Proceedings of 15th IOE Graduate Conference
Peer Reviewed
Year: 2024 Month: May Volume: 15
ISSN: 2350-8914 (Online), 2350-8906 (Print)

Mixed Logit and Probit Model for Intercity Mode Choice in Nepal

Arjun Sigdel [a], Jagat Kumar Shrestha [b]

[a, b] *Department of Civil Engineering, Pulchowk Campus, IOE, Tribhuvan University, Nepal*
[a] 076mstre002.arjun@pcampus.edu.np, [b] jagatshrestha@pcampus.edu.np

Abstract
Modal balance of different transportation mode is important prerequisite for ensuring sustainable transportation. The effect of economic progress made by nation is reflected through change in consumption and behavioral attitude of general population. In transportation sector, it is best identified by preference of more comfortable, reliable and fast transportation mode by transportation users. Therefore, it is important for transportation professional to understand the socio-economic, behavioral, mode specific system variable for efficient management of existing transportation mode and for developing new mode of transportation. Experience of East Asian Mega city shows intercity transportation and understanding the modal share of intercity transport will be of particular importance. Transportation infrastructure is one time large capital investment. Therefore, it is important for transportation planner to project the ridership new transportation mode will generate. Intercity mode choice study is important for understanding economic viability of transportation infrastructure. Traditionally, aggregate modelling was used for mode choice study. Due to the inability of aggregate model to factor individual level data, discrete choice models are used for mode choice analysis of late. This work uses multinomial probit and mixed logit model for study of mode choice of intercity travellers of Nepal. Effect of different system attributes variables and socio-economic variables on mode choice for intercity travel in Nepal is done in this study. Value of time for intercity transport according to this study is Nrs 228.54 per hour. Similarly Value of time for plane mode is found to be Nrs 701.20 (Probit), Nrs 942.94 (Mixed Triangular Distribution), Nrs 754.79(Mixed Uniform Distribution). Value of Time for Car mode is found to be Nrs 613.98(Probit), Nrs 760.72(Mixed Triangular Distribution) and Nrs 754.79 (Mixed Uniform Distribution).

Keywords
Discrete Choice Model, Intercity Transport, Probit Model, Mixed Logit Model, Value of Time

1. Background

One of natural consequences of economic growth is that population tends to concentrates in city. Therefore, reliability, cost effectiveness and comfort-ability of intercity travel becomes questions of huge importance for transportation planning and management of any nation. Choice of intercity travel mode is complex topic influenced by traveler's Socio-economic characteristics, behavioral choices, service and trip attributes. There are generally two techniques for mode choice modelling: aggregate choice and dis-aggregate (discrete choice) model. Aggregate model, which is conventional way of determining mode choices, works on zonal data of certain region. One of limitation of aggregate choice model is that it fails to account for system attributes and taste variation of individual travelers. On this background, dis-aggregate modelling technique was developed, which tries to take account of user's choices at individual level and also encompasses system attributes of different modes. Discrete choice model is utility maximization model that provide mathematical model for analyzing mode choice and modal shift due to introduction of new service. Transportation infrastructure are usually capital intensive. If new transport infrastructure cannot generate enough ridership, investment cannot produce return as expected. This sunk cost can be very critical for developing countries like Nepal with resource constraint. Hence, choice modelling is very important part of demand modelling.

In Nepal, Capital Kathmandu is either origin or destination of large number of intercity trips. Pokhara, Biratnagar, Bharatpur, Butwal, Tikapur, Bhadrapur etc are other prominent cities of Nepal. Currently, public bus, air service and private automobiles are available modes of transportation. With economic growth and rising middle class, choice of transport mode get changed. People will opt for more comfortable and faster mode of transport with increase in incomes. Also, age, sex, time, travel partner, cost bearer, family size are other factors that determine the mode choice made by travelers. It is important for transportation planner to understand why traveler chose one mode over other and what are factor influencing such choices. It is equally important to understand the general trend over time of mode choice behavior. With growth in economy, people will opt for comfortable and expensive mode of transport; this shift in modal choice need to be understood by planner at granular level, and it is important to determine if our current transport infrastructure are resilient enough to cope with this change, and what are interventions needed at policy level to address those change in modal shift.

