ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume 2, Special Issue 1, December 2013

Proceedings of International Conference on Energy and Environment-2013 (ICEE 2013)

On 12th to 14th December Organized by

Department of Civil Engineering and Mechanical Engineering of Rajiv Gandhi Institute of Technology, Kottayam, Kerala, India

ACTIVITY BASED TRAVEL BEHAVIOURAL STUDY AND MODE CHOICE MODELLING

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ABSTRACT

Mode choice behavior is a fundamental element of travel behaviour. It is the demand for activities that produces the demand for travel. In other words the need or desire to engage in an activity at a different location generates a trip. Primary objective of this paper is to study the importance of activity based approaches in travel demand models. An attempt is also made to develop a mode choice model for the rural middle class residents by activity based approach. The study area selected was a village in Ernakulam district of Kerala, India. The data collection was done by using the questionnaire form prepared, by interviewing every member of a household, giving emphasis for the previous day's travel pattern. Preliminary analysis was done using excel to study the socio economic characteristics of the study area. Trip characteristics were analyzed using SPSS. Four wheeler and three wheeler ownerships, license ownership, walking time, waiting time, cost and duration of total trip were found to be the influencing variables. These variables were used for the model preparation which was a trial and error process. Model development and its validation were also done by using SPSS. Mode choice model was developed by applying the multinomial logit model based on maximum utilization theory.

Keywords-Activity based approach, Mode choice, Multinomial logit model, SPSS

NOMENCLATURE

V_{mi} The systematic component (observed) of utility mode m for individual i
E_{mi} The error component (unobserved) of utility mode m for individual i
V_{in} The utility function of mode n for individual i
V_{im} The utility function of any mode m in the choice set for an individual i
P_{in} The probability of individual i selecting mode n
M The total number of available travelling modes in the choice set for an individual i

1. INTRODUCTION

Modelling traveler's behavior with respect to mode choice is crucial for effective planning of future transport networks, policy testing and analysis of existing transportation systems. Particularly in developing countries like India, switching between different modes are very common in trip making of a traveler due to availability of multiple modes. Hence, identification of proper mode choice combination plays a vital role in development of a mode choice model. Although mode choice modelling studies were conducted before, they were based on the four stage modelling approach like the mode choice modelling of work trips/leisure trips etc. Since the need or desire to engage in an activity at a different location generates a trip, it is the activity based approach which can be used more effectively to explain the mode choice behavior. The reason is that only the activity-based approach explicitly recognizes the fact that the demand for activities produces the demand for travel. This study is an effort to understand the mode choice behavior of rural residents based on activity based approach.

2. LITERATURE REVIEW

Activity-based approach was conceived in the 1970s by a group of researchers at Oxford University. This approach aims at the prediction of travel demand based on a thorough understanding of the decision process underlying travel behavior. As the activities engaged in a day are linked to each other, trips made to pursue them are also linked to each other; they cannot be analyzed separately one by one. Analysis of activity and travel characteristics shows the importance of mode choice in any activity-travel decision. The tendency of households to optimize their activity pattern in such a way that trips for different motives can be combined to chains has been a phenomenon of since 1970s [1]. The basic hypothesis is that a household participate in all kinds of non-home
activities to meet their various needs by trips and balances the desire to meet each need as it arises with the transportation expenditures required in travel. This trade-off involved in the household's comparison among alternative travel modes can be expressed in terms of utility theory [2]. Since travellers often chain multiple activities together in a trip chain for greater efficiency and convenience, the influence of trip chain on mode choice was considered [8] by classifying trips to single trip, simple trip chain and complex trip chain. There lies a relationship between mode choice and the complexity of trip chaining patterns of travel behaviour [16]. An individual is visualized as selecting a mode which maximizes his or her utility [17]. The utility of a travelling mode is defined as an attraction associated to a mode by an individual by a specific trip. Therefore, the individual is visualized to select the mode having the maximum attraction due to various attributes such as in vehicle travel time, access point to the transit point, waiting time for the mode to arrive at the access point, interchange time, travelling fares, parking fees etc. This hypothesis is known as utility maximization.

