AMERICANS' TIME USE: A FOCUS ON WOMEN AND CHILD-REARING VIA STRUCTURAL EQUATIONS MODELING

Charlotte Whitehead-Frei Graduate
Student Researcher Northwestern
University
whitehead@u.northwestern.edu
Charlotte.Frei@u.northwestern.edu

Kara M. Kockelman
(corresponding author)
Professor and William J. Murray Jr. Fellow
Department of Civil, Architectural and Environmental Engineering
The University of Texas at Austin
6.9 E. Cockrell Jr. Hall
Austin, TX 78712-1076
kkockelm@mail.utexas.edu
Phone: 512-471-0210
FAX: 512-475-8744

The following paper is a pre-print and the final publication can be found in *Transportation Research Record* No. 2163:32-44, 2010.
Presented at the 89th Annual Meeting of the Transportation Research Board, January 2010

ABSTRACT

This paper describes a model of Americans' time use, in which time spent with children in-home and out-of-home influences activity and travel time allocation. While children's activities and travel are being studied more in depth now than in the past, to date there are few studies that examine time spent with children as a dependent variable within a time-use model. Most existing models of activity and travel participation allocate time to work activities, followed by obligatory maintenance activities, and non-obligatory "discretionary" activities. This model expands the data into 8 different activity categories to determine whether these activities are more or less necessary than past research assumes. The results suggest that total time spent inside the home with children has a statistically significant and negative impact on work, leisure, and personal activities inside the home; but work duration and work travel have no significant or practical impact on time spent with children, everything else constant. There is also some indication that more time spent in in-home activities is associated with greater travel time expenditures. Overall, the 2007 American Time Use Survey contains a variety of details that help illuminate many such questions.

Key Words: time use, activity participation, travel durations, structural equations modeling, gender, children

MOTIVATION

Current research suggests men and women within the same household have very different activity schedules and travel behavior [1,2]. Research in the 1990's credited these intra-household differences to the relative importance placed on wives' careers, as compared to those of their husbands [1, 3]. These studies suggested that implied commute times for both workers influenced a household's choice of workplace locations and home location. More recent work suggests that women spend more time conducting in-home maintenance activities than their male counterparts [2], and the question arises as to how parents spend their time and how children factor into time allocation decisions.

This work seeks to determine what individual and household characteristics affect activity and travel decisions, including overall time spent with children. Structural equations models (SEMs) are employed to explain the relationships between individual and household characteristics and the activity and travel schedule. Travel durations are modeled jointly with activity durations to determine how trip-making is allocated and how such time use impacts time spent with one's children. To date, few models include time with children as a specific activity category, yet one could reasonably argue that this is a significant activity which will impact other activities quite significantly. With the current move in travel demand forecasting toward more sophisticated activity based models, better prediction of time use will improve our understanding of activity allocation and related travel patterns.

Literature Review

There is significant research to date using SEMs for activity and travel time allocations, with the most relevant discussed here. Freedman and Kern [1] used a discrete choice model to determine the implications of two-worker household status on location choices, and concluded that wives' commute burdens influence home and workplace location decisions. In a similar study of time use via detailed in-person interviews with 30 dual-career households in the UK, Green [3] found that residential site selection depended more on the working male's job location, even in households that had recently moved. Using SEMS of 1980 census data, the interview results suggested male worker commute times in the UK in 1995 were declining with respect to 1980 commute times, while those of female workers were increasing in dual career households. Men's commute times were still longer, with roughly two-thirds of males commuting more than 30 minutes to work and about half the women commuting more than 30 minutes. This latter result is likely due to the professionalization of the female workforce, as women seek higher degrees and gain in salary levels [4]; essentially, they probably are becoming harder to place (thanks to deeper but narrower training and occupational interests), making for longer commutes. Green [3] expected the long-run convergence of male and female commute patterns in the UK, and recent American Time Use Survey (ATUS) data suggest this has happened in the US as of 2007, and possibly earlier.

Golob [5] used SEMs to forecast activity participation, travel time, and trip generation based on household characteristics and accessibility measures. To predict trip counts, he used an asymptotically distribution free weighted least squares approach in LISREL software (see, e.g., [6]). Using the Portland 1994 Activity and Travel Survey, the final model divided in-home activities into work and non-work and divided out-of-home activities into work, maintenance and discretionary. Maintenance activities are generally those that are necessary, but not work or education related, such as grocery shopping or seeking medical care, and picking up/dropping off

children. Discretionary activities include participation in hobbies, spectator athletic events, exercise, and socializing. Among the exogenous control variables, number of children and income negatively influenced work duration. Commuting times rose with income. In-home work time was also significantly higher for the highest income group (>$60,000). Non-work activity duration had a highly significant effect on the frequency of chained non-work tours. Both non-work activity duration and the number of these chained trips were estimated to have positive (and statistically significant) influences on travel time to non-work activities. These results are intuitive, but the statistical significance of various linkages in the SEM suggest which activities and trips may most influence daily routines and time expenditure decisions. Golob [5] determined that such models allow researchers a look into travel behavior that is not available from conventional methods where trip generation rates are estimated in isolation – separate from one another and from time use decisions.

Srinivasan and Bhat [2] used seemingly unrelated regression (SUR) techniques to examine in-home activity durations and a mixed (logit-hazard) model for out-of-home maintenance durations by male and female heads in nuclear[1] families. While not an SEM, the results of the model are useful in predicting potential outcome of the work pursued here. Similar to Golob [5], the authors assumed that out-of-home maintenance time is allocated first to subsistence or mandatory activities, then maintenance, and finally discretionary activities. Overall, wives' in-home maintenance durations were the most susceptible to change based on the household attributes and the husbands' activity choices. Out-of home work duration and commute time negatively impacted husbands' in-home maintenance time, while the number and age of children had no effect. To accommodate this, wives' in-home maintenance time increased with their husbands' out-of-home work durations, the number of children under age five, and the availability of a personal vehicle. Females' commute time were not found to affect their in-home maintenance times.