In Nepal, introduction of rail service for intercity travel is hot topic. For successful railway service, it need to generate enough ridership to offset huge investment and operational cost. One reason why people chooses railway service for intercity travel over other mode is because it reduces the travel time compared to bus, while it is less costlier than airplane. From transportation planning perspective, it is important to identify relationship of mode choice with travel cost and travel time.

Issues with intercity transportation may not be immediately apparent, but over time after the problem get consolidated, it can lead to significant structural damage. Increase in income and population , there is rapid escalation in the demand of intercity travel. In case of Nepal, there is very few study to quantify the possible future of intercity transport. The conclusion of study of intercity transport of developed economies cannot be directly applied on Nepal due to different structural factors and dynamics of Nepali society. Therefore, it is warranted to critically examine behavioral dynamics of intercity traveler within Nepal. Morichi and Acharya present a compelling argument about transportation challenges faced by developing Asian nations [1]. Appropriate policy intervention is must before these issues consolidates and make whole structure of intercity transport dysfunctional. In Nepal, very few study have been carried out for mode choice study of intercity transport. This works, therefore, aims for filling this gap by developing probit and mixed logit model for mode choice model for intercity transport in Nepal. Also, value of time in monetary terms for different modes is calculated.

2. Literature Review

Mode choice study is also essential study done prior to introduction of new transportation services because normally transportation project are capital-intensive project, requiring huge capital investment, and it will be important question for transportation planner to know about the ridership new transportation mode will attract. Hence, intercity mode choice study is important for appraisal of financial viability of any transportation project. Before dis-aggregate choice modelling, aggregate modelling was used extensively to determine the mode choices. Aggregate choice modelling, due to its inability to incorporate individual level data and system attributes in analysis, discrete choice model is preferred over aggregate choice model. Watson and Westin (1973) were first to use stochastic model for mode choice modeling over aggregate choice modelling and it was immediately recognized that stochastic modelling was better than aggregate model for intercity trip modelling[2]. Discrete choice model was used by McFadden (1974) to study mode choice scenarios before and after Bay Area Rapid Transit in San Francisco [3]. Since then, many sophisticated discrete choice models are developed to model intercity mode choice. Beginning with binary logistic models, many new discrete choice models like multinomial logit, nested logit, probit, multinomial probit, heteroscedastic extreme value model and mixed logit models are developed for modelling intercity travel. Each iterations of model evolution has addressed the limitations of previous models, and new model has exploited the high computational capacity of newer computer.

Although some research are being carried with regards to urban transport, intercity transport city is rarely being carried out in Nepal. First significant study of intercity mode choice study in context of Nepal was done by Manmohan Joshi using multinomial logit model [4]. Building on that work this paper focuses on mixed logit and probit model for intercity mode choice study in Nepal.

Stratified random samples involve dividing the population into homogeneous subgroups based on certain attributes using prior information. Units are then selected from these subgroups using simple random sampling. This approach is particularly useful when dealing with small subgroups that may not be adequately represented through simple random sampling alone[5]. Stratified random samples involve dividing the population into homogenous subgroups based on certain attributes using prior information. Units are then selected from these subgroups using simple random sampling.

The decision-making process is primarily influenced by two main sources: the characteristics associated with different options and the personal biases or preferences of individuals. The process of estimating choice models involves assigning relative importance to these attributes and characteristics through some empirical data. While conventional data collection techniques can be used to gather data on characteristics like socio-demographics, data on attributes falls into two categories: stated preference(SP) data and revealed preference(RP) data (Hensher, Rose and Greene) [6]. In choice modelling, utility is crucial concept, yet it is impossible to collect data corresponding to utility of given choices. Therefore, in order to quantify utility of certain choices made under different conditions various choice experiment ranging from ranking/rating choices to data collected from RP and SP experiment are available.

