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Understanding Role of Socio-economic Parameters Using Trip Generation

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Abstract
Transportation infrastructure is backbone of development for any region. Travel demand forecasting plays importance role in transportation infrastructure need, which includes road network, terminals, traffic controls and management devices. For effective transportation infrastructure, planner needs to find out travel behaviour and characteristics of road users. The Aim of the study is to discover socio-economic parameters in trip generation rate and develop model to estimate trip generation by household data of Vadodara, Gujarat. It is based on household interview from 1072 households, with 5777 person-trips. The survey includes household characteristics, socio-economic characteristics of household, types of trips made by individuals, trip characteristics, status of trips maker, and individual characteristics of trip maker are collected. The highest trips are made for work with share is of 48% followed by educational trips (30%). The private and public transport modes used in the sample is 80% and 20% respectively. The analysis is conducted by multiple regression and cross classification methods to predict the trip generation for various purposes. In multiple regression influencing parameters observed are purpose trip rate, income of household, household size, number of children, vehicle ownership per household and rate of employment. Another method used for analysis is cross-classification method. In this model main variables taken are household income and number of vehicles (i.e. two-wheeler and four-wheeler) owned by household in respective category. This study is useful for estimating future trips by travel purpose either for individual or for each zone. i.e. aggregate and disaggregate approach for similar cities. Finally, it helps in developing future transportation infrastructure of similar kind of region having similar characteristics to analyze travel demand.

Keywords: Trip Generation, Multiple linear regression, Cross-classification, Socio-economic parameters, Transportation planning.

INTRODUCTION

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Background

Transportation planning of any region plays an important role in the development of the transport infrastructure. To make efficient transportation infrastructure there is need to develop a model to understand the demand or pattern of traffic. One of the key parameter in transportation planning is travel demand forecasting. As the first step in the traditional four-step travel demand modelling, trip generation examines the prediction of future levels of a person or a vehicle travel and is studied with the help of TAZ (Traffic analysis zone) [1]. Trip generation studies are used to projected the target date to provide estimates of the total amount of

travel demand. In trip generation study, trip production is used to describe the trips generated by the residential zones, while trip attraction is used to develop trips generated at the non-home end trips such as employment or shopping/commercial and industrial. Trip generation models can be Obtain if the trips are identified by different purpose and make it modeled separately. Trips can be defined by purpose of trips, time based trips includes peak and off peak period trip and person type based trips mainly depend on its socio-economic characteristics. It is influencing by socio-economic parameter attributes of number of working people in household, number of students, household size and composition, household income, household characteristics such as vehicle ownership, type of house.

Litreture Review

The prior research results are reviewed in this section from a variety of angles, including the socioeconomic factor that influence the travel rate. Also discuss the methods and techniques which are used for data collection and analysis of that data. The impact of social economic variables on trip production for Al-Hadar region in Al-Dora section of Baghdad city studied by Al-Zaidy et al. (2005). Gendered effects of several factors on people employment choice propensity in Bangalore. The researchers gathered data on a variety of characteristics that influence women's mobility, then used data analysis and regression modelling to determine the impact of these variables on the likelihood of choosing a job. Between males and female, there is a substantial disparity in the factors that influence work participation. This was demonstrated by the interaction model's findings, which revealed a substantial influence for market segmentation based on gender (Rahul et al. 2020) [2]. For educational trip in Merida-Venezuela (Quintero, Diaz, and Moreno 2016) [3] study conducted to find out trip generation by transport mode of private, semi-private and public school. This is Suggest that the trip generation rates for private, semi-private, and public schools may be applied to many modes, although the automobile (particular vehicle, school van, and taxi) has the greatest influence on the streets around the schools. Cars at private and semiprivate schools, as well as public transportation and walking in public schools, had more reliable TGRs when adjusted to a normal distribution. In their study from 2009 [4], Oyedepo and Makinde looked at how travels were generated in the Nigerian town of Ado-Ekiti and divided them into three categories: trips for home-based work (HBW), trips for home-based other purposes (HBO), and trips for purposes other than home-based work (NHB). According to the study, those who earn more and own more cars travel less than those who earn less and have fewer cars available. Additionally, those between the ages of 31 and 50 travel more frequently to specific areas of the city. Another important aspect driving the variance in trip generation was family size. When transportation planning was carried out in London, UK, in 1963, a cross-classification method was adopted. There were 108 family classifications as a result of the 6 categories of family income, 3 categories of car ownership, and 6 categories of family structure. For each group in this investigation, the typical travel rate was computed. This is basic analysis approach for carried out the effects of socioeconomic characteristics on trip rates are minimized. This strategy, which clearly needs incredibly comprehensive data, was attempted to utilise at the beginning of the twenty-first century by Everett (2009) [5, 6].

Motivation and Purpose

To develop efficient transportation network first to understand the demand of that region. In some region there is need to develop an airport, railway, metro, BRTS while in other region connectivity of road with other region is sufficient. Based on requirement of that region transportation planner make development respectively. To develop a transportation network there is a need to develop trip generation model. From trip generation model we can estimate number of trips produced by various purposes. This study used to forecast similar kind of another region having same characteristic trip production pattern and their trip generation rate to analyze the travel demand [7].

