

Relationships between Work and Non-Work Activity and Travel Durations in a Developing Country Context

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ABSTRACT

Activity-based microsimulation methods aim to model activity-travel patterns at the level of the individual traveler or decision-maker. However, quite often, individual activity-travel patterns and decisions are influenced through interactions with various agents. Models of activity engagement and time allocation should reflect these interactions to accurately portray the effects that such interactions may have on activity-travel patterns. This paper examines interactions between two adult household members in two-adult households using a data set derived from a household travel survey conducted in Thane city in India. Daily work and non-work activity and travel time allocations between two household members are examined and potential trade-offs and complementary effects are modeled simultaneously using a structural equations modeling methodology. The model estimation results offer significant model coefficients and plausible interpretations consistent with the Indian context. The model meaningfully captures strong interactions, joint activity participation and task allocation among household members and its effects in making work and non-work activity and travel time allocation decisions. Also, this research offers a unique opportunity to compare the study findings with a past study carried out on a data set from Southeast Florida. Comparison between a developed and a developing country context facilitates the understanding about how diverse socio-cultural aspects can influence interaction between household adults and its effect on their activity-travel patterns. Finally, the study suggests activity-based approach can provide suitable framework in the development of advanced modeling techniques in the developing countries like India.

Keywords: Activity-travel duration, time use, inter-person interactions, travel behavior, structural equations, two-adult household

INTRODUCTION

Activity-based travel demand models are seeing rapid development around the world as they begin to replace traditional four-step travel demand models in several major cities in developed countries. These models simulate daily activity-travel patterns of individual travelers at the disaggregate level of the decision-maker with a view to better capture the behavioral basis underlying human activity-travel engagement. These models constitute major enhancements over traditional four-step models as they explicitly consider the role of time and space in determining activity-travel patterns. The conceptual development of activity-based model system is primarily based on the understanding of people's time allocation decisions to various activities on a continuous time domain. However, quite often, individual activity-travel patterns and time allocation decisions are influenced through interactions with various agents. Under this framework, the mechanism of inter-agent interactions and its effects on activity-travel time allocation decisions are recognized as extremely important ingredients in the development of activity-based models. Therefore, activity-based models are breaking new ground in the representation of agent-based interactions with explicit focus on intra-household interactions in activity-travel engagement and making time allocation decisions.

Activity-based model systems are becoming increasingly sophisticated in their ability to incorporate a variety of household interactions and constraints that influence individual activity-travel patterns. Over the past few years, significant advances have been made in understanding the nature of household interactions and its role in explaining activity participation of and travel-activity decisions made by household members (Townsend, 1987; van Wissen, 1989; Golob, 1998; Lu and Pas, 1999; Gliebe and Koppelman, 2005; Srinivasan and Athuru, 2005). Interactions among household members may occur in several ways. Household members may allocate tasks among one another, make joint decisions regarding activity scheduling and task allocation, undertake joint activities, and depend on one another for undertaking activities and travel (particularly in the case of children who depend on adults for their transport) (Golob and McNally, 1997; Browning and Chiappori, 1998; Fujii et al., 1999; Golob, 2000; Srinivasan and Bhat, 2005).

In developing countries, the development and implementation of travel demand modeling systems has generally lagged that seen in developed countries. There are several reasons for this, including resource constraints, staff constraints, knowledge constraints, data constraints, and institutional constraints. In the recent past, with the rapid development seen by several emerging economies and the explosive growth in transportation infrastructure investment, there is a growing interest in the development and implementation of advanced travel demand modeling systems in developing countries. Major household travel surveys have been or are being conducted in various cities of developing countries with a view to help in the development and implementation of new travel demand models that would support transportation planning efforts.

As interactions among household members are undoubtedly important determinants of individual activity-travel behavior, an understanding of such interactions and task allocation behavior is critical to the development of activity-based travel demand modeling systems (Becker, 1965; Chandrasekharan and Goulias, 1999; Simma and Axhausen, 2001). Even though most models incorporate household-level socio-economic

variables as explanatory factors, they may not be sufficient to explicitly account for the range of possible household interactions and task allocations that may take place. There have been several studies in the recent past aimed at exploring and modeling interactions among adult household members with respect to activity and travel engagement; however, virtually all of these studies are based on survey data sets collected in developed countries. This study intends to explore interactions among adult household members with respect to activity and travel engagement patterns from a developing country perspective. Structural equations models of activity engagement and task/time allocation among adult household members are developed and estimated in order to identify the trade-offs and complementary relationships among household members' activity and travel patterns.

India, the second most populous nation after China, has experienced significant economic and technological growth during the past few decades. Although there has been a trend toward adopting some of the ways of the West, particularly among the younger generation and those working in the information technology (IT) industry, the country has retained much of the social norms and culture that have historically defined it. In general, the labor force participation rate of women is significantly lower than that of men; gender roles are rather traditional, with women undertaking the major share of household obligations; family ties are strong (strong intra-household interactions); and vehicle ownership and affordability are low (although vehicle ownership is growing rapidly). Given such contextual differences, it can be expected that intra-household interactions, mode choice, time allocation behavior, and joint activity engagement might be significantly different in India when compared against a developed country.