3. Place of Study and Data Collection

Nepal is developing country sand-witched between two modern economy viz China and India. There are very few cities in Nepal which can be designated as metropolitan city by international standard. However, there is rapid population migration happening from rural hinterland of Nepal to cities like Kathmandu, Pokhara, Biratnagar, Tikapur, Nepalgunj. Due to uneven spatial development and even after adopting federal form of government after 2015, Kathmandu is taking the disproportionate burden of population since all essential modern facilities are located in Kathmandu valley. Therefore, Gangabu Bus park, Tribhuwan Airport domestic terminal and Thankot Check-post located in Kathmandu valley were considered for surveying. Also, few data were collected from Pokhara and Bharatpur. Intercity traveller were selected randomly for interview. Detailed questionnaire inquiring system, user and socio-economic attributes likes travel cost, travel time, age, sex, marital status, income, safety /comfort/reliability perception, destination of intercity traveller were collected. Distance between origin and destination was calculated based on land distance obtained from google maps. For maximum of 25 factors, formula given by Greene [6], i.e. 50+8m, where m is number of factors gives minimum sample size of 250. A total of 429 individuals were asked for interview. 27 samples were rejected due to unreliable answers. Out of remaining, 259 bus users, 252 air travellers and 191 car users were interviewed for survey. The bar plot of choice distribution is shown in Figure 1.

Different types of data collected during survey are briefly discussed below:

1. Choice Situation: It is dependent variable in model and represents revealed choices of respondents. Choice situation in this research are 'Bus', 'Plane' and 'Car'.

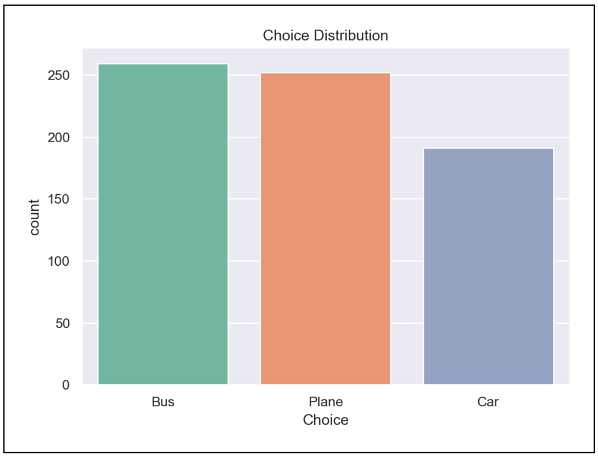

Figure 1: Choice Distribution

2. Distance: It is land distance between origin and destination of travel mode.
3. Travel Time: It is continuous variable. Total travel time is sum of vehicle time and access egress time. For, Air Travel waiting time is added in total travel time. Categorical access egress data are converted to continuous variable by adding random Gaussian noise.
4. Travel Cost: Travel Cost is variable which is representative of cost required for travel(ticket cost). For automobile, it is cost of fuel required for journey if the traveller owns the vehicle. For the traveller hiring car, travel fare is travel cost.
5. Safety: It is ordinal variable on likert scale where scale 1,2,3 corresponds to 'high', 'moderate' and 'low' respectively.
6. Comfort: It is ordinal variable on likert scale where scale 1,2,3 corresponds to 'high', 'moderate' and 'low' respectively.
7. Reliability: It is categorical variable with three categories of high reliability, medium reliability and low reliability.
8. Age: Age is recorded as categorical variable. It is converted to continuous variable by adding Gaussian noise.
9. Cost Bearer: It is categorical binary variable with two option self and office.
10. Employment: It is categorical variable with 'Unemployed', 'Government Job', 'Student', 'Private Job', 'Entrepreneur', 'Self employed' as option.
11. Travel Purpose: It is categorical variable with categories of 'Social', 'Tourism', 'Office' and 'Other'.
12. Travel Partner: It is categorical variable with categories of 'Alone', 'With Family' and 'With Friend'.
13. Frequency: It is categorical variable which denotes the number of similar trip made by user in one year.
14. Income: It is collected as interval data. For analysis, it is then converted into continuous data by adding Gaussian Noise.

