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Author

Goulias, Konstadinos G

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COMPANIONSHIP AND ALTRUISM IN DAILY ACTIVITY TIME ALLOCATION AND TRAVEL BY MEN AND WOMEN IN THE SAME HOUSEHOLDS

Konstadinos G. Goulias

Department of Geography
University of California - Santa Barbara
Santa Barbara CA 93106
Tel: 805-893-4190
Email: goulias@geog.ucsb.edu

Abstract

In this paper, using data from 366 households we study human interaction within and outside the household. In the analysis altruism and companionship between men and women are explored using path analysis to identify gender-roles and mutual influences. Men and women have very different templates of time allocation characterized by lack of symmetry in relationships between men and women. Although women's time allocation has some influence on men's time allocation, it may function as a constraint only when women engage in activities for a considerable amount of time in a day. In contrast, men's influence is significant and substantial at any level of time allocation. Regarding the relationship between altruism and companionship, men appear to be "rationing" their time and allocate time either to relatives or to others. Women appear to be more fully engaged with relatives and with others (presumably functioning as the social network hubs of the household). Finally, travel is not emerging as a cause but as an outcome supporting once again the practice in activity-based models of considering travel demand as derived from the need to participate in activities. It should also be noted that travel is a very small fraction of the total daily time allocation and does not function as a constraint in budgeting time for activities with and for relatives and other persons. A clear hierarchy also emerges from the path model developed here with blocks of variables determining other blocks of variables in a sequence.

Keywords: altruism, companionship, activity models, travel behavior, gender-roles

INTRODUCTION

Activity-based models for travel demand forecasting are increasingly used by academia and practicing consultants for many reasons including their increased realism in capturing human behavior and their ability in addressing relatively new policy issues (for a recent review of fifty activity models see Henson and Goulias, 2006, for a review of operational models in US regions see Bradley and Vovsha, 2006, and for a more in depth treatment of intra-household interactions see Bhat and Pendyala, 2005, and the papers in the special issue of Transportation they edited). At the heart of these travel demand forecasting systems are regression models linking trip maker characteristics to activity participation and travel behavior. Human interaction in the form of travel with other persons is becoming an element of paramount importance in many of these models. Understanding the need for human interaction and its implications for activity and travel participation by individuals and their groups may lead to models that are by far more informative and of superior predictive ability than current practice. In addition, understanding relationships among different persons and their underlying motivations for activity participation can also help us understand the potential impacts of policy triggers to change travel behavior. All this explains a recent surge in research papers and forecasting models that attempt to explicitly account for within-household interactions in activity participation and travel.

The intellectual foundation for many travel behavior models incorporating explicitly human interaction can be traced back to Townsend's dissertation (Townsend, 1987) in which time allocation is viewed as a task allocation exercise within a household and the STARCHILD model (Recker et al. 1986), which again treats time allocation as a task allocation process and the dyadic relationships by van Wissen (1989). Although these foundations provided guidance to travel behavior intra-household interaction models, their emphasis on relationships within households is inadvertently misdirecting research to deal exclusively with this aspect of human interaction forgetting that human sociality extends beyond the household. Models of this type include Simma and Axhausen, 2001, Gliebe and Koppelman, 2002, Meka et al, 2002, Scott and Kanaroglou, 2002, Borgers et al., 2002, Bhat et al., 2003, Salvini and Miller, 2003, Vovsha et al. 2003, Zhang et al., 2005, and Pribyl and Goulias, 2005, Vovsha and Petersen, 2005, Zhang and Fujiwara, 2006, Cao and Chai, 2007, Kato and Matsumoto, 2007. These same models also do not explicitly account for the effects of values in directing human interaction within and outside the household (Etzioni, 1986) and the direct impact of values on scheduling of activities and travel. In addition, these models are still based (in explicit and implicit ways) on the single ego-motivated decision maker assumption of the Bentham-Becker framework (e.g., Polak, 1999, and Jara-Diaz, 2003).

