Mode choice analysis and its dependence of Time, Cost, Distance and Purpose of Trip: A case study of wards in South zone of Ahmedabad City

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Abstract – *Mode choice analysis is an important step in the transportation planning. It reflects travel demand of the population. It helps in deciding the policies for transportation, especially the public transportation. It is affected by many factors, including socio-economic characteristics of household like status (a student, a worker ,an office goers, a homemaker, a retired person), income-group, age, and trip characteristics like trip time, trip cost, trip distance, as well as waiting time, egress and access time in case of public transport. This study was for modeling and analysis of mode choice of trip-makers in wards of South zones of Ahmedabad city. The multinomial logit model is used to model the mode choice in the study area. This was done by SPSS Statistics 21.0 package. The model was made with mode used in trips as dependent variable, and trip time, trip cost, trip distance and purpose of trip (factor) as independent variables. The model was able to explain the variation of 40 to 73% in the dependent variable (mode used).). The prepared model was made with 95% confidence interval for selected model. From the analysis, the conclusion found that the two-wheeler is the most preferred mode, and the trip makers used this mode for various purposes (31% for job, 9.2% for education and 16.3% for shopping).*

Key Words: Mode choice, Logit model, Multinomial logit model, SPSS

1. INTRODUCTION

Mode choice modeling is a most important phase in the transportation planning process. It affects the transportation scenario in any particular region. It is the third step after trip distribution, and followed by traffic assignment in the traditional process of transportation planning. Mode choice can be helpful in analyzing the travel demand and travel patterns of population in any city or any region, as well as in deciding the policies related to transportation. Mode choice can be affected by many features like socio-economic characteristics of trip makers (like income, age, gender, status), trip characteristics (origin and destination of trip, distance between origin and destination, trip time, trip cost, as well as access and egress times, waiting times in public transit, and delay in private modes). Besides all these factors, there are various factors like accessibility of trip mode, traffic congestion, comfort in trip, convenience in trip, flexibility in travel (in terms of time and route), which are unable to quantify, but affects the mode choice of any person.

There are various methods available to model the mode choice of trip makers, like Logit and Probit model, Artificial Neural Network, etc. In all these, logit models are widely used in mode choice modeling.

2. TYPES OF MODAL SPLIT/MODE CHOICE MODELS AND ABOUT MULTINOMIAL LOGIT (MNL) MODEL.

The modal split models are basically of two types, which are namely, Aggregate and disaggregate approach. In both of these, the disaggregate approach, also known as discrete approach, is widely used at present. It depends on the choice made by individual traveler, in short, it considers individual separately in modeling of the mode choice.

In the disaggregate model, of First there was binary logit model, in which the choice for travelling was made between two modes. MNL is the extended version of this model. The logit model is based on the utility or disutility of any mode. The utility equation can be explained as:

$U_i = V_{ij} + \varepsilon_{ij}$ ……………………….(1)

In this, the U_{ij} means "Utility which a trip-maker in zone "i" gets by using the mode "j", V_{ij} means the utility or disutility of the average trip maker, and ε_{ij} is the uncertain factors/unobserved part of utility function. The utility equation (equation (2)) can be explained as:

$U \text{ (or } V) = a_0 + a_1x_1 + a_2x_2 + \ldots + a_nx_n$ ………………(2)

Where, a_0 = mode specific attribute,

$x_1, x_2, \ldots x_n$ = criterion considered for mode choice

$a_1, a_2, \ldots a_n$ = weight factors for the criteria

The utility based model is used for estimation of the modal share or probability of choosing a particular mode. The probability of choosing any mode for travel by a particular trip maker can be calculated by the equation (3):

$P_i = e^{U_i} / \sum_{i=1}^{n} e^{U_i}$ ……………………(3)

Where,

P_i = Probability of choosing "i" th mode from "n" number of modes for travelling.

U_i = Utility of "i" th mode.

3. AIM

The main aim of this study is to analyze the mode choice behaviour of the trip-makers in the wards of South Zone in Ahmedabad City.

4. RESEARCH OBJECTIVES

The main objectives of the study are as follows:

1. To identify the behaviour of people to choose the travel mode.
2. To identify the factors affecting the mode choice behaviour of the trip-makers.
3. To review preference survey for trip modes.
4. To prepare MNL model for different modes of transport.

5. SCOPES

For achievement of the above objectives of the study, the scopes are as follows:

1. To perform the household survey, to understand the travel behavior of trip makers.
2. To analyze the mode choice of trip-makers in the study area by MNL model.

6. LITERATURE REVIEW

Many literatures have been developed for mode choice modeling of trip makers. In the study, the specific literatures were reviewed, which are related to mode choice modeling with MNL model.

Ashlatha (2013) had modeled the mode choice behavior of commuters in trip-makers in Thiruvananthapuram (Trivandrum) city using the multinomial logistic approach (multinomial logit model) with help of the SPSS software (Statistical Package of Social Sciences). The Cochran formula was used to estimate the number of sample to be collected, by which they had decided to collect the 739 samples. The questionnaire was designed for home interview of the commuters. The socio-economic variables, transport system variables, and attitudinal variables were considered in the model. Three categories of transport, viz. Two-wheeler, Bus, and Car were considered in MNL model for mode choice, in which the bus was considered as reference category.

Thomas (2016) has also modeled the mode choice of the commuters in Tiruchirapalli city. 10500 people were interviewed with the designed questionnaire by home interview method, in which, the questions related to household characteristics, personal information of individual, information of trips of individual in weekdays as well as weekends, trip frequency, and preference of mode. MNL model was used to model the mode choice. The NLOGIT software was used for modeling the mode choice behavior of commuters. The data was analyzed and the model was formed by the data. The model was found fairly accurate, and maximum use of two-wheeler was there.

Karli (2017) has modeled the work trips in wards in the West zone of Ahmedabad city. Three wards of west zone, namely Navrangpura, Vasna and Paldi were selected as study area. The income groups (LIG, MIG, and HIG) were considered, and the main focus in the study was on workers and students. The MNL model was used for modeling of the trips, which was formed by SPSS. The model was found to be fair accurate, as there was not much difference in percentage use of modes before and after development of model.

Ram Chandra (2016) has modeled the mode choice of regular commuters on a stretch between Park Circus and Garia, situated in Kolkata city. Mode choice was modeled for three modes - Public transit, Intermediate Para transit, and Private transport.. The travel time, travel cost and waiting time were taken for utility function. The MNL model was formed, which was showing that 82% of the trip-makers in the study area were using bus (public transport), whereas, the usage of private vehicle was only 1%.

Muller (2008) had modeled the mode choice for students for trip from home to school as well as the pattern of school choice in urban area. The Dresden city in Germany was selected as study area. The data was collected in 4700 samples, plotted in GIS and analyzed as well as disaggregated after collection on district scale.

B. Haque (2012) has modeled for school trips in the Sylhet city of Bangladesh. Two schools situated in city were selected as study area by stated preference survey in two stages: The stated preference was consisting of a new transport mode of school-bus in the city, which was of either bus for individual school, or a combined bus for two or more schools. The model was made in BIOGEME package. Most of the trip-makers found to prefer the individual school bus system, but a suggestion was also given for combined system for schools as it can be best suited for the city.