Susilo and Kitamura [7] used SEMs to determine how temporally and spatially stable travel in Osaka, Japan was between 1980 and 2000. They supplemented household survey results with demographic, land use, and network data. While average commute times world-wide have remained relatively stable over time, the authors suggest that this may not be the case at the level of individuals or even groups of similar individuals. In general, their model results suggest that employed males spent more time in work activities than female workers, and that the presence of children reduces time allocations to non-work activities. Over time out-of-home non-work activity durations fell in Osaka, while the number of non-work activities rose, which suggests individuals may be compensating for increased travel time by reducing non-work activity durations.

Lee et al. [8] used simultaneous[2] Tobit models for Tucson data to model time expenditures. Their results suggest that the number and working status of household heads are primary determinants of trip-chaining and time allocation. Interestingly, income and vehicle ownership levels were not found to be strong predictors of chaining behavior. More recently, Lee et al. [9] turned to 2001-2002 Atlanta survey data and land use files. As expected, they found that those with children over 6 years-old spend less time traveling, and those with very young

[1] Srinivasan and Bhat's (2005) nuclear households are male-female couples with at least one employed adult. If children were under 15 years of age, they also were included.

[2] Endogeneity among subsistence, maintenance and discretionary activity durations were calculated for each model and excluded from the independent Tobit equations if found to be insignificant.

children (under 5 years of age) spend less time in out-of-home subsistence and discretionary activities. Age of travelers positively impacts tour durations, possibly due to lower speeds, slower routes, fewer time constraints, and so forth. Lee et al.[9] argue that congestion must have a great impact on activity allocation and scheduling, since time-of-day variables (to indicate peak periods and mid-day) were highly significant in the model, but this simply could be due to standard scheduling preferences (e.g., stores not opening until 10 am, schools letting out between 2 and 3 pm, lunchtime taking place near the noon hour, etc.).

The independent, single-equation Tobits, as used in recent models cited above, are rather simplistic. A move back to systems of equations is worthwhile, to examine how the presence of children, gender, work status and other attributes and activities play a role in men and women's time expenditure patterns. Moreover, few models have emphasized the role of children, and their activities, in time allocation choices. Of course, the desire by parents and other adult household members to serve those children's needs and enjoy time with them are likely to have time-expenditure (and scheduling, travel, and other) repercussions, throughout the day.

The method presented here builds upon prior work and expands into topic areas where past research has suggested it most useful. Using specific activity types, rather than the prevailing work/non-work or subsistence/maintenance/discretionary categories, the approach yields new insights into time allocation. With a greater understanding of how individuals prioritize activities, travel models that make use of activity schedules may be improved by these additional categories. By focusing on single-mother households and mothers in households with two or more adults, this work shows what is possible when the data are made more homogenous and new distinctions between groups are addressed. The following sections describe the specifications and data used.

MODELING APPROACH

To evaluate time-expenditure data in the American Time Use Survey (ATUS), a series of SEMs were evaluated using the R programming language's SEM package for continuous response [10,11]. All 24 hours of a person's day are accounted for in 18 different activity categories, one of which is travel.

Since time use decisions are of primary interest here (for activities and travel), trip and activity counts are not included in the model. This simplifies the model, since integer responses require a special latent structure, tying to a hidden continuous response variable, and many counts may show as zero [12] It also avoids distractions (and added parameters[3] that come with interpreting the highly simultaneous nature of activity participation choices and activity durations.

The final SEM structure selected is depicted in Figure 1. This structure effectively assumes that exogenous variables can impact total travel time, travel time for work activities, time in work activities (both in and out of home), and time with children (both in and out of home). These time expenditures then impact time expenditures in other travel and other activity types (as discussed in the Data section).

Figure 1 reflects the idea that time is first allocated to required activities, namely work and time with children, and remaining time is then allocated to other activities [2, 5 ,7]. The

[3] The model structure already contain seven travel categories and 17 activity categories. Including activity and trip counts would have created too many parameters to estimate the parameters with much accuracy or confidence.

structure also assumes that time spent with children is as important as work and will impact how non-work activity and travel time is allocated. Individuals are likely to approximately allocate durations of desired activities, then choose preferred locations for those activities, and adjust their travel plans to accommodate such schedules, as much as feasible. Ideally, the model could also include arrows from travel time back to activity purpose, but this adds complication for interpretation and parameter estimation.

Time spent with children was separated for in-home and out-of-home settings for two reasons: one is that the nature of children's activities can differ dramatically under such settings (e.g., eating at home versus chasing a soccer ball around at the park) and because the model performed best when out-of-home activities were separated. Children tend to participate in sports, music lessons, and other hobbies that require parents to transport them, and, depending on the activity, the parents may then remain at that location for the duration of the activity.

