Analysis of Household Activity and Travel characteristics in Mumbai Metropolitan Region (MMR)

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ABSTRACT

The environment in which transport analysis and infrastructure planning is taking place has changed completely during the last few decades. While urban sprawl in developing countries is dynamic, the big cities in these countries are reporting sustained pressure due to heavy migration from rural areas and high growth of private mode of transportation coupled with mass transit systems like bus and rail services for meeting mobility needs. As a result, during peak hours, the system reaches crashing point, leads to delays, traffic congestion, and heavy air and noise pollution. Hence the planners and policy makers insisted that the new approaches have to be developed, which should have the capability of predicting the individual responses due to changes in their travel environments. Activity based approach of analyzing travel behaviour is the one virtually resulted from the limitations of traditional trip based models. Hence, this study starts with the analysis of household activity and travel characteristics and it also examines the influence of these characteristics on their activity-travel patterns. Travel decisions are all activity based, hence understanding the activity behaviour is primary for understanding the travel behaviour. In this study, an activity-travel survey was carried out by the author using the newly developed survey instrument, activity-travel diary. Mumbai Metropolitan Region (MMR), in which the financial capital of India, Mumbai is located is the study area for this analysis. Data obtained from the survey was analysed to identifying the activity-travel behaviour of the people in the study area, consequently identifying the patterns of various activity episodes across different household groups. Some observations were made on the relations among socio-economic attributes and their activity and trip making decisions. This paper also addresses development of various representation frameworks for activity-travel patterns of individuals and also the effect of built environment and availability of travel alternatives on these activity-travel patterns. This research provides a platform for studying socio-economic characteristics of the people in the study area and understanding the activity-travel patterns of the individuals in developing countries. This study is the first of its kind in India. This study has been done as a part of development of a prototype activity based travel demand model in the context of developing economy.

Keywords: Activity-Travel Pattern, Representative Activity-Travel Pattern, Activity Profile, Mumbai Metropolitan Region

INTRODUCTION

From the past few decades, the dynamic nature of urban sprawl in developing countries imposing sustained pressure on their major cities due to heavy migration from rural areas and rapid growth of private and public transportation services. As a result, during peak hours, the system reaches crashing point, leads to unacceptable traffic congestion and environmental degradation. Mumbai Metropolitan Region (MMR) is a highly urbanizing area, where traffic load is being amplified by the urbanization trend and the society's changing socio-economic conditions and level of service of transportation infrastructure. Gradual shift from public transport to private transport due to increase in income and car ownership, as well as increase in average trip length due to expansion of urban areas would further amplify the traffic load on roads. This urbanization trend is the most fundamental threat for the society to overcome and expected to considerably influence people's travel behaviour. Under such circumstances, this study aims to identify representative activity-travel patterns and clarify the influential socio-economic attributes and level of service of available travel modes for the identified travel patterns.

In an activity based travel demand model, the primary unit of analysis could be activity, tour or pattern. McNally and Recker (1987) used the activity-travel pattern as the basic unit of analysis and defined the activity-travel pattern as "the revealed pattern of behaviour represented by travel and activities over a specified time period". Individual activity-travel behaviour and their travel patterns strongly depend on socioeconomic characteristics. Van Der Hoorn (1979) studied the travel behaviour and activity-travel patterns of the individuals by dividing the population into different categories based on their socioeconomic characteristics. Many other studies have reported the complexity and variety of individual travel patterns in accordance with the socioeconomic characteristics like household income, household structure, gender and car ownership (Hanson and Hanson, 1981; Mitchell and Town, 1977; Pas, 1984; McGuckin and Murakami, 1999; Sarmiento, 1996; Bhat and Koppelman, 1993).

Though many researchers have concentrated on identifying the impact of socioeconomic variables on the travel pattern choices, significant works paid special attention to the land use variables, investigating the interaction between land use and travel patterns in the development of travel demand models (Ewing, 1995; Golob and Bownstone, 2005; Srinivasan, 2000). Recker et al. (1985) identified various representative activity patterns by relating them to socioeconomic and urban form characteristics. Pitombo et al. (2011) conducted an exploratory analysis of relationships between socio-economic, land use, activity participation variables and travel patterns. In this study, they defined travel patterns to describe the activity sequence, travel modes and travel distances. The identified actual activity patterns need to be reconstructed in a way that is representative of the activity-travel behaviour of individuals in each group. The resulting activity patterns represent distinct sets of behaviour by which the study population can be satisfied. Hence, the

measurement of similarity of individual activity-travel patterns is usually based on different attributes such as transport mode, activity space, time, travel distance, purpose of travel, trip/activity duration. (Bradley and Vovsha, 2005; Gliebe and Koppelman, 2005; Srinivasan and Athuru, 2005; Srinivasan and Bhat, 2005; Buliung and Kanaroglou, 2007; Lee et al., 2007; Chen et al., 2008; Fan and Khattak, 2008; Frank et al., 2008; Chung et al., 2009; Lee et al., 2009; Pinjari et al., 2009; Meloni et al., 2009). Kulkarni and McNally (2000) and Hankang and Meiping (2008) developed a clustering approach to identify groups of similar activity-travel patterns and then an activity pattern generation model was proposed by considering activity-travel pattern as the unit of analysis. McNally (1999) and Wang (1996) have supported the prospects for using representative activity patterns (RAPs) as the basis of forecasting models by showing preliminary evidence that RAPs are stable over conventional planning horizons.

