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Mode choice behaviour of students, integrating residential location characteristics: a study from Kochi City, India

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Abstract

Mode choice decision of individuals plays a vital role in transportation planning. Individual travel behaviour models can be improved by extending the set of influencing variables used for modelling. In a developing country like India, students contribute a major share of total travel demand especially during morning and evening peak hours of traffic; whose individual travel characteristics are very less studied by transportation professionals. This paper presents exploratory and statistical analysis of mode choice behaviour of students in Kochi City, India. The socio-demographic characteristics, activity-travel behaviour as well as residential location characteristics of students during a usual working day is collected using activity-travel survey data, in Kochi Municipal Corporation. Preliminary analysis gives details on daily activity-travel pattern, mode choice preferences and other particulars of commuters in the study area. Statistical models were developed for understanding the factors affecting mode choice decision and separate mode choice models are also developed for different categories of students. Simulation of choice probabilities over different attributes is also done to identify the potential policy variables that can promote the use of sustainable modes.

Keywords: Activity based model, Students, Mode choice behaviour, Residential location parameters, Metropolitan area, Developing country.

1. Introduction

Growing desire for education is producing rapid increase in the number of schools and colleges in and around urban areas. In a developing country like India, the morning and evening peak hour traffic in a working day is causing heavy traffic congestion for all groups of commuters. Student commuters contribute a significant portion in this traffic congestion, but they are understated in most of the travel studies. Understanding travel behaviour of students can help the urban planners to introduce appropriate policy measures to provide a more comfortable travelling environment to other population

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segments. When the students are considered, it will be more efficient to consider them by different categories because the travel behaviour of a small aged, school going student will be entirely different from that of a graduation student. In early ages the household members may be taking the mode choice decision for students based on their living conditions and safety factors. When they grew-up, they themselves will be deciding how to go, with consent from their parents. The conventional travel behaviour models are to be improved to more realistic models for more accurate travel demand prediction. With this intention, studies are developing in a direction to incorporate extended variable sets like land use characteristics, built-environment characteristics etc. in travel demand modelling, as it will be a significantly influencing factor on travel behaviour.

The present study focuses on travel behaviour modelling of students integrating residential location characteristics as one's place of residence will certainly affect his/her travel decisions. The objectives of the study are to model mode choice behaviour of students integrating residential location characteristics and also to compare the travel behaviour of different categories of students. Study also aims to find the potential policy variables that can promote the use of sustainable modes for students by simulation of choice probabilities.

2. Background

Travel behaviour analysis of students has been focused by some of the transportation researchers in different countries, because an appropriate representation of sub population in transportation studies is essential to improve the regional travel demand models. The fundamental theories behind activity based approach were developed during 1970s (Hägerstrand, 1970; Chapin, 1974; Cullen and Godson, 1975), which is successfully used in transportation researches now a day. The complexity of transportation system can be well studied only by analysing different elements within it and performance of theses elements are related to travel demand and user behaviour (Cascetta, 2013). The exploratory analysis of transport studies gives the output that the students behave differently compared to the general population (Khattak et al., 2011). A study about mode choice behaviour and school choice of students have been done in Germany. Multinomial logit (MNL) modelling is used and travel distance, travel cost as well as weather are found to be the influencing factors of mode choice for students (Müller et al., 2008). In Toronto, Canada the influence of built environment and house hold interaction on school travel behaviour of 11 year old students were studied. Geographically weighted MNL modelling is used to explore the mode choice behaviour. From this research it is found travel distance is the most important factor influencing the mode choice decision of the students (Mitra and Buliung, 2014).Mode choice analysis among students in McMaster University, Canada, reveals their mode choice decisions are influenced by a combination of factors such as cost, individual attitudes and environmental factors. MNL modelling is used for the study and the final model gives the key evidence regarding positive utility of travel time. Parking permit for student's vehicle is also a positive, significant and relatively large effect variable that influences the mode choice (Whalen et al., 2013).

Different travel demand modelling studies conducted in India is an important element of discussion. The exploratory and statistical analysis of activity-travel behaviour of non-workers in Bangalore city were studied. Analysis of activity participation behaviour, trip chaining, mode choice behaviour etc. was done using different types of travel demand modelling methods. The study gives out the fact that certain residential lacation parameters affect the activity participation behaviour and factors like population density

on mode choice decision (Manoj and Verma, 2015). Mode choice analysis of workers in Tiruvanthapuram City, Kerala, was also done using MNL modelling method. Its results shows lower age group prefers two-wheeler and higher age group prefer car compared to bus. Female commuters prefer public vehicle and male commuters prefer private vehicles more. Other parameters like income, vehicle ownership, distance, time/distance and cost/distance also have significant effect on the mode choice decision (Ashalatha et al., 2013). Mode choice decision of workers in Chennai city is also modelled. Study include alternate behavioural framework such as random utility minimisaiton, random regret minimisation etc. in addition to most widely used random utility maximisation rule for mode choice decision. Policy results are also evaluated for comparing the performance of all these rules used for selecting the mode choice (Parthan and Srinivasan, 2013).