4. Data Analysis

Data collected from survey questionnaire were transferred into excel spreadsheet. Some questionnaire where surveyor didn't give reasonable answer were omitted. This spreadsheet data was converted to R-package wide data-frame. To create choice situation for alternative mode, imputation of data was done by mice package of R Statistical software. Different imputation technique like polyrog, norm, rainforest were used for imputation of travel cost, travel time, comfort, reliability and safety data to get complete data of choice experiments. Then R programming language library mlogit was used for mixed logit and probit model analysis. Different categorical and continuous variables are used for analysis. For convergence of model and make analysis easier, different variables like distance, travel cost and income are normalized. All analysis shown in this paper is done in per 100 Km distance, Travel cost per Nrs. 1000, and annual income per Nrs. 1,00,000. Correlation analysis was done for all independent numerical variables like distance, travel time, age, income and travel cost. As shown in Figure 2, there is strong correlation between Travel time and Distance. Therefore, independent variable distance is excluded in developing model to avoid multi-co linearity.

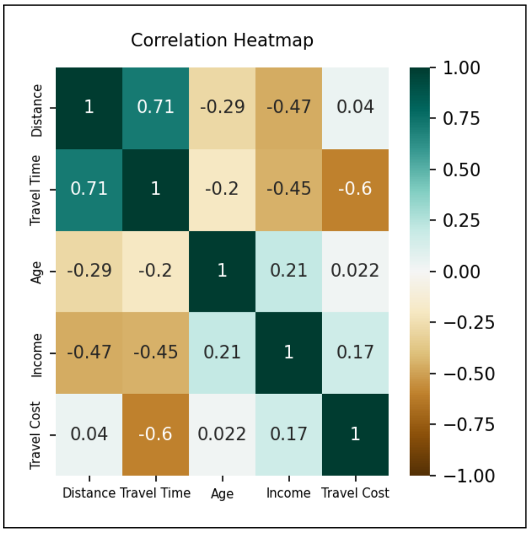

Figure 2: Correlation Heat-map for Continuous independent variable

Details of different variables are given in Table 1.

Table 1: Variables used in analysis

Variables	Descriptions
Mode Choice	Bus, Plane, Car
Purpose	Tourism, Social, Office Works
Children below 5	No Children, Children
Travel Partner	Self, Family, Friends
Cost bearer	Self, Office
Distance	Continuous
Travel Cost	Continuous
Return Trip	Yes,No
Travel Time	Continuous
Frequency	0,1,2,3
Reliability	Low,Medium, High
Gender	Male, Female
Family Size	Continuous
Marital Status	Married, Unmarried
Income	Continuous
Age	Continuous
Comfort	1,2,3 ranked in decreasing order
Safety	1,2,3 ranked in decreasing order

4.1 Limitation of Multinomial Logit

Multinomial logit model makes an 'independence of irrelevant alternatives' assumptions which restricts equal cross elasticities due to change in an attribute affecting only the utility of an alternative 'i' for all alternatives $j \neq i$. This property of equal proportionate change of unchanged modes is highly unlikely to represent mode choice behavior in practical cases [7]. Despite providing very elegant and computationally easier method of intercity modelling, is subject to limitations of random taste variation, restrictive substitution patterns(IIA assumptions) and cannot handle panel data. Therefore probit and mixed logit model is more popular cutting edge method for choice modelling.

4.2 Probit Model

Probit model addresses all these limitations, i.e. it can handle random taste variation, completely relaxes IIA property and is applicable to panel data with temporally correlated errors. Probit model is derived under assumptions of jointly normally distributed unobserved utility components.Like in logit model, utility is decomposed into observed and unobserved parts:

$$U_{nj} = V_{nj} + E_{nj} \quad \forall j$$

Consider the vector composed of each $\epsilon'_{nj} = \langle \epsilon_{n1}, \epsilon_{n2}, \ldots, \epsilon_{nj} \rangle$. In Probit model, we assume that ϵ_n is normally distributed with mean vector of zero and covariance matrix Ω. The density of ϵ_n is given by:

$$\phi(\epsilon_n) = \frac{1}{2\pi^{j/2}|\Omega|^{1/2}} e^{-\frac{1}{2}\left(\epsilon'_n \Omega^{-1} \epsilon_n\right)}$$

The Choice probability is:

$$P_{ni} = \text{Prob}\left(V_{ni} + \epsilon_{ni} > V_{nj} + \epsilon_{nj} \,\forall\, j \neq i\right)$$
$$= \int I(V_{ni} + \epsilon_{ni} > V_{nj} + \epsilon_{nj}) \,\forall\, j \neq i)\phi(\epsilon_n)\, d\epsilon_n$$

Where I(.) is indicator function of whether the statement in parentheses holds. I(.) values is 1 for true statement and 0 for false statements. The integral is over all values of en. This integral does not have closed form solution, and it must be numerically simulated [7].

