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Time-of-Day Choice Behaviour of Commuters in Kochi City, India

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Abstract

Activity based travel demand modelling approach is more significant in developing countries like India, because transportation problems are more diverse and complex here. Among different features under attention for travel demand modelling, time-of-day choice by a particular commuter is an important fragment which can affect the efficiency of the whole transportation system. This study investigates the departure time-of-day choice behaviour of work, education and shopping tours in Kochi City. One's place of residence always acts as an anchorage for his/her daily activity pattern behaviour. Present study is motivated by the need to understand the extent to which departure time-of-day choice behaviour of commuters is affected by their residential location characteristics also in Indian context. The activity-travel data for a usual working day is collected by direct interview method from Kochi Municipal Corporation. Home based tours of commuters are used to calibrate multinomial logit model, which is used to capture the departure time-of-day choice behaviour of different segments of population. A better understanding using extended modelling variables like residential location parameters can lead to more accurate departure time choice forecasts and has important implications for evaluating urban transport plans and policies.

Keywords: Activity based approach; time-of day choice behaviour; multinomial logit model; residential location characteristics; developing country

1. Introduction

Time-of-day choice of individuals for different activities is an important determinant of the temporal pattern of traffic on urban road. Transportation planners and transit operators are facing the common challenge to diffuse the concentration of peak period travel in an effort to reduce peak load requirements. An estimation of the possible strategies directed to achieve this requires an understanding of factors which affect commuter tour timing decisions

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(Abkowitz, 1981). An analysis of individual time-of-day choice is, therefore, important for planning the development and construction of new transportation infrastructure, examining the potential responses to improved operational strategies and assessing the effectiveness of time-of-day specific transportation demand management measures (such as congestion pricing). Some of the recent travel behaviour studies concluded with the fact that the built environment characteristics like residential location, work place or travel system characteristics have significant effect on ones travel decisions. Among these the residential location characteristics can be considered as one of the driving force of commuters travel decision.

In most of the studies the workers are considered for travel behaviour analysis and student segments are completely circumvented. In a working day there will be demand for maintenance activities like religious, recreation, shopping, medical and others. Hence, departure time-of-day choice models are developed in this study for work, education and shopping activities incorporating residential location characteristics along with other personal, household and activity-travel variables. To overcome the trip based time-of-day choice model tours are considered as the fundamental unit of analysis in this study. The main objective of this exercise is to identify the various attributes, which are influencing the departure time-of-day choice of the commuters in metropolitan area of a developing country. The scope of the paper is limited to study departure time choice model for work, education and shopping tours during a working day in Kochi city.

Nomenclature

MNL Multinomial Logit
KMC Kochi Municipal Corporation

2. Literature Review

Abkowitz(1981) analysed departure time choice of work trips. Multinomial Logit (MNL) modelling method is used considering twelve discrete time intervals. In this study occupational characteristics, income, mode, age, gender, location of residence and work and travel time are found to be influential. Bhat(1998) have calibrated joint MNL form for modeling mode choice and an ordered generalized extreme value (OGEV) form, for departure time choice for shopping trips. Parameters related to travel time and travel cost is found to be the significant variables in the study. Steed and Bhat (2000) developed discrete departure time model for home-based non-work trips. Recreational trips and shopping trips are considered in the study. Household income, age, personal status, mode etc. found to have significant effect on the time-of-day choice for non-work trips. Tringides et.al, (2004) have done combined mode and time-of-day choice model for workers and non-workers separately for Southeast Florida region. Bivariate probit modelling method is used in the study. Household size, number of children in a household, number of vehicles owned by each household, age, nature of employment, travel time, expense of travel etc. are the independent variables considered for the modelling. The results of the study proved that for workers the departure time decision precedes the mode choice and for non-workers mode choice decision precedes departure time. This is because the workers will have more constrains due to their work activity schedules. While the non-workers have first preference on the mode choice and after that they aim for departure time choice.

