A case study on worker's non-work activities on a working day in a medium sized city in India

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Abstract

This paper discusses worker's participation, time-of-day choice and duration of activities such as shopping and recreation. Activity-travel details of about 800 workers in Calicut city, a major urban center in Kerala State, India, formed the database for this study. Models were developed in logit modelling and hazard duration modelling framework. An important empirical finding of this study is that the worker's are insensitive to the level of service variables for participation, duration and time of day choice for shopping and recreation. The model results indicate the influence of day of the week on worker's decision to participate in non-work activities as they are not same throughout the week. Results also suggest that non-work trips are not that much flexible. That is, a worker considers participation in either shopping or recreation within the larger range of daily activities and the decision is entirely dependent on the household or personal characteristics.

*Keywords:*Participation; Duration; Time use; Calicut; India.

1. Introduction

Daily commuting pattern of individuals comprises of both work and non-work activities. Non-work travel represents a significant portion of urban trips and corresponds to a large proportion of peak period travel. Previous works on modelling travel demand mainly concentrated on work and work related travel, as work activity participation and concentration are considered as the main reasons for traffic congestion during peak hours. Lockwood and Demetsky (1994), Bhat (1997), Gordon et al. (1998) and Chu (2003) observed that more than one third of the individuals make stops while commuting and they are more likely to be in the evening. The activity scheduling among workers are also likely to differ during weekdays and weekends. This characteristic is similar to the one exhibited by workers in developed countries, (Dharmowijoyo et al. 2015). A consistent finding of these studies is that the daily travel pattern is becoming more complex due to an increasing tendency to make non-work trips in the evening.

Comprehensive transportation studies were conducted in many Indian cities to address these issues. But such studies are limited to metropolitan cities like Kolkata, Mumbai,

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Chennai, Hyderabad, Delhi, and Bangalore. Thus, the objective of this study is to understand the influence of various socio-demographic characteristics of working people on participation, time of participation and duration of engagement in discretionary activities. Such studies are essential for travel demand estimation and also to develop an efficient urban transportation system.

The discretionary activities considered in the study are shopping and recreation. Shopping includes all types of shopping performed for individual or household needs. Recreation includes the spending time with family or friends at beach, park, restaurants etc. This study attempts to explore the non-work participation behavior of workers.

2. Literature review

Activity based travel demand model are advanced models that can effectively handle the variations in activity and travel made by an individual. According to Bhat and Koppelman (1999), behavioral insufficiency and the limitations of the conventional approach in evaluating travel demand management policies have led to the beginning of the activity based approach to demand analysis. Activity based models are extensively used in the majority of the developed countries and are being adopted in the developing world also to solve many practical problems. Further developments took place in the area when various pricing schemes and policies were introduced in transportation planning. In the activity-based approach, travel is a derived demand from the need to pursue activities distributed in space (Jones et al. 1990, Axhausen and Garling 1992). It considers all details of trips and activities along with the personal and household characteristics.

Some of the earlier contributions were made by Oi and Shuldiner (1962) who introduced the concept that travel is a derived demand from activity participation at different destinations and people travel to participate in various activities. It reflects the characteristics of destination, travel mode, time of day and duration of activity. Most of the earlier researches during that time were based on the influential works by Chapin (1974), Hagerstrand (1970), Cullen and Godson (1975) and many others. These earlier works propose that opportunities and choices influence the travel made by an individual and at the same time there are many constraints to it. Later contributions in travel behavior research and generation of activity pattern were made by Havens (1981), Swiderski (1982) and Allaman et al. (1982), Pas (1985) and Timmermans (1988). This was followed by the researches in travel behavior. The earlier contributions in travel behavior were made by Jones et al (1990) and Axhausen and Garling (1992). The contributions by Jovicic (2001) focused on sequence of activities that are planned and executed in the household context. An understanding of the relationship between activity and travel variables, using mathematical models were explored by Pendyala and Ye (2005) and many others in the field. Disaggregate treatment of purpose, time of day and location were researched extensively during these times. Activity-based models, which consider travel decisions are an advanced form of integrated model, which jointly consider both activity participation and travel related choices.Some of the contributions in the area was due to Bhat (1997), Timmermans and Zhang (2009), Jang and Hwang (2009), Habib (2012) and many more.

Study of activity pattern contributes to the understanding of travel generation mechanism and also to the better measurement of value of time, well-being and quality of life (Xu et al. 2009). The sequence of activities and travel that a person undertakes on a day is defined as the activity travel pattern. Example of a simple activity pattern of a working person is home-work-home, designated as HWH. If the person participates in more than one activity then a complex activity pattern is formed. The present study explores the complex activity travel pattern of a worker who participates in either shopping or recreation in addition to work on a working day.

Transport modellers across the country explored different aspects of non-wok travel and proposed different methodologies. Ory and Mokhtarian (2005) adopted binary logit model to analyse the participation in activities. Bhat and Singh (2000) and Ory and Mokhtarian (2005) used multinomial logit models for generating activity pattern. Further advancements in non-work participation was explored using the time of day models, as these variables were found to influence the participation and duration choice. Influence of household and personal demographic characteristics on non-work travel was investigated by Strathman et al. (1994), Bhat (1997), Lu and Pas (1999), Nelson and Niles (2000), Goulias (2002), Bhat et al. (2009). Moreover the employed individuals are more likely to pursue social activities, with an interest to interact with people at work place, while higher educated employees and those with a number of children negatively influences participation in leisure activities, Bhat et al. (2009). Shopping participation of workers is less due to the short time available for personal use and participation in recreation show positive effect, but they spend shorter time for it (Bhat et al. 2016)

Choice of time of day is an important decision process that influences the temporal dimensions of travel demand. Time of day models provide an idea regarding the time at which travel occurs in a day.Earlier models on time of day choice were developed using a broad departure time period similar to morning peak, mid-day peak and evening peak. Activity based approach makes it possible to consider time periods of shorter duration than this broad classification.