4.3 Mixed Logit Model

Mixed logit model probabilities are the integral of standard logit probabilities over a density of parameters. A mixed logit model probabilities can be expressed in following form:

$$P_{ni} = \int L_{n_i}(\beta) \cdot f(\beta)\, d\beta$$

Where, $L_{ni}(\beta)$ is the logit probability evaluated at parameters (β)

$$L_{ni}(\beta) = \frac{e^{V_{ni}(\beta)}}{\sum_{j=1}^{n} e^{V_{nj}(\beta)}}$$

And, $f(\beta)$ is a density function. $V_{ni}(\beta)$ is a portion of utility, which is dependent on parameters of model β. For linear utility, $V_{ni}(\beta) = \beta' \cdot X_{ni}$.

In this case, the mixed logit probability takes its usual form:

$$P_{ni} = \int \frac{e^{\beta' \cdot X_{ni}}}{\sum_j e^{\beta' \cdot X_{nj}}} \cdot f(\beta)\, d\beta$$

And, density function $f(\beta)$ can be triangular(t), uniform(u), normal(n),log-normal(ln), zero censored normal(cn) and other distribution depending on real life situation.

5. Results

First different base models were created by trying different combinations of independent variables. Lickert scale variable likes safety and comfort were not significant at 5 percent significance level. Also, marital status, gender, return trip, travel partner were found to be insignificance at 5 percent significance levels. Therefore, final models were made without including these insignificant variables. Travel time and Travel cost are modelled as generic variable while distance, cost bearer, employment, reliability, income, age are considered as mode specific variables. One Probit model and two mixed logit model (triangular mixing distribution and uniform mixing distribution) model are built for analysis. Bus mode is taken as reference mode for analysis.

5.1 Results of Probit Model

The summary of probit model for mode choice is shown in table 2.

In this model, travel cost is represented as a generic variable, whereas travel time, income, trip purpose, and employment type are treated as mode-specific variables. The travel cost coefficient indicates that the utility of the model decreases as the cost of the mode increases. The travel time coefficients for both planes and cars are negative and significant at the 5 percent significance level. For trips made for official purposes, individuals tend to choose planes over buses, with a log-odds factor of 2.058. When the cost of the trip is covered by the office, travelers prefer planes to buses by a log-odds factor of 2.714 at the 5 percent significance level. Similarly, government employees are more likely to choose planes over buses, with a log-odds factor of 4.108. For tourism-related trips, travelers prefer planes over buses by a log-odds factor of 1.268. The income coefficient is positive and significant at the 5 percent significance level, with a value of 1.904, indicating that higher-income travelers prefer planes over buses. The value of time is determined by dividing the travel time coefficient by the travel cost coefficient. For plane travelers, the value of time is calculated to be NRs. 701.20 per hour. This figure significantly exceeds the average earnings of the typical Nepali citizen, suggesting that plane travel is predominantly accessible to high-earning individuals and professionals. Furthermore, it implies that the majority of plane travelers likely belong to higher income brackets or have their travel expenses subsidized by their employers or other entities. This considerable disparity underscores the exclusivity of air travel in Nepal, highlighting its limitation to a more affluent segment of the population.