Vishnu and Srinivas (2013) developed the tour based MNL departure time models for workers for their work and non-work activities for the population in Chennai city, India. Gender, age, income, employment status, household size, mode used etc. are the significant variables that affect the departure time choice of work and non-work tours of workers. Activity-travel behaviour of non-workers in Bangalore city, India is studied by Manoj and Veram (2015). In the study time-of-day model is calibrated for shopping, recreation and other maintenance trips of non-workers. Eight alternatives are considered by dividing the time of a day from 4:00 to 22:00 as sections of 2 hour duration. MNL modelling is used for model calibration and gender, age, household income, presence of children, activity duration etc. are found to be the significant variables that determine time-of-day choice of non-workers.

Research studies conducted by Ben Akiva, Bowman (1998) and Schirmer et al., (2014) showed that integrating land use and built environment characteristics along with personal and household socio-economic characteristics and activity-travel characteristics will improve travel demand model. Among the built environment variables, residential location characteristics can be considered as one of the driving forces of a commuter's travel decision. The research by Nurlaela and Curits (2012) on modelling 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 from place of residence can change the mode choice decision of individuals. An integrated model on residential location, workplace location and vehicle ownership was developed to find it's the influence on the commuter tour characteristics is found in a research by Paleti et al., (2012). The study concluded that the residential location and work place location characteristics have significant impact on the tour timing and mode choice of an individual. Residential location can be considered as an important trigger of changes in individual travel behaviour. Due to these reasons this variable should be incorporated in the study of travel behaviour dynamics of individual. It is well explained by examining the changes in social environment to personal social network after social move by Lin et al., (2018).

The above reviews shows the time-of-day choice models calibrated for tours are limited when compared to trip level. Also no much studies are focused on the time-of-day choice behaviour of students, who have a good input in morning and evening traffic congestion in a developing country like India. In most of the studies in developed countries secondary data is used which obstructs the modelers to use additional variables like residential location parameters of each household in the analysis. Considering all these issues the following *objectives* have been identified for the present study. 1. Develop departure time-of-day choice models for work, education and shopping activities in a working day. 2. Analyse the role of personal, household, activity-travel and residential location characteristics on timing decisions.

3. Study area and data collection

Kochi Municipal Corporation (KMC), Kerala, India is a metropolitan region selected for present study, which is known as industrial and commercial capital of Kerala state. KMC is spread over 94.88 km^2 and it is the most densely populated corporation in the state with a population density of 6345 persons per km^2. The land use characteristic of KMC indicates almost 75.77% of usable area is under residential use, which is not a preferred characteristic of a metropolitan region. 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 (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. Residential location characteristics collected for each household are GPS coordinates, population density of the region, public bus frequency from nearest bus stop, and distances to city center, nearest bus stop, main road etc. Multiple stage random sampling method is adopted for selecting household for data collection and geographical distribution of samples are ensured. The total response rate of present study is 96.33%, which is crucial as it have direct effect on the final results (Stopher, 1992). The final database contains 2989 household data, which contains personal characteristics of 11,758 persons.

4. Data description and preliminary analysis

The departure time-of-day choice model is extracted from the activity-travel survey data collected from KMC region .The time-of-day model is calibrated for home based tours within the study area for work, education and shopping activity. For developing the time-of-day model seven time periods in a day are considered for the primary analysis, seeing the information about peak and off-peak period of traffic in the study area. For each tour the time-of-day model predicts the combination of departure time from home for the particular activity and departure time from destination. However, all pairs extending overnight were eliminated because the number of overnight tour is insignificant; remaining eleven combinations is given in Table 1. The time period before 8 a.m. is considered as morning pre peak; 8a.m. to 10 a.m. is morning peak period and then up to 1 p.m. morning post peak period. Similarly 1p.m. to 4 p.m. evening pre peak period, 4 p.m. to 8 p.m. evening peak and after 8 p.m. it is considered as evening post peak period. Work and education tours are having similar peak period in morning as well as evening. Percentage variation of time-of-day choice for work and education trips is shown in Fig. 1.