The SEM method was selected for data analysis thanks to its ability to handle a large number of exogenous and endogenous variables, allowing for multiple interactions, rather than equation by equation approaches (such as the tobit work described earlier) or allowance for error correlations only (as in the SUR model of Srinivasan and Bhat [2]). SEMs can estimate the impacts of exogenous variables on endogenous ones, but also relationships among endogenous variables. In addition, all variables are estimated with their own measurement errors, allowing modelers to easily find correlated errors and include them in the model. SEMs can also accommodate missing data [12] – such as zeros in certain activity categories, for this work's application – which makes it easier to run large models with many parameters. For this data and specifications, up to 500 parameters were used in roughly 20 different model specifications. The final model included 36 variables (12 exogenous and 24 endogenous), 56 regression coefficients and 22 covariances for variables with highly correlated normalized residuals. The model was extremely sensitive to additional parameters, but the inclusion of covariance equations improved the overall fit. Even with 78 parameters, however, there is sufficient data for maximum likelihood (ML) estimation[4] of the model [12].

THE DATA

The ATUS measures the amount of time people spend engaged in various activities, with or without children alongside, and the general location of each activity (e.g., workplace, home, someone else's home or shopping center The 12,448 individuals surveyed between November 2006 and October 2007 performed an average of 19.15 activities per day. They were asked about activities on one specific day. Table 2 provides summary statistics for key model variables across all surveyed individuals as well as those for women in households with children under 18.

The model presented here explores more activity types than those modeled in the related literature. The ATUS data set contains 18 different activity types (including travel), and these were aggregated into 8 key activity categories most important for individuals. The categories and example activities are listed in Table 1. For example, work, work related, and educational activities were grouped into "Work/Education". "Maintenance Shopping" is shopping for food, gas, and groceries. Use of "Services" is separate, as the need to outsource household and personal services may change as household characteristics change and other activities demand more time. These services include things like lawn care, health care and salon services.

[4] In all cases, the sample size is 15 times greater than the number of observed variables (36) and five times greater than the number of free parameters.

"Personal" activities include sleeping, personal grooming, and eating and drinking or waiting for food at a restaurant/at home. "Household" activities include cleaning, preparing meals, caring for dependent household adults (e.g. sick and elderly), and any activities related to the maintenance of the household (but not maintenance shopping) . "Leisure" combines hosting and attending social events, relaxing, and participating in sports, exercise, and recreation. Non-leisure "Other" activities include time spent volunteering, caring for non-household members, non-maintenance shopping, and telephone calls unrelated to the other activities (like answering a survey). "Time spent with Children" is reserved for those activities for which the primary purpose is the need or desire to spend time with one's household children. This does not include all activities where one's children were present. Activities include playing with, reading to, and caring for children, as well as attending children's school and sporting events. Finally, time spent "Transporting children" was protected as its own category, which is simply the time spent waiting for children at the destination (before or after an activity) and does not include all travel with children. Each respondent's activity frequencies and durations were calculated, as well as the frequency and duration of the activities with children under 18 present, and the frequency and duration of in-home and out-of-home activities.

The modeled times are for each person surveyed, separately, rather than total household time expenditures. Only one member of each household was surveyed, but age, gender, and relationship to the surveyed individual were collected for all other members of the household. Of course, travel time is another key activity, of great interest to travel demand modelers and transport policymakers. Trip purposes coded in the ATUS data include travel for work and education, personal needs, household needs, services, all shopping, leisure, and (non-leisure) discretionary activities. All of the activities listed above have a corresponding travel purpose except for maintenance shopping. One can assume the distance and time one travels to participate in maintenance shopping is relatively short since groceries and fuel are purchased on a regular basis.

Control variables were selected based on existing SEM research in the areas of activity participation and travel duration [8, 12, 13]. Household size and income, respondent gender and age, employment status, day of week and other variables were included, as shown in Table 2's summary statistics.

As one would expect, there are far fewer cases of single mothers in the ATUS data set (n=571 vs. 2348 non-single mothers). In general, the single mothers have older children, and fewer of them, than mothers in households with two or more heads, despite being 0.9 years younger, on average. Overall, 52% of survey respondents were married, and this held for single mothers and non-single mothers alike. In the case of single mothers, this is largely a result of women who are married to men in the military or for other reasons do not live at home. Unmarried but non-single mothers are more likely to have a parent, sibling, or roommate at home. Fifty-one percent of single mothers are employed, versus only 45% of non-single mothers. And single mothers drive 5.7 minutes longer and make 0.5 more trips per day, on average, than mothers in households with two or more adults. Single mothers are also slightly more likely to live in a metropolitan area than non-single mothers and the rest of the population.

Table 3 lists summary statistics for endogenous variables. Men are generally found to travel further for work and work longer hours, and ATUS activity durations for these activities suggest that single mothers are more like men than non-single mothers. Of course, the first set of data is a reflection of all cases, not only men, so one could look at men in particular to find if this

is true. Still, single mothers work as much as the national average both in home and out of home, for a total work duration of about one hour longer than non-single mothers. Non-single mothers spend slightly more time participating in out-of-home "other" activities (5 minutes per day). Two or more adults in a household result in a survey respondent spending, on average, 18 minutes longer in home with children than single mothers. As expected, single mothers utilize more services both in and out of home, at 2 minutes per day, than non-single mothers, suggesting they have to outsource some necessary activities in order to accomplish all they need in a day. Unexpectedly, however, single mothers have 10 minutes more personal and leisure time than non-single mothers (but still less than the overall average). This reflects the possibility that the presence of other household adults (spouses and parents, for example) also affect one's time use.

MODEL RESULTS

All model estimates are presented in Tables 4, 5 and 6. To obtain the final models, parameters with a p-value greater than 0.10 were removed from the base model. At the same time, covariances were added to the model for variables for which the absolute value of the normalized residuals was much greater than the mean normalized residual. This process was repeated until the best model was obtained.