These limitations may not be a major handicap for applications that simply aim at reproducing observed interaction patterns because the majority of time and number of episodes in a day are dedicated to household members (Goulias and Kim, 2005). Some authors (Timmermans, 2006) call for modeling human interactions by identifying roles and task allocation as well as engagement in joint activities. Our analyses risk to be severely biased when we attempt to explicitly model behavioral processes and understand relationships within households in their entirety of time allocation processes and neglect task allocation and roles and/or expressions of companionship. As our aims for complete

activity-based models increase and as increasingly more sophisticated analytical techniques to identify the mechanisms underlying task allocation is expanded we need this more in-depth understanding. Lack of past fundamental research with focus on travel behavior, however, forces the creation of ad-hoc and very sketchy models of this important aspect in human life.

Human interaction in this paper is examined from two distinct and closely related viewpoints: altruism and companionship. Altruism here is defined as *the unselfish action for the welfare of others without regard for one's self*. This human "value" was studied in the classic times (Gill et al. 1998) and re-examined by E. O. Wilson (1975) and H. Simon (1990). It is claimed today as the key ingredient when studying concerns, attitudes, intentions, and behavior that are either partially or totally in the domain of moral action (Etzioni, 1988). In fact, altruism is a key component in understanding pro-environmental behavior and it is used in studying human behavior as motivation for action. Moreover, a variety of studies also consider as important element the identification of targets for altruistic considerations such as humanity as a whole, future generations, community, and of course own children (Snelgar, 2006).

Companionship can be considered composed of two main aspects: co-participation and intimacy. The concept has been extensively analyzed in child development studies and in the literature about marriage and family (Hicks and Platt, 1970). In this paper is defined as "being together" and sharing time and events by being with relatives or other persons. It is measured by the amount of time alone or with other persons and the number of episodes. This is an extension of sharing rides with other persons and escorting children to school and leaves out the affective component of companionship.

In a continuation of two past studies using the same dataset (Goulias and Kim, 2005, Goulias and Henson, 2006), altruism in this paper takes a pragmatic observational form and it is measured by the amount of time allocated in a day to activities for other persons (relatives, friends, and so forth) and the amount of episodes (activities or trips). The cross correlations among variables measuring altruism and variables measuring companionship gives us a measurement of the relationship between these two concepts. Analysis of the same variable correlations within the same household allow us to study the interaction between two persons that we know are closely related and they are in constant daily interaction. In this paper we attempt to answer the following more fundamental questions:

- What is the relationship between altruism and companionship?
- Is this relationship different between activity participation and travel?
- Is this relationship different between men and women in the same households?
- What is the relationship of women's altruism with men's altruism?
- What is the relationship of women's companionship with men's companionship?

The next section describes the dataset used here. Then, altruism and companionship are analyzed using descriptive statistics and path analysis of a sample that allows studying interactions. The paper concludes with a summary and discussion.

DATA USED IN THIS ANALYSIS

The CentreSIM dataset is from a household and activity diary survey administered between November 23, 2002 and May 30, 2003. The sample frame covers all of Centre County, Pennsylvania, which housed 135,940 residents in 2001. It also includes residents that work in Centre County and reside elsewhere. Each participating household provided voluntarily information about household composition (e.g., number of children by age) and facilities available to the household members (e.g., housing and housing characteristics, vehicles and motorcycles, as well as telecommunication and related equipment). In addition, each household member also reported personal information such as employment, driving ability, marital status, education and so forth. The survey was administered in two stages with the first stage including household and household member questionnaires and included a few questions about opinions and perceptions regarding the Centre County transportation system. The second stage included a smaller sample in which each person in the household provided a two-day complete record of the person's activities and included detailed records of the different transportation options selected. Activity types were reported using an open-ended format that required semantic analysis of respondent entries. Details about activity classification and taxonomy can be found in Goulias & Kim (2005).

The sampling frame is a combination of several pools. These include a database of 46,448 household addresses in Centre County purchased from a commercial mailing list vendor in early October 2002, student address lists available through the Pennsylvania State University (PSU), and a list of University Park Campus employees of PSU who reside outside of Centre County. From this pool, 8,925 households were randomly selected for recruitment in a mail out/mail back household questionnaire. Of the responding households, 2,537 agreed to participate in the second stage activity diary component. Of these observations a sample with complete data was used to derive a few representative patterns of altruistic behavior and perform an initial exploration of interactions within households (Goulias and Henson, 2006). That analysis showed a wide variation in altruistic patterns and was heavily influenced by non-family households (e.g., university-age roommates, cohabiting unrelated adults).