Studies have shown that integrating land use or built-environement variables along with usual parameters like personal and household socio-economic characteristics and activity-travel characteristics will improve travel demand model. Among them residential location characteristics, which comes within the residential location characteristics, can be considered as one of the driving forces of a commuters travel decision (Schirmer et al., 2014). The discrete choice research studies on residential and travel demand models, give the result that integration of land use characteristics improve the forecasting quality travel models (Ben Akiva and Bowman, 1998). The research on modeling the relationship between residential location and mode choice within a behavioral analysis framework in Western Australia resulted in the conclusion that improving the accessibility of public transport can change the mode choice of individuals (Nurlaela and Curits, 2012). An integrated model on residential location, workplace location and vehicle ownership was developed to find it's the influence on the commuter tour characteristics. The characteristics like workplace density, residential location densities, household income, number of workers, number of adults and number of vehicles owned by the household were taken as independent variables of analysis. The study reached on the conclusion that the residential location and work place location characteristics have impact on the tour characteristics and mode choice of an individual (Paleti et al., 2012). Residential location can be considered as an important trigger of changes in individual travel behaviour and so there is a significant change in travel behaviour after a residential move. Due to this reason this should incorporate in the study of travel behaviour dynamics of individual. It can be explained using changes in social environment and personal social network after social move (Lin et al., 2018).

However, most of the researches considering student's travel behaviour are focused in developed countries. Disaggregate modelling of students travel behaviour and its integration with built-environment characteristics has got little attention in developing countries. All these show the importance of activity based travel behaviour modelling of students incorporating residential location characteristics.

3. Materials and methods

3.1 Study area and data collection

Kochi Municipal Corporation (KMC), Kerala, India is the region selected for present study. Kochi is one of the few cities in India which is well connected by the four major modes of transport say road, rail, water and air transport. Metropolitan region of Kochi is the industrial and commercial capital of Kerala state which spread over 94.88 km^2 and it is divided into 74 electoral divisions. As per reports of Census 2011 India, population of KMC is 602,046. KMC is the most densely populated corporation in the state with a

population density of 6345 persons per km^2 (Census of India, Part a, b, c, 2011). Kochi is selected as 5th among the 20 major cities selected under Smart City Mission of Government of India. The land use characteristics of KMC shows almost 75.77% of usable area is under residential use, which is not a preferred characteristic for a metropolitan region. The increased land use for residential purpose is acting as a hindrance for further development of the city. The percentage of land use for transportation purpose is only 5.83%, which is very low for such a densely populated city, resulting in narrow roads and heavy traffic congestion problems in KMC (Development plan of Kochi City, 2010).

Survey instrument is designed accordingly to collect household, residential location, personal and activity-travel characteristics by direct household interview method. Household characteristics such as name of household head, contact details, division number, type of dwelling unit, number of males and females in the house, details of vehicle ownership etc. form the initial part of the diary. The personal characteristics like relationship with household head, gender, age, education, occupation, type of employment, income per month, possession of driving license etc. were included. Residential location characteristics that are likely to influence the travel pattern and mode choice of individuals were identified from literature survey and considering the study area characteristics. The details like reason for selecting present location, distance to main road, distance to nearest bus stop, distance to usual shopping center, distance to city centre and frequency of public transport available for work, education, shopping and city centre were included. A closed end question was provided to record the reason for less preferring the public transport. Extent of telecommunication usage of each household was also measured using the diary.

The total sample size selected was 3000 household (1.89% of total population). Multi stage random sampling method was adopted, as the sample size is big and survey area is large (Richardson et al., 1995). To prevent the chance of clustering of sample on geographical basis, 32 divisions were selected from total 74 divisions according to the distance from the City Center. The number of households from each division was selected by means of Probabilities Proportional to Size (PPS). Households were selected randomly from the 32 divisions considered for survey. Based on the findings from the pilot survey the survey instrument is modified and data from 2,993 households are collected successfully from surveying a total of 3,107 households, using the modified survey instrument. The duration of data collection was 10 months.The total response rate of present study is 96.33%, which is crucial as it have direct effect on the final results (Stopher, 1992).

3.2 Preliminary data analysis

Preliminary analysis explores the contents of a dataset and describes the dataset in a number of ways like response rates, means and standard deviations of responses, frequency distributions and cross-classifications. The coded and edited data, should give a clean dataset which ready for analysis. In present study database preparation of collected data is done using Microsoft Access. The final database contains 2,989 household data, 11,758 personal data and 13,331 trip data. The database preparation, consistency check and exploratory analysis are done using the tables and in built Structured Query Language in Microsoft Access. Mode share of the total respodents from the database is shown in Table 1. Two-wheeler is the most used mode by the respondents in the study area and then comes the public bus. Some respondents are using modes like commercial vehicle

as a part of their job. Least accessibility of train and boat form home or workplace makes them comparatively the least preferred modes by the commuters.The modes whose share is less than 2% is not considered for further analysis.