For structural equations models, there are different ideas about what constitutes a good fit. In general, most research suggests the GFI be greater than 0.90, and in some cases greater than 0.95 [12, 14], but the GFI may be underestimated for small sample sizes (<200) and overestimated for large sample sizes [15]. Here, the first model, for all individuals surveyed, had an adjusted goodness-of-fit index (GFI) of 0.86 with a standardized root mean square residual (SRMR) equal to 0. 07, after controlling for 22 covariances. The subsequent model for mothers in single adult households had an adjusted GFI of 0.70 and an SRMR of 0.11. Since this model had only 571 records (as compared to the first model with 12,248 records), this was expected due to the large number of parameters estimated. Only seven covariances were estimated for the single-mother model. For the final model of mothers in households with two or more adults, the adjusted GFI was 0.82 with a SRMR of 0.08. Ten covariances were estimated to aid in the stability, and these values are satisfactory for a data set of 2348 records.

Table 4 presents the estimated impacts of exogenous variables on activity and travel duration. Income was not statistically significant in any of the models; however, it seemed to be practically significant, since its removal made the models unstable. Income squared was also tested, and also had no statistically significant effects. The number of children under age 18 was estimated to have a negative impact on both in-home and out-of-home work durations for individuals in the main model, as one might expect.

For individuals with a non-working partner, work travel tends to be longer than that for single workers and for individuals whose partner is employed. This suggests that home and work location may be more important for dual-income households than for single-income households, as Green [3] has suggested. Dual-income households may be trading off these locations to achieve optimum travel times for both earners. Further, the employment status of the partner had no statistically significant impact on the work travel of mothers in households with two-plus adults. Since the model controlled for employment status, the positive coefficient for "male's" impact on work travel and work durations suggest that men still do work slightly longer hours and travel further for work than women, overall.

The coefficients for single mothers who drove on the diary day are very interesting. Single mothers who drove still spent more time working than their non-driving counterparts, but the effect is smaller than for the average case and for non-single mothers. Similarly, single mothers who drove spent more time working in-home than individuals in the other two models. Taken together, these results suggest that the mobility provided by vehicle ownership give needed flexibility in activity scheduling for single mothers, a demographic that needs this flexibility perhaps more than any other. Also, since single mothers are the only source of income in their households, this scheduling flexibility could mean they are able to work longer hours and thus provide better for their children.

Finally, age and number of children had no impact on work duration of single mothers. In contrast, mothers in households with two or more adults work more as their children age. This could be another indicator of flexibility, suggesting that single mothers are already working as much as possible throughout their children's lives, while mothers with older children are able to adjust their schedules as their children age.

Table 5 lists the impacts of time spent with children and the exogenous variables on activity durations. In general, the results are intuitive: As one's children's ages increase, time spent with them decreases. Each added child increases overall time spent with children in a statistically significant way, but just about half a minute per day per child, on average. As the number of children increase, time spent working decreases for everyone except single mothers, again suggesting that single mothers are already spending the minimum time working each day. Single mothers tend to spend less time with children out-of-home as the number of children increases, while time with children out-of-home increases with number of children for the other cases. Duration with children, both in and out of home, is estimated to negatively affect work activity duration in all cases except the case of out-of-home-time-with-children on out-of-home-work-time for mothers in households with two or more adults, suggesting that this group's decision to work is independent of time spent with children. As children age, they may be spending less time at home, which could explain why out-of-home work duration is affected by children's age for only mothers in households with two or more adults. The high coefficient on in-home work duration on "weekend" for single mothers is likely because single mothers spend more time working in-home already. For single mothers, time spent in-home with children has less impact on personal and leisure time than it does on individuals in the other models. This suggests that mothers in households with two or more adults choose to sacrifice leisure time and personal time for the sake of other household members, while single mothers, already lacking in these activity durations, may be less willing to give up all their personal and leisure time (or they just had too little of it to begin with). It would be interesting to look into the effects that one's spouse or senior parents have on activity allocation in a future model, as done here with children.

For all individuals who drove on the diary day, time spent with children out-of-home increased. For single mothers this effect was greatest (.1) again suggesting that the mobility provided by a personal vehicle has benefits for household children. Overall, more time spent out-of-home with children resulted in less time spent transporting children. But for non-single mothers and single mothers, time spent transporting children decreased with out-of-home duration with children (.05 and .15 respectively). While these effects are not always so great, their significance relative to one another is useful in suggesting what a possible order of time allocation could be. They also indicate that SEMs are able to distinguish very minor effects that may go unnoticed in other models. These observed effects could mean fathers or other household

members are more likely to transport children to certain activities in the case of non-single mothers. For single mothers, it could suggest that the activities children are engaging in out of the home are just not the kind that require transportation, as their transport means and schedule are likely more limited. For example, single mothers may not spent as much time watching their children play sports or musical instruments, but instead their time out of home is in seeking medical care. It could also mean that these mothers are just not travelling far from home to spent time with their children. Controls for household income and income squared were statistically insignificant in all cases.

Table 6 lists all statistically significant effects among the presence of Children and activity durations. Work duration outside the home was neither a statistically significant (at the 5% level) nor practically significant influence on time spent with children both in or outside the home, and in-home work duration was also estimated to have no impact It would appear that individuals allocate travel time first for work-related travel, leaving less for time leisure, personal activities, and shopping (including maintenance shopping). This applied for mothers in households with two or more adults, but single mothers' travel is not affected by their work travel. Travel with children is not significant for single mothers, perhaps because their activity schedules are less flexible and thus their travel with children is required. For all individuals, time with children increases as travel with children increases, suggesting that these persons bring their children along for more activities throughout the day. Work travel did not impact time spent with children in- or out-of-home in any case.