Table 1. Coding for departure time of work and education tours

Departure time from home	Departure time from work place/school	Coding
2:00 a.m.– 6:00 a.m.	10:00 a.m. – 1:00 p.m.	DT1
2:00 a.m. – 6:00 a.m.	4:00 p.m. – 8:00 p.m.	DT2
6:00 a.m. – 8:00 a.m.	Up to 1:00 p.m.	DT3
6:00 a.m. – 8:00 a.m.	1:00 p.m. – 4:00 p.m.	DT4
6:00 a.m. – 8:00 a.m.	4:00 p.m. – 8:00 p.m.	DT5
6:00 a.m. – 8:00 a.m.	8:00 p.m. - 12:00 a.m.	DT6
8:00 a.m. – 10:00 a.m.	Up to 1:00 p.m.	DT7
8:00 a.m. – 10:00 a.m.	1:00 p.m. – 4:00 p.m.	DT8
8:00 a.m. – 10:00 a.m.	4:00 p.m. – 8:00 p.m.	DT9
8:00 a.m. – 10:00 a.m.	8:00:00 p.m. – 12:00 a.m.	DT10
1:00 p.m. – 4:00 p.m.	3:00 p.m. – 8:00 p.m.	DT11

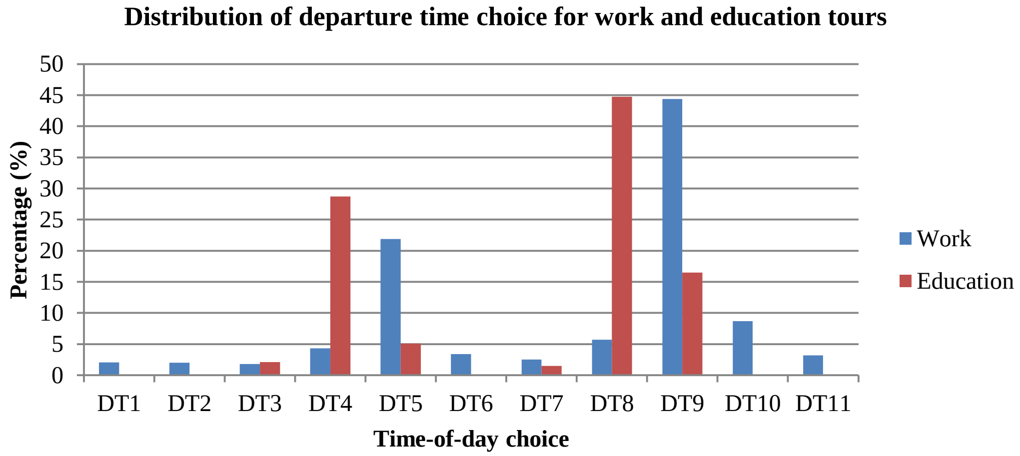

Fig. 1. Percentage Distribution of Departure Time-of-day choice for work and education tours

For work tours, about 22% of workers are departing from home between 6:00 a.m. – 8:00 a.m. and departing from workplace between 4:00 p.m. – 8:00 p.m. and about 45% of workers are departing form home between 8:00 a.m. – 10:00 a.m. and departing from workplace between 4:00 p.m. – 8:00 p.m. For education tours almost 22% of the total students are starting from home between 6:00 a.m. – 8:00 a.m. and starting from their schools/colleges between 1:00 p.m. – 4:00 p.m., as well as 45% of students are staring from their home between 8:00 a.m. – 10:00 a.m. and starting back from their school between 1:00 p.m. - 4:00 p.m. Alternatives having time-of-day choice share greater than 2% is considered for modelling. For work tours ten alternatives are considered such as DT1, DT2, DT4, DT5, DT6, DT7, DT8, DT9, DT10 and DT11. For education tours five alternatives are considered for modelling and they are DT3, DT4, DT5, DT8 and DT9.

In the study area traffic congestion is very prominent that it prevents most of the commuters from much maintenance activities during working days. Among different maintenance activities only shopping is having significant share in a working day. Shopping tours made in a usual working day by all segments of people is considered for modelling. For shopping the average duration is 64.85 minutes and therefore there is no need to consider the combination of different time intervals. The shopping tours are confined into four time periods and they are 7:00 a.m. – 10:00 a.m., 10:00 a.m. – 1:00 p.m., 1:00 p.m. – 4:00 p.m. and 4:00 p.m. – 9:00 p.m., which is represented as am peak, am off-peak, pm off-peak and pm peak. Percentage distribution of departure time-of-day choice for shopping tours is given in Fig. 2. The percentage distribution of departure time choice for shopping indicates maximum shopping tours are taking place after 4:00 p.m., which may be after the primary activity of the commuter. Shopping activity is very low between 10:00 a.m.-1:00 p.m.