Table 1: Categorical variables and coding

Mode used	*Mode share (%)*
Two-wheeler	27.18
Public bus	24.31
Walk	19.52
Auto-rickshaw (Three wheeler)	9.36
School Bus/College Bus / Company Bus	8.77
Bicycle	5.80
Car	3.70
Boat	0.59
Commercial vehicle	0.46
Train	0.31

Percentage distribution of trips by activity type shows that share of work trip are 56.53% and next major share is for education and i.e., 38.19%. No other activities like shopping, recreation, religious etc. are not much predominate during working day. Internal Home-Education-Home (HEH) activity pattern is considered for mode choice modelling. 39.58% of the total commuters are following HEH activity pattern. Mode choice modelling is done considering whole 2193 HEH pattern. The different modes considered for modelling are auto-rickshaw (three wheeler), public bus, school/college bus, bicycle, two-wheeler and walk. According to the travel cost of different modes in the study area auto-rickshaw is the most expensive mode for education as well as school bus and two-wheeler are 35% and 65% less expensive compared to auto-rickshaw. Students can avail the government concession in public bus so the travel cost in public bus is still lesser.

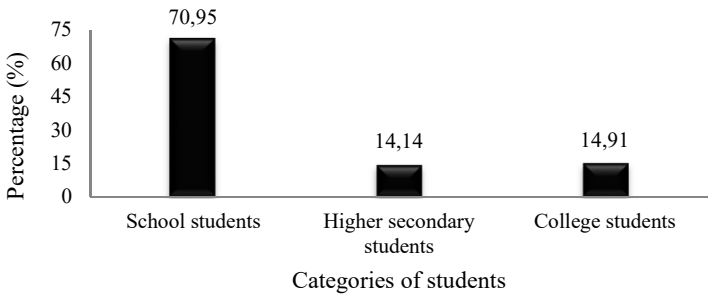


Figure 1: Percentage distributions of different categories of students

There is a considerable difference in the mode choice decision of students at different age, so four different categories are considered for mode choice analysis i.e., total students having HEH pattern, school students, higher secondary students and college students. Percentage distribution of different categories of students is given in Figure 1 and Figure 2 shows the mode share for different categories of students considered for modelling. Up to higher secondary students the mode two-wheeler means dropped

off/picked up by two-wheeler, by parents. For degree students two-wheeler means it is used by the students themselves to travel. The most preferred mode by school students is school bus and it is bus for students in pre-graduation as well as graduation and more categories. Modes like auto-rickshaw and cycle are not used by the degree students.

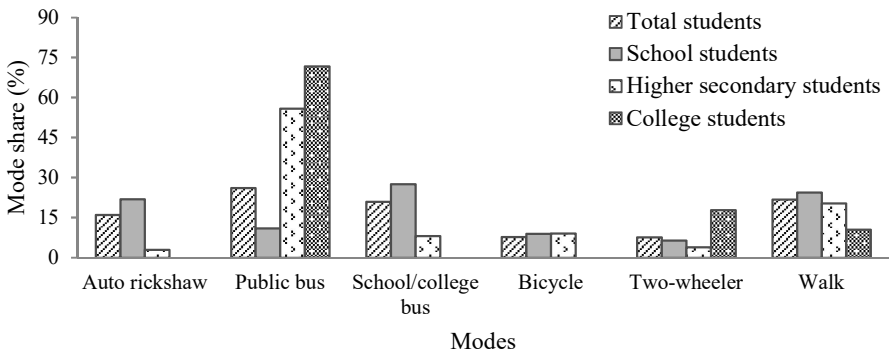


Figure 2: Mode share distribution of different categories of students

Table 2: Categorical variables and coding

Variables	*N*	*Marginal Percentage (%)*	*Variables*	*N*	*Marginal Percentage (%)*
Personal characteristics			***Household characteritics***		
Age			Household income/month (INR)		
3 to 15	1554	70.86	< 10,000	517	23.58
16 to 18	366	16.69	10,000-20,000	916	41.77
19 to 32	273	12.45	20,000-30,000	456	20.79
Gender			> 30,000	304	13.86
Male	1094	49.89	***Residential location characteristics***		
Female	1099	50.11	Population Density (persons/hector)		
Education			<25	152	6.93
School	1556	70.95	25 to 50	1146	52.26
Higher secondary	310	14.14	50 to 100	695	31.69
Degree and more	327	14.91	> 100	200	9.12
Driving License ownership					
Yes	154	7.02			
No	2039	92.98			
N			2193		

Note: 10000INR = 126.3€, 20000INR= 252.6€, 30000INR= 378.9€

Individual status shows 23.10% of the total population is students and 31.89% of the total trips are made by them. The average duration taken for education activity is 6 hours and 12 minutes. Different categorical variables used in the study along with their coding are shown in Table 3 and details of exploratory variables are shown in Table 2. Activity-travel characteristics like travel distance, travel time per unit distance, travel cost, mode used etc.; personal characteristics like age, gender, education, driving license ownership etc. and household characteristics like household income, total number of members in

household, number of workers in a household, cycle ownership, number of motorised vehicle ownership etc. are considered for the analysis in addition to the residential location characteristics. The explanatory variables include mode characteristics, activity-travel characteristics, household characteristics and residential location characteristics. The variables which are supposed to be used as policy variables should be given as explanatory variables.