Asadi (2016) has modeled the mode shift to public transport and mode choice in Guntur city of Andhra Pradesh, with logit model. The binary logit model was used in transit shift modeling and the multinomial logit model was used in mode choice modeling respectively. The mode choice model has resulted that the Intermediate Para transit is having the maximum usage in the study area, whereas the transit shift model has showed that most of the trip makers are having the willingness to shift to the Public transit mode if the walking distance, waiting time, and bus frequency is at its optimum level.

Tushara (2013) has modeled the mode choice for the work trips in the Calicut city in Kerala. The study was done to identify the various variables affecting the mode choice of employees and to develop a model for mode choice in work trips. The model was formed for three types of modes: Car, Bus, and Two-wheeler, where the two-wheeler was taken as a reference category. By this, the main factors affecting the work trips in the study area were age, gender, income, time, two-wheeler ownership, trip time and cost. Maximum employees, who possessed the driver license, and aged in between 18-35, and included in middle income group, were using the two-wheeler.

Philip et al (2013) has modeled the trips based on the activity of the trip makers in the rural area near Kochi city in Kerala. The middle class residents were aimed for the mode choice modeling. The mode choice model was made in SPSS software, based on the trip time, trip cost, vehicle ownership, and license possession as the independent variables. The model was validated and found accurate.

7. STUDY AREA PROFILE

- Ahmedabad city is an important city for long times in Gujarat state. It is having the metropolitan status. The population of Ahmedabad city is 8 millions (as per 2018), with growth rate of 2.98%. The city is having vehicle population of 2 crores (as per year 2017-18), which shows that a person in Ahmedabad is having approximately 2 to 3 vehicles. The modal share of Ahmedabad city (as per 2015) is as per the table given below:

Table 1 - Existing Modal Share of Ahmedabad city

(Source: "Detailed project report for Ahmedabad metro rail project (phase – I)"; 2015)

Mode shares	**Percentages**
Walk	37.2
Bicycles	9.0
Two-wheelers	25.9
Car	3.9
Auto-rickshaw	6.1
AMTS (Bus)	10.3
BRTS	1.1
Others (School bus, Staff bus, GSRTC, Rail)	6.3
Total	*100.0*

- The city is having 5 zones, namely North zone, East zone, South zone, West zone, and New West zone.

- The study was focused on the two wards of the south zone. This zone consists of the following wards, which are namely Khokhra, Maninagar, Danilimda, Baherampura, Lambha, Vatva, Indrapuri.

- The study is concentrated on trip makers in Khokhra and Maninagar.

8. DATA COLLECTION

The household numbers were obtained by the Cochran's formula[12], which can be described as follows:

$$n_0 = Z^2pq/e^2 \ ; \ n = n_0/(1+((n_0 - 1)/N)) \ldots\ldots(4)$$

Where, n_0 = sample size for infinite population
Z = statistical parameter corresponding to confidence level
e = desired margin of error
p = hypothesized true proportion for population
q = 1 - p

According to Indian census, the confidence interval is taken as 95%, and margin of error should be taken as 5%. The value of Z is taken as 1.96 for C.I. = 95%. From the census data, the sample size of household survey was selected. The 388 households were to be interviewed according to the formula, but for more accuracy, the 500 households were interviewed and revealed preferences were also surveyed. The socio-economic characteristics and trip characteristics of households were included in the data.

9. DATA ANALYSIS

The collected data was then classified in the variables related to socio-economic characteristics (age, income, status, income) and trip variables (trip origin, trip destination, mode used in trip, distance covered in trip, trip time, trip cost, mode preferred for trip and reason for preference for any mode). Along with this, the separate analysis was also done for the mode choice of trip makers belonged to the particular classes. All of these can affect the mode choice. The share of trip makers in all the categories is shown in the figures below.