For automobiles, i.e cars, the intercept value is found to be insignificant at the 5 percent significance level. Conversely,

Table 2: Model A: Probit Model

Variable	Coefficient	Z-Value
Generic Variable		
Travel_Cost	**-1.158**	**-5.848(***)**
Coefficient: Plane		
(Intercept)	**-0.952**	**-0.753**
Travel_Time	**-0.812**	**-1.97(*)**
Income	**1.904**	**4.030(***)**
Trip_Purpose:Office	**2.058**	**4.137(***)**
Trip_Purpose:Social	**0.3804**	**0.445**
Trip_Purpose:Tourist	**1.268**	**2.153(*)**
Trip_Partner:Alone	**-0.084**	**0.1828**
Trip_Partner:Family	**-0.497**	**-0.9715**
Cost_Bearer:Office	**2.714**	**5.987(***)**
Cost_Bearer:Self	**-17.71**	**0.999**
Employment:Business	**4.846**	**5.284(***)**
Employment:Gov	**4.1086**	**4.788(***)**
Employment:Private	**3.864**	**4.372(***)**
Employment:Self	**2.348**	**2.588(**)**
Employment:Student	**2.045**	**2.202(*)**
Coefficient: Car		
(Intercept)	**-13.87**	**-0.0046**
Travel_Time	**-0.711**	**-4.97(**)**
Income	**2.464**	**2.905(**)**
Trip_Purpose:Office	**-1.945**	**-1.8815(.)**
Trip_Purpose:Social	**1.440**	**1.79(.)**
Trip_Purpose:Tourist	**1.781**	**1.874(.)**
Trip_Partner:Alone	**-2.639**	**-3.54(***)**
Trip_Partner:Family	**-0.284**	**-0.432**
Cost_Bearer:Office	**-0.378**	**-557**
Cost_Bearer:Self	**7.93**	**0.0002**
Employment:Business	**2.206**	**0.0073**
Employment:Gov	**1.93**	**0.0064**
Employment:Private	**2.051**	**0.0067**
Employment:Self	**1.95**	**0.0064**
Employment:Student	**1.034**	**0.0003**
Log-Likelihood = -215.19		
McFadden Pseudo R-Square = 0.718		
Value of Time(Plane Travel) = Nrs.701.20 per hour		
Value of Time(Car Travel) = Nrs.613.98 per hour		

the travel time coefficient is negative (-0.711) and significant at the 5 percent significance level, consistent with our expectation that increase in travel time reduces utility of mode. Similar to plane travelers, the income coefficient is positive and significant at five percent significance level. Notably, the income coefficient for cars is higher than that for planes. The coefficients for trip purposes, such as office and social trips, are significant at the 10 percent significance level. Additionally, the coefficient for traveling alone is -2.639, indicating that individuals traveling alone are less likely to use a car compared to a bus, by a log-odds factor of 2.639. The value of travel time for car users is NRs. 613.98, which is low compared to plane travel. This can be attributed to the fact that plane travel in Nepal is generally undertaken in emergency situations, where travelers are willing to pay a higher fare.

5.2 Results of Mixed Logit Model(Triangular Dist.)

Second model developed for analysis is mixed logit model where mixing distribution is triangular distribution. Only generic variable considered is travel cost. Travel Time, Income, Age and Trip Purpose is taken as mode specific variable. Result summary of this model is shown in table 3.

In contrast to the probit model, the intercept terms for both plane and car modes are significant in this model. The intercept value for planes (1.587) is significant at the 5 percent level, indicating a log-odds of 1.587 for choosing a plane over a bus. This finding is likely due to planes being more reliable, faster, and more comfortable compared to buses. Both travel cost and travel time coefficients are negative, suggesting that increases in travel cost and time decrease the utility of the mode. The coefficients for trip purpose (office, social, and tourism) are positive and significant, indicating a preference for planes over buses for these types of trips. The coefficient for age is positive (0.0164) and significant, showing that older individuals are more likely to prefer planes over buses. The income coefficient is also positive and significant, indicating that individuals in higher income brackets are more likely to choose planes over buses, with a log-odds factor of 1.994. The value of time for plane travelers, as derived from this model, is NRs. 942.94, which is higher compared to the probit model.