The choice behavior can be modelled using the random utility model which treats the utility as a random variable, i.e. comprising of two distinctly separable components: a measurable conditioning component and an error component as shown below in Eqn. (1).

$$Umi = Vmi + Emi \qquad (1)$$

This theory of utility maximization is used in the framework of logit models.

Logit models are the most commonly used modal split models in the area of transportation planning, since they possess the ability to model complex travel behaviours of any population with simple mathematical techniques. The mathematical framework of logit models is based on the theory of utility maximization. Briefly presenting the framework the probability of an individual i selecting a mode n out of M number of total available modes is given in Eqn. (2).

$$Pin = \frac{\exp(Vin)}{\sum_{m \bullet M} \exp(Vim)} \qquad (2)$$

Logit models are generally classified into two main categories namely binary and multinomial logit models. Binary choice models are capable of modelling with two discrete choices only i.e. the individual having only two possible alternatives for selection, where as multinomial logit models imply a larger set of alternatives which is the reason for using multinomial logit models for studying the mode choice behavior of a population and hence the same is used in this study to develop the mode choice model. Mode choice modelling in multinomial logit form is carried out using SPSS (Statistical Package for Social Sciences) software due to it's various benefits such as effective data management, wide range of options, better output organization etc.

3. ACTIVITY BASED APPROACH

The activity-based approach aims at the prediction of travel demand based on a thorough understanding of the decision process underlying travel behavior. In this sense the activity-based approach is entirely different from the approach taken for the development of the four-step procedure where statistical associations, rather than behavioral relationships, drove model development. Another important distinction is the following recognition: as the activities engaged in a day are linked to each other, trips made to pursue them are also linked to each other; they cannot be analyzed separately one by one. Travel is one of many attributes of an activity. In the conventional approach, activity attributes such as the mode used and travel time consumed in accessing an activity are treated as travel attributes and are the focus of descriptive and predictive models. From this perspective, conventional trip-based models are simply a special case of activity-based approaches. Travel is essential a physical mechanism to access an activity site for the purpose of participating in some activity. While trip-based approaches are satisfied with models that generate trips, activity-based approaches focus on what generated the activity that begot the trip. Many household decisions, occurring over a broad range of timeframes, interact with each other and with the urban development process and transportation system performance. In general the characteristics of activity based approach can be summarized as

1. Travel is derived from the demand for activity participation.

2. Sequences or patterns of behaviour, and not individual trips, are the relevant unit of analysis.

3. Household and other social structures influence travel and activity behaviour.

4. Spatial, temporal, transportation, and interpersonal interdependencies constrain both activity and travel behaviour.

5. Activity-based approaches reflect the scheduling of activities in time and space.

4. STUDY AREA

The rural area selected for data collection is a village in Ernakulam district in the Indian state of Kerala. It is 4.8 km distance from its Taluk main Town Kothamangalam which is known as the Gateway of High range and is 37.2 km from its District Main City Kochi and 175 km from its state capital Thiruvananthapuram.

5. DATA COLLECTION

For developing the activity based mode choice model, the middle class residents of the study area were

interviewed with emphasis given to previous day's travel pattern (for the whole day) of every member of the family concerning household details, personal details and trip details. There were a total of 602 data sets including both trips and non trips. Out of the 602 sample population 174(28% of total) were without any trip data. Within the remaining 427 population 120(20% of total) had multiple trips. 75% of the data (449) was taken for calibration of the model and 25% of data (147) was taken for the validation of the model developed.

6. SOCIO ECONOMIC CHARACTERISTICS

The different socioeconomic characteristics of the rural middle class residents drawn from the preliminary analysis of the data, using excel are given below.

Sample population consists of 50% male and 50% female which satisfies the census data 2012. About 58% of the sample population comes under the working group of age between 21 and 60. 79% of the sample population forms the lower middle class community. Within the sample only 39% hold a license which is justifiable for a rural area.

When the sample is analyzed based on occupation, about 39% comes under the non working group (consisting of infants, house wives and people of age more than 60). When the school and college going students are also added, the actual non working category comes about 63%. Among the working group majority, 24% of total is self employed, which is 64 % of the total working community. Here the government employees are only 5% of total which is 14% of the working community, which gives a clear indication about a rural area.