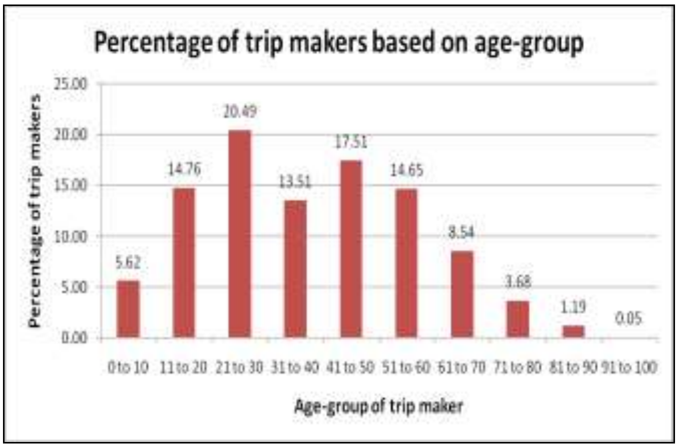

Figure 1 - Percentage share of trip makers based on age groups

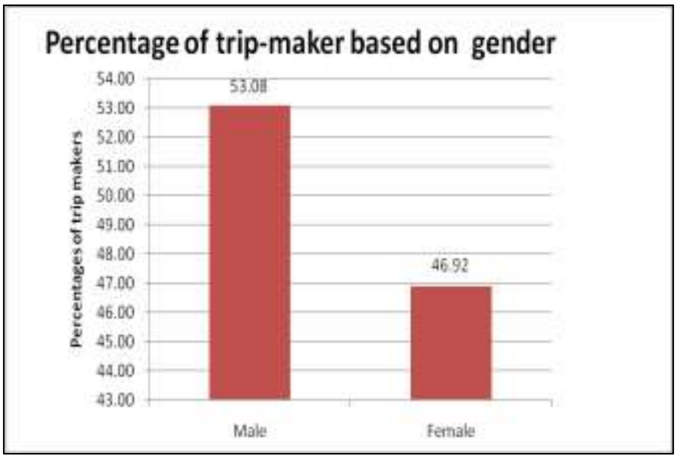

Figure 2 - Percentage share of trip makers based on age groups

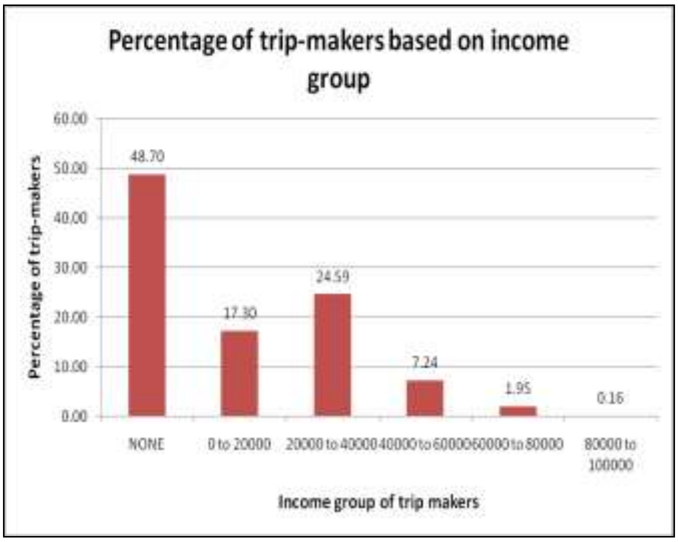

Figure 3 - Percentage share of trip makers based on income groups

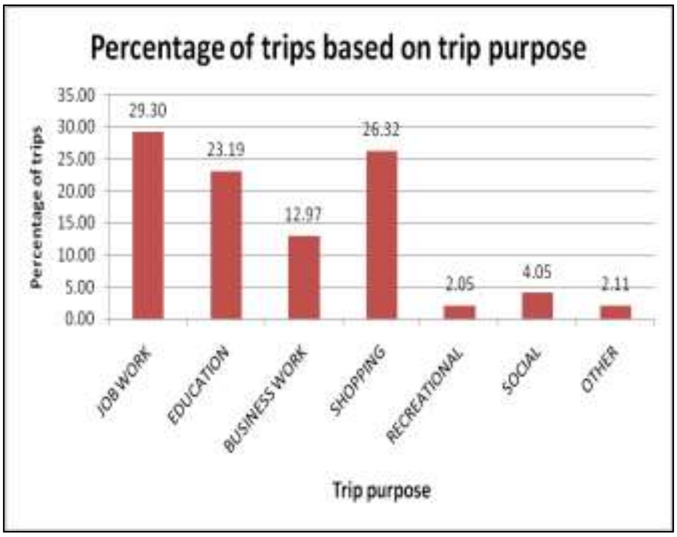

Figure 4 - Percentage share of trip makers based on income groups

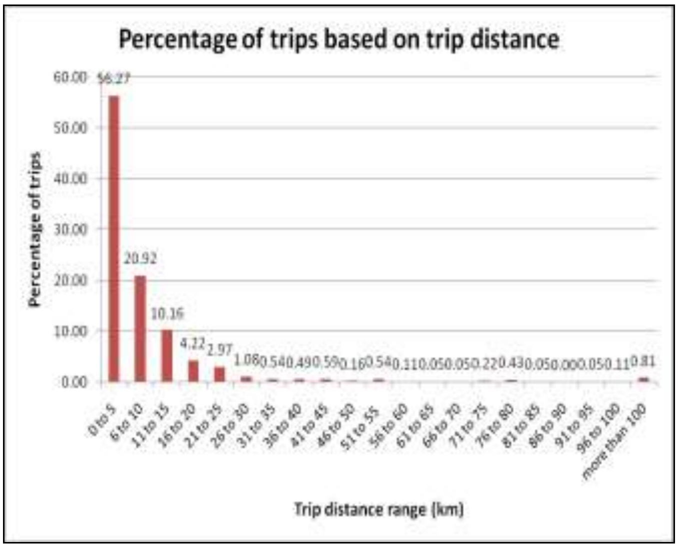

Figure 5 - Percentage share of trip makers based on trip distance

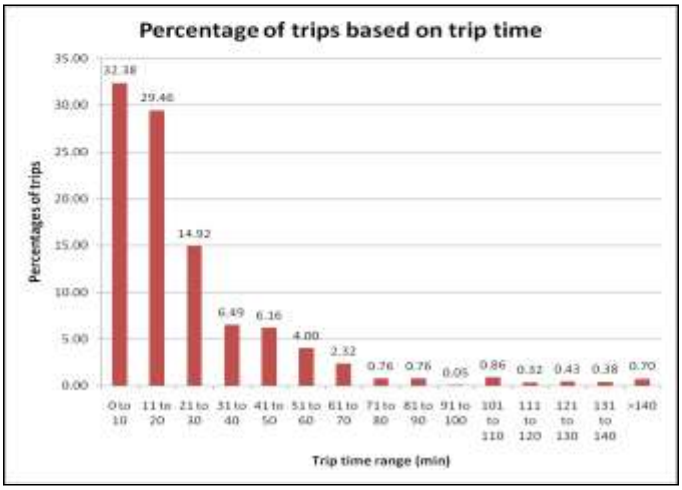

Figure 6 - Percentage share of trip makers based on trip time

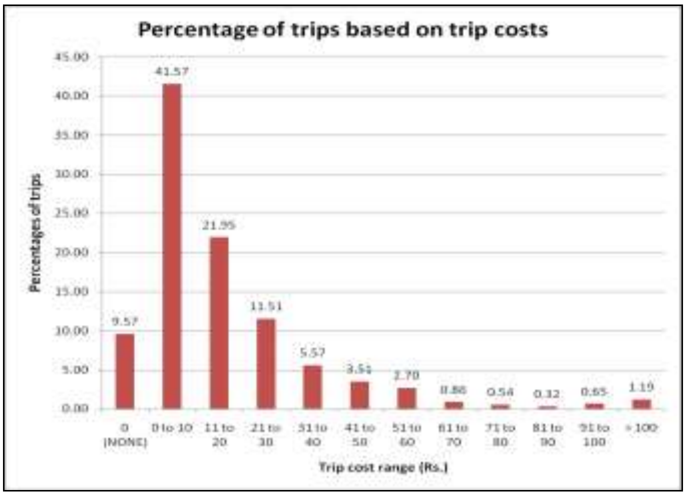

Figure 7 - Percentage share of trip makers based on trip cost

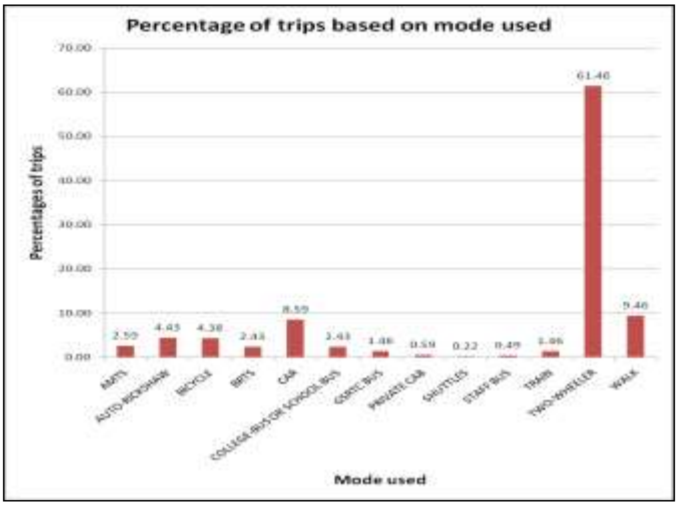

Figure 8 - Percentage share of trip makers based on trip mode used

Along with the mode used presently by the trip makers, the preference given to any mode and the reason for preference to any mode has also been asked to the trip makers, as some trip makers can prefer the mode, which can be different from the mode presently being used by him/her. The mode preference can be affected by various factors, which can vary with person to person.