Based on the previous studies, researchers have arrived at different activity-travel pattern behaviours from different geographic contexts. Many studies have focused on cities in developed countries, but minimal research has been produced in the context of developing countries (Mabazza et al, 2004; Zhang and Fujiwara, 2005, Ye et al., 2008, Hankang and Meiping, 2008) and is absolutely zero when it comes to Indian scenario. However, the characteristics of land use and built environment, household and individual characteristics, travel attributes and activity-travel patterns in India are entirely different from any other country. These circumstances lead to aim at identifying the representative activity-travel patterns and recognizing the influential socio-economic attributes and travel characteristics for the identified activity-travel patterns. The findings of this paper will provide useful insights into activity-travel pattern behaviour in the cities of developing countries.

Keeping in view the aspects discussed above, this paper concentrates on providing insights into the activity and travel pattern making behaviour of individuals and the extent to various activity-travel patterns of the individuals. Keeping track of these issues in mind, the paper first presents the methodology adopted in the study followed by a brief outline of the study area. Further, the paper presents identification of various activity-travel patterns and impact of socio-economic characteristics on these patterns. The paper then discusses the daily activity profiles of individuals to illustrate the daily activity-travel patterns of the individuals. Finally, the paper is concluded by highlighting some future research issues.

METHODOLOGY

The aim of this research is to explore the activity-travel pattern making behaviour of individuals in the study area. Keeping in view of the complexity in identifying activity-travel patterns, purpose of travel is considered as a measure of activity-travel pattern. This study uses a modified version of time-dependent representation of activity-travel patterns introduced by Recker et al. (1983). The research approach develops representative activity travel patterns and also examines the impact of

socioeconomic and travel characteristics on the identified representative activity-travel patterns. Further, individual daily trip and activity profiles including their activity sequencing and the probability of following one activity by another was also analyzed. Along these lines, the methodology proposed in this study can be divided into following steps. First step is the identification of various Representative Activity-travel Patterns (RAPs) made by workers, non-workers and students. Second step involves analyzing the linkage between socioeconomics and the identified RAPs.

Identification of Representative Activity-travel Patterns (RAPs)

This classification is involved in the categorization of individual activity-travel patterns into a limited number of RAPs. Basic use of this categorization is the belief that several groups of individuals have similar travel behaviour that can be captured in RAPs. Characterization of these RAPs provides the base for dealing with complete daily activity-travel patterns of individuals. Though several studies investigated RAPs, still there is no standard depiction over how to build the relationship between RAPs and socioeconomics. In this study, a new approach was proposed for identifying RAPs. First, individuals were segmented into three broad groups based on their lifestyle: workers (all working adults), non-workers (non-working adults, home maker, part time employee and retired persons) and students (all education levels). These categories were selected based on the previous literature and their similar activity travel behaviour. The individual activity patterns of each segment were classified to identify a number of distinct RAPs specific to each of the three defined categories. In this study, eleven RAPs were identified under workers category, seven RAPs were identified under non-workers category and eleven RAPs were identified under students' category. These patterns were defined by considering activity sequence as the measure. Five types of activities were identified and they are represented by a sequence of letters i.e. H-Home, W-Work, M- Maintenance, L-Leisure and S-Study. Individual activity-travel pattern was represented by a sequence of letters, which shows the order of activities performed by the individual during the day. A typical example for the activity-travel pattern, Work-Maintenance-Leisure in between stops at home (HWHMHLH) is illustrated in Figure 1. Table 1 shows the identified RAPs of each of the three defined categories. With respect to pattern choice model, more RAPs would likely to lead more accuracy. However, at some point, care must be taken to prevent adding too many RAPs that may result in the capture of more noise than differences in travel behaviour. Hence, selection of most frequent activity-travel patterns and eliminating the most similar patterns was required for the development of model.