For automobiles i.e. car, intercept value is 1.704. This indicates, provided every thing is same, traveller prefers car over bus by log odd factor of 1.704. Income coefficient is positive and higher compared to Plane, showing that likelihood of choosing car over bus increases with increase in income. For official trip, people are not likely to prefer car over bus. Individuals are more inclined to chose car over bus for social and tourism related trip. Value of time, according to this model, for car user is Nrs. 760.72. Similar to plane traveller, this value of travel time far exceeds the average earnings of a typical Nepali, indicating that car usage is limited to a specific group of high-income individuals.

Table 3: Model B: Mixed Logit (Triangular Distribution)

Variable	Coefficient	Z-Value
Generic Variable		
Travel_Cost	**-1.0043**	**-6.3075(***)**
Travel_Cost(SD)	**0.1778**	**0.3487**
Coefficient: Plane		
(Intercept)	**1.587**	**2.2022(*)**
Travel_Time	**-0.947**	**-2.2656(*)**
Income	**1.994**	**5.0355(***)**
Age	**0.0164**	**2.058(*)**
Trip_Purpose:Office	**2.801**	**6.507(***)**
Trip_Purpose:Social	**0.301**	**0.778**
Trip_Purpose:Tourism	**1.441**	**3.279(***)**
Coefficient: Car		
(Intercept)	**1.704**	**1.772(.)**
Travel_Time	**-0.764**	**-5.847(***)**
Income	**2.717**	**3.6872(***)**
Age	**0.0582**	**4.884(***)**
Trip_Purpose:Office	**-0.395**	**-0.4930**
Trip_Purpose:Social	**1.964**	**2.984(**)**
Trip_Purpose:Tourism	**2.314**	**3.097(**)**
Log-Likelihood =-351.3		
McFadden Pseudo R-Square = 0.524		
Value of Time for plane user = Nrs. 942.94 per hour		
Value of Time for car user = Nrs. 760.72 per hour		

5.3 Results of Mixed Logit Model(Uniform Dist.)

The third model developed for analysis is the mixed logit model, utilizing a uniform mixing distribution. Similar to the previous mixed model, the generic variable is travel cost. Result summary of this model is shown in Table 4. The travel cost coefficient is -0.991, indicating that the utility of the model decreases as travel costs increase. The intercept value for planes is positive and significant at the 5 percent significance level, indicating that, all else being equal, the log-odds of choosing a plane over a bus is increased by a factor of 2.036. This preference can be attributed to the comfort, reliability, and shorter travel times offered by air travel. Consistent with the probit model, the income coefficient for planes is positive and significant at the 5 percent significance level. Additionally, the coefficients for age and trip purpose (office, tourism) are positive and significant at the 5 percent significance level. The value of travel time for the plane mode is NRs. 961.15, which is slightly higher than the value provided by the triangular mixed model.

For automobiles (cars), the results from the uniform mixed model are similar to those from the triangular mixed model. Individuals tend to prefer cars over buses for long journeys, with a log-odds factor of 3.78 at the 5 percent significance level. The travel time coefficient is negative and significant at the 5 percent significance level. Consistent with previous models, the income coefficient is positive and significant. Additionally, the coefficients for trip purpose (social and tourism) are positive and significant, mirroring the previous model. The value of time for car users is NRs. 754.79, which is slightly higher than the value given by the triangular model.

Table 4: Model C: Mixed Logit (Uniform Distribution)

Variable	Coefficient	Z-Value
Generic Variable		
Travel_Cost	**-0.991**	**-6.505(***)**
Travel_Cost(SD)	**0.097**	**0.2725**
Coefficient: Plane		
(Intercept)	**2.0366**	**3.035(***)**
Travel_Time	**-0.9525**	**-2.317(*)**
Income	**2.0784**	**5.637(***)**
Trip_Purpose:Office	**2.808**	**6.945(***)**
Trip_Purpose:Social	**0.333**	**0.94**
Trip_Purpose:Tourism	**1.413**	**3.340(***)**
Coefficient: Car		
(Intercept)	**3.7865**	**4.3348(***)**
Travel_Time	**-0.748**	**-6.203(***)**
Income	**2.935**	**4.1972(***)**
Trip_Purpose:Office	**-0.503**	**-0.675**
Trip_Purpose:Social	**2.003**	**3.423(***)**
Trip_Purpose:Tourism	**2.116**	**3.1421(**)**
Log-Likelihood =-364.13		
McFadden Pseudo R-Square = 0.524		
Value of Time for plane user = Nrs. 961.15 per hour		
Value of Time for car user = Nrs. 754.79 per hour		