Majority of the earlier works concentrated on the use of multinomial logit models for understanding the choice of departure time for commute (Abkowitz 1981; Chin 1990; Mannering and Hamed 1990; Bhat and Steed 2002; Okola 2003; Saleh and Farrel 2005; Hess et al. 2005). Various household and personal characteristics were found to influence time of day choice for non-work in the works of Steed and Bhat (2000), Bhat and Steed (2002), Popuri et al. (2008), Gadda et al. (2009).

The activity travel pattern is the result of time use behaviour of individuals (Bhat and Koppelman 1999). Knowledge of time use allocation behaviour is essential to evaluate the changes in travel pattern and to understand trip chaining behaviour. Duration or time use models are a class of analytical models which are suitable for modelling data that focus on the end of duration occurrence given that the duration lasted for some specific time (Kiefer 1988; Hensher and Mannering 1994). One of the important elements of duration modelling is hazard function. The shape of the hazard function has important implications for duration dynamics. In the case of parametric duration models a particular shape for the hazard rate is usually assumed. Exponential, Weibull, lognormal, log-logistic, Gamma, etc. are some of the common parametric models and these models are useful for forecasting future outcomes. In the non-parametric models no assumptions are made about the functional form. These models are useful when the baseline hazard is not considered. Semi-parametric models are preferred when only a limited part of the information is available in the data. The unseen heterogeneity is measured in parametric hazard models using a random effect estimator.

Age, gender, number of children, income, work duration, number of stops and trip making characteristics influence shopping duration (Bhat 1998, Hamed and Easa 1998,

Niemeier and Morita 1996). The various factors influencing duration of recreational activity are work duration, age, house ownership, presence of school goers, sequence of recreational activity and work end time (Srinivasan and Bhat 2005). Also the characteristics of social activity are highly significant in explaining social activity duration (Berg et al. 2012).
Yagi and Mohammadian (2006) developed activity based travel demand model for Jakarta in Indonesia to understand how the individuals schedule their daily activities and travel using microsimulation process. In the Indian context, Muralidhar et al. (2004) used a micro simulation approach for generating activity pattern and its scheduling using tour as the unit of analysis. Manoj and Verma (2015) explored out-of-home activity durations of non-workers in the Indian context and found that the duration is insensitive to travel time, whereas the time spent on others' activity influences in-home, out-of-home activities and travel behaviour.

3. Study area and data collection

3.1 Study area

This work utilizes the activity and travel information collected from various zones in the Calicut corporation area.The geographical outlooks of the city and the surrounding areas are almost similar to the other parts of coastal and midland zones in Kerala. The municipal corporation is the legal term for the urban local governing body with a population of above 3 lakhs. Calicut, also known as Kozhikode, is one of the medium sized coastal cities in northern region of Kerala. It located on the west coast of India and is the third largest city in Kerala.
According to the 2011 census, the population of Calicut corporation is 0.613255 million spread over an area of 118.59 sq. kms. with a population density of 5171 persons per square kilometer. The city is well connected by road, rail and air. Three national highways, NH-17, NH-212, and NH-213 pass through the city. The total length of road network within the urban area is 335 kms. The road density is 2.824 km per square kilometer. Fig.1. shows the location map of Calicut corporation.

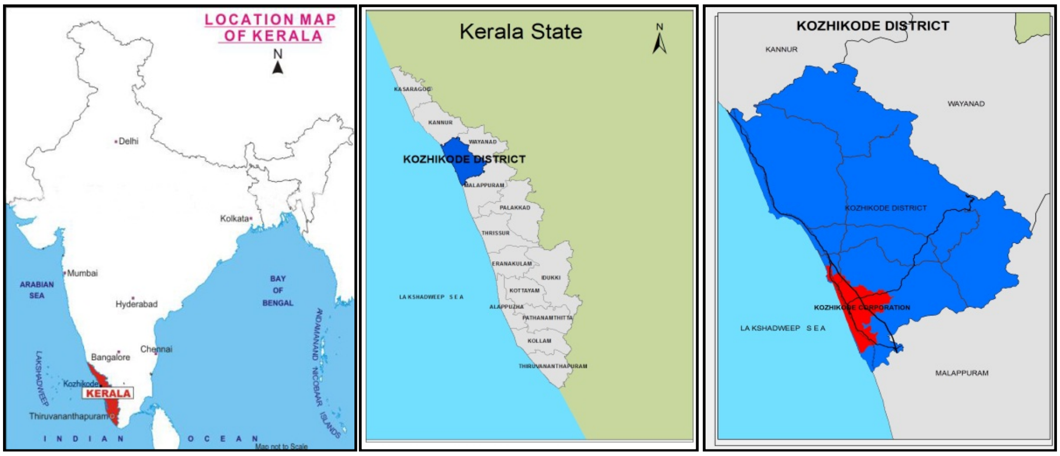


Fig. 1a. Fig. 1b. Fig. 1c.

Figure 1: Location Map of Calicut Corporation

The socio demographic characteristics of the study area based on the sample data and census records are shown in Table 1.