Considering the relevance of household interactions in the development of activity-based travel demand models and the differences that are likely to exist in such interactions between developing and developed countries, the time is ripe to explore and model household activity-travel interactions in a very different socio-cultural and demographic context. This study presents a comprehensive analysis and a series of structural equations models to identify the nature of interactions among adult members in the sample of households contained in the 2001 Thane survey data set. In order to focus the analysis, the modeling effort in this study is limited to the subset of households that contain two adults, one of whom is a worker. The structural equations model development effort examines the relationships between work and non-work activity engagement both within- and between-adult members in the household, while accounting for the effects of children, vehicle availability, and other socio-economic and demographic variables. The study presents a series of models and offers a rich comparison between the interactions found in the India data set and those found in a similar study conducted a few years ago using a travel survey data set from the Southeast Florida region in the United States (Meka et al., 2002).

DATA SETS AND SAMPLE CHARACTERISTICS

This study is based on 2001 Thane Household Travel Survey Data set. To facilitate the particular interest of this research, a subset of 1275 households was extracted from the survey sample of 3505 households. Each household comprises of exactly two adults, at least one of whom is a worker.

In order to make a meaningful comparison between the adult household members, the following method was used to distinguish between the two adults.

- In a given household, the adult member with the longer work duration is assigned person number 1,
- If two adults had identical work durations, then the older individual was assigned person number 1,
- If two adults had exactly the same work durations and age, then the person 1 was assigned randomly to one of them.
- It is to be noted that the terms “person 1 and 2” and “adult 1 and 2” have been used interchangeably in this study.

Table 1 presents the household characteristics for the Thane and Southeast Florida survey samples. The descriptive statistics of the Southeast Florida is obtained from a similar study conducted by Meka et al. (2002). India sample of households is typically characterized by the presence of higher number of children and very low vehicle ownership compared to the Southeast Florida household sample. However, about 14 percent of the Indian households reported at least one two-wheeler. Another very interesting contrast between the Indian and US context is the distribution of the workers in the household. Consistent with the contemporary Indian society, vast majority of the Indian households have only one worker (88 percent) while 60 percent of the Northeast Florida sample is comprised of two workers. In the Indian context, it is very common to find households with only one earning member, who is predominantly male. Traditional gender role is clearly visible here.

The person characteristics of the Indian adults presented in Table 2 are describes in this section. As expected, majority of the Indian adult 1 members are male as much as 92 percent while the other group is dominated by female (90 percent). With respect to age profile, the average age is marginal between the two groups. Younger age group share about 20 percent of the individuals classified as adult 1 while the corresponding percentage is 40 percent for the Adult 2 group. About two-third individuals in the adult 1 segment are in their middle age range. With respect to educational attainment, higher percent of adult 1 group members reported themselves as college graduate compared to the other group. Vast majority of the adult 1 individuals reported their occupation as service or business professional. On the other hand, adult 2 segment consists of as much as 80 percent of homemakers as opposed to the other group where the corresponding share of homemakers is negligible. Again, these findings reveal prominent gender role in the Indian households. These facts are further supported by the income distribution, where it is seen that 85 percent of the adult 2 individuals are non-earning members while only 3.5 percent reported no income in the adult 1 category. Consistent with expectation, greater percent of adult 1 members have driver’s license and transit pass compared to the other adults in the household.

Table 2 also provides corresponding person characteristics for the US adult samples (Meka et al., 2002). It is observed that average ages of the US adult samples are higher than the Indian adults. In addition, the age distributions in the US context are very similar between the adult 1 and adult 2 samples unlike the Indian samples. With respect to employment status, about 60 percent of individuals in the adult 2 group are full-time employed in the US sample, which is a remarkable difference between the US and Indian

contexts. Consistent with employment status, both adult groups in the US sample reported higher income and greater auto usage compared to the Indian adult groups.

ACTIVITY AND TRAVEL DURATIONS OF ADULT HOUSEHOLD MEMBERS

This section provides a descriptive analysis of daily out-of-home activity engagement patterns of the adult samples. Table 3 provides the statistics of average daily trip frequencies, travel and activity durations for adult 1 and 2 groups with respect to work and non-work categories for both data sets. In this study, all work and work-related business activities are categorized as work activities. Notably, business activities are considered as work-related businesses only if the persons have one of the legitimate professions like service, business/professional or farming/laborer. Otherwise, any business activity is considered as personal business, which is treated as a non-work activity. The non-work activity duration is defined in this study as the aggregation of educational, personal business, social, recreational and any other activity durations. Table 3 makes a distinction between the entire samples of adult 1 and 2 and the subset of the adults who actually participated in a particular activity. For example in the Thane sample, 148 persons (among the 1275 classified as person 2) pursued work activity. The average work activity duration for this set of 148 persons is 417 minutes.

With respect to the India sample, average trip frequency of the adult 1 group is much higher than the corresponding average found for the adult 2 group. These findings are quite expected in the Indian context because the zero-trip makes are present in adult 2 group with much higher percentage compared to the adult group 1. However, average non-work trip frequency is higher for those individuals who actually reported such trips than the same group of individuals in the adult 1 category. As opposed to the trip making patterns of the Indian adult samples, group of adult 1 in the US sample exhibits higher work trip frequency whereas adult 2 sample shows much higher non-work trip frequency relative to the other group. In general, both average work and non-work trip frequencies in the US samples (Meka et al., 2002) are found to be much higher than the India samples.