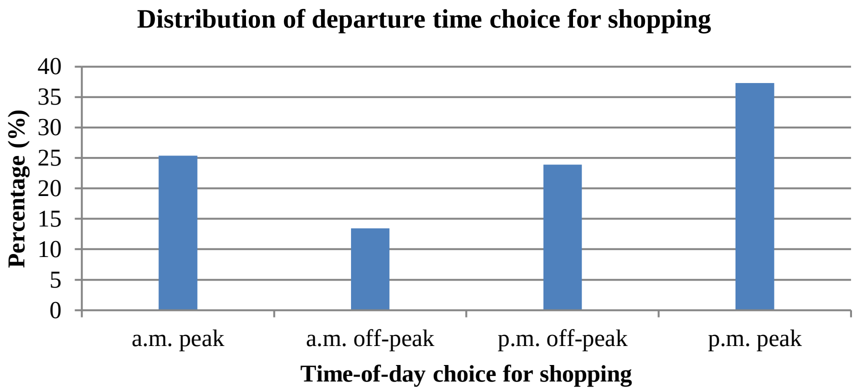

Fig. 2. Percentage Distribution of Departure Time-of-day choice for shopping tours

5. Methodology

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) (Hensher et. al, 2005). In the present study MNL model is used for analysing time-of-day choice behaviour of commuters for home based tours, as almost 90% of tours are simple in nature. The basic form of MNL model for probability of choosing alternative *i* is shown in Eqn. 1(Greene, 2016).

$$\Pr(Choice\ j) = \frac{\exp(\beta_j x_{ji})}{\sum_{m=1}^{J} \exp(\beta_m x_{mi})}, \text{ j = 0,…., J,} \quad (1)$$

Where 'i' indicates the observation or individual and 'j' and 'm' indicates the choices. 'β' represents the coefficient of the variable 'x' considered. The decision of choosing an alternative is based on utility maximisation rule. It can be stated as alternative, 'i', is chosen among a set of alternatives, if and only if the utility of alternative, 'i', is greater than or equal to the utility of all alternatives, 'j', in the choice set, C. This can be expressed mathematically as shown in Eqn. 2.

$$If\ U(X_i, S_t) \geq U\left(X_j, S_t\right) \forall j \ \Rightarrow i > j \forall j \ \in C \quad (2)$$

Where U ( ) is the mathematical utility function, X_i, X_j are vectors of attributes describing alternatives i and j, respectively, S_t is a vector of characteristics describing individual t that influence his/her preferences among alternatives, i > j means the alternative to the left is preferred to the alternative to the right, and ∀ j means all the cases, j, in the choice set. That is, if the utility of alternative i is greater than or equal to the utility of all alternatives, j; alternative i will be preferred and chosen from the set of alternatives, C. In MNL model the deterministic component is assumed to be a function of individual, household, activity, transportation system etc. and the random component is assumed to Gumbel distribution (Independent and Identically Distributed) (Train, 2009). Coefficients are estimated using Maximum Likelihood Estimation technique using NLOGIT software. Household, personal, residential location and activity-travel characteristics are considered for modelling. Flexibility for working time is not available for a significant number of workers within the study area and so it is not considered in the modelling. The variables used in the model development are shown in Table 2.

The model fitness is checked using the statistical measures such as Wald statistics, level of significance, Chi-squared value, model predictability, rho-squared value and adjusted rho-squared value. Wald statistics is used for estimating the significance of each parameter estimated. The initial log likelihood is calculated as measure of a model with only constant parameters and final log likelihood value is the measure computed using all the independent variables used for the model calibration.

