companions	24.13%

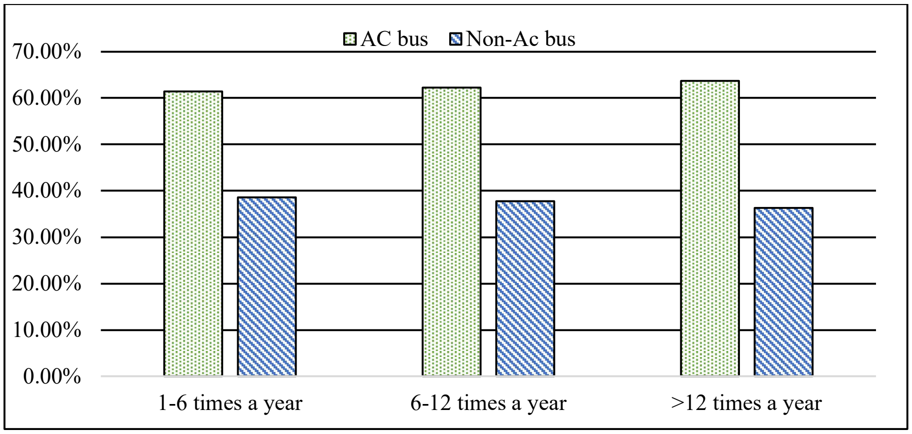

Figure 2: Choice split depending on trip frequency.

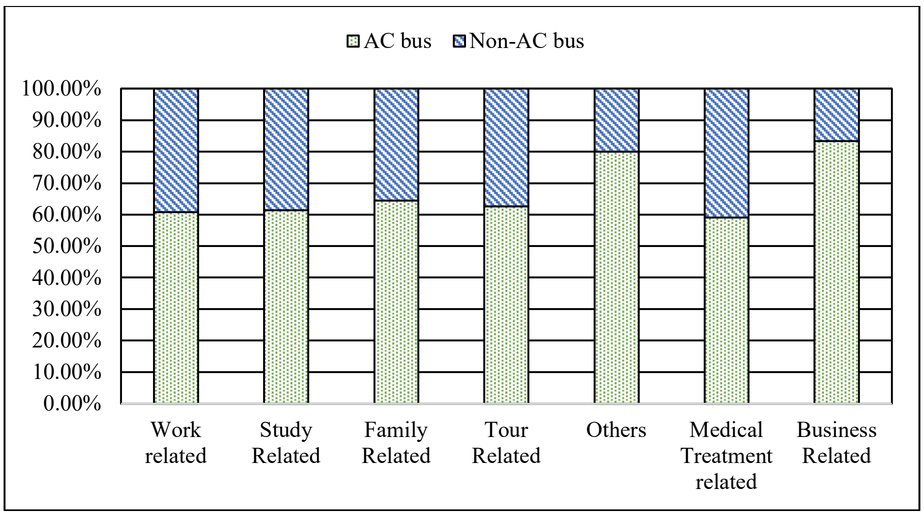

Figure 3: Choice split depending on trip purpose.

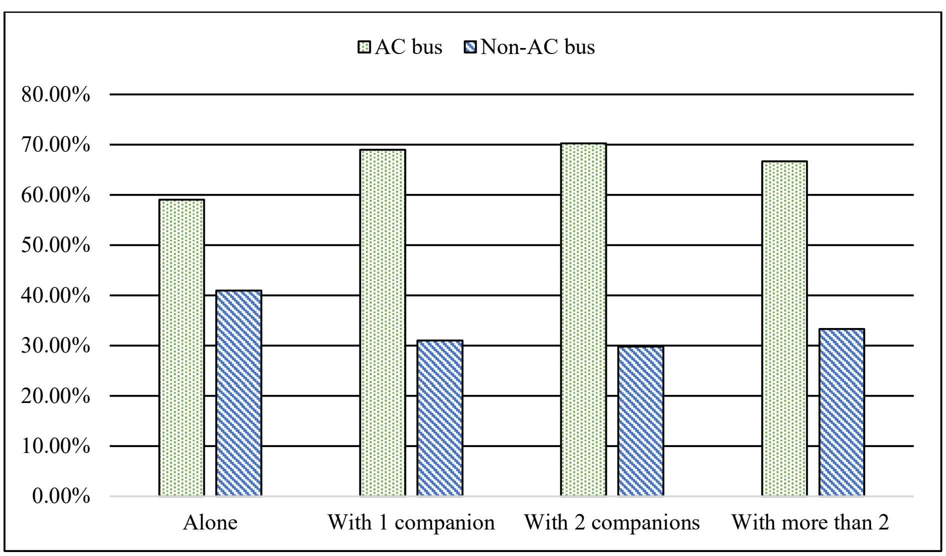

Figure 4: Choice split depending on travel companions.