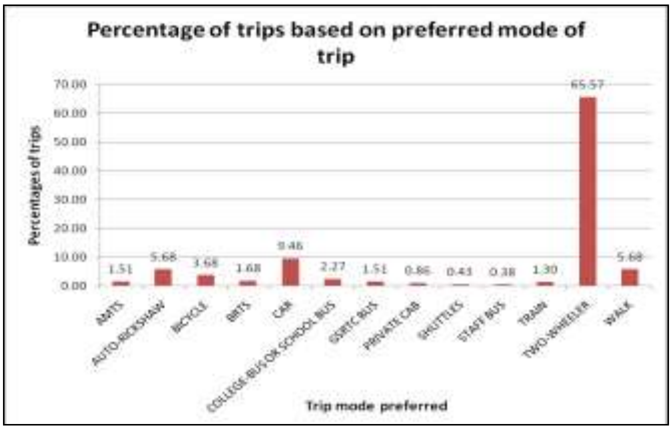

Figure 9 - Percentage share of trip makers based on trip mode preferred

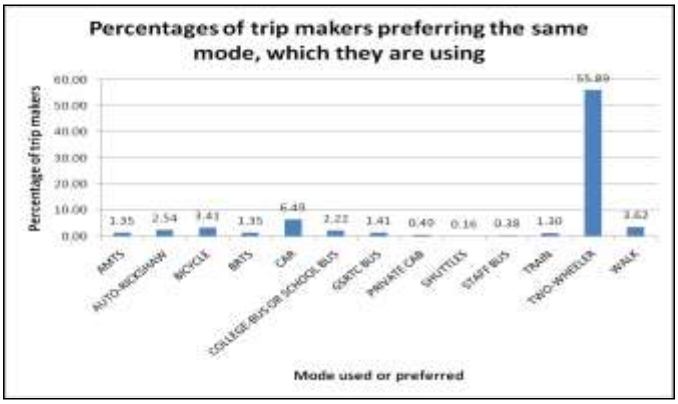

Figure 10 - Percentage share of trip makers based on similarity in trip mode used and preferred

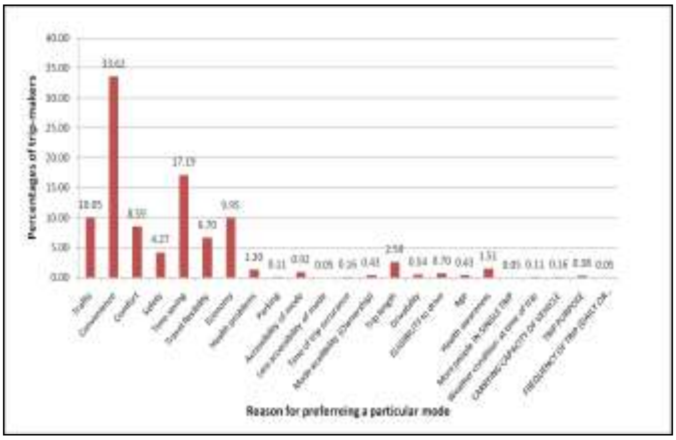

Figure 11 - Percentage share of trip makers based on main reason to preferring any mode

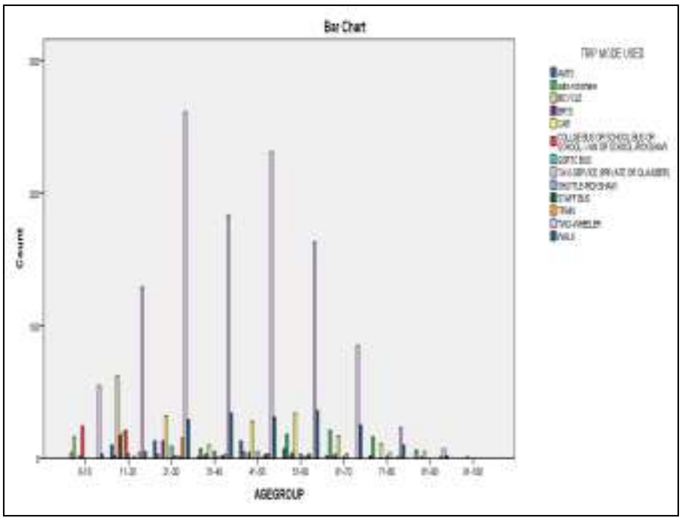

Figure 12 - Distribution of modes used for different age groups of the trip makers

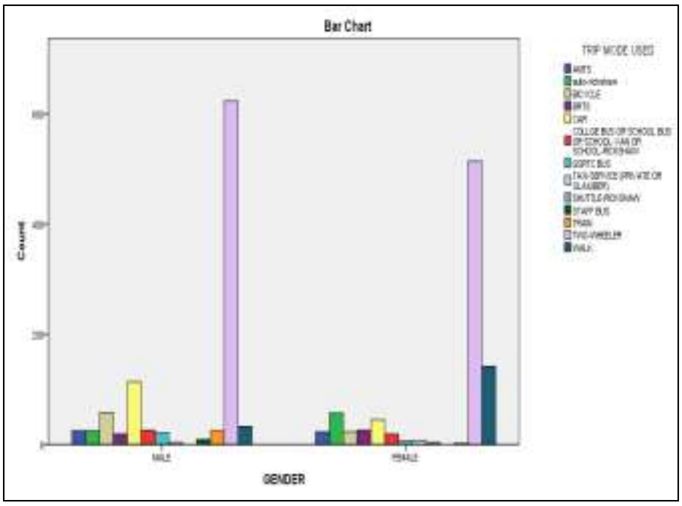

Figure 13 - Distribution of modes used for different age groups of the trip makers

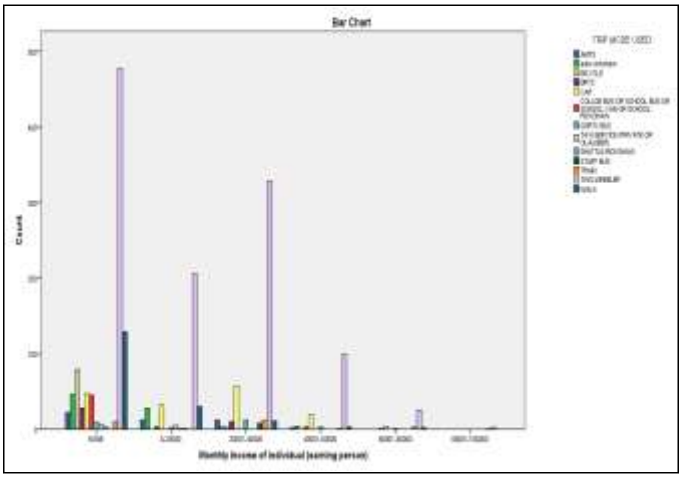

Figure 14 - Distribution of modes used for different income groups of the trip makers