About 58% of total sample population is two wheeler owners and next stands the four wheeler ownership and this itself is a reason for the increased two wheeler trips. Bus is the most frequently used mode and comes around 39%, which is a characteristic of the rural middle class community's travel pattern. 35% of the people use two wheelers as their frequent mode for travel.

Figure 1 shows the mode usage in the study area.

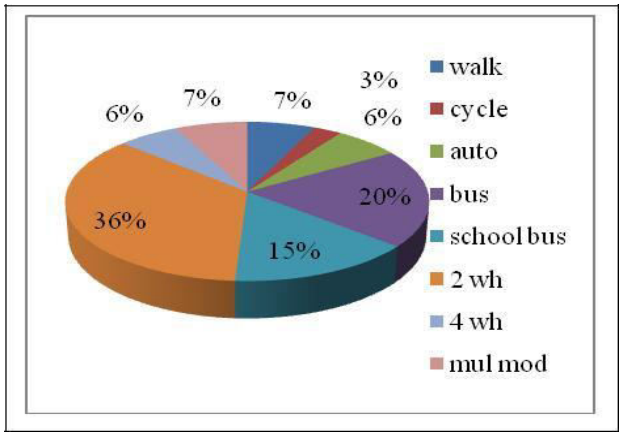

FIGURE 1. MODE USAGE IN THE STUDY AREA

Considering the trip purpose work trips and educational trips are the most frequent trips with 36% and 35% of total trips. Shopping and leisure trips are the least frequent trips which are only 4% of total trips.

Majority of the trips (93%) are single modal trips although there are few (7%) multimodal trips due to less frequency of public transport in the area. Almost 28% of people do not travel frequently and 52% are with

only one trip per day. But there are 20% of people who travel more than one time in a day.

7. MODE CHOICE MODEL METHODOLOGY

Figure 2 is a flow chart showing the step by step procedure of mode choice modelingl methodology.

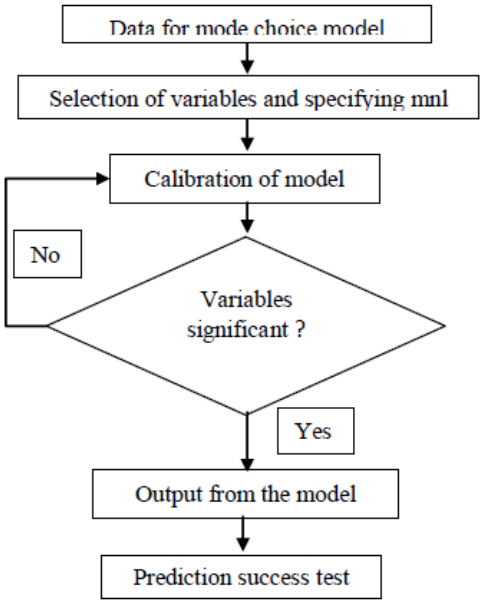

FIGURE 2. MODE CHOICE MODEL

8. EXPLANATORY VARIABLES

Table 1 shows the explanatory variables used in the data collection procedure.

Code	Description
HHMN	No. of males in the household
HHFM	No. of males in the household
HHS	Household size
HHSC	No. of school children in the household
HHCL	No. of college going in the household
HHINF	No. of infants in the house hold
HHINCM	House hold annual income
4WH	four-wheeler ownership
2WH	two-wheeler ownership
3WH	three-wheeler ownership
AGE	Age of the individual
OCCUPATION	Occupation
LICNS	License ownership

GNDR	Gender
TR_PURPS	Trip purpose
TR_WKT	Trip walking time
TR_WTT	Trip Waiting Time
TR_CT	Trip Cost
TR_DRN	Trip Duration

9. EFFECT OF VARIABLES ON MODE CHOICE

House hold size has no significant effect on mode choice because mostly in every mode the highest percentage is shared by household size four, which is the average household size in the rural area consisting of father, mother and two children. Out of people using two-wheelers, 84% are males which are a characteristic of rural area and out of those using bus, and 60% are females. Though the population consists of equal proportion of males and females, a decrease in female share is evident in each mode usage because of the lesser trips by female population which is a characteristic of the rural area. Majority of people travelling in modes like walk, cycle, three-wheeler, bus and school bus does not hold license. There is a significant effect of four-wheeler ownership on mode choice since of those choosing walk, cycle, three- wheeler and bus as their travel mode, 75% does not own a car. The effect of household annual income on mode choice is not significant. The main reason is that in developing countries, lower middle income (annual income between 2.5 to 6 lakhs) people constitute the majority of population in the rural areas. No significant effect for number of household school children on mode choice and the average number of school going children in rural families is two. It is inferred that in agriculture-based rural areas the household college students will very rarely be one or usually be zero since, people after 18 years will be going for job and is a characteristic of the rural area. Almost all the middle class families in the rural area has got at least one two-wheeler.