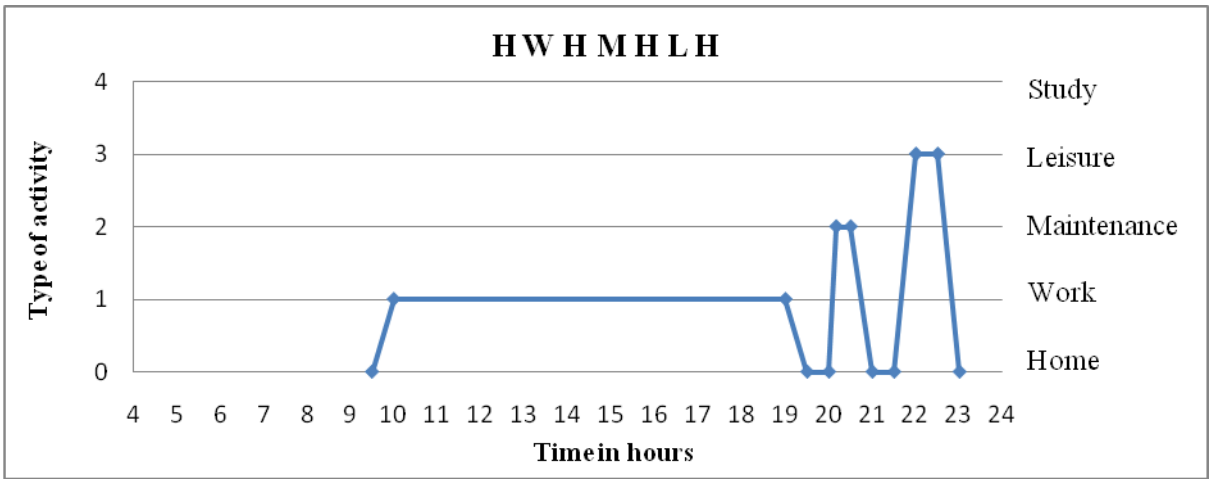


Figure 1 (a)

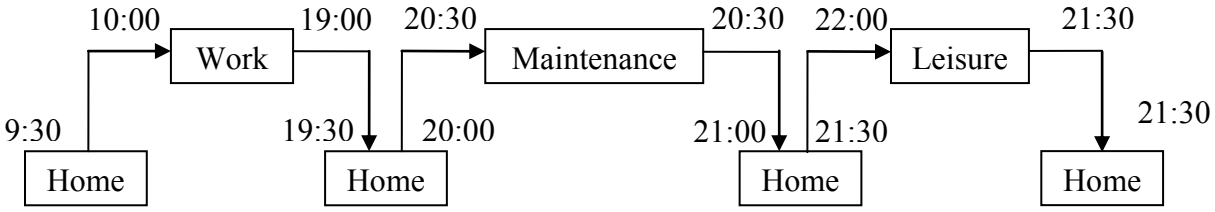


Figure 1 (b)

Figure 1 (a)-(b) Representation of Activity-Travel Pattern, H-W-H-M-H-L-H

Table 1 Identified individual representative activity-travel patterns

Individual Representative Activity-Travel Patterns					
Worker		Non-worker		Student	
RAP Group	Prop. (%)	RAP Group	Prop. (%)	RAP Group	Prop. (%)
H-W-H	43.43	H-M-H	23.9	H-S-H	33.11
H-W-H-W-H	3.31	H-M-H-M-H	13.66	H-S-H-S-H	26.14
H-W-M-H	5.91	H-L-H	19.19	H-S-M-H	0.53
H-W-H-M-H	14.88	H-L-H-L-H	3.9	H-S-H-M-H	7.58
H-W-L-H	1.28	H-M-H-L-H	17.89	H-S-L-H	1.59
H-W-H-L-H	5.08	H	21.46	H-S-H-L-H	11.74
H-W-H-M-H-L-H	3.2			H-S-H-M-H-L-H	2.27
H-M-H-L-H	5.42			H-M-H-L-H	5.38
H-M-H	8.7			H-M-H	3.18
H-L-H	4.26			H-L-H	4.09
H	4.53			H	4.39
All RAPs	100	All RAPs	100	All RAPs	100

Most Frequent Activity Patterns

The focus of this section is to select the most prominent RAPs of people. The main criteria followed while selecting these patterns was that they should cover all the variations in the activity performing styles of people. This selection of activity-travel patterns was achieved by combining the RAPs of similar activity-travel behaviour. Eight types of activity-travel patterns were identified by aggregating several identified RAPs. HWH, HWHWH, HSH, HSHSH RAPs were combined as Work/Study RAP (Pattern 1) by assuming Work and Study RAPs were exhibiting similar activity-travel behaviour. Next, HWMH, HMHWH, HSMH, HMHSH RAPs were combined as Work/Study-Maintenance RAP (Pattern 2). Similarly, HWLM, HLHWH, HSLM, HLHSH RAPs were combined as Work/Study-Leisure RAP (Pattern 3), HWHMHLH and HSHMHLH RAPs were combined as Work/Study-Maintenance-Leisure RAP (Pattern 4), HMHLH RAPs of workers, non-workers and students were combined as Maintenance-Leisure RAP (Pattern 5), HMH and HMHMH RAPs of workers, non-workers and students were combined as Maintenance RAP (Pattern 6), HLH and HLHLH) RAPs of workers, non-workers and students were combined as Leisure RAP (Pattern 7) and All in-home individual patterns were considered as No travel RAP (Pattern 8).