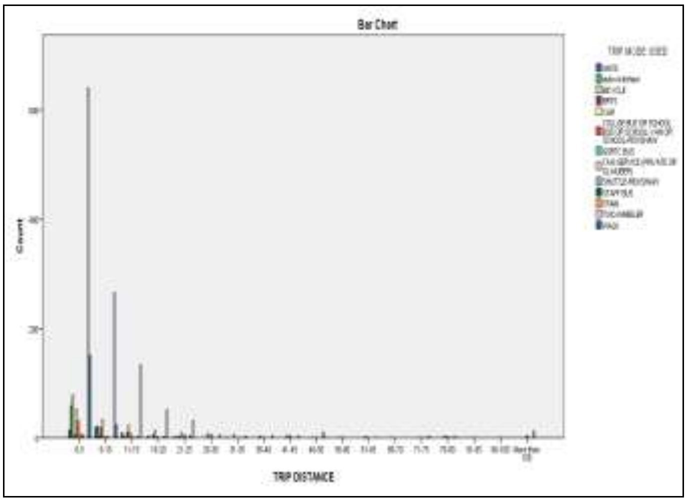

Figure 15 - Distribution of modes used for different trip distance ranges

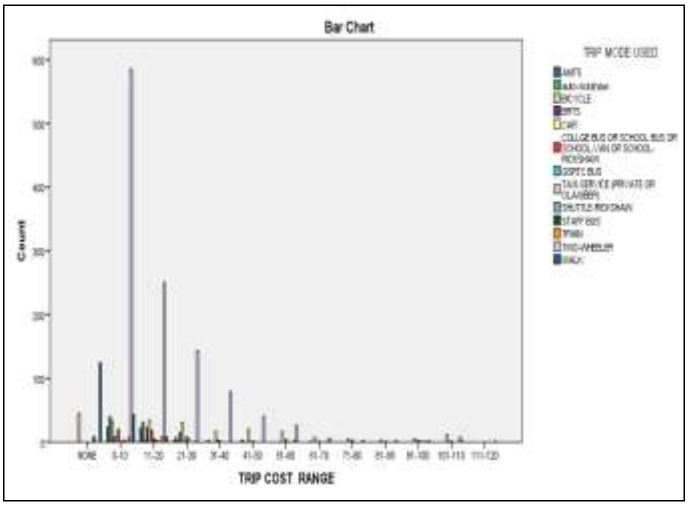

Figure 16 - Distribution of modes used for different trip cost ranges

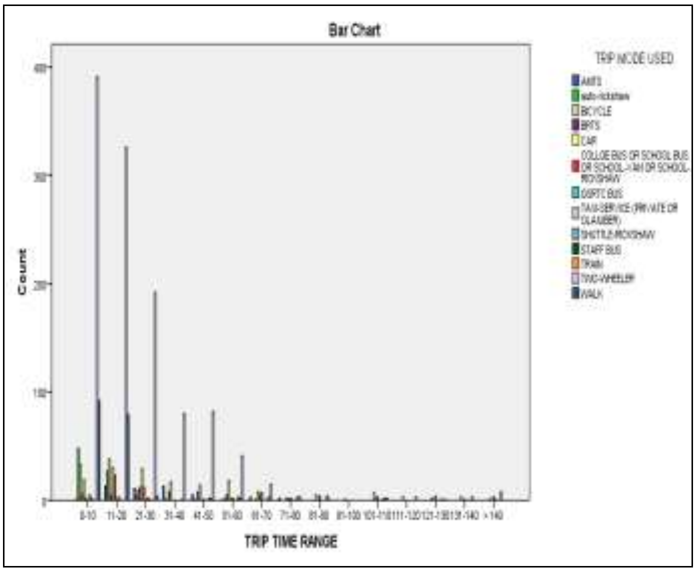

Figure 17 - Distribution of modes used for different trip time ranges

The results and interpretations from the graphs above are shown in following section.

10. RESULTS FROM DATA ANALYSIS

The following results were come from analysis of the collected data:

- 91% in the total trip makers are using the two-wheeler for their trips.
- Maximum of the trip makers are aged between 21 to 30 years, which is 20% of all. It is followed by trip makers between 41 to 50 years, which is 18%.
- The male trip makers are 53%, which is 6% more than the female trip makers.
- Around 66% trip makers are choosing two-wheelers for their trips.
- In all trip purposes, the purpose for which maximum trips are made is the job. These trips are 29% in total. The second highest trips made for a purpose are shopping trips, which are 26% in the total.
- In the trips based on the monthly income group, the group with no income (consisting of retired persons, home-makers, students) is having the maximum (49%) trips. This group is followed by group with monthly income ranged in 20000 to 40000 rupees, which makes 25% of total trips.
- 56% trip makers have the trips ending in 5 km or less.
- In all trips, the maximum trips are completing in the time of 0 to 10 minutes (32% of the total). This value is followed by the trips completing in 11 to 20 minutes.

- The trips costs 10 rupees or less are maximum (42% of the total) in all the trips.
- 65% of the trip makers give their preference to two-wheelers, and the 34% of the total trip makers prefer their mode based on convenience.
- 81% of the trip makers prefer the same mode they are using presently.
- 21 % of the total trip makers are making their trip on two-wheeler in time of 10 minutes or less.
- 35% of the total trips are made on two-wheelers in the distance of 10 km or less.
- 31% of the total trips are the job work trips made in two-wheelers.
- 32% of the total trips are made on two-wheeler with the cost of 10 rupees or less.
- 14% of the total trips are the trips made in two-wheelers by persons aged between 21-30 years.
- 48% of the total trips are made by non-income group on two-wheeler.
- The more preference is given to the two-wheelers, as some persons, who are not using the two-wheeler presently, are also prefer the two-wheeler for their trip.
- The two-wheelers are more preferred for convenience by the trip makers.

11. MODEL DEVELOPMENT

Based on this, the multinomial logit model was developed by SPSS software, after entering the data in software. The mode used was considered as the dependent variables, and the trip time, trip cost, trip distance, and trip purpose was considered as the independent variables or the predictors. The utility equation of the model was as following:

$$U = a_0 + a_1(trip\_time) + a_2(trip\_cost) + a_3(trip\_distance) + a_4[trip\_purpose = 1] + a_5[trip\_purpose = 2] + a_6[trip\_purpose = 3] + a_7[trip\_purpose = 4] + a_8[trip\_purpose = 5] + a_9[trip\_purpose = 6] + a_{10}[trip\_purpose = 7] \quad (5)$$

The statistical tests were performed on the model, which are given in the table 2 and 3. Table 2 (of model fitting information) indicates the results of likelihood test against the null hypothesis, where the parameters are set to zero value, and only intercept exists. The likelihood ratio chi-Square statistic is equal to "[-2*L(null model) – (-2*L(fitted model))]", in which, "L(null model)" is from the log likelihood with just the response variable in the model (Intercept Only) and "L(fitted model)" is the log likelihood from the final iteration (assuming the model converged) with all the parameters. The term "df" indicates the degrees of freedom of the chi-square distribution used to test the Likelihood Ratio Chi-Square statistic and is defined by the number of predictors in the model. The models are shown in table 4, and the interpretations from values in the table 4 are given in below. In these values, the Exp (B) value, called as "odds ratio", is important for modeling, as this value indicates the ratio of independent variable of a particular category to that of the reference category. The model should have the significance value equal to or less than 0.05 if the confidence interval of the model is 95%.

The significance and ability of explanations of variations can be checked by the pseudo R-square values. Three pseudo R^2 values are obtained in the multinomial logit model, namely, Cox and Snell pseudo R^2, Nagerkelke pseudo R^2, and McFadden pseudo R^2. In all these, the Cox and Snell pseudo R^2 acts like R^2 (Co-efficient of Determination - gives an idea of how many data points fall within the results of the line formed by the regression equation). So it is found to be reliable, and higher value of that indicates the higher fit of model. This value has a maximum limit of 1. The model has the pseudo r^2 value of 0.692, 0.730, and 0.398, which means the model can explain the 39.8% to 73% variation in the mode choice in the study area.