Table 2. Variables used in model development

Variables	Definition
Household characteristics	
HIN1	Household income/month, less than 10,000 INR;1if yes 0 otherwise
HIN2	Household income/month, 10,000-20,000 INR; 1if yes 0 otherwise
HIN3	Household income/month, 20,000-30,000 INR; 1if yes 0 otherwise
HIN4	Household income/month, greater than 30,000 INR; 1if yes 0 otherwise
Personal characteristics	
GENM	Gender; male ; 1if yes 0 otherwise
GENF	Gender; female;1if yes 0 otherwise
DLN	Driving license ownership; 1if yes 0 otherwise
DW	Daily wage; 1if yes 0 otherwise
GE	Government employee; 1if yes 0 otherwise
PE	Private employee; 1if yes 0 otherwise
SE	Self-employee; 1if yes 0 otherwise
(For workers)	
ED1	Up to school level; 1if yes 0 otherwise
ED2	Up to higher Secondary level; 1if yes 0 otherwise
ED3	Degree and more; 1if yes 0 otherwise
AG1	Age 17-40 years; 1if yes 0 otherwise
AG2	Age 41-60 years; 1if yes 0 otherwise
AG3	Age >60 Years; 1if yes 0 otherwise
(For students)	
ED1	Up to higher secondary; 1if yes 0 otherwise
ED2	Degree and more; 1if yes 0 otherwise
AG1	Age <18 years; 1if yes 0 otherwise
AG2	Age ≥ 18 years; 1if yes 0 otherwise
Activity-travel characteristics	
WCY	Mode used is walk or cycle; 1if yes 0 otherwise
PVT	Mode used is two-wheeler or car; 1if yes 0 otherwise
PUB	Mode used is public bus, boat or school bus; 1if yes 0 otherwise
AD	Activity Duration(minutes)
TD	Travel distance(km)
APNS	Activity Pattern not simple; 1if yes 0 otherwise
PRS	Person having shopping as their primary activity; 1if yes 0 otherwise
Residential location characteristics	
DMR	Distance to main road (km)
DCBD	Distance to city center (km)
PPD1	Population Density <25 persons/hector; 1if yes 0 otherwise
PPD2	Population Density 25 to 50 persons/hector; 1if yes 0 otherwise
PPD3	Population Density 50 to 100 persons/hector; 1if yes 0 otherwise
PPD4	Population Density > 100 persons/hector; 1if yes 0 otherwise

6. Modelling results and interpretation

In this section the results of parameters estimation are presented and discussed. Departure time-of-day choice model for workers, students and shopping tours in a working day is analysed.

6.1 Departure time-of day choice model for work tours

Parameter estimation of departure time-of-day choice model for workers is given in Table 3. Ten set of departure time choices are considered for modelling. DT4 is considered as the base alternative.

