Analysis and Modelling of Activity-Travel Behaviour of Non-workers from a City of Developing Country, India

M. Manoja, Ashish Vermab

aResearch Scholar, Department of Civil Engineering, IISc Bangalore, Bangalore – 560012, India
bAssistant Professor, Department of Civil Engineering, IISc Bangalore, Bangalore – 560012, India

Abstract

This paper presents the results of an analysis on activity-travel behaviour of non-workers from Bangalore city in India. Using a primary activity-travel survey data, this study models the out-of-home activity participation behaviour of non-workers. Travel behaviour is analysed in the context of stop generation (for maintenance and discretionary activities). The core objective of this analysis is to identify the socio-demographic attributes affecting the activity participation of individuals. The analysis results corroborates earlier findings on factors affecting on non-workers’ travel behaviour. The study also underscores the need for including in-home activity participation characteristics in travel demand models.

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Keywords: Non-worker; Out-of-home activity; In-home activity; Activity-travel pattern; India

1. Introduction

Activity-based approach focuses on the activity participation behaviour of individuals. Nowadays, the adoption of this approach into the travel behaviour analysis is prevalent due to the cognisance that travel is a medium (or derived) for participating in activities that are distributed in time and space. Activity-based approach offers a platform for analysing a variety of transport policies due to improvement in the representation of travellers’ behaviour in demand analysis and modelling. During the past decades, literature has seen substantial progress in the application of this approach in travel behaviour analysis. To the authors’ knowledge, Indian cities have not been made much progress in the application of activity-based travel demand analysis even though travel

* Corresponding author. Tel.: +91-9945670879
E-mail address: manoj@civil.iisc.ernet.in
behaviour related issues are severe in our cities. This study is one such an attempt to analyse the travel demand using activity-based approach from an Indian city.

The objective of this paper is to analyse the activity-travel behaviour of non-workers from Bangalore city in India. This study attempts to address the out-of-home activity participation characteristics of non-workers. Travel behaviour is viewed in terms of number of stops visited for maintenance (related to shopping for personal and household needs, personal and household business, chauffeuring task etc.), and discretionary activities (social, recreational, eating out etc.). The research also tries to investigate the impacts of in-home activity participation on out-of-home activity participation (stop generation) of non-workers.

With the above-mentioned objectives, the rest of the paper is organised as follows. Section 2 briefly introduces the study area and data source. Methodological aspects of the study are covered in section 3. Section 4 describes sample characteristics. Section 5 reports the model estimation results. Finally, section 6 draws a summary to the present work and make conclusions to the research.

2. Study area and data source

2.1. Study area

The region under the ‘West Zone’ of the BBMP (Bruhat Bangalore Mahanagara Palike) zones is the study area for the research (Fig. 1). The West zone is divided into 46 sub-zones (wards). This region has about 1.6 million population, and half a million households. West zone has a density of about twenty thousand persons per square kilometer. This region is also characterised by availability of all modes of surface transport (including metro), socio-economic segregation, and land-use vibrancy. As per the latest information, the overall population of the BBMP zones is 6.6 million (Bruhat Bangalore Mahanagara Palike, 2013).

![Fig. 1. Map of BBMP West Zones](image)
2.2. Data source

The data used in the present study comes from a primary survey conducted by the authors. The ongoing time-use survey collects detailed information about the activities (in-home and out-of-home) performed by all individuals (above 5years old) in a random sample of households residing in the study area. A combined “Day-Planner Stage-Based” diary is introduced for collecting the activity-travel information. The survey is administered as a combination of ‘Face-to-Face’ and ‘Delivered-and-Pick-up’ methods. Since the research is initiated in the middle of the survey, activity-travel information of non-workers available from 523 households are used for the analysis (estimated sample size for the study is 2800).

3. Study context and methodology

This paper attempts to investigate activity-travel behaviour of non-workers. This phenomenon has been gaining interest in the travel behaviour research. The reasons could be that the factors affecting non-workers’ travel behaviour, and the impacts of transportation systems and policies are quite different from that of workers. It can be inferred from past studies that activity-travel behaviour of non-workers are different from that workers in terms of socio-demographic attributes (Misra & Bhat, 2000), travel time frontier and trip rates (Volosin et al., 2013), impacts of highway capacity addition and activity generation (Levinson & Kanchi, 2002), trip-chaining propensity (Misra & Bhat, 2000; Bricka, 2008), and pricing policies (Azari et al., 2013). However, none of these studies have discussed about the impact of in-home activity participation on travel behaviour of non-workers.