Table 1: Socio demographic characteristics of the study area

Characteristics	Census	Sample
Household size	5.55	4.50
Male population	47.86	49.19
Female population	52.14	50.81
Male workers	80.56	84.26
Female workers	19.44	15.74
Non workers	69.36	67.58
Male non workers	32.35	32.42
Female non workers	67.65	67.63
Workers	30.64	32.42

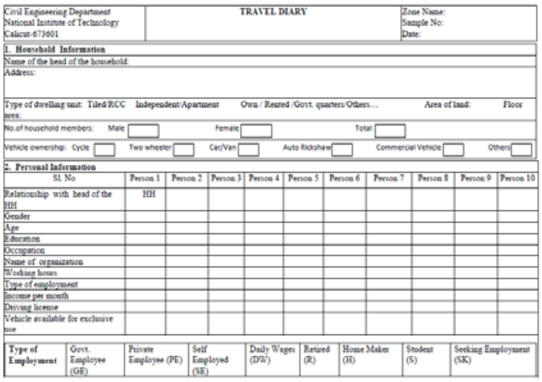
3.2 Overview of travel in Calicut

The traffic congestion existing in the city is due to insufficient road widths, poor road geometrics, mixed vehicular traffic and encroachment on road sides for parking and other activities. Besides, the dependence on personal transport is increasing due to the inefficient and poor quality public transport as well as life style changes. The traffic network is designed to minimize the travel time to anywhere in the planning area to be not more than 30 minutes.

3.3 Data collection

Home interview survey was organized for data collection, using an activity travel diary. Fig. 2.shows the format of travel diary. Face to face interview technique was adopted for data collection. Travel diary was finalized based on the outcomes of pilot surveys. The information collected include details regarding type of activity, start and end times of activity, origin and destination, travel time, travel cost and the activity duration. Due to the time and other resource constraints, information was collected for only one day. The day of the week was indeed used as a variable to determine the day to day variability.

Students were employed for data collection after proper training, and they were able to collect 20 to 25 samples per day. Nine thousand nine hundred one households, spread over the whole study area were surveyed. The response rate from the survey for data collection was 83%.



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TRAVEL DIARY

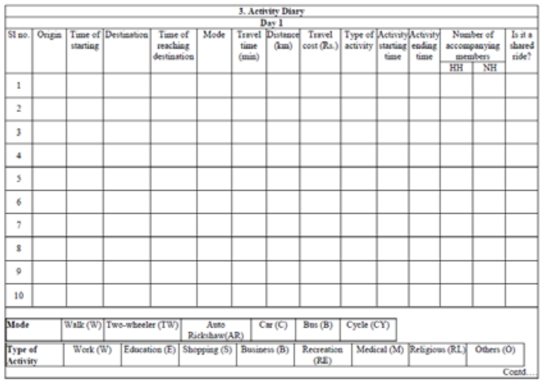
Zone Name:
Sample No:
Date:

1. Household Information
Name of the head of the household:
Address:
Type of dwelling unit: Tiled/RCC Independent/Apartment Own / Rented /Govt. quarters/Others… Area of land: Floor area:
No.of household members: Male Female Total
Vehicle ownership: Cycle Two wheeler Car/Van Auto Rickshaw Commercial Vehicle Others

2. Personal Information

Sl. No	Person 1	Person 2	Person 3	Person 4	Person 5	Person 6	Person 7	Person 8	Person 9	Person 10
Relationship with head of the HH	HH									
Gender										
Age										
Education										
Occupation										
Name of organization										
Working hours										
Type of employment										
Income per month										
Driving license										
Vehicle available for exclusive use										

Type of Employment	Govt. Employee (GE)	Private Employee (PE)	Self Employed (SE)	Daily Wages (DW)	Retired (R)	Home Maker (H)	Student (S)	Seeking Employment (SK)



3. Activity Diary
Day 1

Sl no.	Origin	Time of starting	Destination	Time of reaching destination	Mode	Travel time (min)	Distance (km)	Travel cost (Rs.)	Type of activity	Activity starting time	Activity ending time	Number of accompanying members HH	Number of accompanying members NH	Is it a shared ride?
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														

Mode	Walk (W)	Two-wheeler (TW)	Auto Rickshaw(AR)	Car (C)	Bus (B)	Cycle (CY)

Type of Activity	Work (W)	Education (E)	Shopping (S)	Business (B)	Recreation (RE)	Medical (M)	Religious (RL)	Others (O)

Contd…

Fig. 2a. household & personal data sheet   Fig. 2b. Activity travel details

Figure 2: Format of questionnaire used in the study

Activity travel information of 796 workers who participated in one non-work activity in addition to work activity is used in the present analysis. Working people comprises of government employee, private employee, self-employed person, daily wage worker and the marketing group.

The average household size in the sample data is 4.5. Nearly 44% of the workers belong to the age group 21 to 40, and 40% comes in the range 40 to 55.About 38% of workers depends on two wheelers for commute and 20% on public transportation. Less than 20% of workers use car for work. The average duration of work activity is 435 minutes. 63% of the male workers participate in shopping and 81% participate in recreational activities.

The descriptive statistics on shopping participation reveals that the average age of a worker participating in shopping is 41years, the average shopping duration being 78min. The average duration of recreational activity is 102min. The workers travel on an average of 5.80 km for work. Nearly 37% of the workers participate in recreation during evening peak hours, and 10% during late evening.

4.Modelling methodology

The methodology adopted for modelling various aspects of workers' participation is presented in the following sections. The activity participation behaviour of workers is modelled using binary logit model, because, in the present situation the worker is faced with only two alternatives, either to participate in a non-work activity or not on a working day. Multinomial Logit (MNL) is used for developing time-of-day models because the worker is faced with more than one alternative for time period for shopping and recreation. Time spent in shopping and recreations are modelled using duration models.

4.1 Participation

In a binary choice situation, choice set C_n is denoted as (i, j), where 'i' and 'j' are two alternatives. Eqn. (1) & Eqn. (2) represent the probability of participating in an activity.

$$P_n\left(i/C_n\right)=\frac{1}{(1+e^{-V_n})} \quad (1)$$

$$=\frac{e^{V_{in}}}{(e^{V_{in}}+e^{V_{jn}})} \quad (2)$$

The predictability of the model is assessed by comparing the actual and predicted choice. The utility is determined from the model output. The choice is calculated using binary logit model expression with a threshold of 0.5.