10.MODEL DEVELOPMENT AND VALIDATION

Though all variables were considered in the initial stage those found insignificant were eliminated in the later stages. For the final analysis after a number of iterations the variables found significantly influencing the mode choice is only seven. They are four wheeler, three wheeler and license ownership, total trip walking time, waiting time, cost and duration. Since two-wheeler are the most preferred mode, it is selected as the reference category for the mode choice analysis. The preferred ratio of valid cases to independent variable is 20 to 1. Since the ratio of valid cases (389) to number of independent variables (7) is 55.57 to 1, which is greater than the preferred ratio, the requirement for a minimum ratio of cases to independent variables is satisfied. A likelihood ratio test shows whether the model fits the data better than the null model. Table 2 titled model fitting information, gives a likelihood ratio test of final model against the one in which all the parameter coefficients are 0(null). The chi-square statistic is the difference between the -2log likelihoods of the null and the final models. Since the probability of the model chi-square obtained is 0, less than or equal to the level of significance of 0.05, the existence of a relationship between the independent variables and the dependent variable was supported as per the model fitting information. The overall percentage accuracy rate (83.0%) was greater than the proportional by chance accuracy criteria (40.25%) and hence the criterion for classification accuracy that is a 25% improvement over the rate of accuracy achievable by chance alone is satisfied and the multinomial logistic regression model is found to be useful. All the variables are statistically significant at the 0.05 probability level and hence all the independent variables have overall relationship to the dependent variable as per the likelihood ratio test table given in table 3. Goodness of fit and pseudo R square values is also satisfactory and is given in table 4. Table 5 shows the parameter estimates.

TABLE 2. MODEL FITTING INFORMATION

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 log likelihood	Chi-Square	df	Sig.
Intercept Only	1095.867			
Final	360.604	735.263	35	.000

TABLE 3. PSEUDO R- SQUARE

Cox and Snell	0.849
Nagelkerke	0.900
McFadden	0.660

TABLE 4. PARAMETER ESTIMATES

TR_MODE		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower bound	Upper bound
4 WH	intercept	-0.723	1.101	0.431	1	.511			
	TR_CT	0.101	0.02	26.812	1	.000	1.107	1.065	1.15
	TR_DRN	-0.048	0.016	9.648	1	.002	0.953	.924	.982
	4WH=NO	-3.129	1.117	7.853	1	.005	0.044	.005	.32
	LICNS=NO	2.827	0.596	22.487	1	.000	16.893	5.251	54.343
3 WH	intercept	-1.529	0.784	3.802	1	.051			
	TR_CT	0.083	0.018	20.394	1	.000	1.086	1.048	1.126
	TR_DRN	-0.019	0.009	4.48	1	.034	.981	.964	.999
	4WH=NO	1.267	0.623	4.135	1	.042	3.55	1.047	12.037
	3 WH=NO	-3.901	0.830	22.104	1	.000	.02	.004	0.103
	LICNS=NO	4.29	0.74	33.606	1	.000	72.96	17.107	311.159
MULTI MODE	intercept	-5.62	1.638	11.767	1	.001			
	TR_WTT	1.183	0.324	13.372	1	.000	3.265	1.732	6.157
	TR_CT	0.055	0.016	11.913	1	.001	1.057	1.024	1.091
	4WH=NO	2.092	0.863	5.879	1	.015	8.102	1.493	43.955
	LICNS=NO	3.963	0.909	19.002	1	.000	52.616	8.857	312.587

SCHOOL BUS	intercept	-5.427	2.297	5.58	1	.018			
	TR_WKT	0.368	0.116	10.128	1	.001	1.445	1.152	1.813
	LICNS=NO	7.535	1.824	17.068	1	.000	187.182	52.465	66781.35
BUS	intercept	-3.9	1.79	4.747	1	.029			
	TR_WTT	1.705	0.345	24.5	1	.000	5.504	2.802	10.814
	LICNS=NO	2.903	1.143	6.452	1	.011	18.227	1.94	171.202

11. RESULTS AND DISCUSSION

No numerical problems encountered since none of the independent variables have standard error greater than two and hence the results can be interpreted. Two-wheeler is the base unit of comparison, so it is not present in the parameter estimate table. Overall almost all the parameters have the expected signs.