Table 2 - Model fitting information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	4171.413			
Final	1993.894	2177.519	108	.000

Table 3 - Likelihood Ratio Tests for model

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	1993.894	.000	0	.
TRIP_TIME_RANGE	1985.386	.	12	.
TRIP_DISTANCE	7921.140	5927.247	12	.000
TRIP_COST__RANGE	2574.192	580.299	12	.000
TRIP_PURPOSE	2677.245	683.351	72	.000

The following table shows the estimates of various parameters used in MNL model.

Table 4 - Estimates of various parameters

Trip mode used[a]		B	S.E.	df	Sig.	Exp(B)
AMTS	Intercept	-2.528	1.060	1	.017	
	TRIP_TIME_RANGE	.615	.115	1	.000	1.850

	TRIP_DISTANCE	-.305	.165	1	.064	.737
	TRIP_COST_RANGE	-.866	.179	1	.000	.420
	[TRIP_PURPOSE=1]	.269	1.074	1	.802	1.308
	[TRIP_PURPOSE=2]	.081	1.084	1	.940	1.085
	[TRIP_PURPOSE=3]	-3.028	2.003	1	.131	.048
	[TRIP_PURPOSE=4]	-1.473	1.158	1	.204	.229
	[TRIP_PURPOSE=5]	1.182	1.303	1	.364	3.262
	[TRIP_PURPOSE=6]	-2.193	4.032	1	.587	.112
	[TRIP_PURPOSE=7]	0^b	.	0	.	.
Auto-rickshaw	Intercept	-.886	.559	1	.113	
	TRIP_TIME_RANGE	-.524	.187	1	.005	.592
	TRIP_DISTANCE	.033	.195	1	.867	1.033
	TRIP_COST_RANGE	.300	.119	1	.012	1.350
	[TRIP_PURPOSE=1]	-2.580	.652	1	.000	.076
	[TRIP_PURPOSE=2]	-2.347	.658	1	.000	.096
	[TRIP_PURPOSE=3]	-2.339	.669	1	.000	.096
	[TRIP_PURPOSE=4]	-.953	.514	1	.064	.386
	[TRIP_PURPOSE=5]	-.226	.806	1	.779	.797
	[TRIP_PURPOSE=6]	1.390	.578	1	.016	4.014
	[TRIP_PURPOSE=7]	0^b	.	0	.	.
Bicycle	Intercept	-3.223	3.537	1	.362	
	TRIP_TIME_RANGE	.352	.170	1	.039	1.421
	TRIP_DISTANCE	-.593	.315	1	.060	.553
	TRIP_COST_RANGE	-1.887	.263	1	.000	.152
	[TRIP_PURPOSE=1]	1.635	3.569	1	.647	5.129
	[TRIP_PURPOSE=2]	4.422	3.528	1	.210	83.289
	[TRIP_PURPOSE=3]	.328	3.723	1	.930	1.388
	[TRIP_PURPOSE=4]	.102	3.600	1	.977	1.107
	[TRIP_PURPOSE=5]	.508	4.880	1	.917	1.662
	[TRIP_PURPOSE=6]	1.097	4.556	1	.810	2.994
	[TRIP_PURPOSE=7]	0^b	.	0	.	.
BRTS	Intercept	-3.294	1.059	1	.002	
	TRIP_TIME_RANGE	.259	.114	1	.023	1.296
	TRIP_DISTANCE	.079	.119	1	.507	1.082
	TRIP_COST_RANGE	-.193	.138	1	.161	.824
	[TRIP_PURPOSE=1]	-.568	1.085	1	.601	.567
	[TRIP_PURPOSE=2]	.277	1.076	1	.797	1.320
	[TRIP_PURPOSE=3]	-3.357	2.133	1	.116	.035
	[TRIP_PURPOSE=4]	-1.533	1.188	1	.197	.216
	[TRIP_PURPOSE=5]	1.635	1.227	1	.183	5.129
	[TRIP_PURPOSE=6]	.976	1.284	1	.447	2.653
	[TRIP_PURPOSE=7]	0^b	.	0	.	.
Car	Intercept	-3.520	.680	1	.000	
	TRIP_TIME_RANGE	.309	.074	1	.000	1.363
	TRIP_DISTANCE	.069	.071	1	.327	1.072
	TRIP_COST_RANGE	.381	.058	1	.000	1.463
	[TRIP_PURPOSE=1]	-1.973	.708	1	.005	.139
	[TRIP_PURPOSE=2]	-1.033	.716	1	.149	.356
	[TRIP_PURPOSE=3]	.176	.691	1	.799	1.192
	[TRIP_PURPOSE=4]	-1.156	.751	1	.124	.315
	[TRIP_PURPOSE=5]	.809	.924	1	.381	2.246
	[TRIP_PURPOSE=6]	2.179	.748	1	.004	8.841
	[TRIP_PURPOSE=7]	0^b	.	0	.	.
College bus or school bus or school-van or school-rickshaw	Intercept	-6.340	4.918	1	.197	
	TRIP_TIME_RANGE	.469	.132	1	.000	1.599
	TRIP_DISTANCE	-.653	.221	1	.003	.521
	TRIP_COST_RANGE	.116	.114	1	.308	1.123
	[TRIP_PURPOSE=1]	-.532	5.060	1	.916	.588
	[TRIP_PURPOSE=2]	4.479	4.918	1	.362	88.159
	[TRIP_PURPOSE=3]	-.444	5.256	1	.933	.642
	[TRIP_PURPOSE=4]	.036	5.062	1	.994	1.037
	[TRIP_PURPOSE=5]	.490	6.754	1	.942	1.632
	[TRIP_PURPOSE=6]	.405	6.423	1	.950	1.499
	[TRIP_PURPOSE=7]	0^b	.	0	.	.
GSRTC bus	Intercept	-9.990	11.653	1	.391	
	TRIP_TIME_RANGE	.400	.100	1	.000	1.491
	TRIP_DISTANCE	.370	.080	1	.000	1.447
	TRIP_COST_RANGE	-.038	.106	1	.717	.963
	[TRIP_PURPOSE=1]	3.481	11.653	1	.765	32.506
	[TRIP_PURPOSE=2]	3.218	11.655	1	.782	24.977
	[TRIP_PURPOSE=3]	4.073	11.661	1	.727	58.736
	[TRIP_PURPOSE=4]	2.513	11.740	1	.830	12.347
	[TRIP_PURPOSE=5]	5.668	11.702	1	.628	289.545
	[TRIP_PURPOSE=6]	6.168	11.684	1	.598	477.405
	[TRIP_PURPOSE=7]	0^b	.	0	.	.
Taxi-service (private or ola/uber)	Intercept	-3.808	.916	1	.000	
	TRIP_TIME_RANGE	.324	.262	1	.216	1.383
	TRIP_DISTANCE	.084	.203	1	.679	1.087
	TRIP_COST_RANGE	.360	.235	1	.126	1.434
	[TRIP_PURPOSE=1]	-6.330	1.954	1	.001	.002

