Addressing the challenges of School trips in Belagavi city by Estimating Trip Generation Rate and Mode Choice Modeling –A Case Study

Santosh Chikkabagewadi[1], V.M.Devappa[2], V.V.Karjinni[3]

Research Scholar, Department of Civil Engineering, S. G. Balekundri Institute of Technology, Belagavi, India[1]

Professor & Head, Department of Civil Engineering, S. G. Balekundri Institute of Technology, Belagavi, India[2]

Executive Director, Kolhapur Institute of Technology's College of Engineering, Kolhapur, India[3]

Email: santoshbc90@gmail.com ORCID ID: 0000-0002-6139-7633

Abstract

The aim of this study was to estimate trip generation rate for residential areas and modal split analysis of school trips where Belagavi city in India was selected as a case study. The data were collected through a questionnaire survey distributed among all the households to determine the travel attributes of the trip makers and were further used to calibrate the appropriate model. The relationship between variables were developed using regression technique by using statistical packages for the social sciences (SPSS) software. To calculate the sample size, Levy and Lemeshow's empirical formulas were adopted. A total sample of about 400 households were interviewed in each zone. The results indicated that the total trips are influenced by Number of school going students, Number of workers, Car ownership, Income level and size of the household. The study also focuses on the modes available for school trips in the city. Based on a descriptive examination of the data, four modes—private automobile, auto, bus, and two-wheelers—are taken into account when modelling the mode choice for school excursions.. The multinomial logit model is developed with utility functions for different modes to estimate the modal share of school trips. Development of these models helps to planners, engineers and builders to simulate current and future scenario on the roads with a suitable modeling process.

Keywords : Household attributes, Regression analysis, Modal split, logit model, SPSS statistics

DOI Number: 10.14704/nq.2022.20.13.NQ88345 **Neuro Quantology 2022; 20(13):2763-2772**

1.Introduction

The global population is raising at very fast rate, moreover, the infrastructure demand, transportation facilities and industrialization also growing at very fast rate [18]. Such huge population are more interested in urban areas for their residence, services and schools. These alarming situations have impact on transportation facility of a city. Many researchers through-out the globe finding the solution on such challenges like to optimize the school trips. Few researchers are used LINGO & PSO techniques to optimize the water resources, same soft computing tools are also used for transportation system [17]. Urban problems have many complicated constituent factors, and transportation issues are one of them. In many ways, transportation may be seen as one of the main causes of the urban issues we currently face. Engineers and planners enhance knowledge of the effects of implementing various transportation-related courses of action during this process, such as building new motorways, modifying bus routes, and controlling parking regulations. The typical four-stage transport models of trip generation, distribution, modal split, and assignment essentially begin with trip generation. Through the use of trip generation analysis, it is possible to link the volume of travel within any zone to its socioeconomic and zoning characteristics, including activity levels, land-use intensity, and location within an urban setting. The purpose of this phase is to estimate the overall number of traveller arrivals and departures from each zone[1]. Other languages that may analyse production and attraction of trips, distances between the sub-zones include fuzzy logic and C-mean clustering in MATLAB [2].

The transport system has constituted the fundamental elements in the structure of the urban space**.** The first step in sequentially modeling travel demand is trip generation, which considers trip length and frequency as well as the spatial characteristics of a geographic area[3]. A number of mathematical models that imitate traveller behaviour are used in travel demand modelling[4]. The relationship between many elements influencing the production of trips, such as income, vehicle ownership, home structure, and family size, is compared in this essay. It attempts to estimate the overall number of trips produced and drawn to each zone within the study area. According to this study, the demographic attributes family size, the number of employees, household income and vehicle ownership as well as the land use attributes, all have a strong correlation to the generation of trips. A thorough understanding of the factors which influencing the production of trips related to urban land use is provided by this paper's significant information on the trip generation characteristics of the Belagavi city growth centre. In Indian cities, Rickshaw and van are the main modes preferred by the public which lead to enormous increase in motor vehicle use will have important implication for air quality and traffic injuries. The provision of such facilities has influenced the urbanization process and the spatial distribution patterns of the population, employment, education and other location activities. The long-term effects of accessibility and changes in accessibility brought about by the implementation of transportation projects are being used to build and form urban areas. The decision amongst the several probable routes is based on which has the shortest travel time, keeping in mind the actual physical path travelled from the starting point to the final destination.