Analysis of in-home activity participation is also important from travel demand perspective. In-home activity participation has a direct bearing on travel generation. In-home activity participation does not require individual to travel, while an out-of-home episode does. Studies related to the in-home activity participation characteristics of individuals are gaining impetus over the past years. Akar, Clifton, and Doherty (2011) studied the location choice associated with four types of discretionary activities. Their study reveals that attributes of activities has significant impacts on location choice (in-home or out-of-home). Bhat and Misra (1999) explored the discretionary activity time allocation between in-home and out-of-home and between weekdays and weekend days. They found that apart from sociodemographic characteristics, work schedule of an individual also has bearing on time allocation decisions. Lu and Pas (1999) investigated the interaction between in-home and out-of-home activities using structural equation models. Their study shows that there is a substantial interaction between similar in-home and out-of-home activities and similar and different types of in-home and out-of-home activities. Yamamoto and Kitamura (1999) developed a Tobit model for analysing the time allocation to in-home and out-of-home discretionary activities over multi-day period. The study also investigated the impacts of a variety of attributes on time allocation decisions of individuals. Srinivasan and Bhat (2005) focused on household interactions in in-home and out-of-home maintenance activity generation. Analysis using weekday data reveals that gender, work schedule characteristics, resource availability etc. have strong relation with activity generation. Studies of Bhat, Sivakumar, and Axhausan (2003), Senbil and Kitamura (2003), and Mosa, Ohmori, and Harata (2010) show that in-home ICT (Information Communication Technologies) use has a substantial impact on out-of-home activity participation.

Being cognisant of these facts, and considering the travel behaviour related issues in Indian cities, an understanding of activity-travel behaviour of non-workers is essential. The above-mentioned studies reveal the relevance of activity-travel behaviour of non-workers, and the importance of understanding in-home activity participation characteristics of individuals. The present study contributes to the growing body of research in these areas. It can be distinguished from earlier reported studies in the following ways. First, the study specifically focuses on non-workers’ activity-travel behaviour. Second, it reports study from a city (Bangalore) of developing country India. So far, no studies have specifically addressed the activity-travel behaviour of non-workers from Indian cities. Third, the study is an episode (number of stops of maintenance and discretionary activities) level
analysis (against duration). Fourth, it includes in-home activity durations as explanatory variables in out-of-home activity participation models.

3.1. Statistical Methodology

Due to count data type, this study explores the use of Poisson (or Negative-Binomial) regression models. Identical to traditional regression models, these models portray the relation between count data (against continuous variables in regression) and a set of explanatory variables (Maat & Timmermans, 2006). For a given sample of observations following Poisson distribution, this regression technique models the relation between mean values of the process and a set of explanatory variables (Rodriguez, 2007). In order to ensure the non-negativity condition on the part of Poisson mean value, it is a common procedure to model the relation between logarithm of the mean value and explanatory variables as linear models (See equation 1).

\[
\log(\mu_i) = x_i \beta
\]

In this equation, logarithm of mean \( \mu_i \) is dependent on a vector of explanatory variables \( x_i \). Hence, in this case, the regression coefficients (\( \beta \)) show an expected change in the log of the mean per unit change in the predictor variables. Poisson models can be estimated by maximum likelihood estimation procedure. A variety of goodness of fit statistics is introduced for assessing the fitness of Poisson models (Rodriguez, 2007; Maat & Timmermans, 2006). Sometimes, a given process may not satisfy the mandatory conditions (mean equal to variance) for a Poisson phenomenon. In such situations over dispersion tests are recommended, and based on the results ‘Negative-Binomial’ models can be used (Greene, 2002).

4. Sample characteristics

Activity-travel information of ‘non-student-non-workers’ (retired, unemployed, and homemakers) are used for the present analysis. After data cleaning and checking, 623 (out of 631) individuals remained in the sample. Seventy eight percent of these individuals went out for participating in at least one activity during the diary day. Among those who went outside, minimum number of stops visited is one and maximum is seven. The maximum number of tours observed in the sample is five. About 41% percent of the individual who went out participated in more than one activity types, and the remaining ones participated only in one activity (either maintenance or discretionary). Maximum number of maintenance and discretionary stops observed in the sample is four. Modal split indicates that share of walk is higher compared to other modes (indicates that the survey captures very short trips performed by the individuals).