Objective and Scope of the study

This study aims to discover the socio-economic factors influencing of trip generation rate and develop model to estimate trip generation by household of Vadodara city, Gujrat. In order to address the aim of study, following objective are to study factors influencing to trip generation rates, to develop a trip generation analysis model by using regression and cross-classification methods, to

analyses the impact of factors on trip rate of household for different kind of purposes trips, to estimate number of trips produced by Household.

METHODOLOGY
Identification of Study Area
The study site is selected for this research is Vadodara, Gujarat. In Gujarat, it is the third-largest city. According to a preliminary census report from India, Vadodara had a population of 1670806 people in 2011, with 869647 men and 801159 women living there. It has a 149 sq. km. Road network of Vadodara city is well developed in about 70% of the area and caters to around 80% of city's population. Around, 11.47 sq. km. of area is covered by road, which is 10.59% of total area. More than 80% of roads are surfaced. Average trip length of Vadodara city is 5.4 km, and motorized trip rate is 1.6. Vadodara city is divided in to 12 administrative ward under Vadodara Municipal Corporation.

Data Collection and Extraction
To collect the data, Household survey was conducted in 2019 by Undergraduate student of Faculty of technology and engineering, MSU. 1072 household's, 5777 trips data is collected through this household survey. In this survey household characteristics, socio-economic characteristics of household, types of trips made by household, trip characteristics, status of trip maker, and individual characteristics of trip maker are collected [8].

[Tables 1, 2, 3] shows that data formation of household survey. The highest number of trips making by male which is 68.86% of total trips whereas female contribution is less compare to male. With respect to age group maximum trips is make by the middle age group (25-60) having 57.21% of trips whereas younger age group (17–24) having 22% and school going person age group (<=16) having 16.20%. By the status of the individual trip maker mostly trip making by employed person and studying person 53.28% and 31.04% respectively. House hold have only one person employed person is the highest 57.84% and two persons in household are employed is 29.85% household in sample data. More than 91.42% of household have one or more than one motorized two-wheeler and it is shown in Table 3 that having of two-wheeler in average house hold is 1.6 and near to 60% of household does not have any car and mean of owning car is 0.46. From the below Table 2 it shown that majority of trips are for work related trip and it is Consist of 48.35% of total trips in sample and second highest trip is for educational purpose and it consist of 30.20% of total trips. This is because of these both are primarily purpose of trips in every household. Mostly trips are done by private mode of vehicle which is 79.61% of total trips and public mode consist only 20.39%.

Table 1. Descriptive Statics of HH survey

Socio-economic characteristics	Frequency	Percentage
Gender	*No of trips*	
Male	3978	66.86
Female	1799	31.14
Age		
<=16	936	16.2
17-24	1271	22
25-60	3305	57.21
>60	265	4.59
Status		
Employed	3078	53.28
Unemployed	900	15.58
Studying	1793	31.04
Non-Studying	6	0.1

Socio-economic characteristics	Frequency	Percentage
HH size	**No of HH**	
1	18	1.68
2	140	13.06
3	222	20.71
4	344	32.09
5	199	18.56
>=6	149	13.9
Employed person	**No of HH**	
0	50	4.66
1	620	57.84
2	320	29.85
>=3	82	7.65
Income Group	**No of HH**	
<=15000(Low)	142	13.25
15001–35000(Medium)	348	32.46
35001–70000(Upper Medium)	439	40.95
>70000(High)	143	13.34

Table 2. Descriptive Statics Travel Characteristics

Travel characteristic	Frequency	Percentage
Purpose		
work	2793	48.35
Educational	1745	30.2
Shopping	524	9.07
Other	715	12.38
Type of Mode		
Private	4599	79.61
Public	1178	20.39
Private Mode		
Two wheeler	3018	65.62
Car	658	14.31
Bicycle	289	6.28
Walk	634	13.79
Public Mode		
Auto	350	29.71
Bus	346	29.37
Vanpool	474	40.24

Table 3. Descriptive Statics Vehicle ownership per HH Survey Data

Vehicle Ownership-Two wheeler	No of HH	Percentage
0	92	8.58
1	414	38.62
2	421	39.27
>=3	145	13.53
Vehicle Ownership-Four wheeler		
0	639	59.61
1	379	35.35
>=2	54	5.04

Travel Behaviour of Residents of Vadodara City
Trips by Household Size, Vehicle Ownership, Modal Share, Income Group