Travel for "other" is unaffected by work travel. This suggests that these travel purposes are stable for individuals, and perhaps "other" travel, as defined here, is not as non-obligatory as analysts have presumed. Also, in some cases in-home activities engender travel. In the case of leisure activities, this could mean that relatively active or sociable individuals (who spend relatively more time both in- and out-of-home exercising and socializing) travel to do so. For service-related activity durations, it likely just means that there is some travel involved with securing services in the home.

CONCLUSIONS

Using the 2007 American Time Use Survey (ATUS), this paper examined multiple relationships between household attributes, parents' time spent with children, and parents' time expenditures on various other activities, including travel – with a special focus on single and non-single mothers, and how their patterns differ. The data suggest that the number and age of children have multiple impacts on activity allocation decisions, which impacts travel time allocation for different purposes. This work's use of multiple activity categories (beyond simple work and non-work purposes) yields interesting yet plausible insights into activity scheduling choices, and the ability of SEMs to distinguish small effects in these models suggests that such models are well-suited for predicting complicated behaviors. As expected, higher work travel time expenditures are associated with drops in time towards travel for leisure (which includes sports, exercise, recreation, and socializing). These activities have important implications for Americans' health and quality of life, for both parents and children.

Individuals who drove on the diary day were able to spend more time with their children, suggesting the scheduling flexibility provided by driving is an important benefit, especially for single mothers whose time is limited. Work and work travel did not affect time spent with children, suggesting that time spent with children is an important activity allocation of its own

that merits consideration. The impacts on time expenditures provided by presence of other adults in the households are also worth studying, as it seems that such adults are associated with reductions in a mother's personal and leisure time. These effects combined seem to suggest that more schedule flexibility could be good for everyone. Perhaps transit authorities could further reduce or even eliminate fares for children below a certain age to give mothers without vehicles more flexibility in their schedule and allow them to spend more time with their children, both in- and out-of-home. Vehicle manufacturers and transit providers may do well to cater specifically to single women with different needs than the average individual.

Various potential extensions to this work exist. For example, separate models for households with different structures (e.g., single or dual worker, married or single, employed or not, and presence of children) could be estimated to determine in greater detail the significance of different variables across more homogenous groups. However, for some groups there are rather few records (e.g., unmarried mothers who are the sole household adult), impacting statistical confidence in model results. Variables to indicate the presence of spouses or friends on trips would also be interesting, as well as time of day information by region, to ascertain whether (and how) congestion may impact activity time allocations. More variables could be created for children as well (such as time spent learning, playing, exercising, and attending music lessons/recitals). However, since children are generally not accompanying their parents to work, their involvement in household non-work activities could be sufficient indication of their primary impacts on time allocation. Finally, a trip chain variable could be added to the model system, to simultaneously examine how different persons chain trips and how these decisions impact activity durations. More attributes on household locations (e.g., neighborhood density, distance to workplace, etc.) would also be useful. Nevertheless, this work is an important demonstration of how meaningful the ATUS data are for understanding intra-household time dynamics and anticipating which persons are under the tightest time constraints, how what happens and what that implies for behavior.

REFERENCES

1. Freedman, O. and C. R. Kern. A model of workplace and residence choice in two-worker households, in *Regional Science and Urban Economics* **27**, 241-260, 1997.
2. Srinivasan, S. and C.R. Bhat, Modeling households interactions in daily in-home and out-of-home maintenance activity participation, in *Transportation* **32**, 523-544, 2005.
3. Green, A.E. A question of compromise? Case Study evidence on the location and mobility strategies of dual career households, in *Regional Studies* **31**, 641-657, 1996.
4. Kenworthy, Lane (2008) The Shrinking Gender Pay Gap. *Consider the Evidence* (January 2), at http://lanekenworthy.net/2008/01/02/the-shrinking-gender-pay-gap/.
5. Golob, T.F. A simultaneous model of household activity participation and trip chain generation, in *Transportation Research Part B* **34**, 355-376, 2000.
6. Jöreskog, K. G. and Sörbom, D. *LISREL 8 User's Reference Guide*. Scientific Software, Chicago, 1993.
7. Susilo, Y. and R. Kitamura, Structural changes in commuters' daily travel: The case of auto and transit commuters in the Osaka metropolitan area of Japan, 1980-2000, in *Transportation Research Part A* **42**, 95-115, 2008.

8. Lee, Y, M. Hickman, and S. Washington, Household type and structure, time-use pattern, and trip-chaining behavior, in *Transportation Research Part A* **41**, 1004-1020, 2007.
9. Lee, Y, S. Washington, and L.D. Frank, Examination of relationships between urban form, household activities, and time allocation in the Atlanta Metropolitan Region, in *Transportation Research Part A* **43**, 360-373, 2009.
10. R Development Core Team. *R: A language and environment for statistical computing*, reference index version 2.8.1. R Foundation for Statistical Computing, Vienna, Austria, 2009.
11. Fox, J. Structural Equation Modeling with the sem Package in R. *Structural Equation Modeling* **13**, 465-486, 2006.
12. Golob, T.F. Structural equation modeling for travel behavior research, *Transportation Research Part B* **37**, 1-25, 2003.
13. Roorda, M.J. and T. Ruiz, Long- and short-term dynamics in activity scheduling: A structural equations approach, *Transportation Research Part A* **42**, 545-562, 2008.
14. Schumacker, Randall E. and Richard G. Lomax. *A beginner's guide to structural equation modeling, Second edition*. Mahwah, NJ: Lawrence Erlbaum Associates, 2004.
15. Bollen, K.A. *Structural equations with latent variables*. NY: Wiley. 1989.