As most respondents were students, the majority of trips (37.39%) were for study purposes. Business trips accounted for only 1.78%, while family-related travels made up 11.97%. Medical and other purposes combined totalled 2.67%. Trips for tourism represented 16.42%, and work-related journeys comprised 29.77% of responses (Table 4). According to Figure 3, business travellers show a strong preference for AC buses (83.33%) over non-AC buses.

The number of companions also influences travel behaviour. Travelers journeying alone tend to split almost evenly between AC and non-AC buses, with 59.06% choosing AC buses (Figure 4). But people traveling with 1 or more companions are inclined toward the AC bus service. Around 70.21% of people are using the AC bus when traveling with 2 companions (Figure 4).

The majority of trips occur in the morning (5 am – 12 pm), with a split of 61.5% for AC buses and 38.5% for non-AC buses. Evening travel shows a greater preference for AC buses, with about 72.34% of people choosing them over non-AC buses between 6 pm-8 pm (Table 5).

Table 5: Summery of trip split in different time of travel.

Time of Travel		**AC BUS**	**NON-AC BUS**	**Grand Total**
In the morning (5 am - 12 pm)	Count	369	231	600
	%within row	61.5%	38.5%	100%
	%within column	60.1%	64.17%	61.6%
In noon (12 - 4 pm)	Count	90	54	144
	%within row	62.5%	37.5%	100%
	%within column	14.66%	15.00%	14.78%
In the afternoon (4-6 pm)	Count	87	49	136
	%within row	63.97%	36.03%	100%
	%within column	14.17%	13.61%	13.96%
In the evening (4-8 pm)	Count	68	26	94
	%within row	72.34%	27.66%	100%
	%within column	11.07%	7.22%	9.65%

4. MODEL

Several multinomial logit (MNL) models were iteratively developed, each enhancing the previous one, to identify variables significantly affecting mode choice. After five iterations, factors like cost, in-vehicle travel time, cost for females, travel time, and household income were included in the final model and deemed significant using the Robust t-test.

V1= B_TT_AC* TT_AC+B_COST_AC*CO_AC+B_CO_FEMALE_AC*CO_AC*Female **(1)**

V2=ASC_NAC+B_TT_NAC*TT_NAC+ B_COST_NAC* CO_NAC+B_CO_FEMALE_NAC*CO_NAC*Female + ASC_EVENING_NAC*EVENING+ B_HHI_NAC*HHI **(2)**

The final model's structure includes utility functions V1 for AC buses and V2 for non-AC buses, estimated using the maximum likelihood method. Rho square-value indicated the goodness-of-fit, with parameters detailed in Table 6.

Table 6: Summary of the final logit model.

Name	Description	Value(t-test)
ASC_EVENING_NAC	Indicates whether the trip is occurring in the evening(6-8 pm) or not.	-0.503(-2.39)*
ASC_NAC	Alternative specific constant for Non-AC bus	15.1 (3.58)***
B_CO__AC	Cost parameter for AC bus	-0.013 (-3.91)***
B_CO_FEMALE_AC	Cost perception parameter for the female group in AC bus	0.019 (2.52)*
B_CO_FEMALE_NAC	Cost perception parameter for the female group in Non-AC bus	0.0256 (2.4)*
B_HHI_NAC	Per head household income effect on Non-AC bus rides.	-0.0617 (-5.4)***
B_CO_NAC	Cost parameter for Non-AC bus	-0.072 (-4.32)***
B_TT_AC	In-vehicle travel time parameter for AC bus.	-0.206 (-1.11)
B_TT_NAC	In-vehicle travel time parameter for Non-AC bus.	-2.03 (-4.18)***
Init log-likelihood		-632.8434
Final log-likelihood		-485.8871
Rho-square for the init. model		0.232
Rho-square-bar for the init. model		0.22

*Significant with at least 95% confidence
**Significant with at least 98% confidence
***Significant with at least 99.9% confidence

Table 7: Confusion matrix using prediction and actual data.

Predicted / Actual	AC bus	Non-AC bus
AC bus	**630***	4
Non-AC bus	187	**190***

***Number of correct predictions for each case.**

This refined model, with fewer but significant parameters (t-test value greater than 1.96, indicating 95% confidence), proved effective in predicting travel choices, with about 81.1% accuracy. A confusion matrix in Table 7 details the predictions versus actual outcomes, correctly identifying 630 AC bus and 190 non-AC bus trips.