Figure 1 show the relationship between Household size and Number of trips as well as vehicle ownership and number of trips. The percentage of trips increase with increase in household size. Having two vehicles per household category produced more number of trips. The relation between income group and mode of vehicle chosen by people is shown in Figure 2. The middle income group people prefer walking as mode by 46.85% followed by bicycle 42.91% and upper middle group almost 51.52% trips by car where 44.60% trips by two-wheeler.
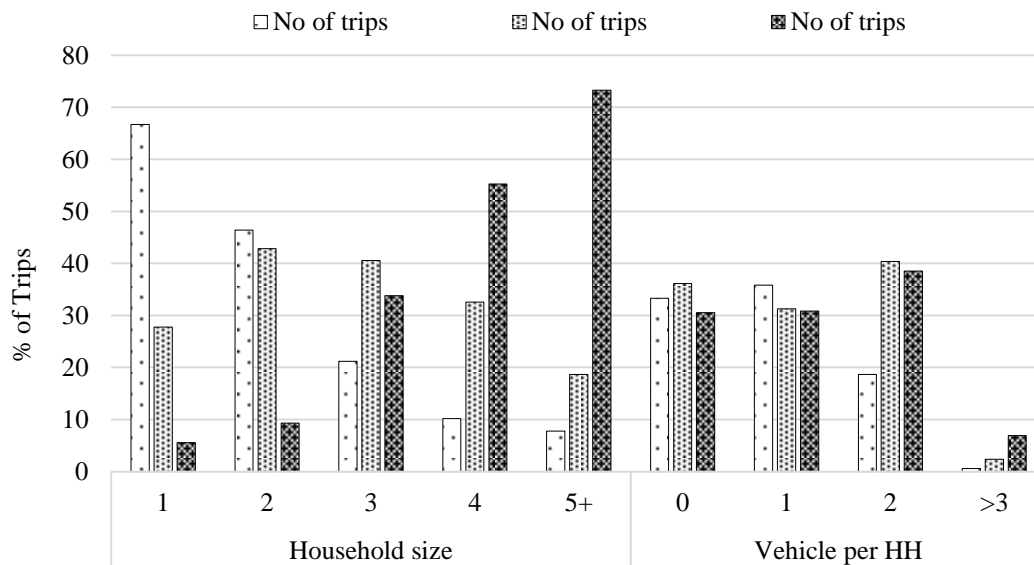
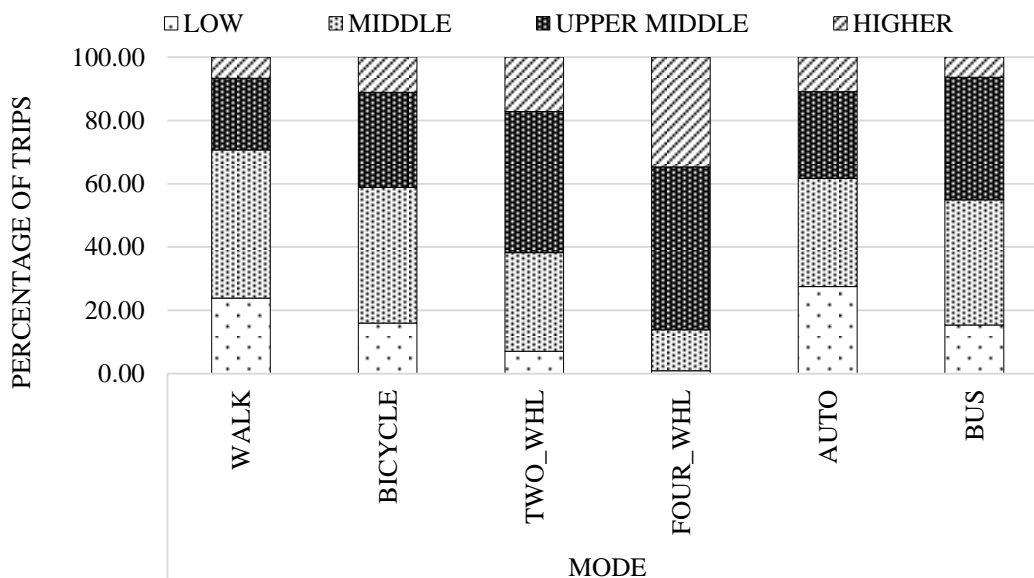**Figure 1.** Percentage of trips by HH size and Vehicle per HH.

Figure 2. Percentage of trips by Different Mode and Income Group.

Trip Characteristic for Work and Education Purpose
Work Trip

As the age group between 31–60 has more employed person contributing as work trip. At having 5 km trip length area nearer to their resident plays major role for work trip. Almost 48.36% trips as work trip in that separated by 91.05% trips as private mode and 8.94% as public mode.