List of Figures and Tables

Table 1. Activity Definitions		
Activity Category	Customary Designation	Example Activities
Work/Education (In/Out)[1]	Work	Work, School
Maintenance Shopping (Out)	Maintenance	Shopping for food, gas and groceries
Services (In/Out)	Maintenance	Any household and personal services, such as lawn care, health care, and salons.
Household (In/Out)	Maintenance	Cleaning, preparing meals, caring for dependent adults (but not maintenance shopping)
Personal (In/Out)	Discretionary	**Sleeping**, personal grooming, eating and drinking or waiting for food at a restaurant.
Leisure (In/Out)	Discretionary	Socialization, relaxing, sports, exercise and recreation
Other (In/Out)	Discretionary	Volunteering, jury duty, non-maintenance shopping, telephone calls unrelated to other activities.
Travel[2]	Travel	Travel was divided into these same categories, including time when children were present
Transporting Children	Travel	Time spent waiting for or with children during pick-up or drop-off
Travel Time with Children Present	Travel	Any time when a child was present for the trip
[1] (In/Out) indicates each activity category was further subdivided into in-home and out-of-home.		
[2]Travel categories were designated for the same groups, except maintenance shopping, for which travel time was not differentiated.		

TABLE 2. Summary Statistics of Exogenous Model Variables.

	All Data					Mothers: 2+ Adults HH Head					Mothers: Single HH Head				
	Mean	Med.	Min	Max	SD	Mean	Med.	Min	Max	SD	Mean	Med.	Min	Max	SD
HH Income (1,000 US$/Year)	63.17	45.00	2.50	200.0	50.34	62.30	45.00	2.50	200	49.56	60.84	45.00	2.50	200.0	48.70
Age of Youngest Child in HH	7.92	7.00	0.00	17.00	5.69	6.45	5.00	0.00	17.00	5.37	7.68	8.00	0.00	17.00	5.13
#Children <18	0.79	0.00	0.00	9.00	1.14	1.92	2.00	1.00	9.00	1.05	1.79	2.00	1.00	8.00	0.94
Trips per Day	4.04	4.00	0.00	22.00	2.89	4.61	4.00	0.00	21.00	3.24	5.01	4.00	0.00	21.00	3.42
Travel Duration (min/day)	73.64	60.00	0.00	1440	78.69	73.73	60.00	0.00	870.0	71.25	78.15	65.00	0.00	539.0	67.84
Age of Respondent	44.11	43.00	15.00	85.00	18.26	38.09	37.00	17.00	85.00	10.03	35.52	35.00	15.00	78.00	9.47
Male	0.47	0.00	0.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Married	0.53	1.00	0.00	1.00	0.50	0.52	1.00	0.00	1.00	0.50	0.53	1.00	0.00	1.00	0.50
Employed	0.46	0.00	0.00	1.00	0.50	0.44	0.00	0.00	1.00	0.50	0.49	0.00	0.00	1.00	0.50
Metropolitan Home Location[1]	0.82	1.00	0.00	1.00	0.38	0.83	1.00	0.00	1.00	0.38	0.87	1.00	0.00	1.00	0.34
Drove on Diary Day	0.70	1.00	0.00	1.00	0.46	0.71	1.00	0.00	1.00	0.45	0.76	1.00	0.00	1.00	0.43
N_{obs}	12,248					2,348					571				

Metropolitan: minimum population of 50,000 or a U.S. Census Bureau-defined urbanized area and a total MA population of at least 100,000 (75,000 in New England), 82% of population lives in Metropolitan area

TABLE 3. Summary Statistics of Endogenous Variables (minutes).

	All Data					Mothers: 2+ Adults HH Head					Mothers: Single HH Head				
	Mean	Med.	Min	Max	SD	Mean	Med.	Min	Max	SD	Mean	Med.	Min	Max	SD
Total Travel Dur. with Children	6.81	0.00	0.00	760.0	29.72	22.47	0.00	0.00	760.0	49.75	17.56	0.00	0.00	385.0	32.40
Travel for Work/Edu. Duration	18.50	0.00	0.00	1230	34.33	14.09	0.00	0.00	355.0	25.60	16.08	0.00	0.00	175.0	27.91
Travel for Household Duration	7.47	0.00	0.00	360.0	22.80	14.01	0.00	0.00	315.0	27.53	19.05	0.00	0.00	309.0	34.62
Out-of-home Dur. with Children	3.47	0.00	0.00	559.0	21.97	13.92	0.00	0.00	403.0	40.14	13.19	0.00	0.00	507.0	51.40
Out-of-home Work/Edu. Activities	211.3	0.00	0.00	1380	253.7	181.0	0.00	0.00	1380	232.2	211.9	0.00	0.00	835.0	238.3
Out-of-home Other Activities	36.53	0.00	0.00	1100	77.61	40.08	0.00	0.00	620.0	76.56	36.34	0.00	0.00	555.0	73.01
Out-of-home HH Activities	7.89	0.00	0.00	930.0	34.39	5.81	0.00	0.00	765.0	25.93	8.07	0.00	0.00	360.0	31.05
Out-of-home Leisure Activities	67.58	0.00	0.00	1073	121.6	65.27	0.00	0.00	798.0	115.4	70.82	10.00	0.00	695.0	126.3
Out-of-home Personal Activities	27.40	0.00	0.00	710.0	41.18	23.04	0.00	0.00	353.0	35.71	22.08	0.00	0.00	350.0	35.01
Out-of-home Maint.Shop. Activities	7.14	0.00	0.00	430.0	19.53	8.49	0.00	0.00	182.0	21.41	7.50	0.00	0.00	145.0	19.67
Out-of-home Services Activities	5.49	0.00	0.00	600.0	27.49	5.83	0.00	0.00	480.0	28.71	7.10	0.00	0.00	299.0	32.07
In-home Duration with Children	23.97	0.00	0.00	990.0	70.15	98.50	60.00	0.00	990.0	122.3	74.25	30.00	0.00	572.0	101.2
In-home Work/Education Activities	235.7	60.00	0.00	1380	261.6	205.2	5.00	0.00	1380	241.5	235.7	120.0	0.00	930.0	248.6
In-home Other Activities	49.69	0.00	0.00	1100	90.94	52.54	6.00	0.00	990.0	86.62	57.62	5.00	0.00	818.0	104.8
In-home Leisure Activities	292.2	255.0	0.00	1378	206.2	233.0	205.0	0.00	960.0	167.9	236.0	190.0	0.00	975.0	193.8
In-home Services Activities	6.11	0.00	0.00	600.0	29.19	6.30	0.00	0.00	480.0	29.29	7.34	0.00	0.00	299.0	32.24
N_{obs}	12,248					2,348					571				