STUDY AREA AND DATA COLLECTION

Analyzing and capturing the travel behaviour and activity-travel patterns requires detailed and quality data due to complexity in finding the relationships between the timing and location of activities and interactions within households. Mumbai Metropolitan Region (MMR), in which the financial capital of India, Mumbai, is located, is the study area for this analysis. Mumbai Metropolitan Region is one of the fastest growing metropolitan regions and an economic power house of the country. As per the Census 2011, the total population of the MMR region is 21.3 million (Census, 2011) and approximately sixty percent of the MMR population is residing in Greater Mumbai (GM), the mother city of the region. The population density of MMR is around 4900 persons per square kilometer as compared to the figure of 20500 for Greater Mumbai. The work participation rate is anticipated to reach about 45% by the year 2031 (from 37% in 2005) which equates to a doubling of the 2005 level of employment.

The MMR with its geographical spread of 4350 square kilometre comprises of 7 municipal corporations and 13 municipal councils and is linked with the core activity centre, GM, through suburban railway system and large network of roads. As per Transform (2008) study, built up land in MMR was measured as 574.76 square kilometres, which is about 13.65% of the total area of the region. Nearly, half of the region has agricultural and open land (50.11%), while more than one fourth of the region has forest and plantations (27.94%). Remaining land has coastal wetlands (6.65%) and water bodies (1.65%).

The transportation system of Mumbai Metropolitan Region is dominated mainly by the public transportation mode. Public transport systems in Mumbai include the suburban railway, buses and intermediate public transport (IPT) modes like taxis and auto rickshaws. About 78% of the trips (53.3% of trips by suburban rail and 24.8% by bus) are carried by public transport modes and remaining trips by the private vehicles (car and two wheelers) and IPT modes (Transform, 2008). Figure 2 shows the land use characteristics of the study area. The activity based data pertaining to this study area was collected by using an appropriately designed survey instrument by the author.