5. DISCUSSION ON FACTORS AFFECTING CHOICES

Utility maximization theory dictates that people seek to maximize utility from their economic decision. In other words, one will choose something when he/she gets highest utility among different choices. The attributes of the utility function (Table 6) demonstrate utility or disutility through their values and signs, associated with various travel and socio-economic characteristics. A positive sign implies increased utility with the attribute, while a negative sign suggests disutility as the attribute increases.

Cost is a crucial factor in choice preferences, treated as an alternative specific parameter in this context. The cost parameter for AC buses was -0.013 and for non-AC buses -0.072, both negative, indicating that utility decreases with rising travel costs. A ratio of 5.5 between the cost factors of non-AC and AC buses suggests that a price increase results in 5.5 times more disutility for non-AC bus users compared to AC bus users for the same price hike.

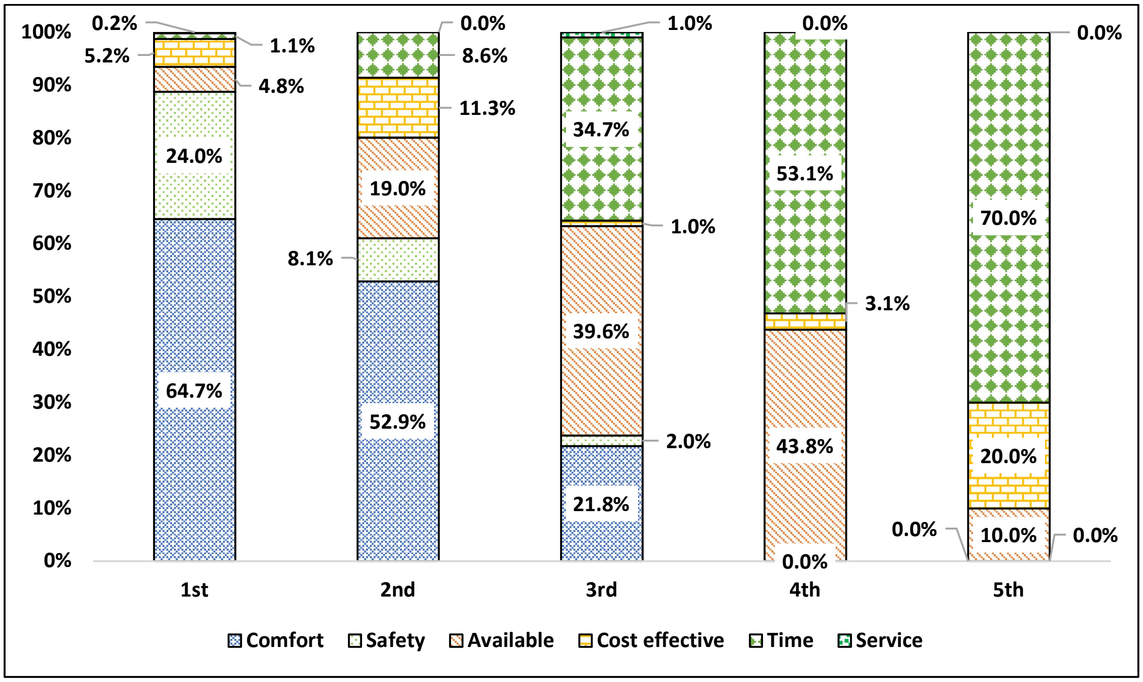

Figure 5: Ranked reasons of AC bus selection.