5. Empirical Investigation

5.1. Variable Selection

Explanatory variables are selected based on the past studies presented in the earlier sections of the paper. Some of the variables are introduced based on the study context. In general, they can be classified into household socio-demographics, individual socio-demographics, and in-home and out-of-home activity participation characteristics. Table 1 presents the list of variables entering in the final model specification.

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Age of an individual (continuous variable)</td>
</tr>
</tbody>
</table>
5.2. Empirical results

Model estimation results for maintenance and discretionary stop generation models are presented in Table 2. Since the mean values of both types of stops were not equal to their respective variances, Negative Exponential model was considered for modelling the behaviour. In case of maintenance-stop model, log-likelihood for Negative Exponential model is -58.21 (compared to a value of -87.43 for Poisson model). This shows that Negative Binomial model is appropriate for the given data. This fact is again verified by the estimate of dispersion coefficient, 1.023 with a Z-statistic = 2.023, at 5% level. This shows the presence of over dispersion in the data, and the suitability of Negative Binomial model in this context. ‘Omnibus’ test shows that the model is significant at 5% level (p = 0.000). The R-squared value (0.461) reveals that the model offers a reasonable fit to the data. In case of discretionary activity stop model, the estimate of dispersion coefficient is 0.947. The log-likelihood was found to be improving from -101.23 (Poisson model) to -65.11 (Negative Exponential model). Here, the R-squared value is also reasonable (0.398). This model is also significant at 5% level.

Table 2. Estimation Results of maintenance and discretionary activity frequency models

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maintenance Stop Frequency Model</th>
<th>Discretionary Stop Frequency Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \beta )</td>
<td>Z-statistic</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.173</td>
<td>-1.98</td>
</tr>
<tr>
<td>Age</td>
<td>-0.014</td>
<td>-2.11</td>
</tr>
<tr>
<td>Age1</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>AGEGRP (1 is base)</td>
<td>2</td>
<td>-----</td>
</tr>
<tr>
<td>PRSVEH</td>
<td>0.042</td>
<td>1.81</td>
</tr>
</tbody>
</table>
The parameter estimates reported in the table represent the change in logarithm of stops for a change in the associated explanatory variable. In case of maintenance activity model, age is found to be negatively associated with stop generation. Jessica et al. 2005 observed a similar trend in their model on household and personal business activities. With ageing mobility related constraints occurs, and individuals may not be interested in participating in out-of-home activities. Personal vehicle availability has a direct bearing on maintenance stop generation (See Wen & Koppleman, 1999, Jessica et al., 2005, and Misra & Bhat, 2000 for contextual results). This is natural as these groups of individual have higher accessibility to facilities. Males are less oriented towards maintenance activity participation. This validates the traditional gender roles present in the society (Wen & Koppleman, 2000). Being a household head is negatively related to maintenance stop generation. One reason could be that, they are 'authoritative' being the head of the family, and can allocate the household responsibilities (including theirs) among other members. Other could be due to their age (most of the household heads were falling in higher age group). With education, the tendency to make maintenance stops is found to be decreasing. It may be due to the stigma, wherein qualified individuals may not be interested travelling for such activities. Married individuals are likely to be making maintenance activity stops. Traditionally, in Indian cities, with marriage an individual achieves a prominent role in the family and eventually has to share household responsibilities. A homemaker is found to be making maintenance activity stops. These groups run the house, and are generally aware of the day-to-day needs of house. A positive effect is observed with income. It is natural to expect that as income grows the needs of households and individuals grows. As the number of workers in the household increases, the non-workers’ stop making increases. It is possible, since the constraints on the part of workers lead to the sharing of responsibilities. Number of non-workers in the household is negatively related to stop generation. This is because; household needs can be shared among non-workers. Number of children in the household has a positive bearing on maintenance-stop generation of non-workers. Children dependent on adults for their travel needs. Hence, adults have to travel for assisting them (take kids to schools, parks etc.). As the duration of the in-home maintenance activities increases, the out-of-home maintenance stop frequency decreases. Those who spend more time on in-home maintenance activities may not be able to dedicate much time for out-of-
home activities (See Mosa et al., 2010 for contextual result). If the individual is found to be participating in other out-of-home activity categories, the frequency of stops for maintenance activities is found to be decreasing. It may be due to the purposeful allocation of resources available to the individual.