With respect to activity durations in the India sample, average work duration for those classified as adult 1 is about 8 hr 20 min. Though the average work duration for the entire adult 2 sample is considerably low, the corresponding average for the non-zero sample is found as high as 7 hours. Group of adult 2 on average is found to spend more time on non-work activities compared to the other group, but the corresponding average for those who actually participated in non-work activities is higher for adult group 1 than the other adult sample. Consistent with the activity duration patterns in the India context, adult 1 group is found to have much higher average work activity duration than the adult 2 group in the US sample (Meka et al., 2002) while the group of adult 2 is found to have higher non-work activity duration than the group of adult 1. Comparison of activity durations between the two countries indicates that the adult 1 group in the India sample is spending exactly the same amount of time on work activity as their US counterpart while both adult groups in the US sample are spending much greater time in out-of-home non-work activities compared to the Indian adult samples. It is also found that the average work activity duration of the adult 2 group in the US sample is quite higher than the corresponding average found for the Indian adult 2 sample. The differences in activity

durations between the two contexts can be attributed to the fact that the rate of out-of-home activity participation among US adults is much higher than that found in the Indian context.

Average travel durations show similar trends like activity durations. In the India sample, those classified as adult 1 spend about 35 minutes traveling to work while those classified as adult 2 spend, on average 4 minutes traveling to work. But group of adult 1 individuals who actually participated in work activities are spending only 5 minutes more than the adult 2 sample on traveling to work. The average non-work travel duration for the group of adult 1 is much higher than the corresponding average for the group of adult 2 while the average non-work travel durations are found to be remarkably similar for those who actually reported such activities. In the US sample, the group of adult 1 is traveling on average 40 minutes to work while the corresponding average for the other group is 30 minutes. On the other hand, the non-work travel duration is higher for the individuals classified as adult 2 than the adult group 1 in the US sample. Consistent with the differences in activity duration between the contexts, the average work and non-work travel durations of the US adult samples are quite higher than Indian adults. The individuals classified as adult 1 in the India sample are spending only about 38 minutes to non-work travel while the same group in the US sample is spending on average 65 minutes for the purpose of non-work travel. Similarly, the corresponding averages for the adult 2 groups in the India and US samples are about 11 minutes and 89 minutes respectively.

MODEL SPECIFICATION

The model specification in this study is explicitly framed to understand the interactions among two adult household heads in their activity-travel engagement patterns. The modeling of within-household interactions in activity engagement involves dealing with multiple endogenous variables in a simultaneous equations framework. Work and non-work activity frequencies, activity durations, and travel durations are all activity and travel related endogenous variables that are inter-connected with one another. When modeling the interactions among several inter-dependent endogenous variables, simultaneous equations systems offer an appropriate framework for model development and hypothesis testing (Golob, 1998; Lu and Pas, 1999; Fujii, et al., 1999; Golob, 2000; Golob and McNally, 1997; Simma and Axhausen, 2001; Chandrasekharan and Goulias, 2001; Fujii and Kitamura; 2000). The study has employed structural equations modeling methodology to capture the interactions between work and non-work activity and travel durations of adult household members. To maintain brevity of the paper, the formulation of SEM is not included here, however, interested readers can refer a wide range of previous literature contributed to the detailed discussion on SEM formulation (Bollen, 1989; Golob and McNally, 1997; Lu and Pas, 1999; Kuppam and Pendyala, 2001; Meka et al., 2002).

Endogenous Variables

Out-of-home non-work activity and travel durations of the two adult members in the household are considered as the endogenous variables. It is considered that participation and the amount of time spent in non-work related activities are potentially dependent on

an individual's engagement in work-related activities and travels and his/her personal and household attributes. An individual may not have full control in scheduling and engaging in his/her work-related activity and travel, but based on his/her work-related and personal or household constraints he/she makes decision to participate in any non-work activity or travel.

As mentioned earlier, non-work activity and travel durations used in this study are the aggregation of durations of various non-work type activity and travel categories reported in the survey such as, school, shopping, social/recreational and other. One could treat these activity types separately in the model specification, but in that case the number of free parameters to be estimated in the model would increase, and accurate estimation of the parameters would require larger sample size. Such factors including increase of the incidence of zero activity and travel durations with the number of activity categories and their implications on model estimation are discussed in a study conducted by Golob and McNally (1997). In the India data set, these problems are very pronounced and therefore, all non-work activity categories are meaningfully aggregated into one category.

Exogenous Variables

In specifying the exogenous variables in the model structure, work activity and travel durations of the household adults and their personal and household characteristics such as income, household size, vehicle ownership, age, number of children etc are adopted as explanatory variables in the analysis.

Postulated Activity-Travel Causal Structure

The postulated causal structure among the endogenous variables is shown in the Figure 1. The causal effects between the non-work activity-travel durations of the household adult members are hypothesized as a recursive system, which is explicitly based on the consideration that non-work activity engagement patterns among adult 2 (secondary adult) members in the household are likely to be influenced by the non-work activity-travel patterns of the adult 1 (household head) members while the reverse effects are very unlikely to occur. Consistent with the socio-economic characteristics and activity-travel patterns previously seen of the adult members in the households, these expectations can be judged to be fairly realistic in the Indian context. Secondly, it is postulated that non-work travel is derived by the necessity to participate in a non-work activity, thus, a unidirectional causal effect between non-work activity and travel durations (non-work activity → non-work travel) has been considered in the model structure.

The postulated direct effects between endogenous-endogenous and exogenous-endogenous in the model structure can be broadly classified into seven sections: 1) intra-person activity-travel interactions; 2) inter-person activity-travel interactions 3) intra-person activity interactions; 4) inter-person activity interactions; 5) intra person travel interactions; 6) inter person travel interactions; 7) effects of demographic and socio-economic characteristics on activity-travel duration. Some key interactions found from the model estimation results are discussed in the next section.