4.2 Time of day choice

The general form of a multinomial logit model is expressed as given in eqn. (3).

$$P_n(i) = \frac{e^{V_{in}}}{\sum_j e^{V_{jn}}} \quad (3)$$

For the development of time-of-day choice models, the day is divided into different time periods of two hours. (i) Early morning from 6.00 am to 8.00 am, (ii) Morning Peak (MP) from 8.00 am to 10.00 am, (iii) Late Morning (iv) from 10.00 am to 12.00 noon, (v) Afternoon (AN) from 12.00 noon to 2.00 pm, (vi) Late Afternoon (LAN) from 2.00 pm to 4.00 pm, (vii) Evening Peak (EP) from 4.00 pm to 6.00 pm, (viii) Late Evening (LEV) from 6.00 pm to 8.00 pm. The model predictability is determined in similar manner using utility.But, in this case, the alternatives are more and so the probability for all alternatives is determined using eqn (3). The alternative with the highest probability is taken as the predicted one.

4.3 Activity duration

Activity time use behaviour is modelled using non-parametric, parametric and semi-parametric models. Eqn. (4), Eqn. (5) and Eqn. (6) show the distributions used for parametric models.

Exponential, $$h(t) = \lambda \qquad \lambda > 0 \quad (4)$$

Weibull, $$h(t) = \lambda P(\lambda t)^{P-1} \qquad \lambda, P,\ t > 0 \qquad (5)$$

Weibull parametric model is a two-parameter model where (λ) is the location parameter and (P) is the shape parameter. The location parameter is attached to t because it determines whether the hazard rate is increasing, decreasing or constant over time.

Log-Logistic, $$h(t) = \frac{\lambda^{1/\Upsilon} t^{[(1/\Upsilon)-1)]}}{\Upsilon\left[1+(\lambda t)^{1/\Upsilon}\right]} \qquad \lambda, \Upsilon,\ t > 0 \qquad (6)$$

The log-logistic model has two parameters (λ) and (Υ), where 'λ'is the location parameter and 'Υ' is the shape parameter.

The standard procedure used to account for unobserved heterogeneity is the random effects estimator (Flinn and Heckman, 1982). Weibull parametric specification with Gamma distribution, shown in Eqn. (7), is generally used to model data with unobserved heterogeneity, denoted by 'w'. This formulation involves specification of a distribution for 'w'across decision makers in the population

Weibull, $$h(t) = h_o(t)\, exp(-\beta x + w) \qquad (7)$$

The model suitability is determined by plotting the observed and predicted survival distributions.

4.4. Statistical significance

The model fitness is assessed using statistical measures, namely, t-statistic, level of significance, chi-squared value, model predictability, adjusted likelihood ratio index (ρ^2) and Akaike Information Criterion (AIC) as applicable. t-statisticis a ratio of the departure of an estimated parameter from its notional value and its standard error. Level of significance is the probability of rejecting the null hypothesis in a statistical test when it is true. Chi-squared value is the difference between initial log likelihood value and final log likelihood value that is tested for statistical significance. The initial log likelihood value is a measure of a model with no independent variables, i.e. only a constant or intercept. The final log likelihood value is the measure computed using all variables that have been entered into the model. The rho-squared value is used to describe the overall goodness of fit of the model. It is calculated as (Ben-Akiva and Lerman, 1987) given in eqn.(8)

$$\rho^2 = 1 - \frac{LL(\beta)}{LL(c)} \tag{8}$$

where$LL(c)$ = log-likelihood for the constant only model and $LL(\beta)$ = log-likelihood for the estimated model.Adjusted likelihood ratio index (ρ^2) (Ben-Akiva&Lerman, 1985) is another measure for model fitness

$$\rho^2 = 1 - \frac{LL(\beta) - K}{LL(c)} \tag{9}$$

where K is the number of parameters used in the model.

The Akaike information criterion(AIC) is a measure of the relative quality ofstatistical modelsfor a given set of data. The value is used to compare different models developed using the same data. AIC is given by -2LL+2K, where LL is the log likelihood at convergence.

5. Model development and analysis

A wide range of variables were tried in the model development and only significant variables are presented in Table 2. In the present work, interactions among household members are considered through dummy variables like presence of infants, presence of school goers and family of employed couples and school goers.

Table 2: Variables used in the model development

Variable	Description
HHSIZE	Number of members in each household
PINF	1 if there are at least one child who is less than 3 years old; 0 otherwise
ECSG	1 if there are at least one school goer with employed couples; 0 otherwise
GEN	1 if the individual is male; 0 otherwise
AGE	Age of individual in years
TWCH	1 if mode used for travel is two wheeler; 0 otherwise
TD	Distance travelled for work in Km
SHRIDE	1 if the individual shared travel cost with someone; 0 otherwise
AFTWK	1 if the person travelled for non-work activity after reaching home from work; 0 otherwise
WHOME	1 if the person makes an additional stop for non-work activity during

	his return travel from work to home; 0 otherwise
FRIDAY	1 if the person travelled for non-work activity on Fridays; 0 otherwise
NON-WORK	Include shopping or recreational activities made on a working day

5.1 Activity Participation Models

For developing shopping participation model, all workers who participated in shopping on the survey day were assigned value 1 and those who have not participated in shopping were assigned value 0.Two third of the data was used for calibrating the model and one third was used for validation. The results of analysis of worker's decision to participate in shopping and recreation are presented in Table 3.