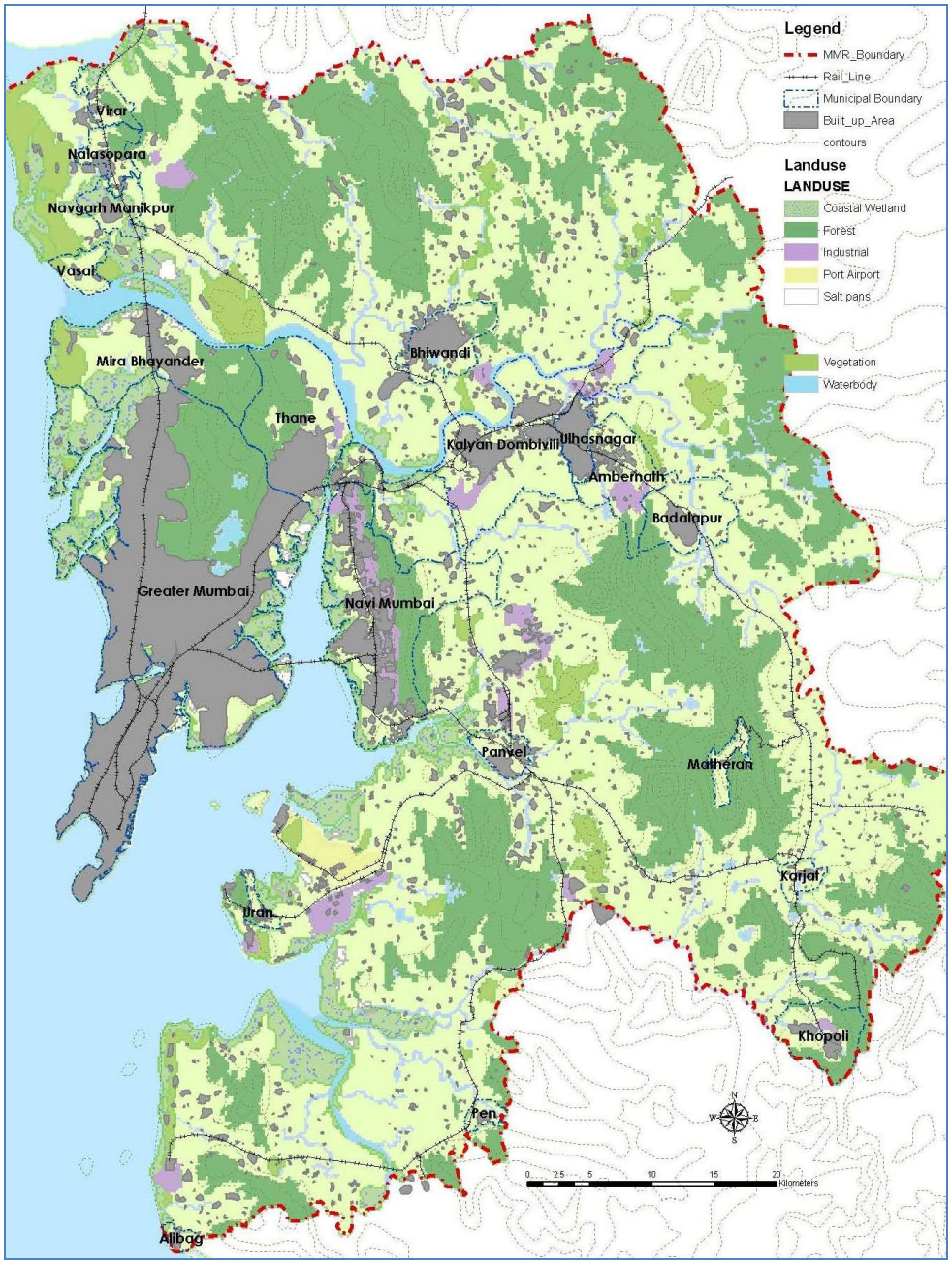


Figure 2. Study area (Transform, 2008)

Following a standardized procedure for question formulation and pertaining to the data needs of an activity based model development, a new survey instrument called activity-travel diary was designed. The survey instrument was designed in such a way that it can overcome the limitations of traditional travel diaries like lack of time use concept and their inability to represent interaction between household members. The questionnaire included in this instrument was reviewed by academic experts to check its suitability to developing countries like India. Though the survey booklet was formulated in three languages, viz., English, Hindi (Indian national language) and Marathi (regional language), respondents reported the data in different languages including regional languages, viz., English, Hindi, Marathi, Gujarati and Telugu. A geographically stratified random sampling method was adopted for the data collection by considering zonal information, income level, type of residence etc. as sampling frame. Though many advanced methods are available, the use of paper-based diaries in developing countries allowed us to reach some categories of people who do not have internet access and/or who are not comfortable with computers. In view of the requirement of the data and based on experts opinion, Drop-off And Pick-up (DAP) method of survey administration was adopted for the study. As a preliminary step, a pilot survey was conducted to evaluate the performance of the designed survey instrument and the respondent's reaction to the survey process. The main survey was carried out for a sample size of 350 households with a net response rate of 36 percent. In addition to the diary, each respondent was provided with the questionnaire about their household and personal characteristics. To capture complex interactions and to observe even the activities which are occasionally carried out by the individuals, a continuous 15 day activity-travel survey was proposed for this study. Both in-home and out-of-home activities were collected in this survey. Households with children over the age of 5 years were considered for the survey. The data set used in this study was the first of its kind which carries a 15 days travel diary data set that included all trip purposes and transport modes. Each activity pursued by individuals was described by start time, end time, description of activity, activity location, mode of travel, travel time, travel cost, waiting time, accompanied household members and comfort level in using public transport.

SOCIOECONOMIC CHARACTERISTICS

This section provides a descriptive analysis of socioeconomic characteristics of households and individuals sampled for the study. The work force ratio was found to be 42.8 percent compared to 38.4 percent in Transform (2008) study and 39.7 percent in Census (2011). In Gender composition, male-female ratio was found to be 1.13 against 1.12 in Transform (2008) and 1.2 in Census (2011). This comparison suggests that the sample-population distortion is minimal in the study. Vehicle ownership (car and two-wheeler) data shows that 39 percent of households have no vehicle, 36 percent of them have one vehicle and rest of the sample has more than one vehicle at their home. This analysis clearly demonstrates the level of dependency on public transport in the study area. More than 60 percent of the households fall into middle class, who fall in the monthly income range of Rs.20000 to Rs.50000. More than 40 percent of the respondents do not have a minimum

education level of secondary school education, and nearly 45 percent of respondents have pursued graduation and above. These statistics clearly show that there are significant variations in income level and education level in the study area. Table 2 shows some selected descriptive statistics which represent socio-economic characteristics of the sample.

Table 2 Descriptive statistics from the sample data

Household characteristics	**Mean**	**Std Dev**
Household size	3.64	1.23
Gender		
Males per household	1.94	0.85
Females per household	1.7	0.89
No. of workers	1.56	0.77
Children age <5 years	0.3	0.48
Vehicle ownership (No. of vehicles per household)	0.921	0.891
Passenger cars per household	0.365	0.531
Two wheelers per household	0.524	0.654
Bicycles per household	0.024	0.153
Others (Taxis, Rickshaws etc.)	0.008	0.089
Licensed drivers per household	1.06	0.855

ACTIVITY-TRAVEL PATTERN ANALYSIS

Activity-travel survey conducted by the author in 2011 was used to identify the individual activity-travel patterns. The majority of activity-travel patterns in the sample data set (51 percent) are made by workers. Non-workers (23.63 percent) constitute individuals those are adult i.e. greater than 18 years and are not employed. Majority of non-workers are women and are homemakers. The students (25.36 percent) consists of all school going children including those pursuing higher education i.e. graduation and post-graduation. The actual data used consists of 2655, 1230 and 1320 activity-travel patterns of workers, non-workers and students respectively.