MODEL ESTIMATION RESULTS

A comprehensive structural equation model was estimated on the sample of 1275 households to explore causal linkages between two adult persons in the household. Hypotheses regarding inter-person interaction coupled with statistical measures of fit and significance were used to guide the model development process. Finally, a model was accepted when it offered behaviorally sound interpretations and satisfactory statistical indications. The model estimation process was accomplished using PRELIS 2 (Jöreskog and Sörbom, 1999a) and LISREL 8 (Jöreskog and Sörbom, 1999b) software. The model structure and specification can be seen in Table 4 and Table 5. The causal relationships are presented in terms of direct, indirect and total effects. To understand these different effects, let's consider Table 4, where person 1 non-work activity duration affects person 2 non-work activity duration. However, person 1 non-work activity duration also affects person 1 non-work travel duration. In turn, person 1 non-work travel duration affects person 2 non-work activity duration. Thus, person 1 non-work activity duration also indirectly affects person 2 non-work activity duration through the mediating variable – person 1 non-work travel duration. The indirect effect of person 1 non-work activity duration on person 2 non-work activity duration is the product of the two direct effects that cause the indirect effect. The total effect of person 1 non-work activity duration on person 2 non-work activity duration is the sum of the direct and indirect effects.

All of the model coefficients presented in Table 4 and Table 5 are statistically significant at the 0.05 level of significance with a few exceptions that are significant at the 0.1 level or below. The model χ^2 goodness-of-fit statistic indicates that the hypothesis that the matrix of sample moments is equal to the matrix of model implied moments can not be rejected at the 0.05 level of significance. The adjusted goodness-of-fit index (AGFI) is a measure of the relative moment of the sample variances and covariances that are predicted by the model, adjusted for the df of the model relative to the number of variables (Bollen, 1989; Golob and McNally, 1997). The AGFI for the model estimated in this study is 0.999. Thus the model fit is statistically acceptable. The other measures of fit provided at the bottom of the Table 5 are also in line with agreeable standards of fit for a structural equations model of this nature. It should be noted that some not statistically significant coefficients are retained in the models for model sensitivity and because the coefficients offered plausible behavioral interpretation. In the discussions that follow, it should be noted that person 1 represents the adult in the household who spent the longest time working and older in age and may therefore be considered the primary worker or head of the household.

The model estimation results provide very insightful and logically consistent findings. In the following section, the results obtained from this present study on the India sample will be compared with the previous study (Meka et al., 2002) carried out on US sample whenever such comparisons apply.

Intra-Person Activity-Travel Interaction

Table 4 presents the interactions among the endogenous activity-travel variables. As expected, for both person 1 and person 2, non-work activity duration has positive impact

on his/her non-work travel duration, which indicates longer non-work activity engagement is likely to cause longer non-work travel duration. The structural equations model provides a mechanism for quantifying the effects between the variables. The amount of travel generating from these activities can be determined by the magnitudes of the estimated coefficients. For instance, the total effects of non-work activity on non-work travel estimated for person 1 and person 2 are 0.38 and 0.44 respectively, which means that one hour of non-work activity duration requires about 23 minutes of non-work travel for person 1 and 26 minutes of non-work travel for person 2.

In the US context, the intra-person interactions with respect to non-work activity-travel patterns were found to be consistent with the Indian situation. The US model showed that non-work activity duration of person 1 directly affects non-work travel duration. The causal effects are consistent for person 2 as well. The positive coefficients indicate that non-work travel duration increases with non-work activity duration. One hour of non-work activity requires about 17 minutes of non-work travel for the person 1 and the corresponding figure for person 2 is 8 minutes in the US context (Meka et al., 2002).

The model structure in Table 5 shows the intra-person causal effects with respect to work and non-work activity-travel interactions. Person 1 work activity duration negatively affects non-work travel durations for the same person, which indicates non-work travel decreases with increase in work activity duration. Estimated coefficient suggests that every one hour increase in work activity tends to reduce non-work travel duration by 9 minutes. However, reverse relationship is found with respect to person 2 where work activity duration is positively affecting the same individual's non-work travel duration. One hour increase in work activity duration of person 2 increases his/her non-work travel duration by 5 minutes. These findings can be explained by the fact that household heads are less likely to engage in non-work travel after work possibly due to their long working hour and at the same time if the second adult in the household is a worker, then the person shows greater tendency to undertake household maintenance-related non-work activities/travels perhaps because of shorter working hours compared to his/her partner. This is a typical example signifying trade-off between the adult members in their household task allocation in the Indian household.

However, in the US context (Meka et al., 2002), work activity duration negatively affects non-work travel duration for both adult samples. A 60 minutes increase in work activity duration for person 1 would bring about 4 minutes decrease in non-work travel duration for that person and the corresponding value for person 2 is 5 minutes. These findings convey a clear distinction in task allocation patterns between the adult members in a household in a developed and a developing country context.

Consistent with the effects of work activity duration, one's work-related travel duration negatively affects his/her non-work activity duration in both Indian and US contexts. However, work travel duration of person 2 in the India model does not show significant effect on non-work activity duration of that person.

Inter-Person Activity-Travel Interaction

The India model indicates no significant total effect of non-work activity duration of person 1 on non-work travel duration of person 2. However, non-work travel duration of

person 1 has significantly positive net effect on non-work activity duration of person 2. The model suggests that a 30 minutes increase in non-work travel duration of person 1 contributes to a 2.4 minutes increase in non-work activity duration person 2. Similarly in the US context, positive interactions were found between these variables and the model showed that an hour of non-work activity of person 1 would induce 5 minutes increase in non-work travel duration of person 2. These findings indicate the complementary nature of discretionary activity participation by the adult members in the household.