Table 3: Participation models for shopping and recreation

	Shopping		**Recreation**	
Variables	Coefficient	t-statistic	Coefficient	t statistic
Constant	3.128	2.565[b]	-1.297	-1.980[c]
Household variables				
PINF	0.848	5.993[a]	-0.392	-3.377[a]
ECSG	0.731	1.924[c]	-0.478	-1.873[b]
HHSIZE	-0.165	-1.763[c]		
Personal Variables				
GEN	-0.338	-1.727[c]	0.715	3.133[a]
AGE	0.116	1.797[c]	-0.112	-1.700[c]
Activity-Travel Variables				
SHRIDE			0.994	2.215[b]
WHOME	1.726	5.110[a]		
AFTWK	1.613	4.223[a]		
FRIDAY	-6.091	-5.901[a]	2.008	5.400[a]
Goodness of Fit Measures				
Log-likelihood for constant only model	-367.155		-377.245	
Log-likelihood at convergence	-226.386		-337.682	
Chi-squared	281.538		79.125	
Rho squared value	0.383		0.105	
Adjusted log likelihood ratio index (ρ^2)	0.356		0.078	
Percent correctly predicted	78.53		71.33	
N	531		531	

Notes:[a]Significant at 0.01 level. [b]Significant at 0.05 level. [c]Significant at 0.1 level.

5.1.1 Shopping participation model

Among the household variables, presence of infants in the household has a positive influence on the worker's choice to participate in shopping activity, which might be due to more shopping needs. Family of employed couples and school goersalso has a similar effect on shopping participation. The worker belonging to a household with more members is less likely to participate in shopping.

Among the individual socio-demographic variables, age has a positive effect on the choice of shopping activity, indicating that elder workers do more shopping than younger ones. Gender also influences the participation in shopping and females are more likely to participate in shopping compared to male workers. The most preferred period for shopping activity is a work-home and post home arrival period. Day of the week influences the workers shopping on a working day and they are less likely to shop on Fridays. Adjusted log likelihood ratio index (ρ^2) for the model is 0.356 with a predictability of 78%.

5.1.2 Recreation participation model

Presence of infants negatively influences the decision of a worker to participate in recreational activity. Individuals with small children in their household are less likely to participate in recreation. Similar effect is produced by the dummy variable representing a family of employed couplesand school goers.

The age variable effects show that older workers, compared to young workers, are less likely to participate in recreational activity. Men are more likely to participate in recreation activity compared to women. Shared ride positively influences participation in recreational activities. Fridays are more preferred by workers to participate in recreational activities.

The value for adjusted likelihood ratio index (ρ^2) for recreation is 0.078 and is low compared to that of shopping participation model. This suggests the need for an extensive study of the determinants affecting workers' participation in recreational activities.

5.2 Modelling time of day choice of workers for non- work activities

Time of day choice models give an idea as to when an individual will participate in an activity. The dependent variable consists of the time period beginning from 6.00 am to 8 pm.

5.2.1 Time of day choice model for shopping

Table 4 presents the results of time of day choice model developed for shopping activity of workers. The model results show that the adjusted log likelihood ratio index (ρ^2) value of the model is 0.227. The model has a predictability of 66.56%.

Table 4: Time-of-day model for shopping

	Activity Timing					
Variable	MP (8 to 10)	LM (10 to 12)	AN (12 to 14)	LAN (14 to 16)	EP (16 to 18)	LEV (18 to 20)
Constant	-0.290 (-0.352)	-0.654 (-.734)	-31.813 (-1.000)	-0.576 (-0.878)	1.631 (3.774)	0.716 (1.263)
Household Variables						
ECSG		-	-	0.961 (2.152)[b]		
Activity-Travel Variables						
FRIDAY	-1.410 (-1.726)		-2.427 (-2.483)[a]		-1.486 (-3.736)[a]	
WHOME					-1.391 (-4.329)[a]	1.373 (2.753)[a]
Goodness of Fit Measures						
Log-likelihood for constant only model	-639.283					
Log-likelihood value at convergence	-481.634					
Chi- squared	315.297					
Rho squared value	0.246					
Adjusted likelihood ratio index (ρ^2)	0.237					

Percent correctly predicted	66.568
N	373

The model constant indicates that the workers are more likely to participate in shopping during evening peak hours. No personal variables are found to influence choice of time of day. A family of employed couples and school goers are more likely to prefer late afternoon time for shopping activity. Workers prefer to shop in the late evening during their return journey to home after work.

5.2.2 Time of day choice model for recreation

The model for predicting the time of day choice behaviour is developed using MNL technique and the results are given in Table 5. The model has adjusted log likelihood ratio index (ρ^2) of 0.100 and 66.78% predictability.

Table 5: Time-of-day model for recreation

Activity Timing						
Variable	MP (8 to 10)	LM (10 to 12)	AN (12 to 14)	LAN (14 to 16)	EP (16 to 18)	LEV (18 to 20)
Constant	-3.395 (-1.479)	-1.148 (-0.223)	-0.515 (-0.275)	-2.488 (-1.153)	-1.176 (-0.634)	0.330 (0.205)
Household Variables						
HHSIZE						-0.279 (-1.540)[c]
Activity-Travel Variables						
FRIDAY						1.672 (2.806)[a]
Goodness of Fit Measures						
Log-likelihood for constant only model					-505.192	
Log-likelihood at convergence					-454.294	
Chi- squared					101.796	
Rho squared value					0.101	
Adjusted likelihood ratio index (ρ^2)					0.088	
Percent correctly predicted					66.78%	
N					286	

Notes:[a]Significant at 0.01 level. [b]Significant at 0.05 level. [c]Significant at 0.1 level

Model constants indicate that the workers are more likely to participate in recreation during the late evening hours. Among the household variables, the household size negatively influences the time of day choice. Day of the week also influences worker's time of day choice for recreation. On Fridays, the workers select time after 6.00 pm to 8.00 pm for recreation.