Table 3: Explanatory variables and coding

Variables	*Mean*	*Minimum value*	*Maximum value*	*Standard deviation*
Mode characteristics				
Travel Cost (INR)	22.96	0	768	51.08
Travel time per unit distance (min./km)	3.55	1	50	8.13
Activity-travel characteristics				
Total travel distance (km)	7.06	0.1	64	6.82
Household characteristcs				
Total household members	4.75	1	14	1.4
Number of workers/ household	1.38	0	6	0.68
No. of cycles/household	0.42	0	3	0.64
No. of motorised vehicle/household	1.15	0	9	0.92
Residential location characteristics				
Distance to nearest bus stop (km)	0.55	0.02	3	0.32
Frequency of buses/hour from nearest bus stop	11.1	1	30	7.18
Distance to city center (km)	8.03	0.5	13.4	3.64

3.3 Model framework

Multinomial logit model has been widely used for choice modelling, which gives the choice probabilities of each alternative as a function of the systematic portion of the utility of all the alternatives (Koppelman and Bhat, 2006). Conditional logit model is the multinomial logit model itself; in which the explanatory variables include attributes of the choice alternatives (for example travel cost) as well as characteristics of the individuals making the choices such as age (Greene, 2016). The basic form of conditional logit model is given in Equation (1).

$$\Pr(Choice\ j) = \frac{\exp(\beta_j x_{ji} + \gamma_j z_i)}{\sum_{m=1}^{J} \exp(\beta_m x_{mi} + \gamma_m z_i)} \quad ; \ j = 1 \ldots J \qquad (1)$$

Where ‘i’ indicates the observation or individual and ‘j’ and ‘m’ indicates the choices. ‘β’ represents the coefficient of the variable ‘x’, choice varying attribute and ‘γ’ represents the coefficient of the variable ‘z’, related to the individual and household characteristics. In this study conditional logit modelling is used for mode choice analysis. Log likelihood function is considered as the model estimator. Wald statistics and P-value (significance value) is calculated for each parameter to estimate its significance. The goodness of fit measures for multinomial logit model like likelihood ratio /Chi square value, rho-square value, adjusted rho-square value, percentage correctly predicted and Akaike Information Criterion (AIC)/N. After developing the final model simulation of choice probability is also done, this gives the variation of probability of choosing an alternative for a particular variation in the value of an attribute.

4. Results and discussion

The estimation results of mode choice model for all categories of students for HEH pattern is given in Table 4 and goodness of fit measures and percentage correctly predicted for model validation are summarised in Table 5. All these measure assure that all the calibrated models are reasonably good for prediction of mode choice at individual level.

Table 4: Parameter estimates of mode choice models for students

Total students					
	Modes				
Variables	*Public bus*	*School bus*	*Bi-cycle*	*Two-wheeler*	*Walk*
Constant	0.111	-2.115	1.146	-3.601	3.482
Travel time/distance	-0.085**	-0.060*	-	0.108**	-
Travel cost	-	-0.008**	-	-	-
Travel distance	-		-	-	-0.714***
Gender; Male	-		-	0.754***	-
Travel distance	0.275***	0.337***	-0.140*	-	-
Age; 3 to 15yrs	-	1.406**	-	1.647***	-1.418***
Age; 16 to 18yrs	-	-1.159*	-	-	-
Age; >19yrs	2.426***	-	-0.404***	2.005***	-
Driving License Ownership	-	-	-	2.922***	-
Household size	-0.272***	-	-	-	-
No. of motor vehicles/household	-0.282**	-	-	0.822***	-0.257**
No. of bi-cycles/household	-	-	2.269***	-	0.280*
No. of workers per household	-	-0.276*	-	-0.824***	-
Monthly household income; 10,000-20,000 INR	-	0.796***	-0.825**	-	-
Monthly household income; >30,000 INR	-	1.594***	-	-	-
Population density/hector; 25-50 persons	-	-	-0.570*	-	-
Distance to city center	-	-0.049*	-	-	-
Distance to nearest bus stop	-0.418	-	-	-	-0.051
Frequency of buses/hr.	0.022*	-	-0.105***	-	-
School Students					
Variables	*Auto-rickshaw (Three wheeler)*	*Public bus*	*Bi-cycle*	*Two-wheeler*	*Walk*
Constant	-0.757	-6.586	-6.319	0.047	0.664
Travel time/distance	-	-	-	0.086**	-
Travel distance	-0.220***	-	-0.422***	-	-1.096***
Gender; Female	-	-	-0.978***	-	-
Age	-	0.517***	0.565***	-	0.205***
Household size	-	-0.242*	-	-	-
No. of motor vehicles/household	-	-0.396*	-	0.775***	-
No. of bi-cycles/household	-0.412**	-	1.812***	-	-
No. of workers per household	-	-	-	-0.722**	-
Monthly household income; <10,000 INR	1.121***	1.032**	1.030**	-	1.340***
Monthly household income; 10,000-20,000 INR	0.915***	0.894**	1.499***	0.805**	0.900***
Monthly household income; >30,000 INR	-0.643*	-	-	-	-
Population density/hector; <25 persons	-	-1.243**	-	-	-1.561***
Distance to city center	-	-	-	-	0.118***
Higher Secondary students					
Variables	*Public bus*	*School bus*	*Bi-cycle*	*Two-wheeler*	*Walk*