For discretionary activity model, estimate of ‘age1’ is positive (Jessica et al., 2005 observed negative trend in a contextual study). Individuals in this age group are active and might be interested in out-of-home activity participation. Age group ‘2’ shows a negative effect compared to ‘1’. It should be viewed from Indian context, where, as age grows (for age group ‘1’) individuals dedicate more time for religious and social activities. However, age group ‘2’ shows the trend observed by Jessica et al. 2005. This might be due to mobility constraints. As in case of maintenance activities, personal vehicle ownership is directly related to discretionary activity generation. Being a male has a positive influence on discretionary activity participation. This result has to speak about the gender role in society. Household heads are found to be making more discretionary activity stops. Due to their age and experience, it is common in traditional Indian families that they share a major role in social and other religious activities. Unlike in maintenance activity model, education is positively related to discretionary activity generation (see Akar, Clifton & Doherty, 2011 for similar result). Education opens the horizons, which in turn has a direct bearing with socio-recreational activity participation of individuals. Married individuals are less out-of-home oriented. They have (especially women) to share the household responsibilities and may not be finding time for out-of-home activities. Similar is the case with homemakers. As expected income has a positive influence on discretionary activity participation. As the number of children in the household increases, the discretionary activity participation decreases. Individuals have to find time for caring them, and this may be reason behind this trend. Similar is the case with number of older people in the household. In-home maintenance activity duration has a negative effect with discretionary stop generation. Similar is the case with in-home discretionary activity duration. Lu and Pas (1999) observed a similar trend in their analysis. As in maintenance-activity generation model, participation in other activity types is negatively related to the participation in discretionary activity type.

6. Summary and Conclusions

This research reports an analysis of activity-travel behaviour of non-workers from Bangalore city in India. To the authors’ knowledge, it is the first attempt to analyse travel behaviour of non-workers from an Indian city based on activity-based approach. Using a primary activity-travel survey data, this study models the maintenance and discretionary stops frequency of non-workers. The study attempts to identify the impacts of socio-demographic attributes on activity participation characteristics of non-workers. It also compares the findings with earlier reported studies. Due to count data type, Negative Exponential model (as observed from the data) was considered for modeling the behaviour.

In case of maintenance stop frequency model, age was found to be negatively related to the stop frequency. Similar case was observed with being female, head of household, education status, and number of non-workers in the household. In-home maintenance activity duration also had negative bearing with number of maintenance stops. Similar was the case if an individual had participated in other out-of-home activity type. Other variables like household income, vehicle ownership, number of children in the household, number of workers in the household etc. have showed positive relation with stop frequency.

In case of discretionary stop frequency model, individuals in age groups <50 years showed a positive relation with stop making. Similar trend was observed for individual in age group 50-65. Apart from this, vehicle ownership, gender (male), household income, head of household, education etc. have also showed a positive relation with stop frequency. Individual in age group >65 years, married individuals and homemakers showed a negative relation with stop frequency. Similar trend was observed for variables like number of children and older people in the households. In-home maintenance and discretionary activity duration were negatively related to the
discretionary activity frequency. A similar trend was observed if the individual had participated in other out-of-home activity type.

Overall, the study could provide an initial insight into the travel behaviour of non-workers from an Indian city. It also corroborates the findings with earlier reported studies, and reveals the impacts of some other parameters affecting non-workers activity-travel behaviour. However, the research is a beginning with many issues worthy of further investigation. With more data available in due course, the present study can be extended to a disaggregate stop level analysis (unlike aggregate models for maintenance and discretionary activity models). Further possible extensions include: (a) analysing trip-chaining propensity (b) impacts of mode choice and land use on trip-chaining (c) and finally, development of a framework for predicting the activity-travel patterns of non-workers incorporating in-home activity participation characteristics and effects of land-use transportation systems parameters. It is hoped that these objectives can be fulfilled in due course.

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