A combination of home and school interviews gives detailed information for the analysis of data. Trips are classified by purpose and the number of houses by the type of dwelling unit. It is observed that the full interview survey technique is more expensive and it may be possible to collect needed information only at the survey rate of eight hours per day. The home questionnaire survey is quicker and it may be possible to collect data of about 20 to 25 households per day. While full interview survey yields very precise data, the same cannot be expected from the latter one. The other methods of survey have limited scope and do not yield useful information. To overcome these difficulties experienced in HIS procedure, an alternative methodology "School Interview Technique (SIT)" was implemented simultaneously to collect the data.

The objectives of this paper are as follows :

1. To understand the relation between factors which influencing the trip generation for commuter trips by regression analysis.
2. To develop modal share of school trips by using the utility function for Multinomial logit model (MNL).

This paper is structured as follows: Section 1 is introduction and the work's goals. Section 2 presents reviews of relevant literature. Section 3 presents the research study, Section 4 describes the methodology, and Section 5 presents the findings and a conclusion. Section 6 concluded with summarising the study's findings.

2.Literature review

Activities involving travel might be regarded as a significant and necessary aspect of people's daily lives [5]. In the process of forecasting travel demand, the trip generation phase comes first, then processes for trip distribution, mode selection, and traffic assignment[6]. The trip generation rates are developed by relating the independent variables to the number of trips generated based on a survey. In developing nations, local governments, planning agencies, and private citizens are in charge of urban planning and transportation, and high-income nations decide how frequently their citizens travel inside cities[7]. Using a questionnaire-based household survey, the primary data, such as socioeconomic and travel characteristics, can be gathered. Secondary data are received from corporation officials[8]. A self-reporting survey sample of 821 people was used by S. M. Dave et al. [13] to analyse data on the travel habits of elementary school students in the Vadodara city study region. Parents typically choose autorickshaws and vans for their children's school travels in numerous Indian cities, including the capital city. Regarding these modern modes of transportation, the concerns of driver behaviour, safety, comfort, and overcrowding of children in vehicles were examined. The schoolchildren were given an alternative in the form of a planned coordinated bus mode that would serve two or more schools concurrently and be coordinated, and the response to this service was predicted using logit models. More than 60% of respondents expressed dissatisfaction with the current travel modes, according to the study results. Door-to-door service and frequency of service are the most persuasive arguments for adopting the present transportation options of auto-rickshaw and van. If it is possible to save costs and travel distance, the likelihood of switching to coordinated bus mode rises.

The majority of school trips generated by different modes of vehicles which influencing the variables. The simplest model for categorical placement or the likelihood of belonging to a category on a dependent variable based on numerous independent variables is the multinomial logistic (MNL) regression[9]. When a car with automatic driving operates on public highways, there is a coordination issue when it comes to collisions with emergency vehicles. From the perspective of safety and ride comfort, the effectiveness of pre-deceleration running based on the earlier identification of emergency vehicles via vehicle to vehicle communication is investigated [19]. Driver requests to interfere from level 3 automated vehicles due to functional limits in some circumstances. Unplanned control authority action would result in inadequate situational awareness, which would ultimately create hazardous situations [20].

3.Study area

Belagavi, second capital city and an important educational center of Karnataka State is having three Universities namely Visvesvaraya Technological University, Rani Channamma University and KLE Medical University. It has two allopathic Medical Colleges, three Homoeopathic Medical Colleges, two Ayurvedic Medical Colleges, two Dental Colleges, seven Engineering Colleges and many other polytechnics, management, pharmacy, nursing, horticulture and other graduation colleges. It covers an area of 44.47 sq.km. consisting of 58 municipal wards with the total population of 4, 88,157 (2011 census) and around 1, 11,436 households which including defense area falling under Cantonment Board comprising of seven wards. It has been observed that very less interaction of overall trips takes place between cantonment area and Belagavi city in particular, as most of the activity locations such as work establishments, shopping centers and recreational facilities are situated within the cantonment limits.[10]

Fig. 1. Location of Belagavi city and major road networks

[https://www.mohua.gov.in/upload/uploadfiles/files/54Belgaum_KRN_sfcp-min.pdf]

3.1 Travel Behavior Information and Demographics Zonal Analysis

Trip rates vary depending on the land usage. A residential area with a high density of homes, for instance, may result in more trips than one with a low density of homes. On the other hand, a low density neighbourhood can contain high standard of living, which might result in a lot of private vehicle journeys. Household Interview Survey (HIS) and School Interview Survey (SIS) database containing 1000 samples were used to identify the travel behavior of travelers. The survey was carried out in seven important zones (wardwise) and a route between Central Bus terminal (CBT) to Udyambag Industrial area of Belagavi city where we find residential area, commercial space and more number of schools on those streets. Database was categorized based on the purpose as home based work trips, school trips and other trips.