Constant	-1.102	-3.798	-4.356	-2.434	11.307
Travel time/distance	-	-	-	-	-0.546***
Travel distance	0.369*	0.381*	-	-	-1.751***
Gender; Male	-	-	2.345**	-	-
No. of bi-cycles/household	-	-	2.334***	-	-
Monthly household income; <10,000 INR	2.835***	-	2.819**	-	-
Monthly household income; 10,000-20,000 INR	-	-	-	-	-2.140**
Population density/hector; >100 persons	-	-	-	-	3.254**
Distance to nearest bus stop	-0.484	-	-	-	3.174*
College Students					
Variables	*Public bus*	*Two-wheeler*			*Walk*
Constant	-10.365	-12.759			-
Travel time/distance	-0.563***	-0.840***			-0.882**
Travel cost	0.272*	-			-
Travel distance	0.877**	1.052***			-
Gender; Female	-	-3.440***			-
Frequency of buses/hr.	0.162**	0.131*			-

* **, **, * ==> Significance at 1%, 5%, 10% level

Note: 10000INR = 126.3€, 20000INR= 252.6€, 30000INR= 378.9€

Table 5: Goodness of fit measures calculated for mode choice models

Variables	**Total students**	**School students**	**Higher secondary students**	**College students**
Log likelihood for constant only model	-2410.798	-1721.605	-251.995	-165.376
Log likelihood at convergence	-1551.914	-1106.555	-127.971	-67.599
Likelihood ratio /Chi square value (P-value)	1826.193 (0.000)	1265.673 (0.000)	267.707 (0.000)	207.718 (0.000)
Rho-squared value	0.356	0.3573	0.4922	0.5912
Adjusted rho-squared value	0.349	0.3460	0.4639	0.5662
Percentage correctly predicted	59.016	59.730	78.26	86.190
AIC/N	2.236	2.30	1.758	0.872
N	1464	1038	207	210
Validation: Percentage correctly predicted	55.418	54.247	72.816	78.846

4.1 Total students

Mode choice analysis is a method of arriving at a decision on which mode is chosen by a particular commuter under a set of circumstances. For mode choice analysis 2193 HEH patterns are available, in which 1464 patterns used for calibration of model and 729 patterns were used for validation. Goodness of fit measures calculated assures that the model calibrated is reasonably good. The significant variables and policy variables from the final model are discussed as follows. All the estimated parameters are interpreted by taking auto-rickshaw as the base. Considering the parameter estimate of travel time per unit distance shows two wheeler is the most preferred mode and public bus is the least preferred one. The result is supported by student mobility simulation model claibrated for University students of Calabria, South Italy (Mazzulla, 2009) and also the mode choice mode calobrated for McMaster University, Canada (Whalen et al., 2013). This indicates

that students have the tendency to choose private mode as the travel time per unit distance of public bus as well as school bus is very high. School bus is the least preferred mode as the travel cost is considered. Travel distance is the next significant factor that influences the mode choice decision of students. For longer travel distance is students more prefer school/college bus and when the travel distance decreases the preference to bi-cycle and walk increases. Researches about mode choice behaviour of students in Germany and Canada also have made the similar observation that travel distance is one of the main factors that influence the mode choice decision of students (Müller et al., 2008; Mitra and Buliung, 2014).

Gender of the student is found to have significance only for two-wheeler and it is more preferred by male students. Another personal characteristics having significant influence is age of the students. Students, whose age is greater than 19 years, are most preferring public bus and then two-wheeler. And students below 15 years are more preferring school bus and two-wheeler. This can be because the parents are more conscious about safety of their kids at younger age and so they used to drop the students by themselves or send them by school bus. Walk is least preferred by the same age group. Driving license ownership is also a significant factor promoting the usage of two-wheeler for education. When the number of workers in a household increases students least prefer two-wheeler and school bus compared to other modes. This is because usually number of workers is more in a household where the household head is not able to earn a high amount needed to look after his family members, so those students cannot afford the expensive modes for education like school bus or two-wheeler. Public bus and bi-cycle are least preferred compared to school bus and auto-rickshaw as the total number of members increases in a household. The ownership of motorised vehicles by a household has a significant negative effect on use of sustainable modes like public bus and walk and also has a positive significant influence on usage of two-wheeler. High monthly income of household imparts a positive effect on students to use school bus and also negative effect on usage of bi-cycle. Parents having high monthly income will always be able to afford the school bus charges compared to parents from lower income level.