Table 3. Departure time-of-day choice model for work tours

Time-of-day choice	DT1		DT2		DT5		DT6		DT7	
Variables	Coeff.	Wald Statistics	Coeff.	Wald Statistics	Coeff.	Wald Statistics	Coeff.	Wald Statistics	Coeff.	Wald Statistics
Constants	0.285	0.235	-27.479	-12.993	-10.488	-10.608	-28.291	-13.548	4.066	3.253
TT	-0.011*	-1.754	0.011*	1.746	-	-	-	-	-	-
AD	-0.006***	-2.815	0.044***	14.770	0.022***	13.006	0.047***	16.352	-0.011***	-5.784
PB	-	-	-	-	-	-	-	-	-1.234*	-1.781
DW	-	-	-	-	0.682**	2.511	-	-	-	-
SE	-	-	-	-	-	-	-	-	1.060**	2.071
GE	-	-	-	-	-	-	-1.972*	-1.812	-	-
APNS	-	-	-	-	-3.332***	-9.410	-2.186***	-3.436	0.850**	2.053
AGE2	1.011***	2.648	-	-	-	-	-	-	-	-
AGE3	-	-	1.251*	1.942	-	-	-	-	-	-
HIN1	0.701*	1.746	0.844**	2.037	-	-	-	-	-	-
HIN3	-	-	-	-	-	-	0.786**	2.363	-	-
DCBD	0.141**	2.175	-	-	0.107***	2.584	-	-	-	-
Time-of-day choice	DT8		DT9		DT10		DT11			
Variables	Coeff.	Wald Statistics	Coeff.	Wald Statistics	Coeff.	Wald Statistics	Coeff.	Wald Statistics		
Constants	2.101	2.114	-1.630	-1.951	-21.573	-12.318	-1.759	-1.189		
TT	-	-	-	-	-	-	-0.024***	-3.239		
AD	-0.008***	-4.882	0.008***	5.679	0.037***	16.842	-	-		
PVT	-	-	-	-	-	-	2.458**	2.232		
WCY	-	-	-	-	-	-	2.176*	1.942		
GENF	1.059***	3.029	-	-	-1.200**	-2.456	-1.063*	-1.754		
PE	-	-	0.654**	2.460	2.396**	2.140	0.698*	1.729		
SE	1.140***	3.045	0.649**	2.181	2.302**	2.044	1.531***	3.757		
APNS	-0.747**	-2.369	-3.710***	-13.213	-3.837***	-6.992	-	-		
AGE1	-1.001**	-1.972	-0.592**	-2.110	-	-	-	-		
AGE2	-	-	-0.479*	-1.723	-	-	-	-		
DLN	0.717**	1.983	0.312*	1.720	-	-	-	-		
HIN3	0.501*	1.786	0.674***	3.484	-	-	-	-		
HIN4	-	-	0.359*	1.734	-	-	-	-		
PPD2	0.858**	2.289	-	-	-	-	-	-		
DCBD	0.125***	2.710	-	-	-	-	-	-		
Log likelihood for constant only model								-3359.588		
Log likelihood at convergence								-2176.542		
Rho-squared value								0.3521		
Adjusted rho-squared value								0.3473		
Percentage correctly predicted								56.709		
Chi-squared value								2366.092		
N								1976		

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

The workers who are travelling in early morning like 2:00 a.m. and returning during evening pre peak time are having more travel time to their work destinations compared to workers in DT1. Activity duration is another factor that has significant effect on the time-of-day choice. The one who is having maximum activity duration is starting in morning pre peak time and departing from workplace after the evening peak period. Private vehicles, walk and cycle are preferred by the person who is departing in evening pre peak, because most of them are having complex activity pattern. Gender is also found to be a very significant parameter that influences the time-of-day choice. Female workers mostly prefer departure time from home in morning peak hour and departure from working place before evening peak hour. This is because the female workers don't prefer to go early from home and coming back late to home due to their responsibilities to look after their family and children. Job status of each employee is also a significant parameter on time-of-day choice. Private employees and self-employees are having various time choices due to their varying range working time. Daily wages and government employees are having almost fixed working time. Middle age and old age group are travelling in very early morning as this category of people are working in places like harbor and they also belongs to the less income group. The young workers don't prefer to depart from working place before evening peak period as they will usually have more working time. The high income people prefer to travel in morning and evening peak hour, may be because they always prefer a comfortable working duration. The commuters from residential area of medium population density prefer to start from their place of residence in morning peak time and depart from their work place before evening peak period. As the distance from city center increases they prefer to start from home in morning pre peak period as they have to travel more to reach their work place.

6.2 Departure time-of-day choice model for education tours

Students also contribute a considerable amount of traffic at morning and evening peak period. The parameters estimated for time-of-day choice model for students is shown in Table 4. The more the travel time students prefer to depart at pre-peak hours in the morning. Students having more activity duration is starting in pre peak time in the morning and returning during the evening peak period.