Table 1: Important zones of Belagavi city [11]

[https://www.censusindia2011.com/karnataka/belgaum/belgaum/belgaum-m-corp-population.html, City Corporation Belagavi]

Sector	Zone	No. of wards	Population	Households
Zone-I	Angol, Majagoan	08	69,949	17,037
Zone-II	Vadagoan yellur	08	67,515	15,365
Zone-IIIA	Tilakwadi	09	67,986	15,879
Zone-IIIB	Shahpur	10	70,899	15,962
Zone-IV	College road	05	40,510	9295
Zone-V	Shivabasav Nagar	08	69,209	15,438
Zone-VI	Kanabargi	10	1,02,089	22,460
Total		58	4,88,157	1,11,436

4.Methods

4.1 Home Interview Survey (HIS)

A comprehensive interview includes interviewing the head of the household as much as possible and recording all the details directly. A questionnaire form was prepared which including questions on Number of family members, number of workers, number of school going students, car ownership, income level, mode of transportation, purpose of trips etc. and distributed among the family members and forms are collected by the interviewer after giving sufficient time for fill up. It is recognized that a comprehensive consultation method is very expensive and it is possible to gather only the necessary information on the number of interviews in eight hours per day of questioning. The home questionnaire survey is fast and it is possible to collect data on 20 to 25 households a day. A household interview survey was conducted to gather information on travel and socioeconomic traits. For the data gathering, simple random sampling was taken into consideration. The sample size was calculated using empirical calculations provided by Levy and Lemeshow (2008) under the assumption that the population had a normal distribution. 500 samples of households from each zone are chosen at random for the socioeconomic survey. Income, vehicle ownership, household sizes are the independent variables that determine the frequency of personal trips [16]. The likelihood of additional trips being taken increases with family size. Additionally, more trips will be made if both the husband and wife work than if only the husband does. The number of travels taken for educational purposes will be significant if the family has a big number of school-age children. The family's age distribution also determines the cost of the trips. Fewer trips are anticipated from older people than from younger people.

4.2 School Interview Survey (SIS)

Active Transportation is another name for non-motorized transportation which includes Walking and cycling. In the medium-sized cities Patna and Jaipur, walking trips made up 35.5% and 39.5% of all trips, whereas bicycles and rickshaws made up 31.1% and 29.2%, respectively[12]. Because the expected walk time variable is shown to be significant, the likelihood of using public transportation rises if it is available and the pickup location from home is located along a route with an estimated walk time of not more than five minutes[13]. As per present scenario of Belagavi City, there are very less (26%) non motorized transport (NMT) found in work as well as school trips.

The School Interview Survey (SIS) is an indirect way of collecting household characteristics data for all planning studies of urban transportation. In this approach, the data on commuting, household characteristics, employment, neighborhood land use composition etc. is collected in a questionnaire designed for the use of higher school/college students. Thus, about 400-500 questionnaires from each school may be collected in a week period resulting about 80-90 samples per day. This saves a lot of time and labor. Once the sample size based number of households is finalized, the numbers of school/colleges are carefully selected for data representing whole study area. The preliminary analysis of the data revealed that school trips were slightly higher than work trips in the total number of trips performed and households belonging to all socio-economic characteristics were not evenly covered.

Seven zones of Belagavi City have been chosen as the study region as the initial step in conducting an analysis of trip generation model. There are a number of pertinent independent variables that affect how many people travel to the city centre. Additionally Socio-economic data, Size of the family, monthly income, ownership of a vehicle, and employment status have all been gathered. from the two techniques Household survey and School Interview Surveys. The data is used to compile information about the identified independent variables from each zone. The Demographic information (total population, geographic area, and population density) was gathered from the Urban Development Authority (BUDA). The selected parameters from each zones were used in correlation and regression analysis, and the most effective regression model was developed to forecast the number of visitors who will travel within the zones of a city. The number of trips produced from the chosen area, denoted by the letter "y," is the dependent variable chosen for regression modeling. The validity of the developed multiple regression models has then been checked to see whether it is valid or not.