Residential location characteristics are also found to have significant effect on mode choice decision of students. Bi-cycle is less preferred by students residing in places having less population density and walk is preferred by those students in high population density region. Most of the households residing in high population density region belong to lower income group and they more prefer nearby schools. Residential location density is proved to be an influencing varible on mode choice descision in recent researches (Paleti et al., 2012). Preference to use public bus decreases with decrease in accessibility to bus stop and increases with increase in frequency of public buses from nearest bus stop. Increase in bus frequency also has a significant negative effect on usage of bi-cycle. School bus is the least preferred mode as distance to city center increases.

4.2 School students

School level students include students up to 10th standard students (3 to 15 years), whose mode choice decision is usually taken by parents considering more importance to their safety. Total 1556 HEH patterns are available for this category, in which 1038 is used for calibration and 518 is used for validation. Among 1556 school students 49.81% of them are male and 50.19% of them are female. Age of school students varies from 3 to 16 years. Travel time per unit distance is one of the mode characteristics that have influence on mode choice decision. Considering the travel time per unit distance the most

preferred mode is two-wheeler and has a negative effect on all the other modes for school students. Auto-rickshaw, bi-cycle, two-wheeler and walk are significantly less preferred compared to school bus and public bus as the travel distance increases. Parents are more concerned about the safety of their children due to the social circumstances presently existing in the society and so they more prefer school bus for younger students. Female students are less preferring bi-cycle and there is no significant effect of gender in selecting other modes. Public bus, bi-cycle and walk are significantly preferred by the school students when compared to school bus as their age increases. As they grow up they will be able to travel independently and this will result a shift from the costly mode school bus to other sustainable modes.

As the number of workers in a household increases, two-wheeler become the least preferred mode, because school students are dropped/picked-up by two-wheeler by household members and this may not be possible if most of them are going for work. Auto-rickshaw and school bus are more preferred with increase in household size and public bus is the least preferred mode. Bi-cycle ownership has a significant positive effect on choosing it as a mode for education by school students and a negative effect on choosing auto-rickshaw. Motor vehicle ownership of household has a positive effect on choosing two-wheeler and a negative effect on choosing public bus. Auto-rickshaw, public bus and auto-rickshaw are preferred by the students from lower and middle income family and two-wheeler is more preferred by middle income group. Students from higher income more prefer school bus for education. Residential location characteristics also have significant effect on mode choice decision of school students. Public bus and walk is significantly less preferred by the students from low population density region compared to school bus. Walk is the most preferred mode when the distance from city center is more from the residential location. This is because when the accessibility to schools at city center decreases, parents have a tendency to choose nearby schools for their children. Public transport frequency per hour has a positive effect on using public bus and a significant negative effect on using bi-cycle. All the goodness of fit measures shows the model is reasonably good and model validation is also done. Even though all these parameters are examined there will be some more hidden reasons behind the mode choice of a school going student, because in this case the commuter may not be the decision maker always. So the model is more explained by mode, household and residential location characteristics than individual characteristics.

4.3 Higher secondary students

The higher secondary students usually travel alone and they have an opinion about their mode to travel. Students from 16 to 18 years belong to this category. Students are ready to travel more distance than they travelled for their schooling. Parents also offer less control over students decisions at this age i.e. travel decisions are made by the commuter itself with less interaction from their parents. Most preferred mode of higher secondary students is public bus. 54.52 % of students in this category are male and 45.48% of them are female. 310 HEH patterns are available for higher secondary category, in which 207 patterns are used for model calibration and 103 patterns are used for validation. Considering the mode characteristics walk is the least preferred mode when travel time per unit distance is considered. Public bus and school bus is significantly preferred by the higher secondary students as the travel distance increases and walk is least preferred. Male students and bi-cycle ownership has significant positive influence on choosing bi-cycle as the travel mode. Bi-cycle and public bus is most preferred by the

students from low income level due to least travel cost and walk is the least preferred mode for students from middle income level compared to all the other modes. When accessibility to nearest bus stop from residential location increases, higher secondary students significantly prefer walk. Bi-cycle is the most preferred mode when the distance from city center increases to the residential location. Students coming from high population density region also prefer walk the most. All the goodness fit measures and validation holds fit for a good model and it also have good prediction capacity.

4.4 College students

College students are considered as grownup members of the family and they are free to take their own decisions. But in India most of this category have not started earning by themselves dislike a grown up student in a developed country. This financial constraint can affect their mode choice decision too. Total 314 HEH patterns are available for this category in which 210 is used for model calibration and 104 is used for model validation. 45.57% of the college students are male and 54.43% of them are female. Three modes public bus, two-wheeler and walk are mostly used by the students in this category. Walk is considered as the based mode for the analysis. Public bus is the most preferred mode college students when the travel cost is considered. Due to concession provided by government public bus is very cheap for students. Travel time per unit distance has a significant negative effect on all the modes. Two-wheeler is the most preferred mode by when the distance to college increases and public bus is also significantly preferred when compared to walk. Two-wheeler is the least preferred mode by female students and they prefer walk more. Driving license ownership and motor vehicle ownership have positive effect on choosing two-wheeler and household income has no significant influence in mode choice decision. As public bus frequency increases the probability to choose public bus significantly increases. Model has reasonable goodness of fit measures and has good prediction capacity.