5.3 Activity duration models

Parametric, semi-parameric and non-parametric hazard duration models were developed to understand effects of the factors influencing duration of acitivity participation.To accommodate the unobserved heterogeneity in the model, Weibull distribution is assumed for the parametric model. The AIC value obtained for the shopping and the corresponding adjusted log likelihood ratio are presented in Table 6. Results of non-parametric models are not given here. Cox model falls under the category of semi parametric models.

Table 6: Duration model results for shopping and recreation

Duration model	Shopping			Recreation		
	AIC	Rho squared	Adj LL index ratio	AIC	Rho squared	Adj LL index ratio
Cox model	3705.9	0.008	0.006	2731.8	0.006	0.004
Weibull parametric model	297.576	0.376	0.247	239.00	0.252	0.169
Weibul heterogeneity model	732	0.028	0.026	627	0.02	0.01
log logistic model	201.364	0.163	0.143	221.15	0.084	0.071

Adjusted likelihood ratio index (ρ^2) value is the highest and the AIC value is the lowest for Weibull parametric hazard model and hence, selected for determination of the duration of shopping and recreation activities of working people. Parametric duration model results for shopping and recreation are presented in Table 7.

Table 7: Parameters and t statistics for duration model

Variables	Shopping		Recreation	
Constant	2.618	(24.123)	2.074	(23.943)
Personal Variables				
GEN	-0.0649	(-2.029)[b]	0.117	(2.125)[b]
Activity-Travel Variables				
TWCH			0.083	(1.591)[c]
TD	0.013	(4.625)[a]		
FRIDAY	-0.1541	(-4.608)[a]		
WHOME	-0.119	(-2.701)[b]		
AFTWK	-0.087	(-1.834)[c]	0.069	(1.505)[b]
Ancillary Parameters				
Sigma	0.273	(20.288)[a]	0.350	(15.649)
Lambda	0.146		0.131	
P	3.663		2.855	
Goodness of Fit Measures				
Log likelihood value at constant	-131.789		-143.854	
Log likelihood value at convergence	-82.140		-107.503	
AIC	182		229	
Rho squared value	0.376		0.252	
Adjusted log likelihood ratio index (ρ^2)	0.308		0.204	
N	373		286	

Notes:aSignificant at 0.01 level. bSignificant at 0.05 level. CSignificant at 0.1 level.

The results indicate that the Weibull distribution parameter P is highly significant and greater than 1, implying an increasing hazard function. That is, the longer a commuter stays in a shopping activity, the more likely he/she will end it. The results also show that the heterogeneity factor is not significant. The reason for this may be due to the accommodation of heterogeneity by the distributional assumption in the hazard model.

It is, hence, implied that the vector of independent variables captures all the variability in shopping duration.

It is also observed that female workers are likely to engage in shopping for longer time compared to males. But if the travel distance to work place is more, then they spend longer time for shopping. The day of the week also influences shopping duration. Commuters pursuing shopping activities during work to home travel and after work period have shorter duration for shopping.

Male workers are more likely to spend more time for recreation. The transportation mode appreciably influences duration, and commuters using two-wheeler are likely to spare longer time for recreational activities. Commuters pursuing recreational activities after work period engage in them for longer duration.

A graphical comparison was also made on the observed and predicted data to analyse survival distributions and it was apparent that the Weibull-parametric hazard model fits the observed duration data better than the other models.

6. Results and discussions

The results of modelling provide suitable behavioural understandings regarding a worker's activities in a medium sized city in India, using a wide range of explanatory variables. In the context of individual characteristics, it is found that females are more likely to participate in shopping activities, which signify their responsibilities towards household maintenance along with work. This is similar to the findings reported by wen and Koppelman (2000), Chu, Y. L., (2003), Bhat et al. (2009), Srinivasan and Bhat (2005) andBhat et al. (2010). The age variable effects show that older workers, relative to younger workers, are less likely to participate in recreation activities and are more likely to participate in shopping activities. This is consistent with the observations by yamamoto and kitamura (1999), where there is lower tendency of older workers to participate in recreational activities and higher likelihood to participate in household shopping activities.

The coefficients associated with households with infants offer very acceptable interpretations. For example, workers from households with infants (children of less than 5 years of age) are more inclined toward shopping activities and less towards recreation. This may be because the presence of infants forces extra time constraints on worker's activities, which can result in fewer or no stops for recreation. Similar is the case with family of employed couples with school goers for both shopping and recreational activities.

As the number of members in a household increases, the likelihood of pursuing shopping activity by a worker decreases due to the sharing of household tasks by other members in the household which reduces the need for each worker to pursue shopping on a working day. A similar finding is reported by Chatman (2008), that an increase in household size is associated with reductions in daily vehicle miles of travel. Workers, are more likely to consider the work-to-home journey or the after work period for undertaking non-work activities. The findings are similar to the one reported bhat et al. (2010) and Lockwood and Demetsky (1994). Workers are more prone to undertake recreation on fridays.

7. Conclusions

This paper presents a case study from a medium sized city of a developing country, India, describing the activity-travel behaviour of workers on a working day. Some essential conclusions have been obtained in this study as summarized hereafter.

i. A family of employed couple and school goers has important consequences for the participation in recreation and time of day choice for shopping.
ii. The presence of infants favoured worker's participation in shopping on a working day.
iii. Gender has an important impact on shopping and recreation activity participations.
iv. The model was able to capture the influence of household size on time of day choice for recreation.
v. Majority of workers engage in shopping during evening peak hours
vi. Workers having shared ride are more likely to participate in recreational activities and is the major variable influencing duration.