4.3 Multiple Linear Regression Analysis Equation

Knowing the projected future values of the independent variables, the equation generated in this approach is utilized to calculate the future values of trips. Using a statistical approach, the equation of the required type is created from current data pertaining to independent factors and the dependent variable[14]. Attraction models that take spatial correlation into account are feasible, and their benefits over earlier models which shows spatial correlation into account are investigated[15].

$$Y = a_1x_1 + a_2x_2 + a_3x_3 + \ldots\ldots + a_nx_n + U$$

Where, Y= Dependent variable, X_1, $X_{2,\ldots}$= Independent variables

4.4 Mode Choice Modeling

Using the logit model, it is possible to determine the likelihood that a specific mode will be chosen. This model calculates the likelihood that a trip planner will select a specific mode based on the utility function of that mode.

$$Pm = \frac{e^{Um}}{\sum_m e^{Um}} \quad \ldots.1$$

Where, Pm denotes the probability of selecting the mode

Um denotes the utility function of the mode

5.Results and Discussion

From the study on analysis of trip generation, School going children, workers, Income and Household size were influencing on generating the trips everyday moderately. Higher the school going children and Higher the household size affects the demand on Private vehicle usage. Regression models performed for attributes with trip generation per day. It is found that school trips and work trips are more significant by statistical measure at 95 % level of confidence. From the study on development of the Modal share modeling, it shows that Auto and 2-Wheeler vehicles carries maximum number of school trips compared to Bus transportation in city. Hence there is a demand for Public Transportation to simulate present and future road conditions using an appropriate modelling method.

5.1 Trip generation model and its analysis

A zone's future land use, socioeconomic composition, and type of transportation infrastructure are taken into account in the trip generation analysis stage of the travel demand forecasting process to create models that predict how many school trips a zone will generate. The dependent variable is the generation of zonal trips, and the prime elements, such as the total population, the number of houses, the size of families, the ownership of cars, the income, the number of workers, the number of students, etc., are the independent variables. Following table 2 gives the average value of variables taken from each zone of study area. Dependent and Independent variables are studied by using Multilinear regression analysis where

Y= Number of Trips generated

X_1= No. of School students in family

X_2= No. of workers in family

X_3=Income level

X_4=Car ownership

X_5=Household size

Table 2. Average value of dependent and independent variable of each zone

Zone	Y	X1	X2	X3	X4	X5
I	3.06	1.67	1.35	16.9	0.25	4.53
II	2.84	1.1	1.6	18.2	0.46	4.79
IIIA	2.99	1.42	1.4	31.72	0.86	3.72
IIIB	2.97	1.48	1.33	24.48	0.48	4.48
IV	2.93	1.2	1.2	29.2	0.2	3.2
V	2.86	1.38	1.1	32.48	0.83	4.47
VI	2.5	1.21	1.4	25.3	0.58	5.3

Table 3. Multinomial logistic Regression model of the factors influencing trip generation

Zone	Regression model	R	R-square	SEE	Remarks
I	$Y = 0.122 + 0.935X_1 + 0.899X_2 + 0.009X_3 - 0.15X_4 + 0.005X_5$	0.937	0.878	0.27	Significant
II	$Y = 0.787 + 0.791X_1 + 0.753X_2 + 0.010X_3 - 0.045X_4 - 0.041X_5$	0.724	0.524	0.49	Significant
IIIA	$Y = 1.22 + 0.649X_1 + 0.766X_2 - 0.002X_3 - 0.191X_4 - 0.013X_5$	0.717	0.514	0.511	Significant
IIIB	$Y = 1.537 + 0.610X_1 + 0.719X_2 - 0.003X_3 - 0.202X_4 - 0.037X_5$	0.660	0.435	0.532	Significant
IV	$Y = 1.653 + 0.342X_1 + 0.522X_2 + 0.019X_3 + 0.022X_4 - 0.064X_5$	0.46	0.211	0.62	InSignificant
V	$Y = 1.012 + 0.644X_1 + 0.757X_2 + 0.006X_3 - 0.030X_4 - 0.037X_5$	0.667	0.444	0.564	Significant
VI	$Y = 0.903 + 0.678X_1 + 0.772X_2 + 0.002X_3 + 0.036X_4 - 0.029X_5$	0.745	0.554	0.511	Significant

The table 3 gives the different regression model that determines the proportion of variance between dependent and independent variables. The squared r value shows the data goodness of fit with regression model. Zone I gave an highest effective value of R square equal to 0.878 , indicating that the explanatory variables such as Number of students in family, Number of workers in family, income level, Car ownership, Household size included in the model explain 87.8% of the dependent variable whereas Zone-IV has lowest R square value.