Characteristics of Workers

Classification was started using the workers subset. RAPs with equivalent activity-profiles and only small differences in time are combined to avoid over defining the RAP. Eleven-group RAP set was identified for the analysis. The identified RAPs and the impact of socioeconomic characteristics on these patterns are presented in Table

3. The overall workers group contributes to slightly more than 50 percent of the total activity-travel patterns. For the overall group, the average age of the individuals is 34 years, male to female ratio is 1.76, average household size observed for the group is 3.51 and vehicle ownership is observed as 0.93.

Table 3 Impact of socioeconomic characteristics on identified workers RAPs

RAP group	Prop (%) of Patterns	Percent share of characteristics			
		HH Size	Veh Own	Age	HHInc
		Avg	Avg	Avg	Avg
H-W-H	43.43	3.79	0.87	38	30-50
H-W-H-W-H	3.31	3.71	1.04	34	30-50
H-W-M-H	5.91	3.1	0.97	32	30-50
H-W-H-M-H	14.88	4.1	0.69	37	30-50
H-W-L-H	1.28	2.95	1.33	28	30-50
H-W-H-L-H	5.08	3.76	1.15	39	30-50
H-W-H-M-H-L-H	3.2	3.97	0.95	47	30-50
H-M-H-L-H	5.42	2.5	0.48	26	20-30
H-M-H	8.7	4.16	0.87	36	30-50
H-L-H	4.26	2.66	0.44	21	20-30
H	4.52	3.92	1.49	38	30-50
All RAPs	100	3.51	0.93	34	30-50

[Age in years, HHInc in thousands]

The work RAP (H-W-H) contained the majority of activity-travel patterns (43.43 %) and correlated well with overall group's socioeconomic statistics. The work-maintenance in-between stop at home (H-W-H-M-H) RAP is the next dominating group in the set after work RAP with 15 % of the individuals. The typical work day of this RAP is also similar to work RAPs; the main difference is that most of the members are engaged in morning maintenance activity (viz. dropping child at school) and evening maintenance activity (viz. shopping activity) after reaching home from work. Surprisingly, RAP maintenance activities (H-M-H) made the third largest in the group with nearly 9 percent and comparing to overall socioeconomics of the group, it exhibited slightly higher values in household size and age. On the other side, RAP leisure activities (H-L-H) exhibited lower values when compared to overall socioeconomics of the group. Examining the travel characteristics of all RAPs of workers group, it is observed that maximum leisure travel occurred late in the evening (evening walk, chatting or roaming with friends etc.) and considerable percentage of individuals from low income group are involving in work related activities in weekends also.

Characteristics of Non-workers

A similar process to the one used to identify the groups for working adults was used to identify the RAPs for the non-working adults. A six-group RAP set was selected for analysis from the data. The group is dominated with maintenance RAPs (H-M-H) consisted nearly 24 percent of the total activity patterns. Even though some of the groups were named in a similar fashion to the groups identified for workers, the specifics of the RAPs were different for this data subset. Table 4 presents the socioeconomic statistics of each of the six RAPs.

For the overall group, the average age of the individuals is more than 48 years, male to female ratio is 0.28, average household size observed is nearly 4 and the vehicle ownership is observed as 0.87. A clear distinction can be observed between worker RAP group and non-worker RAP group in-terms of the average age and male-female ratio. Surprisingly, the second largest RAP in the group is no travel RAP with 21.5 percent. This infers that considerable percent of RAP members in this group are not keen to make any travel activities, perhaps due to most of the RAP members in this group are home makers and retired persons. Investigation on travel characteristics of non-worker RAP group revealed that maintenance RAPs (H-M-H) are dominated by women in weekday and men in weekends. It is also observed that average number of activities in the non-workers RAP group is considerably higher than workers RAP group, perhaps due to non-workers short trip making behaviour for maintenance or leisure activities.

Table 4 Impact of socioeconomic characteristics on identified non-workers RAPs

RAP group	Prop (%) of Patterns	Percent share of characteristics			
		HH Size	VehOwn	Age	HHInc
		Avg	Avg	Avg	Avg
H-M-H	23.9	3.53	0.93	44	30-50
H-M-H-M-H	13.66	4.57	0.65	38	30-50
H-L-H	19.19	3.72	0.86	51	30-50
H-L-H-L-H	3.9	4.27	1.06	62	20-30
H-M-H-L-H	17.89	3.79	1.03	48	30-50
H	21.46	4.01	0.72	47	30-50
All RAPs	100	3.98	0.87	48.3	30-50

[Age in years, HHInc in thousands]

Characteristics of Students

Students made up the final category of classification. The classification was similar to the working adult RAP group and a final eleven-group RAP set was selected for further analysis. The group is dominated with the study related RAPs (H-S-H and H-

S-H-S-H), which is obvious. Students from higher education contributed more for other RAPs. Table 5 presents the socioeconomic statistics of each of the eleven RAPs as well as the overall group. The average age of individual observed in this RAP group is 15 years, the split between male and female is 64 % to 36 % and a very few number has driving license. Further, it was observed that the households who fall in this RAP group tend to have their own houses.