In this paper attention is focused on households with two or more adults (older than 18) persons of different gender and for whom at least two diaries per person were completed and the majority of data is available. This produces 366 households with complete data. Of these 366 households, 212 (57.9%) contain two persons, 73 (19.9%) have three persons, 59 (16.1%) have four persons, and the remaining 22 (6.0%) have five persons. Table 1 provides a summary of the household characteristics showing the sample to be composed of couples and nuclear family households living in single family housing of middle to high income range. The majority of these households are married persons (98.6%) and a few of these households are adults of opposite gender living together in a single family home that they own. A substantial proportion (16%) of these households reported annual household combined income exceeding \$100,000 at the time of the survey. This wealth is also reflected by the car ownership levels and the home characteristics.

Table 2 gives us a more detailed description of the sample with focus on the woman-man dyads we will analyze in more depth. The average age of women is 49.3

years and that of men is 51.1 years. Both men and women show substantial levels of labor force participation with unequal proportions between them (more men work full time than women and more women work part time than men). In retirement, however, we have close to equal proportion between men and women in the sample with 64 households having both the man and the woman in retirement. Home duty is almost exclusively in the domain of women. This sample was selected from a region that is dominated by university-related jobs (the major employer is PSU that also attracts a variety of technology and service companies). As a result the sample is also dominated by university graduates.

Table 1 Social and demographic characteristics of the households

Variable	Average	Stand. Dev.
Number of persons age 4 or younger	0.15	0.41
Number of persons 5 to 12 years old	0.25	0.59
Number of persons 13 to 15 years old	0.09	0.29
Number of persons 16 to 18 years old	0.09	0.30
Number of persons 19 and older	2.12	0.42
Household size	2.70	0.95
Number of vehicles owned	2.32	0.98
Number of bicycles	1.67	1.70
Number of bedrooms of the home	3.12	0.82
Number of cars garage/carport can hold	1.55	1.15
	Percent	
Single family home residents	0.85	
Households that own their home	0.87	
Household annual combined income < \$50k	31.4	
Household annual combined income > \$100k	16.1	

Table 2 Dyad Characteristics

	Women Percent	Men Percent		
<i>Employment Status</i>				
Full time (≥ 40 hours/week)	41.8	65.0		
Part time (< 40 hours/week)	18.0	5.0		
Home duties	13.3	1.1		
Retired	19.9	21.8		
<i>Education Level</i>				
Four-year college degree	27.5	23.9		
More than four-year degree (MS, Ph.D.)	19.4	33.2		
	Average	Std. Dev.	Average	Std. Dev.
Age	49.3	14.6	51.1	14.6
Daily activities excluding trips	13.0	4.7	11.4	3.9
Daily trips	4.4	2.4	4.6	2.4

Table 3 reports time allocation and episode allocation to activities and travel. These are the base indicators used to describe companionship and altruism and these same indicators are used to estimate relationships between companionship and altruism in this paper. Similar to the findings in Goulias and Kim (2005) that used the entire sample, total activity time alone in a day is of comparable but much lower magnitude to the activity time with relatives. The dyads in this paper dedicate more time with relatives than the entire 1471 persons of the CentreSIM survey data, which in addition to couple and families also contained single person households. In addition, women spent on average 54 more minutes than men with their relatives (46.1% of their 24 hours). Men, however, dedicate more time with other persons than their spouses/partners (approximately more than 21 minutes per day). Time allocated with unknown persons is at similar levels as the entire sample (Goulias and Kim, 2005). In the second portion of Table 4 we find the indicators of altruism for women and men. Women dedicate 230 minutes per day for relatives while men allocate approximately 90 minutes less per day. This difference is not allocated to others. However, this remarkable difference between men and women is not observed in the travel indicators. Similar patterns about caring for household members and others are found in the American Time Use survey (<http://www.bls.gov/news.release/atus.t10.htm>). No direct comparisons are appropriate between the national survey and the small sample used here.