In addition, it can be seen from Table 5 that the net total effect of work activity duration of person 1 on non-work activity duration of person 2 is negative. It appears from the model that every 60 minutes of work activity duration of person 1 would bring about 1 minute of non-work travel duration of person 2. This finding again suggests complementarities in activity-travel interaction because when person 1 works longer, the tendency of non-work activity participation jointly with other member significantly reduces. Conversely, work activity duration of person 2 has positive effect on non-work travel duration of person 1, which rather signifies task allocation because when person 2 is heavily involved in subsistence activities, the person 1 is more likely to undertake longer non-work travel to pick up some maintenance activities to run the household. A 60 minutes increase in the work-activity duration of person 2 contributes about 5 minutes increase in non-work travel duration of person 1. These findings are quite consistent with that found in the previous study on the US sample (Meka et al., 2002).

Intra-Person Activity Interaction

Table 5 presents intra-person causal effects between work and non-work activity durations for the adult members in the Indian households. As expected, work activity duration of person 1 has a significant effect on non-work activity duration of that person indicating that as the person works longer, the amount of time he/she is spending on non-work activity duration decreases. Corresponding model coefficient indicates that an hour of work activity reduces non-work activity duration by 11 minutes for a typical Indian household head. The US model exhibits similar effects for both person 1 and person 2 adult segments where an one hour increase in work activity duration is associated with a decrease of about 9 minutes and 12 minutes in the duration of non-work activities respectively (Meka et al., 2002).

Inter-Person Activity Interaction

The model also provides insightful causal relationships between work and non-work activity durations. Non-work activity duration of person 1 in the India model affects positively the non-work activity duration of person 2 suggesting joint participation in non-work activities by the household adult members. But, work activity duration of person 1 is found to have negative effect on non-work activity of person 2, thus, capturing the complementary nature of non-work activity engagement between the adult members while work activity duration of person 2 affects positively the non-work activity duration of person 1. The model suggests that a 60 minutes increase in work activity duration of person 2 entails 5 minutes increase in non-work activities for person 1. The trade-offs in task allocation between the adult members are captured here because when

the secondary adult member in the household is heavily involved in subsistence activities, the household head possibly tends to pick up some maintenance activities.

The US model suggests that a 10 minute increase in the non-work activity duration of person 1 contributes to about 3.25 minutes increase in non-work activity duration for person 2. Thus, it appears that person 1 and person 2 would jointly spend 3.25 minutes together while person 1 would spend the other 6.75 minutes performing a non-work activity outside home alone. Consistent with the Indian model, the net effect of person 1 work activity duration on person 2 non-work activity duration is found to be negative in the US model, but no significant relationship was found between person 2 work activity duration and person 1 non-work activity duration. It appears in the US context that trade-offs in task allocation among the adult members occur in a rare occasion because they possibly maintain an individual-specific designated set of daily activity agenda and therefore, any change in one's mandatory activity duration does not seem to significantly affect other's non-work activity engagement pattern (Meka et al., 2002).

Inter-Person Travel Interactions

The model also provides very meaningfully consistent findings with respect to inter-person travel interactions. It is found that person 1 non-work travel duration has a positive direct effect on person 2 non-work travel duration. It appears from the model coefficient that a 30 minutes increase in the non-work travel of person 1 leads to an increase in non-work travel duration by 4 minutes for person 2. Therefore, person 1 and person 2 would jointly spend 4 minutes of non-work travel while person 1 would spend 26 minutes of daily non-work travel alone. The model also suggests that work travel duration of person 1 is negatively affecting the non-work travel duration of the other. This relationship is appeared to be consistent for person 2 as well. Again, this is an example of complementarity in non-work travel interaction suggesting that when one of the household adult is spending more time on work-related travel, the chances of traveling jointly with other member in the household reduces. The model estimated on the US sample (Meka et al., 2002) shows remarkably similar patterns of inter-person travel interaction as the Indian model.

So far, it is seen in the India model that as work activity duration of an adult member goes up, the propensity of the other adult to undertake non-work activity increases indicating the trade-off in task allocation between the adults. The model also suggests that work travel duration of one of the members negatively affects the non-work travel duration of the other member. The previously described interaction may seem to be contradictory with the later one. But there may be a plausible interpretation to explain these effects such as, even though a person is not undertaking any non-work travel jointly with the other member spending more time on work-related activity and travel, still he/she could solely undertake a short non-work travel by looking for destinations in close proximity to accomplish his/her desired non-work activity.

Effects of Demographic and Socio-Economic Attributes

Socio-economic and demographic characteristics of the adult members are found to have significant and meaningful effects on inter-person and intra-person non-work activity-travel engagement patterns in the Indian context. The estimated model coefficients presented in Table 5 suggest that adults living in a household with no children consistently show positive effect on non-work activity and travel duration for both adult members. This finding is quite consistent with expectation because in a household with no children adults are less burdened with household obligation and childcare responsibilities. Therefore, they would have freedom to spend greater amount of time in non-work activity and travel.

Person 1 being in his/her middle age group, high educated, employed in the service sector is found to have negative effect on the non-work activity-travel of person 2. This is again an example of complimentary nature of non-work activity-travel (mainly discretionary in nature) engagement, where household head is a busy working person and has less time available to participate in non-work activities with person 2 and then person 2 is also less likely to undertake such activities.

