Determinants of Mode Choice for Intercity Travel

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1 INTRODUCTION

Mode choice analysis is a preferred approach to understand the commuter's travel behavior and their response towards new or upgraded alternatives (Hensher *et al*., 2005). It estimates the probable shift and the resulting mode share of different modes used by commuters. The issue in predicting mode share is the ability to model and explain the probable changes in it (Forinash & Koppelman, 1993). It is important to identify which attributes should be provided in a transportation mode to encourage commuters to use it for their travel. Such analysis can be applied by the transit authorities to improve their services and encourage use of sustainable alternatives to commute.

In this study we try to explore attributes that influence the mode choice of commuters during intercity travel. The perception of commuters is assessed by asking them to select a transit system out of bus, regional rapid transit system (RRTS), and train for intercity travel considering the case of the National Capital Region (NCR). The RRTS is a dedicated, high-speed transit with comfortable commuter service proposed to connect Delhi with the regional nodes in NCR (National Capital Region Transport Corporation, 2023).

Various conditions are developed further in which the mode share is estimated by providing the better service of influencing attribute in either of the alternative. Conducting such studies will help in identifying the attributes or services that can influence the decision and also to understand the travel behavior of commuters during intercity travel.

2 METHODOLOGY

A stated preference (SP) experiment was developed to understand the travel behavior of commuters from the Meerut city of Uttar Pradesh in selecting a transit system to reach Delhi. In the mode choice experiment, the passengers were asked to select between the bus, RRTS, and train as their preferred mode of travel irrespective of the mode currently used by them to travel to Delhi. The above alternatives were compared on the basis of five attributes: travel cost, travel time, access time, safety and comfort. Quantitative attributes like travel cost, travel time, and access time were considered as it is since they were in cardinal linear form. Alternatively, dummy coding was applied over safety and comfort attributes where the best attribute levels i.e. 'Both safety alarm and CCTV' (Safety I) and 'AC with seat available' (Comfort I) were considered as the base level. Having 'Either safety alarm or CCTV' and 'No safety alarm or CCTV' were considered as Safety II and Safety III levels, while 'Non-AC with seat available' and 'Non-AC and no seat available' were Comfort II and Comfort III levels respectively.

With three attribute levels under each attribute for every alternative, 45 choice sets were generated by employing the D-optimal design which were further blocked into 9 groups with 5 choice sets in each group (see Figure 1 for sample choice set). The commuters travelling from Meerut to Delhi were considered as the target population, and responses from 370 respondents resulting in a total of 1850 choice sets were collected.

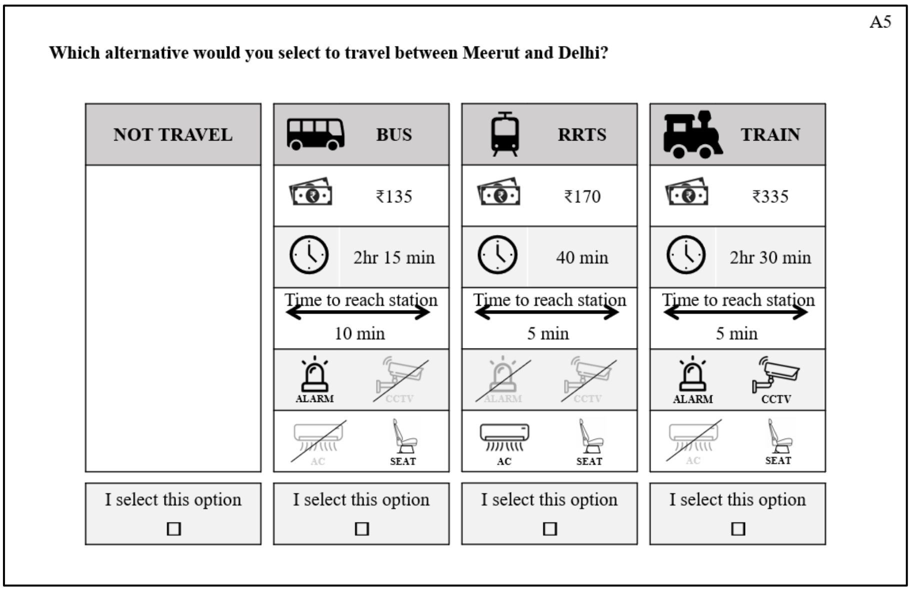

Figure 1 – *Sample choice set presented to respondents*

A mixed logit (ML) model is applied as it explains the variation in the choice of respondents towards each attribute. To ensure the accuracy of the results, Halton draws with 500 replications is applied in the discrete choice model (Bhat, 2003), represented as:

$$U_{jtq} = \sum_{k=1}^{K} \beta_{qk} x_{jtqk} + \varepsilon_{jtq} = \beta_q' x_{jtq} + \varepsilon_{jtq} \tag{1}$$

In which, U_{jtq} is the utility of an alternative j for an individual q in a choice set t, β_q' is the coefficient matrix, x_{jtq} is the vector of explanatory variables, and ε_{jtq} is the error. However, in ML, the β_{qk} is not a constant parameter and varies with the choice of respondent to capture the heterogeneity and can be expanded to the following equation:

$$\beta_{qk} = \beta_k + \delta_k' z_q + \eta_{qk} \tag{2}$$

Where, β_k is the mean, δ_k' is the standard deviation of the random parameter, and η_{qk} is the error term for β_{qk}. The model assumes a general distribution such as normal, lognormal, uniform, or triangular for η_{qk}, and in this case, a uniform distribution is assumed for all the random parameters due to which the choice probability can be expressed as:

$$P_{jq}(X_q, z_q, \Omega) = \int_{\beta_q} L_{jq}(\beta_q | X_q, \eta_q) f(\eta_q | z_q, \Omega) d\eta_q \tag{3}$$

3 RESULTS

The results obtained after applying the above model are explained below. The output of the ML model is explained first which assists in identifying the most preferred alternative as well as the attributes influencing the decision of commuters. Different conditions are developed further in order to see the impact of the influencing attribute on the mode share for intercity travel.