4.5 Simulation of choice probability

Simulation of choice probabilities will give the plot of simulated choice probabilities of each mode with respect to variation in value of a particular attribute. The plots can give an idea on resultant choice probabilities over a range of variation. Simulations of choice probability for total students over different parameters are discussed here. Simulation of choice probability over travel distance is given in Figure 3, which gives the variation of choice probabilities when total travel distance of education tours varies from 0-20km. Choice probability of auto-rickshaw shows a positive slope at initial values then shows its maximum value from 4-6km and after that it has a negative slope. Public bus and school/college bus is showing a continuous increase in choice probability with increase in distance and among them school bus is showing maximum choice probability after 6.5km.

Choice probability of cycle is steeply decreasing after 8km. Variation of choice probability of two-wheeler with travel distance is very less compared to other modes. Walk is having maximum choice probability when total travel distance is less than 4km and as the distance increases its probability decreases continuously. Figure 4 shows the variation of choice probability of different modes with variation of number of workers in a household from 0 to 6. The choice probability of school bus and two-wheeler decreases continuously and that of all the other modes increases continuously. All the modes are

showing almost linear variation and public bus is having maximum choice probability over all the other modes.

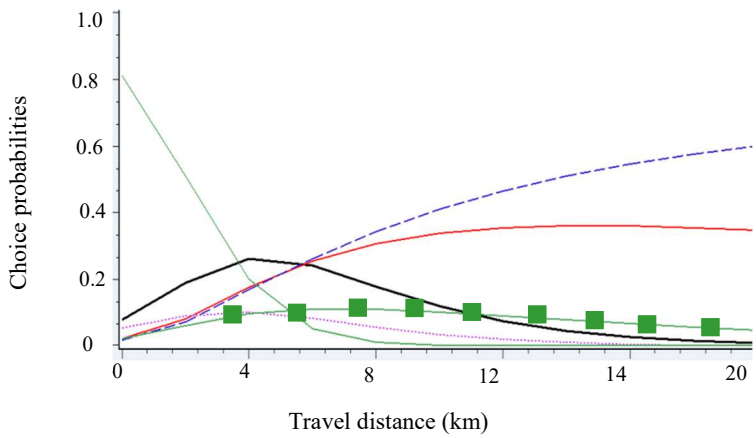


Figure 3: Simulation of choice probability over travel distance

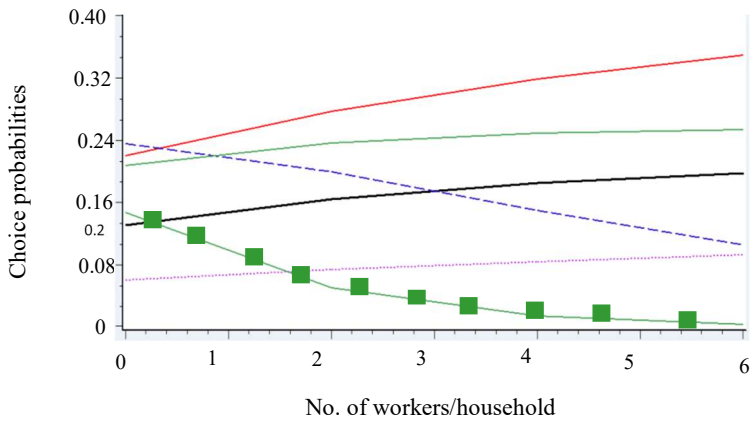
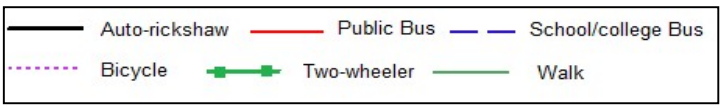


Figure 4: Simulation of choice probability over no. of workers per household



Choice probabilities of modes are also simulated over the residential location characteristics like accessibility to public transport and distance to city center, which is illustrated in the Figure 5 and Figure 6 respectively. As accessibility to public transport increases, it causes a linear decrease in the choice probability of public bus, two-wheeler and walk and at the same time there is an increase in the choice probabilities of auto-rickshaw, school bus and bi-cycle. This is because when the accessibility to public transport increases students more prefer auto-rickshaw, schools bus and bi-cycle, which have more accessibility from residential locations. The accessibility of public transport is found to be an influencing variable on mode choice decision in the mode choice models developed for Western Austarlia(Nurlaela and Curits, 2012) .