A similar negative effect is found on non-work activity and travel duration of person 1 when the person 2 is a worker. It is quite expected that being a worker, person 2 would have less time available to jointly participate in a non-work activity or travel with the other adult member in the household and therefore, person 1 would also be less likely to undertake any non-work activity or travel. Again, this effect captures the complementary nature of non-work activity and travel among household members.

On the other hand, when person 2 is low educated, he or she influences positively the non-work activity duration of person 1. In the Indian context, low educated individuals who belong to the person 2 category are most likely to be female homemakers who don't usually participate in any out-of-home activity in a regular basis and prefer to stay at home to bear the major share of in-home household maintenance activities. Therefore, the household head who is most likely to be the male member (person 1) undertakes most of the non-work maintenance activities like shopping, child pick-up/drop off etc. in a daily basis. This is a typical example of in-home and out-of-home task allocation between male and female partners in an Indian two-adult household. Again, the same variable affects the non-work travel duration of person 1 in a negative manner. The possible reason behind this is that if the person 1 has less time available to undertake such non-work activities because of his/her work-related obligations then he or she could look for destinations in close proximity to get their non-work activities done to minimize their non-work travel duration.

In the US context (Meka et al., 2002), socio-economic and demographic characteristics are found to have significant effects on non-work activity-travel engagement patterns of adult members in the household as well. The model shows availability of two vehicles in the household negatively affects non-work activity and travel duration of the adult members in the household. This is possibly because greater availability of vehicles is likely to eliminate the need of joint participation in maintenance activities and travels for the household members; rather it allows them to distribute their responsibilities among themselves in pursuing certain designated activities. Such arrangements tend to reduce non-work activity and travel durations potentially for each of

the household members. Presence of children in the household positively affects the non-work activity and travel duration of person 1 while it affects negatively the non-work activity and travel duration for person 2. These effects clearly captures designated task allocation between the members suggesting that person 1 tends to be responsible for undertaking out-of-home childcare responsibilities such as child drop-off and pick-up while person 2 is more likely to pick up major in-home childcare responsibilities.

CONCLUSIONS

This study intends to explore interactions among adult household members with respect to their activity and travel engagement patterns from a developing country perspective. Structural equations models of activity engagement and task/time allocation among adult household members are developed and estimated in order to identify the trade-offs and complementary relationships among household members' activity and travel patterns. A sample of 1275 households drawn from the 2001 Household Travel Survey in the Thane Metropolitan Area, India has facilitated to achieve the goal of this research. In order to focus the analysis, the modeling effort in this study is limited to the subset of households that contain two adults, one of whom is a worker. The person with the longer work activity duration in the household was designated as person 1 and the other person was defined as person 2.

The model results have provided very insightful findings consistent with a developing country perspective. The estimated model has provided a comprehensive understanding of the intra-person and inter-person interactions in non-work activity and travel engagement patterns. The model meaningfully captures strong interactions, joint activity participation and task allocation among the household members in the Indian context. The structural equations modeling framework has also allowed accounting for the effects of children, vehicle availability, and other socio-economic and demographic variables. The socio-economic characteristics of the household adults are found to have very insightful effects on intra-person and inter-person non-work activity-travel patterns in the Indian context.

Considering the socio-cultural differences that are likely to influence the nature of household interactions between developing and developed countries, the study offers a rich comparison between the interactions found in India and the US contexts. Comparison between the countries reveals remarkable consistencies in non-work activity-travel engagement patterns and task allocation behavior of the household members in a developing and a developed country context. Remarkably, these findings indicate clear consistencies in relationships despite the hypothesized differences that we expected to see between Indian and US contexts. Therefore, it can be concluded that activity-based models are proving to be more universally applicable as they are based on fundamental behavioral principles and processes. Fundamental human behaviors are likely to be consistent regardless of cultural and social differences and that makes the applicability of activity-based models more versatile in any social context. Therefore, it is envisioned that such models can make valuable contribution to the development of advanced model systems in the developing countries like India.

In this particular study, non-work activities had to be grouped together due to the rather low participation rates in maintenance and leisure activities (when treated

separately). This is considered as a limitation of this study as such arrangement may cause some ambiguity in interpreting the model coefficients. Therefore, it is important to preserve the disaggregate activity purpose classification in terms of maintenance and leisure activity categories in the model structure whenever possible. One should note that the nature of household interaction in pursuing these activities may be very different from each other because maintenance activities may be allocated between adults (suggesting a trade-off) while leisure activities may be conducted jointly (suggesting a complementary effect).

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TABLE 1 Household Characteristics

Characteristics	Thane, India	Southeast Florida
No. of households	1275	1262
Average household size	3.3	3.4
2 persons	32.8%	32.5%
3 persons	26.1%	23.6%
4 persons	26.0%	26.8%
5+ persons	15.1%	17.0%
Average household size	1.28	0.98
0 Children	32.8%	46.4%
1 Children	26.1%	21.2%
2 Children	26.0%	21.9%
3+ persons	15.1%	10.1%
Average car ownership	0.04	2.3
0 car household	95.8%	0.9%
1 car household	3.9%	10.1%
2 car household	0.3%	63.1%
3+ car household	0.0%	24.9%
Average two wheeler ownership	0.16	NA
0 two-wheeler household	85.2%	NA
1 two-wheeler household	13.9%	NA
2 two-wheeler household	0.9%	NA
Home ownership		
Own	75.7%	NA
Rented	20.7%	NA
Govt. Quarter	3.3%	NA
Company home	0.3%	NA
Home built-up area		
< 250 sq. ft	34.3%	NA
250-500 sq. ft	51.5%	NA
501-750 sq. ft	12.1%	NA
751-1000 sq. ft	1.2%	NA
> 1000 sq. ft	0.9%	NA
Workers		
1 worker	88.5%	21.0%
2 workers	11.5%	60.9%
3+ workers	0.0%	18.1%