Educational Trip

[Figures 1,2,3,4,5,6] Age wised we clearly see that below 23 cover 92.86% trip as educational purpose. It is observed that 30.34% trips made as educational purpose. 54.52% student preferred two-wheeler as the mode of travel followed by 41.53% giving preference to public mode [9].
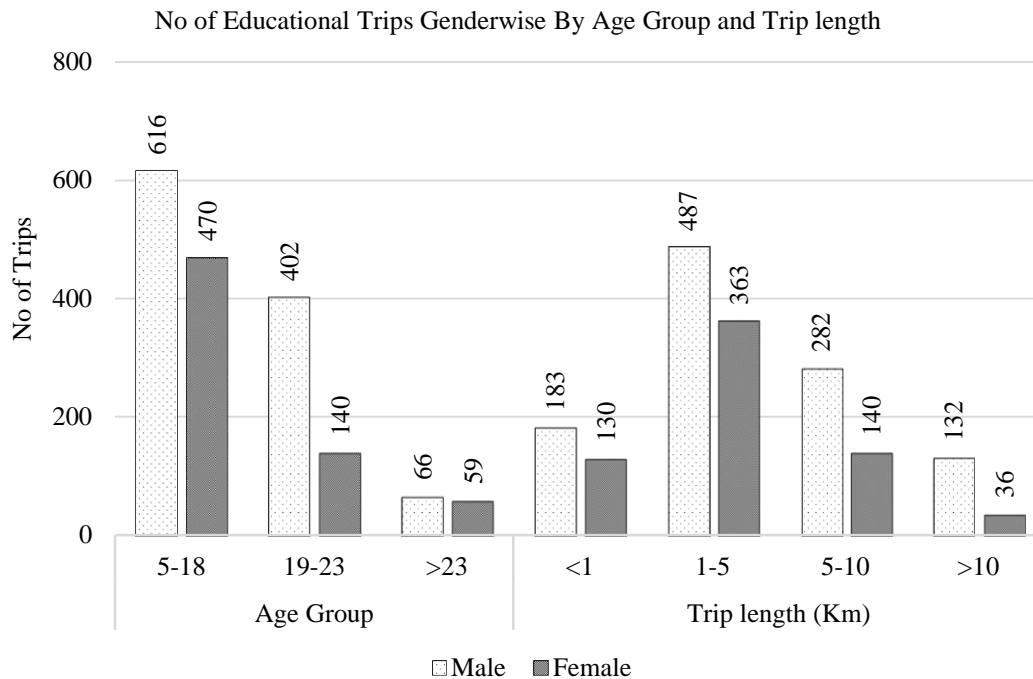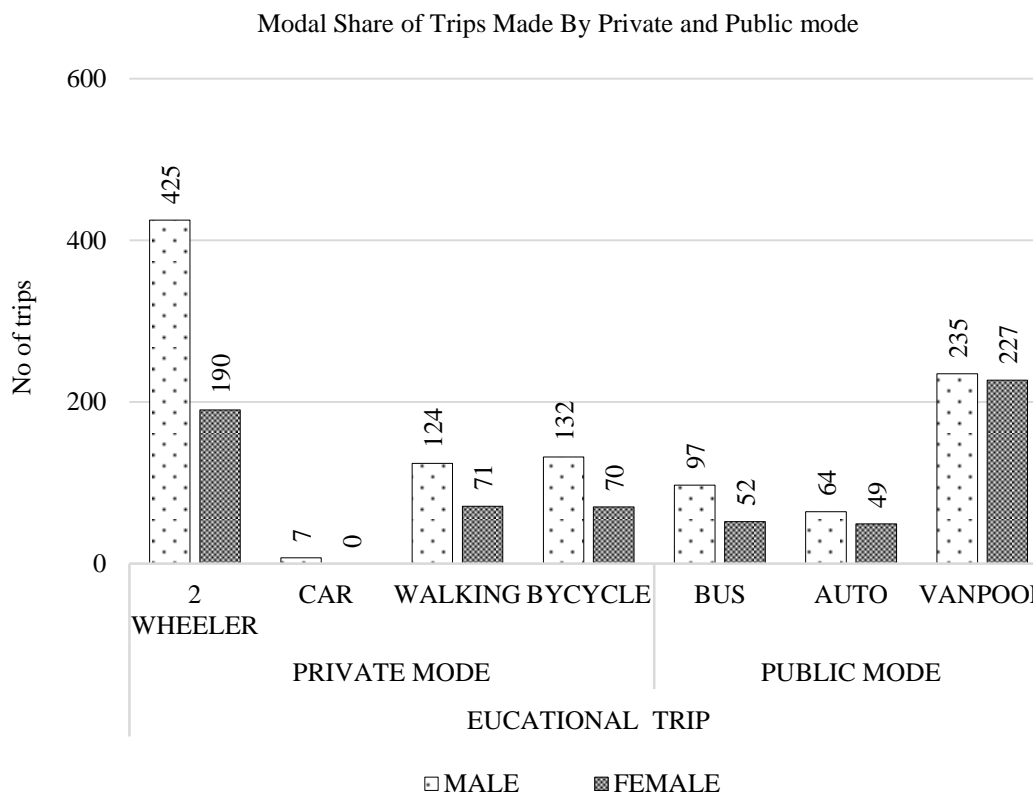
No of Educational Trips Genderwise By Age Group and Trip length

Figure 3. Work trip by Age and trip length.

Modal Share of Trips Made By Private and Public mode

Figure 4. Work trip by mode of vehicle.