Table 4. Departure time-of-day choice model for education tours

Time-of-day choice	DT3		DT4		DT5		DT8	
Variables	Para-meter	Wald Statistics	Para-meter	Wald Statistics	Para-meter	Wald Statistics	Para-meter	Wald Statistics
Constants	-2.687	-3.373	-0.888	-2.584	-23.836	-9.811	5.578	10.348
TT	0.019^{***}	3.105	0.025^{***}	8.981	0.046^{***}	8.089	-	-
AD	-	-	-	-	0.049^{***}	10.149	-0.013^{***}	-9.423
PR	-	-	-	-	-	-	0.492^{***}	2.641
PUB	1.406^{**}	2.550	0.489^{***}	2.584	-	-	-	-
AGE1	-0.762^{*}	-1.835	0.789^{***}	3.833	1.786^{***}	3.251	-	-
HIN1	-	-	-	-	-	-	0.333^{**}	2.262
HIN4	1.161^{**}	2.138	1.412^{***}	4.833	-	-	-	-
PPD1	-	-	-0.879^{**}	-2.427	-	-	-	-
PPD3	-	-	-0.346^{*}	-1.695	-	-	-	-
PPD4	-	-	-1.553^{***}	-4.377	-1.645^{*}	-1.775	-0.504^{**}	-2.133
DCBD	-0.082	-1.357	-0.085^{***}	-3.941	-0.192^{***}	-3.482		
Log likelihood for constant only model						-1810.2944		
Log likelihood at convergence						-1404.9683		
Rho-squared value						0.2239		
Adjusted rho-squared value						0.2178		
Percentage correctly predicted						61.34		
Likelihood ratio /Chi square value (P-value)						810.6521(0.000)		
N						1446		

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

Early going students are preferring buses and students departing from home at morning peak period prefer private vehicles. Students having age less than 18years most prefer to depart from home during morning pre peak period. Low income group students are more departing from home during morning peak period and departing from home during evening pre peak hours. This may be because most of them are studying in schools near to their residential area and they need to start from home late and come back to home early. High income people prefer more high quality schools having the working hours in between 8.00 a.m. to 1.00 p.m. Students residing in low and high population density region are less preferring the departure time during morning and evening non-peak periods. As distance from city centre increases students prefer to depart during morning and evening peak time.

6.3 Departure time-of day choice model for shopping

Number of shopping tours is very less compared to work and education tours in a working day. The shopping tours within the study area are only considered for modelling. Four time-of-day choices are considered for modelling and the results are presented in Table 5. From exploratory analysis it is evident that in a working day the most preferred time chose for shopping is p.m. peak period. This is because the working people usually prefer shopping on the way back from the work place. People more travel for shopping in a.m. and p.m. off peak period otherwise they are selecting nearby shopping destinations. In working days the activity duration for shopping purpose is comparatively less. The low income people prefer the shopping in morning peak hour, as they have to earn money for shopping from their daily wages and they can buy things only when they are in need of it. The non-working people are least preferring the p.m. peak period for shopping. The population density and distance to city center have positive effect on p.m. off peak and p.m. peak period respectively.

Table 5. Departure time-of-day choice model for shopping

Time-of-day choice	a.m. off-peak		p.m. off peak		p.m. peak	
Variables	Parameter	Wald Statistics	Parameter	Wald Statistics	Parameter	Wald Statistics
Constant	-1.412	-0.770	0.619	0.450	3.154	2.350
TD	0.126*	1.770	0.129**	1.970	-	-
AD	-0.0154**	-2.000	-.0148**	-2.24	-	-
HIN1	-	-	-1.594**	-2.31	-1.562**	-2.160
PUB	-	-	1.799*	1.710	-	-
PRS	-	-	-	-	-2.713***	-3.530
PPD3	-	-	1.652*	1.700	-	-
DMR	-	-	-	-	1.532**	2.010
Log likelihood for constant only model					-177.8829	
Log likelihood at convergence					-128.648	
Rho-squared value					0.2768	
Adjusted rho-squared value					0.2078	
Percentage correctly predicted					57.463	
Likelihood ratio /Chi square value (P-value)					98.471(0.000)	
N					174	

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

7. Summary and Conclusions

From the exploratory analysis it is evident that the departure time-of-day choice for work and education are having almost similar peak period in morning as well as in evening. So by altering the time period for work and education can successfully split the peak hour traffic, which can mitigate the congestion to a great extent. Students are less departing in evening peak hour compared to workers as the activity duration of education is less compared to that of work.