3.1 Mode Choice Analysis

The results after performing ML analysis are showcased in Table 1, where the train is considered as the base alternative. As the random parameters are statistically significant, it reflects that the utility of all the attributes except the access time differ among commuters. The negative coefficient of travel time and travel cost attributes indicates that an increasing value of these attributes lead to disutility among passengers. Similarly, the negative coefficients of safety and comfort attributes portray that they play an influential role in the mode selection by passengers during intercity travel. From the given alternatives, the RRTS is observed to be the most preferred one having maximum utility. The result also shows that lack of comfort during travel is considered as the highest disutility by commuters.

Table 1 – *Parameter estimates from the models*

Variable	Multinomial Logit (MNL)		Mixed Logit (ML)	
	Coefficient	*t-statistics*	*Coefficient*	*t-statistics*
Random parameters in utility functions				
Travel Cost			-0.0035	-5.784***
Travel Time			-0.0110	-2.223**
Safety III			-0.5843	-4.087***
Safety II			-0.4247	-3.260***
Comfort III			-2.5221	-11.987***
Comfort II			-0.6825	-4.818***
Nonrandom parameters in utility functions				
Travel Cost	-0.0027	-6.573***		
Travel Time	-0.0051	-1.665*		
Safety III	-0.3844	-3.438***		
Safety II	-0.2543	-2.451**		
Comfort III	-2.2361	-15.848***		
Comfort II	-0.5247	-4.425***		
Access Time	0.0062	0.550	0.0099	0.731
Alternative specific constants				
Not Travel	-2.2792	-4.522***		-4.387***
Bus	0.2026	1.473		1.807*
RRTS	2.3359	7.394***		5.987***
Derived standard deviations of parameter distributions				
Travel Cost			0.0000	0.028
Travel Time			0.0186	2.648***
Safety III			0.0003	0.000
Safety II			0.0107	0.010
Comfort III			2.6514	5.683***
Comfort II			1.1728	1.775*
Number of observations	1850		1850	
Draws			500	
Log likelihood function	-1189.839		-1180.824	
Chi-squared (p-value)	420.832 (0.000)		2767.641 (0.000)	
Pseudo R^2	0.150		0.540	

***99% confidence level, **95% confidence level. *90% confidence level

3.2 Mode Share under Different Conditions

As the commuters expect a better comfort during intercity travel, this study further assessed different scenarios in which the mode choice of commuters is assessed when better comfort facility (availability of AC and seat) is provided in either of the alternative. Provision of AC and an assured seat in bus increases its mode share by at least 5.5%, while in case of train it increases by almost 5%. In case of better comfort in RRTS, its mode share increases by more than 14% and attracts more than 90% of the commuters, showcasing the dominance of RRTS. Thus, RRTS is observed to be the most preferred alternative within commuters for intercity travel even after providing better comfort facilities in other alternatives.

Table 2 – *Estimated mode share after providing better comfort*

Choice	Base	AC and seat in Bus	AC and seat in RRTS	AC and seat in Train
	% Share	*% Share*	*% Share*	*% Share*
Not Travel	6.88	5.88	1.49	6.15
Bus	7.41	13.10	2.83	6.47
RRTS	78.29	74.56	92.89	75.19
Train	7.42	6.46	2.79	12.19
Total	100.00	100.00	100.00	100.00

4 DISCUSSION

The study provides valuable insights in identifying the attribute shaping the mode choice for intercity travel. The ML model identified the attributes influencing the mode choice decision by underscoring the role of travel time, travel cost, access time, safety and comfort. Out of the given alternatives of transit systems for intercity travel, the RRTS is observed to be the most preferred alternative, which may be because of its balance of travel efficiency and perceived quality. Alternatively, provision of comfort is observed to be the most influencing attribute during intercity travel which is further used to analyze different scenarios. There is some improvement in the mode share of bus (5.69%) and train (4.77%) after providing AC and an assured seat but fail to counter the effect of RRTS.

The findings showcase that qualitative attributes such as comfort and safety have a major effect on intercity travel mode selection compared to travel cost, travel time and access time. The major inclination of commuters towards RRTS should be considered by the policymakers and transit authorities to invest in its infrastructure and amenities to meet the travel demand if they want commuters to abandon use of personalized vehicles for intercity travel. This study highlights the impact of enhanced intercity travel experience based on targeted improvements in comfort of various transit systems. Further studies may consider assessment of other attributes such as reliability, efficiency, or environmental impacts to develop a more commuter-centric sustainable transit systems that can attract personalized vehicle users.

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