Table 4. Estimated Total Effects of Exogenous Variables on Activity and Travel Duration (*z*-values, showing only effects significant at the *p* =0.05 level).

	To								
	Travel for Work/Education Duration			Out-of-home Work/Education Duration			In-home Work/Education Duration		
From	1[1]	2[2]	3[3]	1	2	3	1	2	3
Number of HH Children <18				-0.04 (-4.78)	-0.07 (-4.14)		-0.03 (-4.91)	-0.06 (-3.59)	
Age of Youngest HH Child		0.03 (2.11)			0.07 (3.90)			0.07 (4.42)	
Age				-0.08 (-10.9)	-0.09 (-5.83)		-0.08 (-11.8)	-0.10 (-6.25)	-0.09 (-2.43)
Male	0.05 (5.94)	-	-	0.10 (14.5)	-	-	0.09 (16.5)	-	-
Weekend	-0.05 (-5.96)	-0.04 (-2.28)	-0.08 (-2.39)	-0.27 (-39.9)	-0.30 (-18.5)	-0.34 (-10.8)	-0.22 (-37.6)	-0.29 (-18.8)	-0.44 (-13.2)
Holiday				-0.03 (-4.99)			-0.02 (-3.22)		
Drove on Diary Day				0.21 (26.9)	0.15 (9.23)	0.11 (3.24)	0.16 (21.0)	0.12 (7.49)	0.21 (6.17)
Partner is Unemployed	0.03 (3.88)		-			-			-
Metropolitan	0.05 (6.30)	0.04 (2.75)	0.07 (2.20)						

[1]All Data
N = 12,226
Adj. goodness-of-fit index = 0.86
SRMR = 0.07

[2]Mothers: 2+ Adults HH Head
N = 2,348
Adj. goodness-of-fit index = 0.82
SRMR = 0.08

[3]Mothers: Single HH Head
N = 571
Adj. goodness-of-fit index = 0.70
SRMR = 0.11

Table 5. Impact of Children on Activity and Travel Durations (*z*-values, showing only effects significant at the *p* =0.05 level).

	To																				
	In-home												Out-of-home								
	Duration with Children			Personal Activity Duration			Leisure Activity Duration			Work/Education Activity Duration			Duration with Children			Child Pick-up Activity Duration			Work/Education Activity Duration		
From	1[1]	2[2]	3[3]	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Number of HH Adults		-0.09 (-																			
Number of HH Children <18	0.42 (43.1)									-0.03 (-4.91)	-0.06 (-3.59)		0.16 (17.5)	0.08 (3.94)	-0.10 (-2.30)				-0.04 (-4.78)	-0.07 (-4.14)	
Age of Youngest HH Child	-0.21 (-25.4)	-0.50 (-28.7)	-0.44 (-10.7)								0.07 (4.42)			-0.07 (-3.52)						0.07 (3.90)	
Age	-0.11 (-12.7)		0.09 (2.41)							-0.08 (-11.8)	-0.10 (-6.25)	-0.09 (-2.43)							-0.08 (-10.9)	-0.09 (-5.83)	
Gender: Male (dummy)	-0.13 (-15.7)									0.09 (16.5)			-0.04 (-4.70)						0.1 (14.5)		
Weekend (dummy)	-0.04 (-5.36)	-0.10 (-5.79)								-0.22 (-37.6)	-0.29 (-18.3)	-0.44 (-13.7)							-0.27 (-39.9)	-0.30 (-18.5)	-0.34 (-10.8)
Holiday (dummy)		-0.04 (-2.16)								-0.02 (-3.22)									-0.03 (-4.99)		
Drove on Diary Day (dummy)		-0.04 (-2.13)								0.16 (21.0)	0.12 (7.49)	0.21 (6.17)	0.03 (3.63)	0.07 (3.50)	0.10 (2.47)				0.21 (26.9)	0.15 (9.23)	0.11 (3.24)
Unemployed (dummy)	0.02 (2.12)																				
Partner is Unemployed (dummy)														-0.04 (-2.04)							
Metropolitan (dummy)	0.02 (2.23)	0.04 (2.21)																			
Total Travel Duration	0.06 (7.77)	-0.05 (-2.75)											0.05 (5.21)								
IN Duration with Children				-0.09 (-10.5)	-0.19 (-10.1)	-0.12 (-3.15)	-0.23 (-31.7)	-0.23 (-14.7)	-0.20 (-6.06)	-0.01 (-3.53)	-0.03 (-4.01)	-0.18 (-4.95)									
OUT Duration with Children																0.07 (8.04)	-0.05 (-3.15)	-0.15 (-4.29)	-0.01 (-2.30)		-0.08 (-2.55)

[1]All Data
N = 12,226
Adj. goodness-of-fit index = 0.86
SRMR = 0.07

[2]Mothers: 2+ Adults HH Head
N = 2,348
Adj. goodness-of-fit index = 0.82
SRMR = 0.08

[3]Mothers: Single HH Head
N = 571
Adj. goodness-of-fit index = 0.70
SRMR = 0.11

Table 6. Estimated Effects of Activity and Travel Durations on Travel and Children Variables (*z*-values, showing only effects significant at the *p* =0.05 level).