TABLE 2 Person Characteristics of the Adult Household Members

Thane, India Survey 2001			Southeast Florida Survey 1999		
Characteristics	Adult 1	Adult 2	Characteristics	Adult 1	Adult 2
Sample size	1275	1275	Sample Size	1262	1262
Gender			Gender		
Male	92.2%	9.6%	Male	NA	NA
Female	7.8%	90.4%	Female	NA	NA
Age			Age		
Average in years	39	34	Average	42	43
18 to 30 years	20.2%	41.8%	18 to 30 years	16.0%	17.9%
31 to 40 years	45.1%	42.8%	31 to 40 years	28.4%	28.7%
41 to 50 years	26.8%	9.6%	41 to 50 years	30.7%	25.0%
51 to 60 years	4.5%	3.2%	51 to 60 years	15.8%	15.1%
61 years and over	3.4%	2.5%	61+ years	6.6%	10.8%
Missing	0%	0%	Missing	2.5%	2.5%
Education					
Illiterate	6.0%	12.6%	NA	NA	NA
Up to SSC	58.4%	60.5%			
Up to HSC	11.6%	9.0%			
College Graduate	23.9%	17.8%			
Occupation			Employment Status		
Service	64.6%	9.4%	Full Time	90.3%	63.0%
Farmer/Laborer	7.4%	1.2%	Part Time	7.5%	12.8%
Business/Professional	21.6%	3.7%	Not Employed	1.3%	23.0%
Student	0.0%	1.1%			
Homemaker	0.9%	80.6%			
Retired/Unemployed	5.5%	4.0%			
Personal Inc/Month			Person Inc/Yr		
No income	3.5%	85.1%	\$0-20 K	9.9%	23.8%
≤ Rs. 5,000	56.2%	8.0%	\$21K-40K	26.1%	23.7%
Rs. 5,001-15,000	38.2%	6.5%	\$41K-60K	19.0%	11.7%
Rs. 15001 and above	2.1%	0.4%	\$61K-80K	5.8%	4.7%
			\$81K+	8.3%	3.4%
			Missing	30.9%	32.7%
Vehicle ownership			Work Mode		
No vehicle	75.1%	96.4%	SOV	87.6%	84.2%
Car	6.1%	0.7%	Car/Van Pool	10.3%	12.5%
Two wheeler	11.8%	2.3%	Transit	0.9%	1.5%
Bicycle	7.0%	0.6%	Other	1.4%	1.8%
Driver License	19.5%	4.0%	NA	NA	NA
Transit pass	27.8%	4.7%	NA	NA	NA

TABLE 3 Activity-Travel Patterns of the Adult Household Members

Purpose	Thane, India Survey 2001				1999 Southeast Florida Survey	
	Adult 1 (All)	Adult 1 (Actually Participated)	Adult 2 (All)	Adult 2 (Actually Participated)	Adult 1 (All)	Adult 2 (All)
Daily Trip Frequency						
Work	0.93	1.03 (1144)	0.12	1.02 (148)	1.19	0.73
Non-work*	1.06	1.10 (1214)	0.48	1.67 (367)	2.48	3.61
Daily Out of Home Activity Duration (min)						
Work	498	498 (1144)	47	417 (148)	498	207
Non-work	20	291 (87)	40	228 (226)	44	105
Daily Travel Duration (min)						
Work	35	39 (1144)	4	34 (148)	43	30
Non-work*	38	40 (1214)	11	39 (367)	65	89

*includes return home trips

TABLE 4 Structural Equation Model Estimation Results (Causal Effects between Endogenous Variables)

Endogenous variable	Effect	Person 1 Non-work activity duration	Person 1 Non-work travel duration	Person 2 Non-work activity duration	Person 2 Non-work travel duration
Person 1 Non-work activity duration	Direct Indirect Total	--	--	--	--
Person 1 Non-work travel duration	Direct Indirect Total	0.38 0.00 0.38	--	--	--
Person 2 Non-work activity duration	Direct Indirect Total	0.03 0.02* 0.05**	0.04 0.00 0.04*	--	--
Person 2 Non-work travel duration	Direct Indirect Total	-0.06 0.06 0.00	0.11 0.02* 0.13	0.44 0.00 0.44	--

*Significant below 90 percent level

**Significant at 90 percent level

All other variable significant at 95 percent level

TABLE 5 Structural Equation Model Estimation Results (Causal Effects of Exogenous Variables on Endogenous Variables)