Table 4 Dyadic daily time allocation in companionship and altruism

	Women			Men		
	Avg*	Std*	%	Avg*	Std*	%
Companionship						
Activity Alone	381	291	0.265	366	284	0.254
With Relatives	664	293	0.461	610	290	0.424
With Others	224	211	0.155	245	235	0.170
With Unknown	91	233	0.063	113	278	0.078
Travel Alone	29	34	0.020	46	68	0.032
Travel with						
Relatives	35	48	0.024	32	49	0.022
Travel with Others	12	29	0.008	21	63	0.014
Travel with						
Unknown	3	11	0.002	7	24	0.005
Altruism						
Activity for Self	880	311	0.611	914	338	0.635
For Relatives	230	213	0.160	139	176	0.097
For Others	156	197	0.108	172	211	0.119
For Unknown	96	264	0.067	110	291	0.076
Travel for Self	42	40	0.029	57	62	0.040
Travel for						
Relatives	25	36	0.017	23	51	0.016
Travel for Others	9	34	0.006	19	62	0.013
Travel for						
Unknown	3	13	0.002	5	23	0.004

* time in minutes per day

Travel shows an interesting difference between men and women. First, men tend to spent on average 26 minutes on the road more than women. This difference between the two partners is mostly due to men traveling for longer time alone and with other persons. Second, travel with relatives does not follow the same relative proportions of the time allocated to activities. Both men and women allocated substantially more time with relatives than activities alone. In travel, women spend 29 minutes alone and 35 minutes with relatives and men spend 46 minutes alone and 32 minutes with relatives. This shows a clearly different pattern in time allocation between activity participation and travel.

Table 5 shows the episodes allocation by these dyads per day. Women participate in more activities per day than men. These added activities are either alone or with relatives. When we turn to the altruistic measures these added activities are for relatives. The story emerging from the time allocation and episode allocation between men and women in the same households appears to be that women take on more tasks in the household that are directed towards their relatives and to perform these tasks they also need more time and activities than men. We will come back to this after the correlation analysis.

Table 5 Dyadic daily episode allocation in companionship and altruism

	Women			Men		
	Avg	Std	%	Avg	Std	%
Companionship						
Activity Alone	5.4	3.7	0.312	4.5	3.1	0.279
With Relatives	5.5	3.1	0.316	4.7	2.4	0.293
With Others	1.4	1.3	0.082	1.4	1.4	0.088
With Unknown	0.7	1.8	0.040	0.8	2.2	0.051
Travel Alone	1.9	1.8	0.109	2.3	1.9	0.142
Travel with						
Relatives	1.8	1.8	0.103	1.5	1.7	0.095
Travel with Others	0.5	0.9	0.028	0.5	0.9	0.032
Travel with						
Unknown	0.2	0.6	0.011	0.3	0.9	0.019
Altruism						
Activity for Self	7.9	3.9	0.459	7.9	3.7	0.489
For Relatives	3.3	3.1	0.192	1.8	2.2	0.113
For Others	1.0	1.3	0.057	1.0	1.3	0.064
For Unknown	0.7	1.9	0.040	0.7	2.1	0.045
Travel for Self	2.4	1.8	0.138	2.8	2.0	0.172
Travel for						
Relatives	1.4	1.7	0.081	1.1	1.6	0.071
Travel for Others	0.4	0.8	0.022	0.5	1.0	0.031
Travel for						
Unknown	0.2	0.7	0.011	0.2	0.8	0.015

PATH ANALYSIS

Using the time allocation variables from Table 5 we estimate a path model. Path models are a sub-category of the Structural Equations Models (SEM). SEMs are models of multiple regression equations that contain latent variables as indicators of the observed variables and a set of exogenous variables that are regressed against the latent variables. Path models are SEMs that do not include latent variables and thus similar to simultaneous equations in econometrics. SEMs are increasingly used in travel behavior to unravel causes and effects or to simply study complex correlation patterns. The review by Golob (2003) provides the reasoning, formulation, and many examples using these models. The data analysis here is similar to the man-woman interactions studied by Golob (1998) and Golob and McNally (1997) with some important differences. The key differences are: a) we start model estimation assuming there are no exogenous variables in the model; b) the variables used in the model system are time allocations by men and women; and c) no other exogenous variables are used.

Structural equations models with observed variables have the following form:

$$y = By + \Gamma x + \zeta$$

where $y = p \times 1$ vector of observed endogenous variables.

$x = q \times 1$ vector of observed exogenous variables.

$B = p \times p$ matrix of coefficients of the y-variables.

$\Gamma = p \times q$ matrix of coefficients of the x-variables.