Upon observing the activity and travel characteristics of students RAP group, it was understood that average number of activities in this group is considerably higher than workers RAP group, perhaps due to their short distance/duration maintenance or leisure activities. A clear observation was that the time spent on maintenance activities is considerably less than time spent on leisure activities.

Table 5 Impact of socioeconomic characteristics on identified students RAPs

RAP group	Prop (%) of Patterns	Percent share of characteristics			
		HH Size	VehOwn	Age	HHInc
		Avg	Avg	Avg	Avg
H-S-H	33.11	4.04	1.16	13	50-75
H-S-H-S-H	26.14	4.39	0.86	14	30-50
H-S-M-H	0.53	1.8	0.47	15	20-30
H-S-H-M-H	7.58	4.57	0.64	19	30-50
H-S-L-H	1.59	2.93	2.2	16	50-75
H-S-H-L-H	11.74	4.38	0.77	14	30-50
H-S-H-M-H-L-H	2.27	4.5	0.46	16	10-20
H-M-H-L-H	5.38	3.52	0.45	19	10-20
H-M-H	3.18	3.4	0.78	17	30-50
H-L-H	4.09	2.77	0.77	9	20-30
H	4.39	3.22	0.91	12	20-30
All RAPs	100	3.6	0.86	15	30-50

[Age in years, HHInc in thousands]

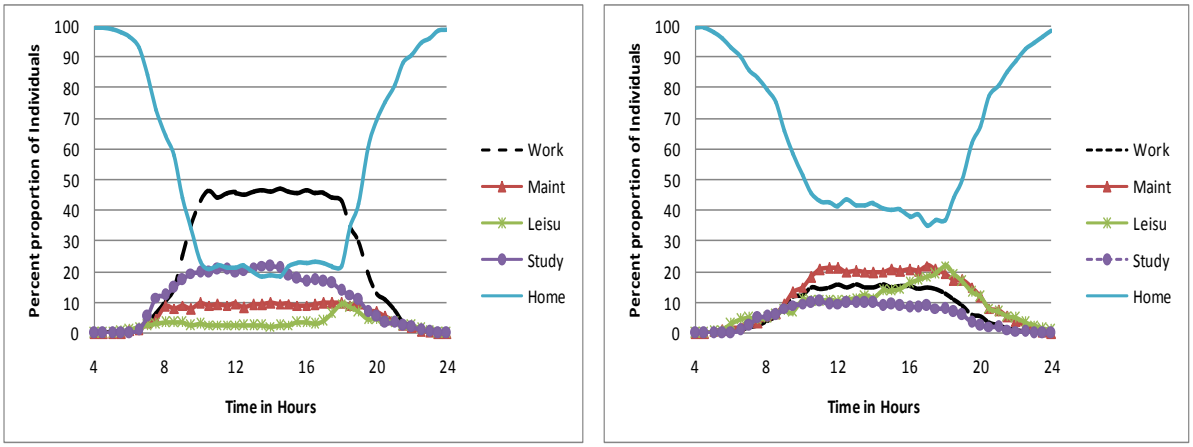
DAILY ACTIVITY PROFILES OF INDIVIDUALS

This section provides the daily activity profiles (sequence of activities) of different groups: male and female, weekday and weekend. The profiles are helpful to illustrate daily activity patterns of individuals. These profiles show how many people are engaged in each activity in each hourly time frame during a day. The advantage of these representations is that, it facilitates understanding of the daily activity sequence of each individual group and helps embed the type of activities, their timing, and sequencing of activities. In this study, for simplicity of analysis, each activity type was recorded every 15 minutes to create daily activity profile. Clear distinction was made between weekday and weekend. In addition, to add flexibility in representation, all

activities were aggregated to only five major categories: Home (all in-home activities), Work (all work related activities), Maintenance (self-care, shopping and all other maintenance related activities), Leisure (all the social and recreational activities), and Study (class and research related activities).

Activity Profile of Individuals: Weekday vs Weekend

Figure 3(a)-(b) shows the comparison of daily activity profiles of individual group for weekday and weekend. Comparisons show that daily activity patterns have some peak hours in all types of activities. The peak hours in work activity appear later in the morning around 10 a.m. and later in the evening around 6 p.m., perhaps due to work travel of individuals. In these hours, nearly 40 percent of individuals in the study area are involved in work related activities, in which 50 percent is in weekdays and just 15 percent in weekends. However, the leisure activity is showing distinctive peak observed after 6 p.m. in both weekdays and weekends. This might be due to social and recreational activities like going to evening walk, meeting friends or having a party etc. A small portion of individuals are undertaking maintenance activities almost entire day (from 8 a.m. to 8 p.m.), although major portion of individuals are non-workers.