Endogenous Variable	Effect	Person1 Work Activity Duration	Person1 Work Travel Duration	Person2 Work Activity Duration	Person2 Work Travel Duration	HH Size=2 (no children)	Person1 Age: 31 - 45	Person1 Highly Educated	Person1 Occu: Service	Person1 Income Rs.5K+	Person2 Male	Person2 Worker	Person2 Low educated
Person1 Non-Work Activity Duration	Direct	-0.18	-0.07	0.09	0.00	0.13	-0.16	0.25	-0.08	-0.13	0.00	-0.07**	0.23
	Indirect	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	-0.18	-0.07	0.09	0.00	0.13	-0.16	0.25	-0.08	-0.13	0.00	-0.07	0.23
Person1 Non-Work Travel Duration	Direct	-0.08	0.00	0.04*	-0.04*	0.16	-0.18	-0.09**	-0.10	-0.10	0.00	0.00	-0.11
	Indirect	-0.07	-0.03	0.03	0.00	0.05	-0.06	0.10	-0.03	-0.05	0.00	-0.03*	0.09
	Total	-0.15	-0.03	0.07	-0.04	0.21	-0.24	0.01	-0.13	-0.15	0.00	-0.03	-0.02
Person2 Non-Work Activity Duration	Direct	0.00	0.04*	0.17	0.00	0.00	0.00	-0.24	-0.06	0.00	0.32	-0.58	-0.43
	Indirect	-0.01	0.00*	0.01**	0.00*	0.01	-0.02	0.01	-0.01	-0.01	0.00	0.00*	0.01*
	Total	-0.01	0.04	0.18	0.00	0.01	-0.02	-0.23	-0.07	-0.01	0.32	-0.58	-0.42
Person2 Non-Work Travel Duration	Direct	0.00	-0.05	0.00	0.00*	0.06	0.00	0.10	0.00	-0.05**	0.18	-0.20	0.00
	Indirect	-0.01**	0.02*	0.08	0.00*	0.02	-0.02	-0.12	-0.04	-0.01	0.00	-0.26	-0.20
	Total	-0.01	-0.03	0.08	0.00	0.08	-0.02	-0.02	-0.04	-0.06	0.18	-0.46	-0.20

N=1275; $\chi^2 = 4.95$ with 15 df ; p-val = 0.99; GFI=0.99; AGFI=0.999; RMSEA=0.001

*Significant below 90 percent level

**Significant at 90 percent level

All other variable significant at 95 percent level

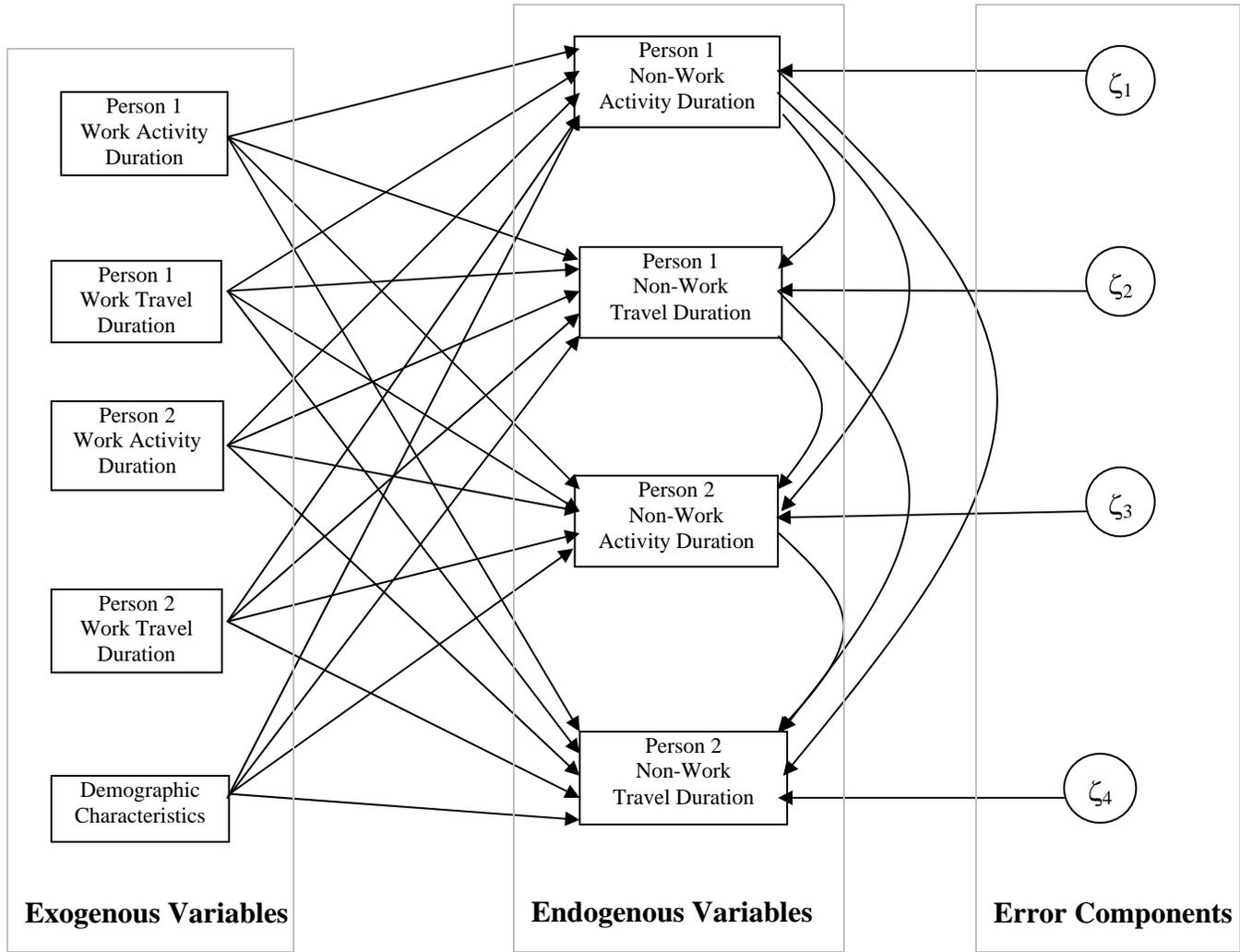


FIGURE 1. Postulated Activity-Travel Causal Structure