Activity duration is the most significant factor that influences the student’s and worker’s departure time choice. Both categories need to travel in the peak hour to meet their activity time schedules, as flexibility of timing is not much offered for them compared to that in a developed country. It is also find that commuters who are having less primary activity duration is having more chance for engaging in other maintenance activities. Age, gender, household income/month, mode choice, type of employment type of activity pattern, travel time and activity duration are the significant factors on time-of-day choice for workers, whereas for students the significant factors are age, household income/month, mode, travel time and activity duration. For shopping people more prefer the departure time during evening peak time in a working day, because most of the shopping activities occur while returning from the work place or after reaching the home from work place. The non-workers prefer non-peak period for shopping and they are spending more time for shopping in a working day. In the study it is revealed that all the departure time-of-day choice models are influenced by residential location characteristics like population density, distance to city center and accessibility to main road. Overall, the analysis shows that individual, household, activity-travel and residential location characteristics are the key determinants of departure time choice of work, education and shopping tours in a working day.

This study models the MNL departure time-of-day choice models in a working day and it can be extended with more advanced modelling methods and also extended to a combined time-of-day choice and mode choice model for better practical application. The travel behaviour in a non-working day can also be studied in detail. The study does not considered the intra household interaction which may influence the departure time, when a household member is accompanying the commuter. Shortening the time interval of departure time choice can help to study the detailed departure time choice behaviour in a minuscule level.

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References

Abkowitz, M.D., 1981. An analysis of the commuter departure time decision, Transportation,10.3, 283-297.

Ben-Akiva, M., Bowman, J. L., 1998.Integration of an activity based model system and residential location model", Urban Studies 35.7, 1131-1153.

Bhat, C.R., 1998. Analysis of travel mode and departure time choice for urban shopping trips, Transportation Research Part B: Methodological, 32.6, 361-371.

Development Plan for Kochi City, Volume 1: Study and Analysis, Department of Town and Country Planning, Government of Kerala, India, 2010.

Greene, W. H., 2016. NLOGIT Version 6.0, Reference Guide, Econometric Software, Inc., pp. 678.

Hensher, D. A., Rose, J. M., Greene, W. H., 2005. Applied choice analysis a primer, Cambridge university press, New York, pp. 717.

Koppelman, F. S., Bhat, C. , 2006. A self-instructing course in mode choice modeling: multinomial and nested logit models, U. S. Department of transportation federal transit administration.

Lin, T., Wang, D., Zhu, M., 2018. Residential location and changes in travel behavoiur: What is the role of social context change?, Article in press, Transportation research Part A, DOI: 1016/j.tra.2018.03.015.

Manoj, M., Verma, A. , 2015. Activity-travel behaviour of non-workers from Bangalore City in India, Transportation Research Part A, 78, 400-424. DOI: 10.1016/j.tra.2015.6.006.

Nurlaela, S., Curtis, C., 2012. Modeling household residential location choice and travel behaviour and its relationship with public transport accessibility, Procedia – Social and Behavioural Sciences, 54, 56-64.

Paleti, R., Bhat, C. R., Pendyala, R. M., 2012. An Integrated Model of Residential Location, Work Location, Vehicle Ownership, and Commute Tour Characteristics, Technical paper, Department of Civil, Architectural and Environmental Engineering, The University of Texas, Austin.

Schirmer, M. P., Eggermond M. A. B., Axhausen W. K., 2014. The role of location in residential location choice models: a review of literature, Journal of Transport and Land Use, 7.2, 3-21.

Steed, J., Bhat, C., 2000. On modeling departure-time choice for home-based social/recreational and shopping trips. Transportation Research Record: Journal of the Transportation Research Board, 1706, 152-159.

Stopher, P.R, 1992. Use of an activity-based diary to collect household travel data, Transportation, Dordrecht, The Netherlands, 19, 159 – 176

Train, K. E.,2009, Discrete Choice Methods with Simulation, Cambridge University Press, Cambridge, pp. 378.

Tringides, C., Ye, X. and Pendyala, R., 2004. Departure-time choice and mode choice for nonwork trips: alternative formulations of joint model systems, Transportation Research Record: Journal of the Transportation Research Board, 1898, 1-9.

Vishnu, B., Srinivasan, K.K., 2013. Tour-based departure time models for work and non-work tours of workers, Procedia-Social and Behavioral Sciences, 104, 630-639.