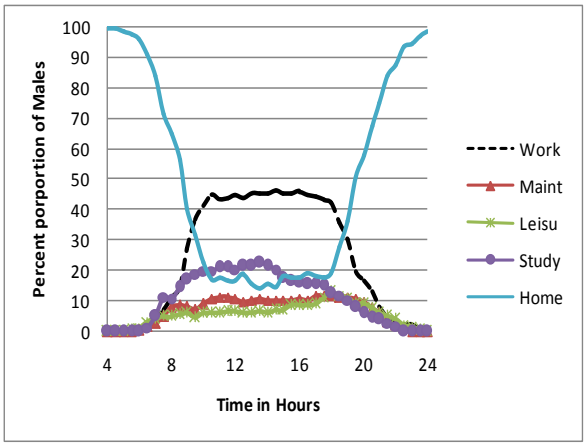


3 (a) 3 (b)

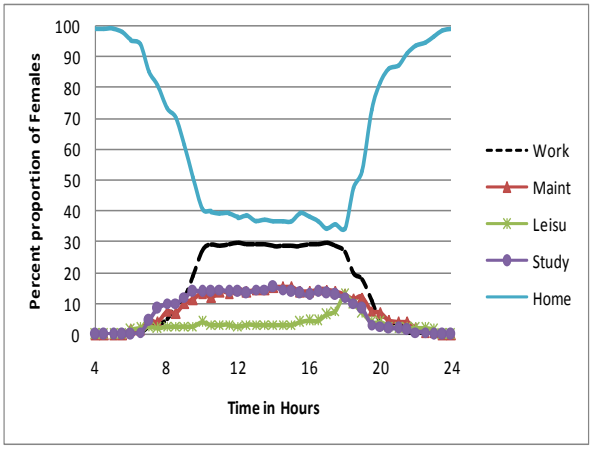
Figure 4(a)-(b) Daily activity profile of Individual in Weekday and Weekend

Activity Profile of Individuals: Men vs Women

Figures 4(a)-(b) illustrates the daily activity profiles of individual group, men and women respectively. Men are dominating with work related activities (more than 50 percent) and women are making more proportion of maintenance and leisure related activities. It also show that men are more likely engaged in recreation (leisure activities) at noon compared to women and less involved in maintenance activities.



4 (a)



4 (b)

Figure 4(a)-(b) Daily activity profiles of Individuals – Male and Female

RESULTS AND DISCUSSION

Identification of activity-travel patterns is a crucial part of the activity based travel demand modelling frame work. This study, identified various regular activity-travel patterns made by the individuals in the study area, also examined the relation between socio-demographic characteristics and activity-travel patterns. To conduct this analysis, this paper proposed a methodology for identifying RAPs and selecting most frequent RAPs based on collected data set. In this study, it was found that, maximum share of activity-travel patterns were taken by simple work RAPs in weekdays and maintenance RAPs in weekends and most of the activity-travel patterns were formed by male activities. A greater proportion of activity-travel patterns were undertaken during weekdays than weekends. All the travellers in the sample were using public transport for undertaking most of the work travel patterns.

The aim of the analysis undertaken in this study was to identify the relationships between activity-travel pattern behaviour with individual socioeconomics and various other factors. The current analysis demonstrated that household characteristics like household income, vehicle ownership and individual characteristics like age, gender, type of travel pass and activity-travel characteristics like time of day, time spent on activities and travel have a significant impact on all activity-travel patterns. The analysis recognized that decision making of activity-travel pattern choice undertaken by men and women varies significantly. It was found that all types of weekday activity patterns were dominated by men and weekend maintenance and leisure activity patterns were dominated by women. Observing the relation between activity pattern choice and duration of various activities, it was found that weekday travel patterns were dominated by work related activities, whereas weekend patterns were dominated by maintenance and leisure activities. Surprisingly, considerable percentage of individuals were not making any travel patterns both in weekdays and weekends.

Overall, the research effort provides promising insights on activity-travel pattern making behaviour of individuals in developing world (especially for the cities like Mumbai Metropolitan Region). This study also explores the interaction between various socioeconomic characteristics and the identified RAPs. Further, the identified RAPs will be useful for generating various activity-travel patterns by using Monte Carlo Simulation. These identified activity-travel patterns are useful for replacing existing conventional trip generation models by converting the patterns into trips. Further, for policy evaluation and planning, simulating a fully specified activity-travel pattern with all activity scheduling attributes could replace both trip generation and trip distribution models by producing origin-destination tables. Finally, this study leads to development of a micro-simulation based prototype of activity based travel demand model.

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