Trip distribution by age and trip length
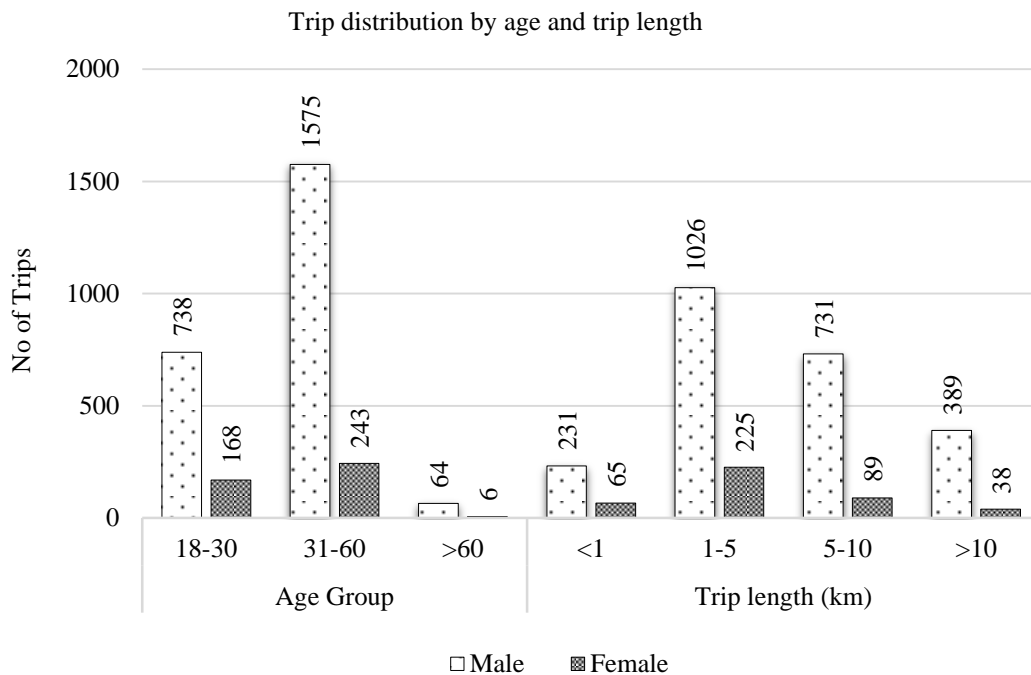
Figure 5. Educational trip by Age and trip length.

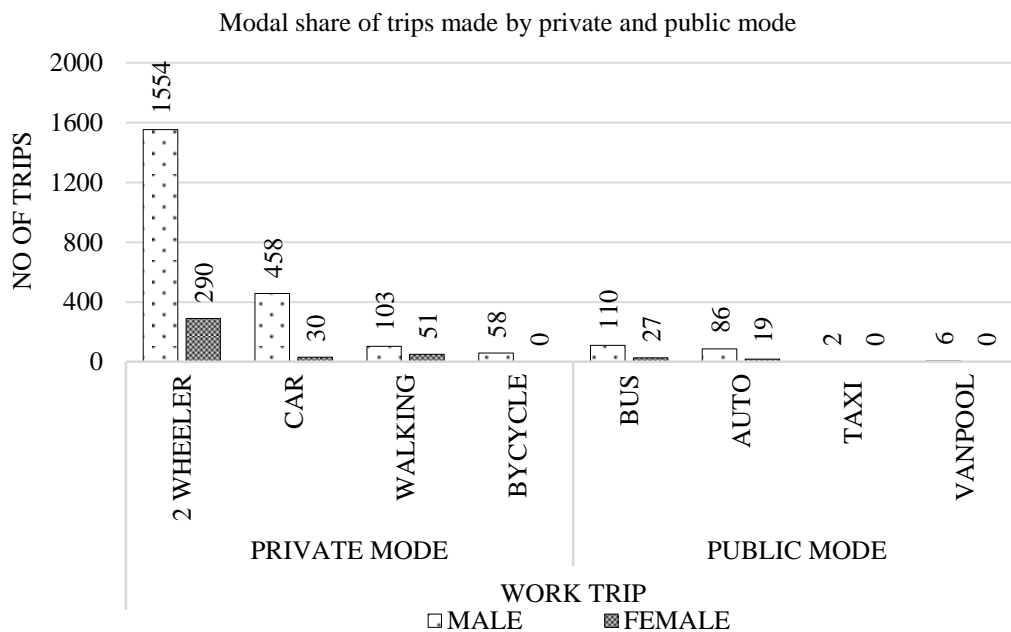Modal share of trips made by private and public mode

Figure 6. Educational trip by mode of vehicle

Data Analysis

For data analysis we made our model by two different approaches as aggregate model and disaggregate model. Considering all trip making behaviour separated by mode and their trips by different purpose generally taken as aggregate level or traffic analysis zone as a part of aggregate model analysis. The "average" zonal productions and attractions are derived from aggregate models that are typically based on home interview origin and destination data that has been aggregated into zones. Traffic analysis zones tend to contain a mixture of socio- economic behaviour. For that we used multiple regression analysis to explain the socio-economic parameter like household size, gender wise trip making behaviour, vehicle ownership, travel cost, family income etc. Where using

disaggregate approach as estimate the travel demand on the basis of individual decision-making characteristic. Cross classification analysis made as to estimate the number of trips generated by the household groups with the different income group, vehicle ownership and household size. The disaggregated approach uses data directly and is based on large samples of home types and travel activities.