Here we can interpret the significance of all the independent variables in distinguishing between pairs of groups defined by the dependent variable since the independent variable also has an overall relationship to the dependent variable in the likelihood ratio test and also the significance of the Wald estimates are less than 0.05.

i. Of attributes of traveler variables, a negative constant of all the modes considered other than two wheeler accounts for the unobserved factors to be in the negative direction of choosing these modes compared to two-wheeler. In other words unobserved factors influence positively to prefer two-wheeler than any other mode.

ii) People who have no four wheeler ownership, has a negative influence on choosing four wheelers than two wheelers compared to those having four wheeler ownership. The same is the case with choosing three wheelers compared to two wheelers between those without and with three wheeler ownership.

iii. The variable no license has a positive influence on all modes compared to two wheelers than those who hold a license.

iv. Trip duration is having a negative influence on 4 and three wheelers compared to two wheelers.

v. The value of Exp (B) is 18.227 for bus mode, which is >1 implies that for each unit increase in no license the odds are increased in choosing bus as mode.

vi. The value of Exp (B) is 0.981 for three - wheeler mode, which is <1 implies that for each unit increase in no three wheeler ownership the odds are decreased in choosing three wheeler as their

mode by (.981-1=- 0.019 = 1.9%).

The equations below are obtained as mode choice models for rural residents for the selected study area. Two-wheeler is the reference group and does not appear in the table of parameter estimates. By definition, the log of the odds of the reference group is set to zero (0). So the log of the odds for two wheeler passengers is equal to zero.

$U\ (_{2\ WH}) = 0$

To calculate the log of the odds for four wheeler passengers, the coefficients for the four wheeler from the table of parameter estimates and the variables are multiplied. The log of odds for different modes are obtained as

$U_{(4\ WH)}$ = -.723 + .101 (TR_CT) - 0.048 (TR_DRN) - 3.129 (4WH) + 2.827 (LICNS)

$U_{(3WH)}$ = - 1.529 + .083 (TR_CT) - .019 (TR_DRN) + 1.267 (4WH) - 3.901 (3WH) + 4.290 (LICNS)

$U_{(MULTI\ MODE)}$ = - 5.620 + 1.183 (TR_WTT) + .055 (TR_CT) + 2.092 (4WH) + 3.963 (LICNS)

$U_{(SCHOOL\ BUS)}$ = - 5.427 + .368 (TR_WKT) + 7.535 (LICNS)

$U_{(BUS)}$ = -3.900 + 1.705 (TR_WTT) + 2.903 (LICNS)

The model developed was also validated with an accuracy of 100 % for four wheeler travelers and multimode choosers and 92%, 82% and 94% for school bus users, bus passengers and two wheeler users respectively.

8. CONCLUSIONS

A multinomial logit model to study the mode choice behavior of rural middle class residents is developed. The study helped to draw the socio economic characteristics of a typical agriculture based rural village area. The activity based approach really helped to study the travel pattern in a realistic way. For the empirical analysis the data used is collected by means of household survey of every individual of the middle class family and software tool SPSS is used to develop the model. Four wheeler and three wheeler ownership, license ownership, trip walking time, waiting time, cost and duration are found to be the most influencing factors for the choice of mode. The model developed could greatly help the policy makers and will be the area of interest for public transport service providers who are interested in attracting choice riders.

9. SCOPE AND LIMITATIONS

Activity based approaches have scope to find the influence of the different areas on the congestion of the towns but to apply this method on rural areas has got only a limited scope. There is a scope to find the effect of the time of the day of the trip on the modes used with a detailed data collection by activity based approach.

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