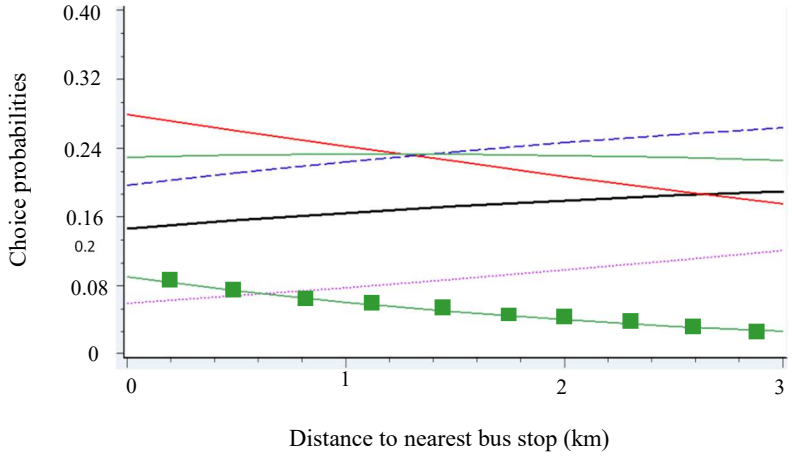


Figure 5: Simulation of choice probability over distance to nearest bus stop

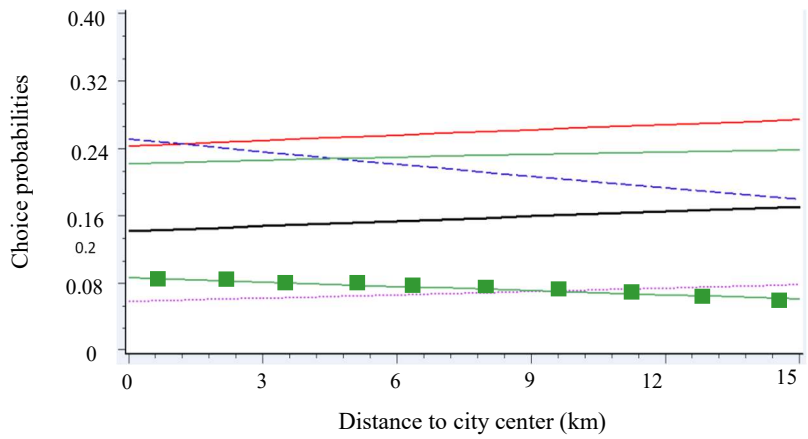
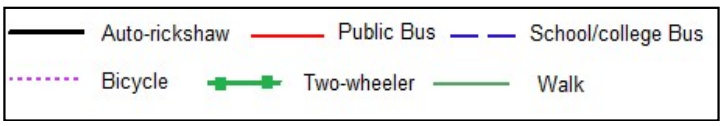


Figure 6: Simulation of choice probability over distance to city centre



As the distance from city center to place of residence increases the choice probabilities of school bus and two-wheeler is showing a decreasing trend, whereas choice probabilities of all other modes have a slight increase. Because when the residential location is more away from city center, students are more likely to choose the schools near to their place of residence and so the probability of modes choose to travel for small distance increases.

5.Conclusions

The study has identified the mode choice behavior of students in a developing country, integrating residential location characteristics. The major findings from this study can be summarised as follows. Residential location characteristics like population density, bus frequency from nearest bus stop, accessibility to nearest bus stop and city center, etc. also

have significant effect on mode choice behaviour of students. Considering safety of children and monthly income of household, school bus is the most preferred mode for school students whereas public bus is preferred by higher secondary and college students. As travel distance increases school students more prefer school bus, whereas higher secondary students prefer public bus and college students prefer public bus and two-wheeler. Gender is the less significant variable for mode choice decision of higher secondary students compared to the school and college students. Household size and number of workers per household is significant for mode choice behaviour of school students and not significant for other two categories..

Number of motorised vehicle per household is positively significant for two-wheeler usage for all the categories. Bicycle ownership has significant influence on its usage among school and higher secondary students and it is not at all used by college students. School going students from low income houses are choosing bicycle and walk as the most preferred mode and higher students prefer public bus and bicycle. School going students from low population density region least prefer walk and public bus, whereas higher secondary students from high population density prefer walk to school. When accessibility to bus stop increases higher secondary students prefer walk. When distance from city center increases the school students more prefer walk and it has no significant effect on the other two groups. Increase in frequency of bus from nearest bus stop can decreased the use of bicycle for school students and it can also increase the preference of public bus usage by college students. Simulation of choice probability gives out that, decreasing travel distance, increasing accessibility to public transport etc. can promote the use of sustainable modes for education.

This paper provides valuable insights on mode choice behaviour of students in metropolitan region of a developing country. The travel behaviour studies of workers are usually made by transportation experts; whereas students also contribute a good volume of traffic, which are less studied. The models developed in this study will be much helpful for policy makers to introduce various schemes, incorporating student's mode choice behaviour, in order to reduce morning and evening peak hour traffic congestion in urban area caused by the students. The findings from the present study are very relevant for attaining the goals of Smart City Mission for Kochi city, as one of its main focus is the improvement of transportation system in the city area by promoting the use of sustainable modes, for an overall reduction in road congestion and improvement of air quality parameters (Smart city proposal, 2016).

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