$\zeta = p \times 1$ vector of equation errors.

As mentioned earlier we depart from a model that includes all variables as ys and as the correlation structure is pruned from any insignificant coefficients in matrix B we end up having a few xs.

Estimation of model parameters is accomplished by minimizing the difference between sample covariances and the covariances produced by a model. The analyst develops a series of model formulations, compares them, and the best fitting model can be selected for further analysis. The population covariance matrix of the observed variables (Σ) is a function of a set of parameters:

$$\Sigma = \Sigma(\theta) = \begin{bmatrix} \text{covariance matrix of } y & \text{covariance matrix of } y \text{ and } x \\ \text{covariance matrix of } x \text{ and } y & \text{covariance matrix of } x \end{bmatrix}$$

$$= \begin{bmatrix} (I - B)^{-1}(\Gamma\Phi\Gamma' + \Psi)[(I - B)^{-1}]' & (I - B)^{-1}\Gamma\Phi \\ \Phi\Gamma'[(I - B)^{-1}]' & \Phi \end{bmatrix}$$

where $\Phi =$ covariance matrix of x .

$\Psi =$ covariance matrix of ζ .

The unknown parameters $B, \Gamma, \Phi,$ and Ψ are simultaneously estimated by finding a set of parameters such that the covariance matrix ($\hat{\Sigma}$) produced by the model is as close as possible to the sample covariance matrix (S). To verify that a fitting function is defined and minimized. Maximum Likelihood estimation method assuming a multivariate normal distribution was employed here. ML estimation was found fairly robust to deviation of multivariate normality and sample size commonly used in transportation research (Golob, 2003).

In path models, there are three type of effects of one variable on another: direct, indirect, and total effects. The direct effects, which are estimated as B and Γ , are the influences of one variable on another that is not mediated by any other variable, while the indirect effects are ones mediated by at least one intervening variable. The total effects are the sum of the direct and indirect effects. It should be noted that interpreting a model with the direct effects only provides misleading conclusions when the direct and the total effects are very different. It is the total effects that should be used in interpretation and these are the only effects we examine in this paper. Figure 1 provides an overall description of the model reported here. Each quadrant contains six variables (3 for activity and 3 fo travel) for a total of 24 variables. We analyze correlations within the quadrants and across the quadrants. In this way we can answer questions of the type: If a woman spends more time in a day caring for relatives will she allocate less time to other persons and less time with other persons? How different is this time allocation between travel and activities? Or of the type if a woman spends more time with relatives will the man in the house also spend more time with relatives?

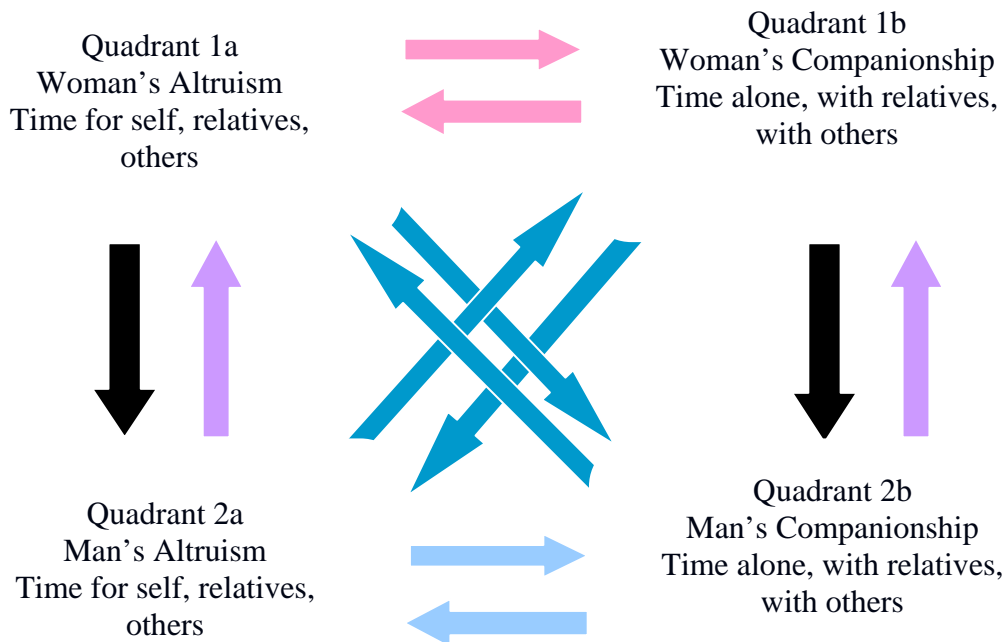


Figure 1 A pictorial representation of the different relationships we test and assess