The day of the week also influence participation and workers are less likely to participate in shopping on Fridays and more likely to participate in recreational activities on this day. An important empirical finding of this study is that the workers' non-work activity participations are insensitive to the level of service variables for participation, duration and time of day choice. Also in a similar study in the Indian condition it was observed that the non-workers' out-of-home activity durations are insensitive to travel time, Manoj and Verma (2015). These results imply that there will be no time based displacement of activities like shopping or recreation in the presence of any policy measures that affect level of service variables. Results also suggest that shopping and recreation trips are not much flexible. That is, the worker's decision to participate in these activities are entirely dependent on the household or personal characteristics.The reason may be the design of traffic network provided in the Calicut city which minimize the travel time to anywhere in the city to be not more than 30 minutes. (Master plan Kozhikode urban area 2015). To the knowledge of the authors, this is the first attempt to model worker's activities on a working day, which considers the entire sequence of out of home activities of a worker in the Indian context.
The study can be further extended to assess the increase in trip chaining of shopping and recreation with other stops. Finally all the above models can serve as a major input in the development of travel demand models.

References

1. Abkowitz, M.D. (1981). "An Analysis of the commuter departure time decision". Transportation, Vol 10 (3), 283-297.
2. Allaman, P.M., Tardiff, T.J., Dunbar, F.C., (1982). "New Approaches to Understanding Travel Behavior". National Cooperative Highway Research Program Report 328. TRB, Washington D.C.
3. Bhat, C.R., (1997). "Work travel mode choice and a number of non-work commute stops".Transportation Research Part B, Vol 31. 41-54.
4. Bhat, C.R., S.K. Singh., (2000). "A comprehensive daily activity travel generation model system for workers". Transportation Research Part A, Vol. 34 1-22.

5. Bhat, C.R., (1998). "A model of post home arrival activity participation". Transportation Research Part B, Vol. 32, No.6, 387-400.
6. Bhat, C.R., Koppelman, F. S., (1999). "A retrospective and prospective survey of time-use research". Transportation, 26(2), 119-139.
7. Bhat, C.R., Jennifer.L. Steed, (2002). "A Continuous-Time Model of Departure Time Choice for Urban Shopping Trips". Transportation Research Part B, Vol. 36, No. 3, 207-224.
8. BindhuMuralidhar, S. L., Dhingra, Tom V. Mathew, (2004). "Activity travel pattern of the residents of the city in a developing country", 10th World Conference on Transport Research (WCTR), Istanbul, Turkey.
9. Bhat,C.R., Sebastian Astroza, Bhat, Aarti., Kai Nagel, (2016). "Incorporating a Multiple Discrete-Continuous Outcome in the Generalized Heterogeneous Data Model: Application to Residential Self-Selection Effects Analysis in an Activity Time use Behavior Model", Transportation Research Part B: Methodological, Volume 91, Page 52-76 DOI: 10.1016/j.trb.2016.03.007
10. Chapin, F.S., (1974). "Human Activity Patterns in the City: things people do in time and space". Wiley, London.
11. Chatman, D. (2008). "Deconstructing Development Density: Quality, Quantity and Price Effects on Household Non-Work Travel". *Transportation Research Part A*, Vol.
    42,No. 7, 2008, pp.1008-1030.
12. Chin, A.T.H. (1990). "Influences on commuter trip departure time decisions in Singapore". Transportation Research Part A, Vol. 24(5). 321-333.
13. Chu, Y. L., (2003). "Emperical analysis of commute stop making", journal of the Transportation Research board,vol. 1831 DOI: 10.3141/1831-12
14. Cullen, I., and Godson, V., (1975). "Urban Networks: The Structure of Activity Patterns. Progress in Planning", 4 (1), 1-96.
15. Dick Nelson., John Niles., (2000). "Observations on the Growth of Non-work Travel Growth". Transportation Research Board, 79th Annual meeting, Washington, D.C.
16. Dimas B. E. Dharmowijoyo, Yusak O. Susilo, Anders Karlstrom, (2015) . "Day to day variability in travellers activity travel patterns in the Jakarta metropolitan area", Transportation, 43:601–621, DOI 10.1007/s11116-015-9591-4.
17. Erika Spissu, Abdul RawoofPinjari, Bhat,C.R., Ram M. Pendyala, Kay W. Axhausen, (2009). "An analysis of weekly out-of-home discretionary activity participation and time-use behavior" , Transportation , 36:483–510.
18. Goulias, K.G., (2002). "Multilevel analysis of daily time use and time allocation to activity types accounting for complex covariance structures using correlated random effects", Transportation, 29, 31-48.
19. Hagerstrand. T., (1970). "What about people in regional science?", Presidential Address. Papers of the Regional Science Association, 24, 7-21.
20. Havens, J., (1981). "New Approaches to understanding travel behavior:role, lifestyle, and adaption In new Horizons in Travel behavior research" , Lexington Books. D.C. Health, Lexington MA.
21. Hensher, D.A., Mannering, F.L., (1994). "Hazard-based duration models and their application to transport analysis". Transport. Reviews, 14(1), 63-82.
22. Hess, S., Daly, A., Bates, J., (2005). "Departure time and mode choice analysis of three stated preference data