	[TRIP_PURPOSE=2]	-5.293	2.099	1	.012	.005
	[TRIP_PURPOSE=3]	-5.658	3.009	1	.060	.003
	[TRIP_PURPOSE=4]	-1.217	.870	1	.162	.296
	[TRIP_PURPOSE=5]	-.859	1.572	1	.585	.424
	[TRIP_PURPOSE=6]	-.416	1.213	1	.731	.659
	[TRIP_PURPOSE=7]	0^b	.	0	.	.
Shuttle-rickshaw	Intercept	-6.215	15.483	1	.688	
	TRIP_TIME_RANGE	.220	.635	1	.730	1.245
	TRIP_DISTANCE	-2.390	1.949	1	.220	.092
	TRIP_COST_RANGE	.092	.506	1	.856	1.096
	[TRIP_PURPOSE=1]	3.404	15.404	1	.825	30.070
	[TRIP_PURPOSE=2]	3.961	15.385	1	.797	52.485
	[TRIP_PURPOSE=3]	-.125	16.408	1	.994	.882
	[TRIP_PURPOSE=4]	2.561	15.401	1	.868	12.949
	[TRIP_PURPOSE=5]	.751	21.041	1	.972	2.120
	[TRIP_PURPOSE=6]	.398	20.322	1	.984	1.488
	[TRIP_PURPOSE=7]	0^b	.	0	.	.
Staff bus	Intercept	-8.298	7.500	1	.269	
	TRIP_TIME_RANGE	.989	.206	1	.000	2.688
	TRIP_DISTANCE	.078	.148	1	.597	1.081
	TRIP_COST_RANGE	-1.532	.345	1	.000	.216
	[TRIP_PURPOSE=1]	3.067	7.433	1	.680	21.476
	[TRIP_PURPOSE=2]	-2.509	7.674	1	.744	.081
	[TRIP_PURPOSE=3]	-.376	8.049	1	.963	.687
	[TRIP_PURPOSE=4]	.599	7.813	1	.939	1.821
	[TRIP_PURPOSE=5]	-.535	12.475	1	.966	.585
	[TRIP_PURPOSE=6]	1.901	10.939	1	.862	6.692
	[TRIP_PURPOSE=7]	0^b	.	0	.	.
Train	Intercept	-4.705	1.474	1	.001	
	TRIP_TIME_RANGE	.200	.122	1	.102	1.222
	TRIP_DISTANCE	.554	.093	1	.000	1.740
	TRIP_COST_RANGE	-.281	.125	1	.025	.755
	[TRIP_PURPOSE=1]	-1.153	1.522	1	.449	.316
	[TRIP_PURPOSE=2]	-1.435	1.563	1	.358	.238
	[TRIP_PURPOSE=3]	-1.109	1.636	1	.498	.330
	[TRIP_PURPOSE=4]	-1.993	1.899	1	.294	.136
	[TRIP_PURPOSE=5]	-3.622	5.643	1	.521	.027
	[TRIP_PURPOSE=6]	-18.997	.000	1	.	5.619×10^9
	[TRIP_PURPOSE=7]	0^b	.	0	.	.
Walk	Intercept	1.639	.654	1	.012	
	TRIP_TIME_RANGE	.122	.160	1	.447	1.129
	TRIP_DISTANCE	-.149	.221	1	.500	.861
	TRIP_COST_RANGE	-2.953	.223	1	.000	.052
	[TRIP_PURPOSE=1]	-1.078	.651	1	.098	.340
	[TRIP_PURPOSE=2]	-2.328	.702	1	.001	.097
	[TRIP_PURPOSE=3]	-1.505	.704	1	.033	.222
	[TRIP_PURPOSE=4]	-.049	.582	1	.933	.952
	[TRIP_PURPOSE=5]	.788	.774	1	.309	2.199
	[TRIP_PURPOSE=6]	1.033	.771	1	.180	2.808
	[TRIP_PURPOSE=7]	0^b	.	0	.	.

The utility equations of model for all modes are as following:

- U_{AMTS} = - 2.528 + 0.615(TT) – 0.315(TD) - 0.866(TC) + 0.269[TP1] + 0.081[TP2] - 3.028[TP3] – 1.473[TP4] + 1.182 [TP5] + 2.193[TP6]……………………………………………………………….(6)
- $U_{Auto\text{-}rickshaw}$ = - 0.886 - 0.524(TT) – 0.033(TD) – 0.3(TC) - 2.580[TP1] – 2.347 [TP2] – 2.339[TP3] – 0.953[TP4] – 0.226[TP5] + 1.390[TP6] …………………………………………….(7)
- $U_{Bicycle}$ = - 3.223 + 0.352(TT) – 0.593(TD) – 1.887(TC) + 1.635[TP1] + 4.422[TP2] + 0.328[TP3] + 0.102[TP4] + 0.508[TP5] + 1.097[TP6] …………………………………………….(8)
- U_{Car} = - 3.520 + 0.309(TT) +0.069(TD) + 0.381(TC) – 1.973[TP1] - 1.033[TP2] + 0.176[TP3] – 1.156[TP4] + 0.809[TP5] + 2.179[TP6] ……………………………………………… …………………..(9)
- U_{BRTS} = - 3.294 + 0.259(TT) + 0.079(TD) – 0.193(TC) – 0.568[TP1] + 0.277[TP2] – 3.357[TP3] – 1.533[TP4] + 1.533[TP5] + 0.976[TP6] …………………………………………….(10)
- $U_{College/school\ bus}$ = -6.340 + 0.469(TT) – 0.653(TD) + 0.116(TC) – 0.532[TP1] + 4.479 [TP2] – 0.444[TP3] + 0.036[TP4] + 0.490[TP5] + 0.405[TP6] …………………………………………….(11)
- U_{GSRTC} = - 9.990 + 0.400(TT) + 0.370(TD) – 0.038(TC) + 3.481[TP1] + 3.218[TP2] + 4.073[TP3] + 2.513[TP4] + 5.668[TP5] + 6.168[TP6] …………………………………………….(12)
- U_{Taxi} = - 3.808 + 0.324(TT) + 0.084(TD) + 0.360(TC) – 6.330[TP1] – 5.293[TP2] – 5.658[TP3] – 1.217[TP4] – 0.859[TP5] – 0.416[TP6] ……………………………………………………………..(13)
- $U_{STAFF\text{-}BUS}$ = - 8.298 + 0.989(TT) + 0.078(TD) – 1.532(TC) + 3.067[TP1] – 2.509[TP2] – 0.376[TP3] + 0.599[TP4] –

0.535[TP5] + 1.901[TP6] ……………………………………………………(14)

- $U_{Shuttle}$ = - 6.215 + 0.220(TT) – 2.390(TD) + 0.092(TC) + 3.404[TP1] + 3.961[TP2] – 0.125[TP3] + 2.561[TP4] + 0.751[TP5] + 0.358[TP6] ……………………………………………………(15)

- U_{Train} = - 4.705 + 0.200(TT) + 0.554(TD) – 0.281(TC) – 1.153[TP1] – 1.435[TP2] – 1.100[TP3] – 1.993[TP4] - 3.692[TP5] – 18.997[TP6] ………………………………………………………………..(16)