5.4 Two Generic Variable model

All previous models are developed by taking only travel cost as generic variable. Generally, both travel cost and travel time are taken as generic variable for analysis. The result of this model is shown in Table 5. Here, travel time coefficient is found to be positive, which is counter-intuitive result. Other result predicted by this model is rougly similar to previous model. The value of time for intercity travel in general obtained by this model is Nrs. 228.54, which is roughly similar to other developing country.

Table 5: Model D) Two Generic Variable Model

Variable	Coefficient	Z-Value
Generic Variable		
Travel_Cost	**-1.282**	**-5.640(***)**
Travel_Time	**0.293**	**5.021(***)**
Coefficient: Plane		
(Intercept)	**4.666**	**5.165(***)**
Income	**2.588**	**3.004(**)**
Trip_Purpose:Office	**4.35**	**4.850(***)**
Trip_Purpose:Social	**0.206**	**0.387**
Trip_Purpose:Tourism	**2.022**	**3.18(***)**
Age	**0.018**	**1.611**
Coefficient: Car		
(Intercept)	**-0.716**	**-0.781**
Income	**4.278**	**3.86(***)**
Trip_Purpose:Office	**0.875**	**0.9385**
Trip_Purpose:Social	**1.168**	**1.98(*)**
Trip_Purpose:Tourism	**2.715**	**3.69(**)**
Age	**0.031**	**4.368(***)**
Log-Likelihood =-357.02		
McFadden Pseudo R-Square = 0.5334		
Value of Time = Nrs. 228.54 per hour		

6. Discussions

McFadden Pseudo R square of all three model are in suitable range of 0.5-0.7. This shows that model is neither over-fitted not under fitted. Travel time coefficient being positive is counter-intuitive result for Model D. Multinomial logit model of intercity travel done by Manmohan Joshi [4] also shows similar results. Further research should be carried out to find out if this is common result among developing and developed countries. This also shows that research from western countries cannot be blindly applied in local context. Higher income consistently leads to preference of air and private mode of transportation. Therefore, as Nepal become more developed, and people starts to earn more, it is certain that people will opt for air travel. This prospect is not good for aim of achieving modal balance and sustainable transport. Therefore government should prioritize and invest in reliable, safe and comfortable mass transit system in Nepal.

7. Limitations

Since the data is collected in Buspark, airport terminal and vehicle leaving valley, perfect choice setup is not established for this research. For ideal choice experiment, experiment should be designed such that interviewees get choice situation before making choice. This is major limitation in this study. Data Imputation is used for filling this gap. Also, data was collected in limited time. More cutting edge model like hereroscedacity mixed logit model can be used for further analysis of data.

References

[1] Shigeru Morichi and Surya Raj Acharya. Strategic perspectives on intercity transport development in asian countries. In *Proceedings of the Eastern Asia Society for Transportation Studies Vol. 8 (The 9th International Conference of Eastern Asia Society for Transportation Studies, 2011)*, pages 17–17. Eastern Asia Society for Transportation Studies, 2011.

[2] Peter L Watson and Richard B Westin. Transferability of disaggregate mode choice models. *Regional Science and Urban Economics*, 5(2):227–249, 1975.

[3] Daniel McFadden. The measurement of urban travel demand. *Journal of public economics*, 3(4):303–328, 1974.

[4] Manmohan Joshi and Surya Raj Acharya. Mode choice modeling for intercity travel in nepal. In *Proceedings of IOE Graduate Conference*, pages 239–246, 2019.

[5] Juan de Dios Ortúzar and Luis G Willumsen. *Modelling transport*. John wiley & sons, 2011.

[6] Samuel B Green. How many subjects does it take to do a regression analysis. *Multivariate behavioral research*, 26(3):499–510, 1991.

[7] Kenneth E Train. *Discrete choice methods with simulation*. Cambridge university press, 2009.