sets" http://www.transport.gov.uk/stellent/groups/ dft_econappr/documents/page/ dft _econappr_040159.pdf.
23. Jennifer. L. Steed, Bhat, C.R., (2000). "On Modelling Departure time choice for home based social recreational and shopping trips". Transportation Research Record, 1706(1), 152-159.
24. Jones, P.M., F.S., Koppelman, J.P., Orfeuil, (1990). "Activity Analysis: State of the Art and Future Directions. Developments in Dynamic and Activity-Based Approaches to Travel Analysis", Gower, Aldershot, England, pp. 34-55.
25. Jovicic, G., (2001). "Activity based travel Demand modeling-A literature study" Danmarks transport Forskning.
26. Kay W. Axhausen, Tommy Garling, (1992) Activity based approaches to travel analysis: conceptual framework,models and research problems" Transport reviews, Vol.12 No. 4, 323-341."
27. Lockwood, P.B., Demetsky, M.J., (1994). "Methodology for Non-work travel analysis in Suburban Communities". Final Report, Virginia Transportation Research Council.
28. Lu, X., Pas, E.I., (1999). "Socio-Demographics, Activity Participation and Travel Behaviour". Transportation Research Part A, Vol. 33, No. 1, 1999, pp. 1-18.
29. Mannering, F.L., Hamed, M.M., (1990). "Ocurence frequency and duration of commuters work to home departure delay". Transportation Research part B, Vol 24, No.2, 99-109.
30. Manoj, M., Verma, A., (2015). "A structural equation model based analysis on non-workers activity travel behaviour from a city of developing country", Transportation, Springer.
31. Master Plan for Kozhikode Urban Area (2015), Town and Country Planning Department, Government of Kerala.
32. Mohammad, M., Hamed, Said, M. Easa, (1998). "Integrated modelling of Urban shopping activity". Journal of urban planning and development,124(3),115-131.
33. Nicholas M. Kiefer, (1988). "Economic Duration Data and Hazard Function. Journal of Economic Literature", Volume XXVI, 646-679
34. Niemeier, D.A., Morita, J., (1996). "Duration of trip making activities by men and women: A survival Analysis", Transportation, 23, 353-371.
35. Okola, A., (2003). "Departure time choice for recreational activities by elderly non-workers", Transportation Research Record 1848, 86-93.
36. Ory, D.T., Mokhtarian, Patricia, L., (2005). "Don't work, work at home, or commute?" Discrete choice models of the decision for San Francisco Bay Area residents", http://escholarship.org/uc/item/71q8b94r
37. Pas, E.I., (1985). "State of art and research opportunities in travel demand another prospective", Transportation research Part A (19),460-464.
38. Pauline van den Berg, Theo Arentze , Harry Timmermans, (2012) . "A latent class accelerated hazard model of social activity duration", Transportation Research Part A 46, 12–21.
39. Pendyala, R.M., X., Ye, (2005). "Contributions to Understanding Joint Relationships Among Activity and Travel Variables", In H. Timmermans (ed.) Progress in Activity-Based Analysis.Pergamon, Elsevier Science Ltd., Oxford, UK, pp. 1-24.

40. Peter, Gordon, Ajay Kumar, Richardson, H.W., (1988). "Beyond the journey to work", Transportation Research part A, Vol. 22 No.6, pp. 419–426.DOI: 10.1016/0191-2607(88)90045-3.
41. Rajagopalan, B.S., Pinjari, A.R., Bhat, C.R., (2009). "Comprehensive model of worker non-work activity time use and timing",. Transportation Research Record.Vol 1, 51-62.
42. ShashankGadda., Kara M. Kockelman., Paul Damien (2009). "Continuous Departure time Models: A Bayesian Approach", Transportation Research Record, No. 2132: 13-24.
43. Saleh, W., Farrell, S., (2005). "Implications of congestion charging for departure time choice: work and non-work Schedule flexibility", Transportation Research part A, vol. 39, 773-791.
44. Srinivasan, S., Bhat, C. R., (2005). "Modelling household interactions in daily in home and out of home maintenance activity participation", Transportation, vol. 32, no 5, 2005, 523-544.
45. Strathman, J.G., Dueker, K.J., Davis, J.S., (1994). "Affects of household structure and selected travel characteristics on trip chaining". Transportation, 21, 23-45.
46. Swiderski, D., (1982). "A model for simulating spatially and temporally coordinated activity sequences on the basis of mental maps. In: Recent Advances in Travel Demand Analysis" (S. Carpenter and P. Jones, eds.), pp. 314-344. Gower, Aldershot.
47. Tae Youn Jangand Jee Wook Hwang(2009), " Direct and Indirect Effects on Weekend Travel Behaviors KSCE Journal of Civil Engineering" 13(3):169-178 DOI 10.1007/s12205-009-0169-6.
48. Timmermans, H.J.P., (1988). "Multipurpose trips and individual choice behaviour: an analysis using experimental design data". In: Behavioural modeling in Geography and Planning (R.G. Golledge and H.J.P. Timmermans, eds.), pp 356-367.Croom Helm, London).
49. Walter Y. Oi, Paul W. Shuldiner, (1962). "An analysis of urban travel demands", Published for the Transportation Center at Northwestern University by Northwestern University Press.
50. Wen, C. H., and F. S. Koppelman,(2000) "A Conceptual and Methodological Framework for the Generation of Activity-Travel Pattern", *Transportation*, Vol. 27, No. 1, 2000, pp. 5-23.
51. Xu, L. Zhang, J., Fujiwara, A., (2009). "Modelling the interaction between activity participation and time use behaviour over a course of the day", In: Proceedings of the Easter Asia Society for Transportation studies, vol. 7.www.easts.info/publications/journal_proceedings/./100475.pdf
52. Yagi, S., Mohammadian A., (2006). "An Activity-Based Micro-simulation Model of Travel Demand in the Jakarta Metropolitan Area", Paper presented at the 11th International Conference on Travel Behaviour Research, Kyoto, Japan.
53. Yamamoto, T., and R. Kitamura. "An Analysis of Time Allocation to In-Home and Out-of-Home Discretionary Activities across Working Days and Non-Working Days", *Transportation*, Vol. 26, No. 2, 1999, pp. 211-230.
54. Yasasvi, Popuri, Moshe, Ben Akiva, Kimon, Proussaloglou, (2008). "Time of day modelling in a tour based Context the Tel Aviv Experience", www.camsys.com/pubs/kb_pubs_toll_Time_of_Day.pdf.

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