	To																										
	IN with Children			OUT with Children			Travel for Work/Edu.			Travel for Other			Travel for Household			Travel for Leisure			Travel for Personal			Travel for Shopping			Travel for Services		
From	1[1]	2[2]	3[3]	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Total Travel Duration with Children Present	0.06 (7.77)	-0.05 (-2.75)		0.05 (5.21)																							
Travel for Work/Education Duration													-0.02 (-2.83)	-0.04 (-2.11)		-0.05 (-5.66)			-0.06 (-6.95)	-0.07 (-3.95)	-0.09 (-2.46)	-0.05 (-5.52)	-0.06 (-3.51)				
Out-of-home Work/Education Activities							0.44 (20.1)	0.52 (12.0)	0.51 (5.09)																		
Out-of-home Other Activities										0.35 (20.4)	0.37 (10.3)	0.17 (2.76)															
Out-of-home Household Activities													0.22 (27.8)	0.16 (9.83)	0.14 (4.50)												
Out-of-home Leisure Activities																0.41 (46.1)	0.46 (23.2)	0.30 (7.20)									
Out-of-home Personal Activities																			0.35 (43.0)	0.34 (18.8)	0.41 (11.6)						
In-home Work/Education Activities							0.07 (3.27)																		0.49 (22.7)		
In-home Other Activities										0.06 (3.69)		0.14 -2.28															
In-home Household Activities															-0.06 (-1.96)												
In-home Leisure Activities																-0.07 (-7.16)	-0.05 (-2.34)	-0.09 (-2.19)									
In-home Maintenance Shopping Activities																						0.27 (31.4)					
In-home Services Activities																									0.08 (3.52)		

[1]All Data
N = 12,226
Adj. goodness-of-fit index = 0.86
SRMR = 0.07

[2]Mothers: 2+ Adults HH Head
N = 2,348
Adj. goodness-of-fit index = 0.82
SRMR = 0.08

[3]Mothers: Single HH Head
N = 571
Adj. goodness-of-fit index = 0.70
SRMR = 0.11

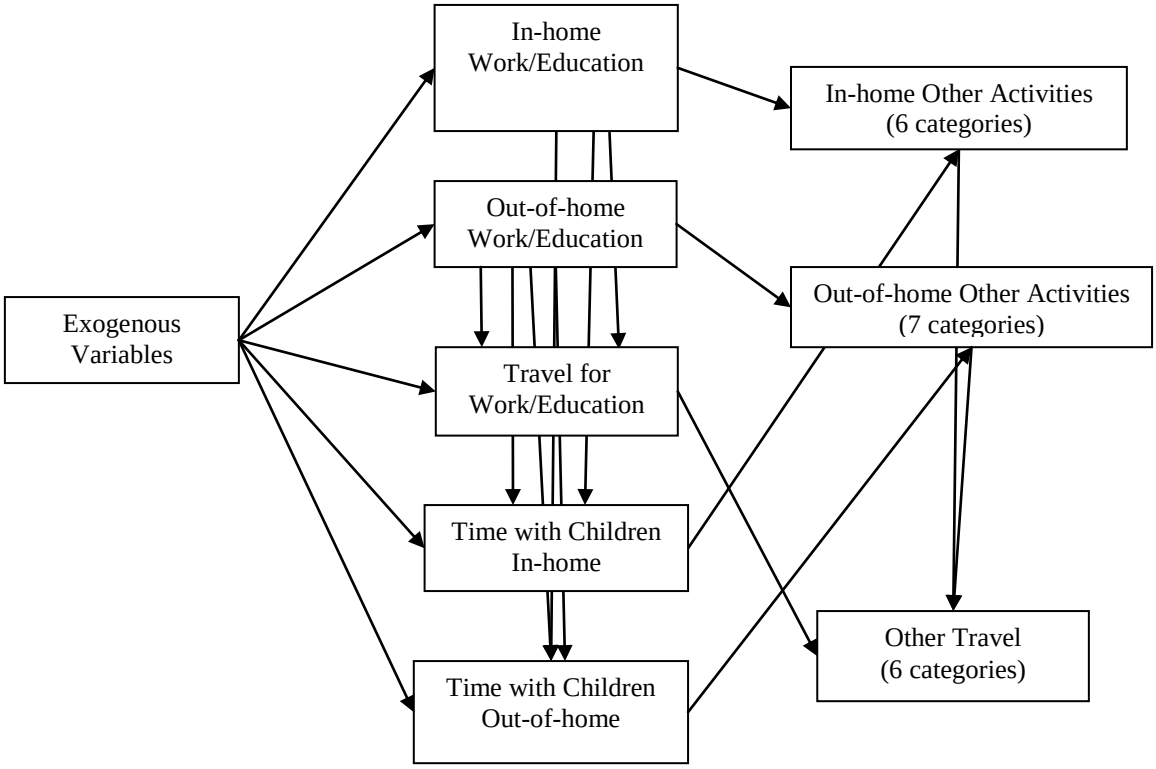

FIGURE 1. Structural Equations Model Specification for ATUS Data