The final model reported here is the result of a series of nested specifications in which a model with most of the arrows (the arrows are groups of regression coefficients) of Figure 1 leads the sequence. Then, coefficients are eliminated whenever they are not significantly different than zero. A well fitting model is selected as the final model capturing correlations among variables. The final model contains 22 dependent variables and 2 independent variables. These emerged as independent (exogenous) based on the sequence of specifications. The two variables that emerged as exogenous are the amount of time for relatives by women and the amount of time for one's self by women indicating that other factors, not included here, predetermine these variables and they are the pegs around which schedules are defined.

Goodness of fit measures for these models are reviewed by Golob (2003). The chi-square value of model fit is 93.02 with 117 degrees of freedom and a p-value of 0.95, which implies there is very small difference between the observed covariance matrix and the one reproduced by the path model ($\text{chi-square}=93.02 < 2 \cdot 117=2 \cdot \text{degrees of freedom}$ is the rule of thumb mentioned in Golob, 2003). The CFI and TLI are both equal to 1.0 and the Root Mean Square Error of Approximation is lower than 0.000 while the Standardized Root Mean Square Residual is 0.028. All these indicators show a well fitting model.

Table 6 contains the total effects among these six variables in the path model (time for unknown persons is excluded because it was found irrelevant for all variables). Table 6 and subsequent tables contain directional effects. The rows are the cause (origin of an arrow of influence) and the columns represent the impacted variables (destination of an arrow of influence). The values reported by the cells of the tables are the impacts (called total effects). The diagonal cell values show of Table 6 show N/A telling us that a variable cannot cause itself. The rest of the cells are interpreted as follows. Looking at the first row of Table 6 we find the influence of variable "time allocated to activities for a woman's self" in a day on "activity time for relatives", "activity time for others", "travel time for self", "travel time for relatives", and "travel time for others." A minute increase in time allocated to activities for a woman's self" corresponds to a decrease of 0.216 minutes travel time with relatives but no decrease or increase to activity time with relatives. Table 6 and all subsequent tables show the total effects that are significantly different than zero at the 95% confidence level and higher (a * is added when the level is between 90% and 95%). A positive total effect means the cause is creating an increase for the impacted variable and a negative sign the opposite. The size of the total effect is also important because all variables here are measured as minutes per day. An empty cell implies a corresponding total effect that is zero. In contrast, a 0.000 shows an effect smaller than 0.000 but still significantly different than zero.

We first examine altruism and time allocation for women. Allocating time to activities for one's self influences in a significantly different than zero way only time allocation to travel by lowering the amount traveling with relatives and by a very small amount travel for one's self. The second row of total effects of Table 6 shows the impact of time allocation for relatives on all the other variables. First, no relationship is found between time for relatives and time for self. This is the first indication we have that these two decisions may not be influenced by time budget considerations because tasks for relatives and for self are fixed for a person and are predefined and dictate what happens to all other time allocations. The positive relationship between travel time for relatives

and activity time shows that the more activity time one allocates for relatives the more travel time for relatives she will need. All this at the expense of the other three times that need to be decreased to fit within a 24 hour period with traveling for self suffering the highest decrease by an order of magnitude more than all the other variables. Allocation of activity time for others does not influence either activity time allocation for self or activity time allocation for relatives. It influences substantially travel time allocation for others and it inhibits travel time allocation for one's self and relatives in similar magnitudes. Turning to travel time for self and travel time for others we see they do not influence any other variable in this group. Similar results were obtained for travel time for relatives although a negative but very small effect is found for activity for others and travel for self. Overall this shows that activity time allocation predetermines travel time allocation. Activity for self and activity for relatives are the two driving forces of this block of variables.