Standard error of the estimate in Zone-I is lowest of 0.27 (27%), represents the average distance that the observed values fall from the regression line.

The equation can predict the trips generated in each households of a city based on their variables X_1,X_2,X_3,X_4 and X_5

It can be stated that all the variables which are modeled with a multiple linear regression equation can allow us to make prediction of data generated from each households of a city.

5.2 Estimation of Modal Share

The specific attribute for each of the modes, β(Bus), β(Car), β(Auto), β(2W) are estimated by regression analysis. The utility function using the logit model to determine the unknown values of β for each of the modes is comparable to the trip makers' stated mode choice. The input x variables for all four alternative modes is obtained by questionnaire survey. The mean values of specific attributes for different modes are given in table.

The Utility function, in general,

$U = \beta + \alpha_1 x_1 + \alpha_1 x_2$

Where, U is the Utility function

x1, x2,…xn are the criteria for mode choice

β is the mode specific attribute

α_1, α_2…are the weight vectors of each criteria

Table 4. Mean values of Specific attributes for different modes

Mode attributes, β	Value obtained
Bus	11.76
Car	11
Auto	12
2-Wheeler	11.5

The final form of the utility equation for all four modes along the route choice 1 i.e. from Udyambag to Khasbag is as follows:

$U_B = \beta - 0.006(\text{Travel cost}) - 0.0002\ (\text{Travel time})$

$U_B = \beta - 0.006(TC) - 0.0002\ (TT)$

5.3 Probability and Modal Share

The mean Travel time and Travel cost as perceived by school trips along the routes are given below. Using Multinomial logit model and Utility function, the number of trips generated by each mode is calculated.

Table 5. Travel time and Travel cost for four different modes

Bus		Car		Auto		2W	
TT (min)	TC (INR)	TT (min)	TC (INR)	TT (min)	TC (INR)	TT (min)	TC (INR)
15	35	50	30	80	20	14	15

Table 6. Probability of Choice and Number of trips made.

Mode	Probability of choice of mode	Number of trips by each mode
Bus	0.325	163
Car	0.123	62
Auto	0.281	141
2-Wheelers	0.269	135

Table 6 shows that the bus mode, which has the highest probability of 0.325 (32.5%), will result in 163 trips, followed by the auto mode (second highest probability at 0.281 (28.1%), the car mode (12.3%) and the two-wheeler mode (26.9%). Auto-rickshaws and two-wheelers obviously play a significant part in school transportation. The promotion towards bus transportation facility is very poor with the reason of no dedicated bus transport facilities available to reach these schools. Hence the Private vehicles (Car & Auto) have the highest probability of usage which could produce more trips compare to Public vehicle (Bus).

5.4 Limitations of the approach

The study's limitations are less number of respondents and the regression analysis's assumption. Including more representative respondents from various zones of Belagavi city will increase the regression model's accuracy.

This study will be helpful to future researchers because there aren't any thorough studies available addressing the trip generation growth in City. Additionally, more variables that influence trip creation can be researched for future research.

6.Conclusion and future Works

The main factors that affect the production of trips are Number of students in family (X1), workers per household (X2), Income level (X3), Car ownership (X4), Household size (X5). Home-based school trips and work trips represents a large proportion of the total trips and these trips have related to the number of students and workers per household. The results of regression modeling show that here is a significant relationship between effective independent variables on Commuter trips generated (Y) in all zones of a city.

On the other side the modal share along the Central Bus Terminal to Udyambag industrial area corridor was analysed. Each mode's utility function was developed and used in the Logit model. The analysis of the Modal share shows that Private vehicles (Auto and 2-Wheelers) carries maximum number of trips or has the highest probability of usage which could produce more trips compared to Bus transportation in city. Hence there is a demand for Public Transportation to simulate current and future scenario on the roads with a suitable modeling process.

Based on the findings of the research, After business excursions, school trips make a secondary contribution. Most of the school trips generated in Indian cities are with respect to Auto, Van and 2Wheelers. In future, the detailed investigation on service quality of city bus transportation could be extended to promote usage of Public transportation in city.

Acknowledgement

The authors would like to acknowledge the support from Belagavi Urban Development Authority (BUDA) and staff from Research centre S.G.B.I.T Belagavi.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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