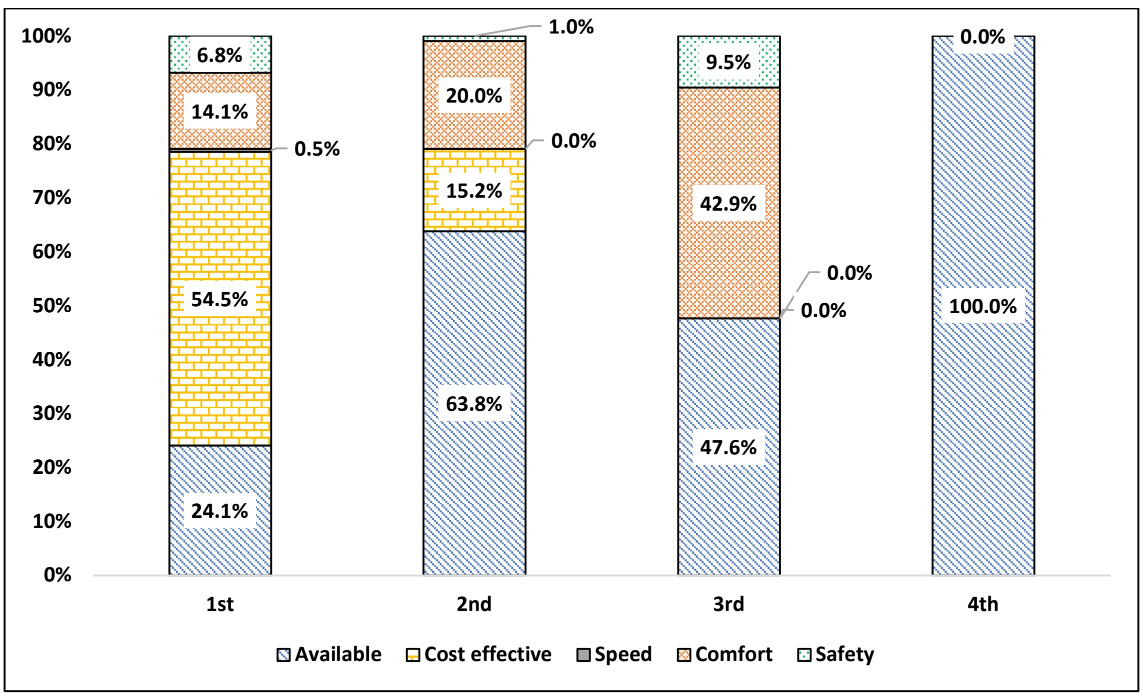

Figure 6: Ranked reasons of Non-AC bus selection.

The cost parameter differs for female travellers on AC and non-AC buses. Initially, a positive sign for females on AC buses might suggest utility gain from increased travel costs. However, when combined with the overall cost parameter, the effective impact for females on AC buses is negligible (0.006), and significantly negative (-0.0464) for non-AC buses. This indicates female travellers are indifferent to AC bus price changes but experience disutility from increased prices on non-AC buses. The preference for AC buses among women can be attributed to their perceived safety and comfort. Safety and comfort ratings on a 5-point Likert scale are higher for AC buses (3.77 and 4, respectively) compared to non-AC buses (3.3 and 3.1).

In-vehicle travel time parameters for both bus types are negative (Table 6), reflecting the general dislike for longer travel times. The more negative parameter for non-AC buses suggests a stronger aversion to extended travel in these buses. In fact, people are likely to get almost 10 (-2.03/-0.206 from table 6) times more disutility for traveling in Non-Ac bus for same time of travel than AC bus.

The negative parameter for household income per head for non-AC buses indicates that as household income increases, the disutility for non-AC buses also rises. Higher-income individuals tend to prefer AC buses for a safer, more comfortable experience.

Evening travel, particularly between 6 pm and 8 pm, shows a negative utility for non-AC buses (Table 6) due to safety concerns, leading to a preference for AC buses.

People were asked to rank reasons for choosing AC and Non-AC buses. For AC bus, 64.7% and 24% respondents choose comfort and safety respectively as their 1st reason. And 70% ranked time as the last reason for travelling in AC bus (Figure 5). For Non-AC bus, 24.1% and 54.5% respondents choose availability and cost effectiveness as their reason for choosing Non-AC bus (Figure 6). This means, people are choosing AC-bus for its perception of extra comfort and safety regardless of cost and travel time whereas people are choosing Non-AC bus for its availability and lower travel cost. This outcome is reflected in the model by the cost and travel time parameters. As people who chose AC bus were less sensitive to travel cost and travel time indicated by lower parameter value of these attributes.

6. CONCLUSIONS

This research developed a mode choice model using revealed preference (RP) data from an online survey. The data was cleaned, outliers removed, and analysed through tables and charts to understand travel patterns, reasons, and characteristics. Key influencing factors identified were travel cost, time, household income, family size, and time of travel. The model quantifies the impact of these factors on choice, providing insights into how safety, comfort, and availability influence decisions.

The observed indifference of women towards AC buses, attributed to the enhanced safety and comfort not found in non-AC buses, could have substantial policy implications. Implementing measures to improve the safety of bus services might encourage more women to switch from private modes to bus transportation.

The study faced limitations, primarily due to the COVID-19 pandemic, which restricted data collection methods. Instead of an intercept survey for more uniform data across different modes, an online survey was conducted using Microsoft Forms in various social media groups. This method may have introduced bias, as it likely attracted responses from a specific demographic.

Since the research was conducted in 2021, there have been significant increases in the costs of both AC and non-AC buses. These changes may have impacted user behaviour in unforeseen ways, suggesting the need for further research to explore these potential shifts.

Given these constraints, the authors recommend additional research into latent variables and their impact on choice, aiming to develop a systematic approach to studying these factors.

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