- U_{Walk} = 1.639 + 0.122(TT) – 0.149(TD) – 2.953(TC) – 1.078[TP1] – 2.328[TP2] – 1.505[TP3] – 0.049[TP4] + 0.788[TP5] + 1.033[TP6] …………………………………………..…………………………(17)

12. RESULTS FROM MODEL

The model was having the following result:

- The "Two-wheelers" was taken as a reference category in the dependent variable "trip mode used", as it is the most used mode.
- Here, the following codes are assigned to the various purposes of trips.
  - 1 = Job work trips
  - 2 = Educational trips
  - 3 = Business work trips
  - 4 = Shopping trips
  - 5 = Recreational trips
  - 6 = Social trips
  - 7 = Other (miscellaneous) trips
- Factors in the model are also having the reference category, and other categories are compared with it. In this model, the category "other trips" of trip purpose is taken as reference category, and the other categories are taken with respect to it.
- The public transport modes, i.e. AMTS and BRTS are having the trip time 1.850 and 1.296 times the trip time of the two-wheeler. The cost of both the public transport modes (AMTS and BRTS) is 0.420 and 0.629 times that of the two-wheeler. The distance most likely to be covered in both the public transport modes (AMTS and BRTS) is 0.737 and 0.858 times that of the two-wheeler. The work trips likely to be occurred in AMTS are 0.159 times those in two-wheelers. In all the trips, the social trips are very less likely to be occurred (0.00004 times of the two-wheeler) in the AMTS. Similarly the work trips likely to be occurred in BRTS are 0.567 times those in two-wheelers.
- The auto-rickshaw is having the trip time 0.592 times that of the two-wheeler, and its trip cost is 1.350 times that in two-wheelers. The distance likely to be covered in the auto-rickshaw is 1.033 times that in two-wheeler.
- In all the trips, the social trips are most likely to be occurred (4.124 times of the two-wheeler) in the auto-rickshaw
- Taxi and cab services are having the trip time 1.383 times that of two-wheeler, whereas trip cost of taxi is 1.434 times that of two-wheeler. The distance of taxi service more likely to be covered for trip is 1.087 times that of the two-wheeler.
- The work trips are less likely to be occurred in taxi services (0.00003 times the other trips) than the two-wheeler.
- Shuttle services are having the trip time 1.245 times that of two-wheeler, whereas trip cost of shuttle-rickshaw is 1.096 times that of two-wheeler.
- The distance is very less likely covered in trip of shuttle-services (rickshaw), if compared to distance (0.002 times) covered in two-wheeler. This is because some shuttle-rickshaws run for very short length in the study area.
- Walking is having the most likely trip time to be taken is 1.129 times that of two-wheeler, whereas trip cost of shuttle-rickshaw is 0.052 times that of two-wheeler. The distance likely to be covered by walking is 0.861 times that of the two-wheelers. Most of the trips occurred by walking are the social trips, which are 2.808 times the other trips.
- Bicycle is having the trip time 1.421 times that of two-wheeler, whereas trip cost of bicycle is 0.152 times that of two-wheeler. The distance likely to be covered by bicycle is 0.553 times than that of two-wheeler. The educational trips are most likely (83 times the other trips) to be occurred by the bicycle.
- The transportation facility provided by educational organizations to their students, i.e. school / college bus, are consisting of the trip time 1.599 times that of two-wheeler, whereas trip cost of shuttle-rickshaw is 0.898 times that of two-wheeler. The distance likely to be covered by all these is 0.521 times than that of two-wheeler. The educational trips are most likely to be occurred by these modes, which is but obvious.
- The staff bus facility for the employees provided by organization, especially in the industrial area, takes more time 1.794 times) than the two-wheeler, and the trip cost is 0.110 times the cost in two-wheeler. The distance likely to be covered by staff bus is 0.810 times of two-wheeler. The work trips are most likely to be occurred in the staff buses, but they are very less when compared with two-wheelers.

- Train, an economical mode for outstation trip, mostly preferred on outstation trip, has the trip time likely to be 1.222 times more, whereas the cost is likely to be 0.755 times that of the two-wheeler. The distance most likely to be covered by the train is 1.74 times that of the two-wheeler. The work trips in outstation are most likely to be occurred in the train, compared to the trips with other purposes.

- The probability of choosing a mode for given conditions (Trip time = 0-10 minutes, trip distance = 0-5 km, trip cost = 0-10 rupees, trip purpose = work trip) were obtained from the utility equations of all the modes, which are mentioned above. The conditions were considered based on maximum shares of trip makers in all the categories. By the equations, the following results can be obtained.

Table 5 - Probability of mode choice of trip maker (by utility equations) in the given conditions

Mode	Probability of using the mode (%)
AMTS	21.47
Auto-rickshaw	4.64
Bicycle	8.81
BRTS	8.80
Car	3.18
College/school bus	0.35
GSRTC	1.12
Taxi	0.03
Staff-bus	1.04
Shuttle	2.73
Train	1.66
Walk	46.18

13. CONCLUSION

By this model, we can find the two-wheeler as the most used mode, as well as the most preferred mode. This mode is widely used in the most of the necessary trips, i.e. work trips (31% for job and business trips), educational trips (9.2%), shopping trips (16.3%) and other trips for home makers and/or retired persons respectively. This mode is mostly preferred due to its time saving property, and for avoiding traffic congestion, especially in the old congested areas of the city.

Most of the trip-makers prefer the two-wheeler mode for convenience in trip, as well as flexibility of travel. In this, the drivers of the two-wheeler as well as the passengers in the two-wheelers are also included.

In all the trips, maximum portion is of job work trips (29.3%). These trips are most frequent trips, as they are done on the daily basis. Most of the work trips are done by two-wheelers (21.8%), as the trip makers are flexible to travel in terms of time and route, the trip makers are able to avoid the traffic congestion, and is economical than car for the same distance.

By comparing the trip time ranges in various modes, the two-wheelers are mostly used, as well as they are having the maximum (21.1%) trips in the time of 10 minutes or less. This scenario is followed by the trips in the time range of 11 to 20 minutes (17.6%).

In the trip distance of 5 km or less, the usage of two-wheeler is maximum (34.6%) in all the modes. It is followed by the walking mode (8.2%). This is due to the consideration of shopping, recreational, social trips are also considered, which are relatively short, and made by the housewives, retired persons, elders, and children, etc.

Most of the trips are having the cost range of 11 to 20 rupees (41.6%), in which, obviously, the two-wheelers are more (31.6%), which is due to more average than the car for same distance.

In the trips which are made by all the age-groups, most of the trips are made by age group of 21 to 30 years (20.5%). This age group is having the different characteristics, like students or office-goers or businessmen, etc.

The non-earning group, like home-makers, retired persons, elderly, and students, is making more trips, compared to the earning group. But excluding them, the population in income group in between 20000 to 40000 is making the more trips.

In the preference to trip mode, most of the trip-makers (96%) preferred the mode they are using.

Most of the population prefers two-wheeler (65.6%) in all the modes, when comparison in preference to any particular mode was made. It was found that most of the trip makers depend on convenience in trip (33.6%) when they are choosing any particular mode.

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