RESULTS AND DISCUSSIONS
Multiple Linear Regression
By fitting a linear equation to the data, multiple linear regression seeks to model the relationship between two or more explanatory variables and a response variable. observed data. Every value of the independent variable x is associated with a value of the dependent variable y. This factor measures the separate influence of each factor acting in association with the other factor.

$$y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + \ldots \ldots \ldots + b_n x_n \quad (1)$$

Where,

y = dependent variable, x = independent variables, (a, b) = constants

Two or more independent variables, which can be continuous (for example, an interval or ratio variable) or categorical, are present in the data (i.e., an ordinal or nominal variable). (1) The dependent variable and each independent variable, as well as the dependent variable and all independent variables taken together, must have a linear relationship. (2) The presence of multi-collinearity, which happens when data contain two or more independent variables that are strongly associated with one another, is not permitted. Multi-linear regression is carried out to develop model for work trip and educational trip with their mode wise classification. To develop regression models the significance level (α) was set at 0.05, for confidence interval 95%, to eliminate factors which are statistically does not contribute any role to making trip of that purpose group. The statistical analysis performs in the IBM SPSS Software to predict the influencing parameter. The variable which are taken part in this analysis and their results are shown in Table 4. Work trip model influencing by the parameter male participation, rate employed person per households are giving some positive effect to trip generation but the same side travel cost and time negatively influence to shift their model share making trip behaviour. Also the two-wheeler mode plays predominant role to making the work trips by private mode. Since the r-square value is in the range of 0.5 to 0.7, this number is typically regarded as having a modest impact size. Considering the educational trips as different mode wise the factor which are showing positive effects are male involve to making trips, no of school going children and no of Collage students. As we separated out the mode in private to public two-wheeler per family member change the scenario to shifting them for another mode. As Indian prospective to choice of mode generally depends upon the overall cost of their travel. i.e. the travel cost taken as the independent variable for making trip generation model. Educational trip as public mode negatively affects the total vehicle per family member on model [10].

Table 4. Regression results for work and education trip made by private and public mode

Model data		Regression analysis for Work trip		Regression analysis for Education trip	
		Private Mode	*Public Mode*	*Private Mode*	*Public Mode*
Code	*Independent variable*	*Co-efficient of the variables*			
a_0	Constant value	-0.016#	0.187#	-0.085#	1.337***
x_1	Trips by male	0.164**	0.038#	1.813***	0.024#
x_2	Trips by Female	*	*	*	*
x_3	Family Member	*	*	*	*
x_4	Rate of employment per household member	1.458***	1.855***	x	x

x_5	Number of Two-wheeler per Household	0.196***	*	0.064**	*
x_7	Number of Car per Household	*	*	*	*
x_8	Rate Total vehicle per family member	*	*	*	-0.253**
x_9	Travel time	*	-0.001#	*	*
x_{10}	Travel Cost	0.001**	-0.003#	-0.001**	0.003**
x_{11}	Family income	*	*	*	*
x_{12}	Number of school going children	x	x	0.887***	1.427***
x_{13}	Number of college student	x	x	0.715***	1.378***
Model fit	R square	0.513	0.729	0.661	0.457
	Std Error of Estimate	0.321	0.235	1.053	1.245

Note: "x" denotes a variable that is not involved in the regression; "*" denotes that the regression coefficient is insignificant; Significant values: 0 '***', 0-0.05'**', 0.05-0.1'#') [Table 4]

Table 5. Household Income Category

Category	Household income per month
Low	<15001
Middle	15001–35000
Upper middle	35000–70000
High	>70000

Table 6. No of household by income group

Income group	No. of HH	% of HH
low	142	13.25
middle	348	32.46
upper middle	439	40.95
high	143	13.34

Cross-classification analysis

Cross-Classification is used in the FHWA Trip Production Model, which has the following sub-models. (1) Present the distribution of families across various income levels using the income sub-model (e.g. high, medium and low). (2) The relationship between household income and car ownership (3) Trip production sub-model: Identifies the connection between each household's travel patterns and the independent variables. (4) Goal of the trip sub-model: Connects trip purposes to income in such a way that trip products can be split between several purposes. The origin-destination travel surveys are used to create these models. Data classified into their sub-model. Taking income group model separated by 4 parts as shown in the [Tables 5, 6]. and categories by number of households. Trips and number of household data formatting into income group and their vehicle ownership consider (two-wheeler and four-wheeler) [9].

Number of Household by Income and Vehicle Ownership

In middle income group household having 1 two-wheeler ownership has the highest percentage of 54.23 while higher income group household has more share in more than 3 vehicle ownership. For comparing the four-wheeler ownership upper middle income group has almost 53.53% one car per household. As Increase the income level people having more vehicle ownership [Figure 7, 8].

Trip Rate by Income Group and Vehicle Ownership

In below [Figure 9] middle income group having more than 3 Two-wheeler has more trip rate up to 8.19. Where higher income group people have same trip rate for having two or more than 3 vehicle ownership is 7.0. Shifting to four-wheeler ownership highest trip rate made by the middle income group having more than 3 cars per household.
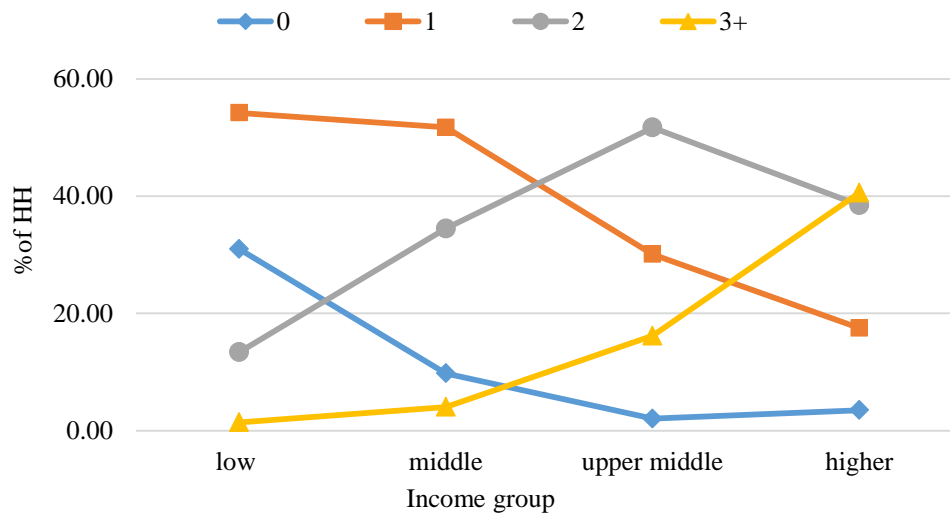
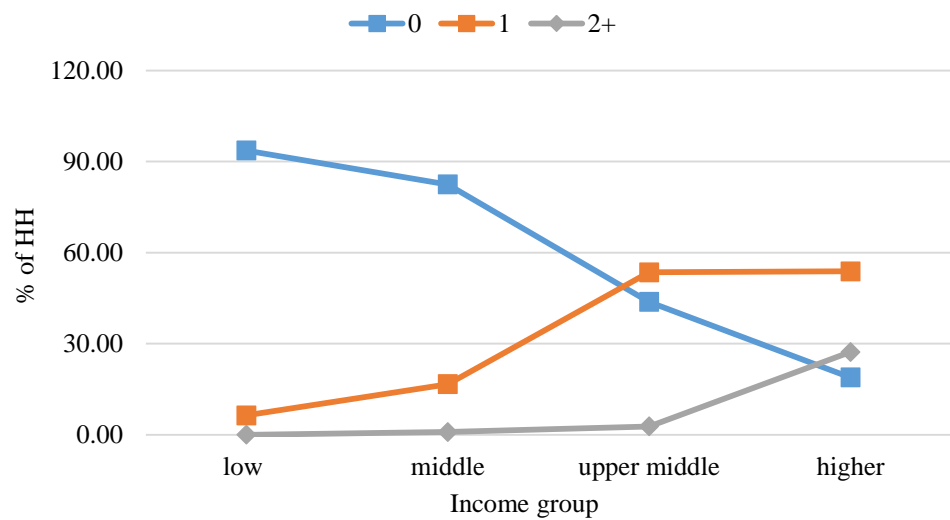**Figure 7.** Percentage household by income group and 2w ownership.

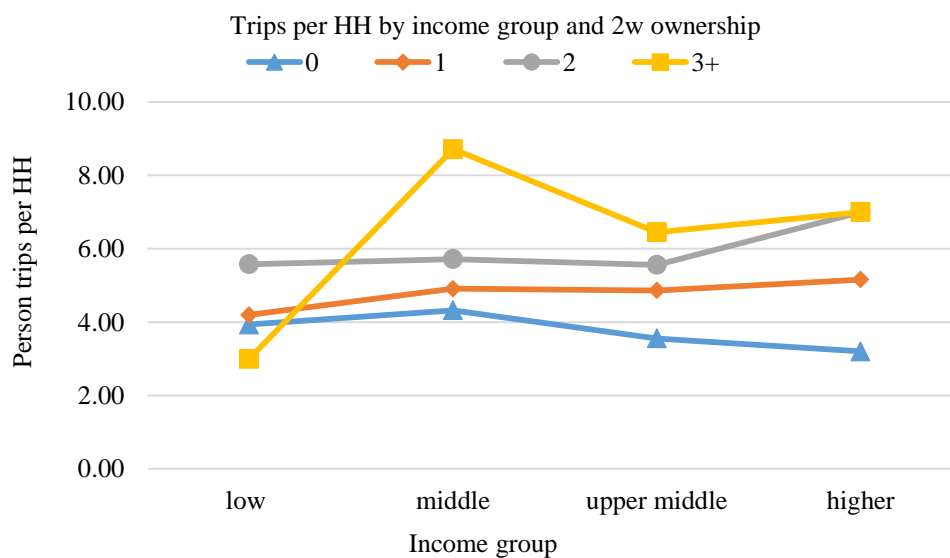**Figure 8.** Percentage household by income group and 4w ownership.

Figure 9. Trip rate for 2w ownership**.**

Number of Trips by Different Trip Purpose

By deducting outlier data every income group has higher percentage in the generating the work trip with two-wheeler and four-wheeler also. Using two-wheeler as making educational trips more by the upper middle and high income group people is 19.53% and 18.88%. respectively. [Figures 10, 11]
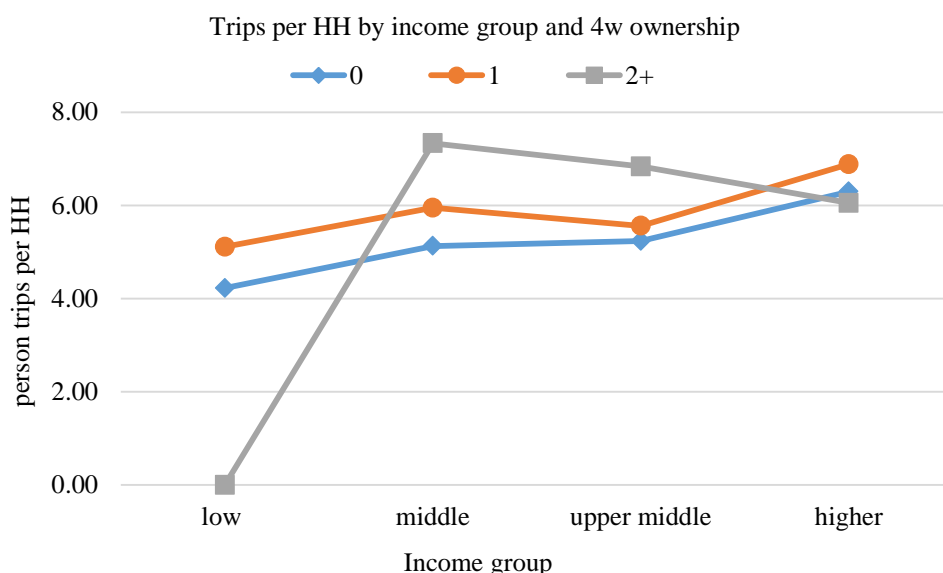

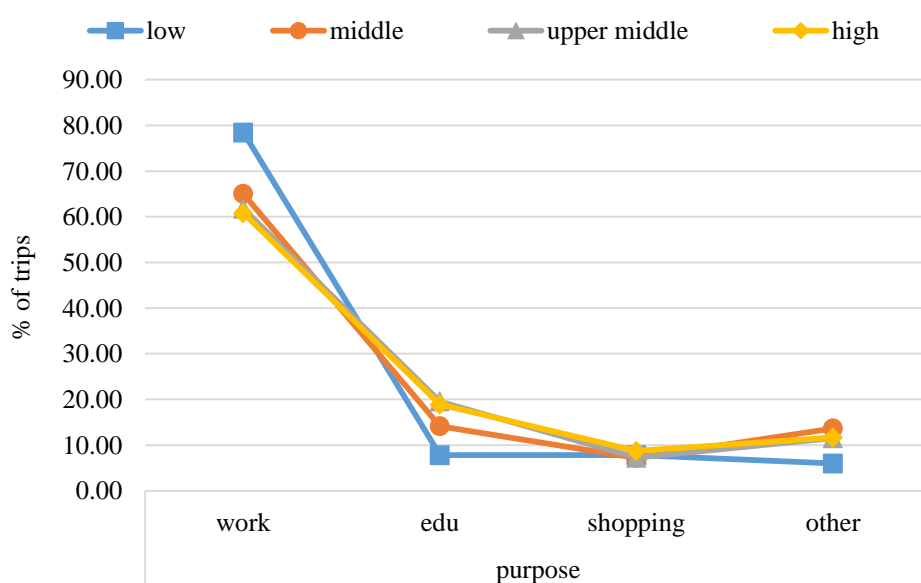**Figure 10.** Trip rate for 4w ownership**.**

Figure 11. percentage of 2w and car trip with income purpose wise

CONCLUSIONS

Trip generation plays major role for any planning process. From that we can easily predicted the future trips making behaviour of their region. And according to them we can provide some new infrastructure facility. In this study area Vadodara city surrounded by many small cities from that people more tends to move for their employment opportunity purpose. From the data almost 48.36% people making trips as work purpose. For work trip factor which are positively affected is male person per household, employment rate per household and also vehicle ownership per household. But the another side the where the trip length increase people shift to the public mode. Travel cost and travel time affected as negatively in the work trip by different mode. The majority of trips are produced by

the male (68.86%) and from total trips 53.28% of trips are generate by the employed person. Generally educational trips are generated by the person who are pursuing their education. So that school and college students are most influence factor to create educational trip. Educational trips made by public mode the two-wheeler per family member negatively affect to their trip production. Analysis carried out by cross-classification method income and vehicle ownership parameter affected by trip production. Two-wheeler is most used mode in developing Country like India, so majority of HH has at least one and two Two-wheeler in HH. In Vadodara city low income category and High income category HH are less in comparison to middle and upper middle income category HH and also they produced more trips. So the income plays the key role in this model. High income category HH have accessibility to having more vehicle in HH, trip rate of this category household are shows high as compared to other HH. Most trip are produced by each category HH is work trip and second most trip generate is educational trip which is necessary. In car ownership category, majority of household (59.61%) in Vadodara city does not owning any car, household with one car are (35.35%) 379 and 54 (5.04%) household have 2 or more than 2 Car in their household. Highest number of trip produced by the car and two -wheeler is work purpose trips and their proportion is almost 78.44%. Education trips are very less Generate by using car as transport vehicle, because most educational trips are generated by using 2-wheeler and vanpool.

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