Table 6 Total effects among the altruism indicators (relationships within quadrants 1a and 2a of Figure 1)

WOMEN						
Activity			Travel			
WOMEN	SELF	REL	OTHER	SELF	REL	OTHER
Activity	SELF	N/A		0.000	-0.216	
	REL		N/A	-0.027	-0.216	0.193
	OTHER			N/A	-0.158	-0.170
Travel	SELF			N/A		
	REL			-0.000	-0.000	N/A
	OTHER					N/A
MEN						
Activity			Travel			
MEN	SELF	REL	OTHER	SELF	REL	OTHER
Activity	SELF	N/A	-0.237	-0.242	0.022	-0.024
	REL		N/A	-0.362	-0.045	0.052
	OTHER			N/A	0.031	
Travel	SELF			N/A		
	REL				N/A	
	OTHER					N/A

The second portion of Table 6 shows the relationships for men. Similarly to women, men's travel time allocation does not influence activity time allocation. It is clear that the binding constraint on time allocation emerges from the duration of activities and not from the travel time required to reach activity locations when we consider a 24 hour allocation of time for both men and women. Trade-offs among activities for men are then dictated by the allocation of time to one's self (all except one total effect are negative) and time allocated to relatives which again causes most total effects to be negative. The positive total effects are between travel for self with activity for self and travel for relatives with activity for relatives implying that the amount needed for the activity dictates also the amount of time traveling to the activity locations. The more the

time needed for the activity and the longer the travel time is. In addition, the overall template of relationships among all these variables for men and women, although they are very similar, they also display a key difference: time allocated for self is a stronger driving force for men than for women because it influences all the variables in this block (quadrant). Travel emerges as an outcome serving the need to participate in activities and does not influence their total daily durations.

Table 7 shows the companionship relationships. In this block of variables the lack of influence from travel to activity is even more pronounced than for the altruism relationships by women and for men. Again, even when the total effects are significantly different than zero they are extremely small. The similarity with altruism is also valid for the role of time allocation alone and with relatives. Both indicators are independent of each other, they are not influenced by any other variables in this block, and they influence in a substantial way activity with others and all three indicators of travel (alone, with relatives, and with others). Time budgeting is also evident. When women spend more time alone they also tend to spend less time with relatives but more time with others, traveling for longer time with others, and in a substantial way traveling alone. When these women spend more time with relatives, they tend to spend less time with others, less time traveling alone, and less time with others. In contrast, they tend to allocate more time traveling with these same relatives. This same positive relationship is also found between the time spend with others in activity and the time spend with others in travel. The relationships of Table 7 indicate that spending more time in activities (alone, with relatives, or with others) requires also spending more time traveling alone, with relatives, or with others respectively.

Table 7 Total effects among the companionship indicators (relationships within quadrants 1b and 2b of Figure 1)

WOMEN							
		Activity			Travel		
WOMEN		ALONE	REL	OTHER	ALONE	REL	OTHER
Activity	ALONE	N/A		0.337	1.149	-0.563	0.343
	REL		N/A	-0.291	-0.472	0.301	-0.103
	OTHER			N/A	-0.493		0.313
Travel	ALONE				N/A		
	REL	0.000			0.000	N/A	0.000
	OTHER						N/A
MEN							
		Activity			Travel		
MEN		ALONE	REL	OTHER	ALONE	REL	OTHER
Activity	ALONE	N/A			0.011*	-0.018*	-0.023
	REL	-0.673	N/A	-0.112	-0.027	0.033	-0.007*
	OTHER	-0.768	0.000	N/A	0.032	-0.033	0.021
Travel	ALONE				N/A		
	REL					N/A	
	OTHER						N/A

* significance levels lower than 95% and higher than 90%

Men are different in their companionship relationships exhibiting causal arrows that are somewhat more complex than women. In the second portion of Table 7 in correspondence of activity we see that when men allocate more time with relatives they allocate less time to themselves and to others in activity and in travel. When they allocate more time with others they need to allocate more time traveling with these other persons but also traveling alone (e.g., if they ride somewhere with another person they may need to return home alone).

We turn next to the relationships between altruism and companionship starting from women's allocation and relationships among the variables considered here. They show a very strong positive relationship among the times allocated to relatives and the times allocated to others. Women that spend more time for relatives tend to also spend more time with relatives and with others in activities and in travel. Similar trends are observed for activity allocation to other persons. All this happens at the expense of time alone. Men exhibit a different correlation pattern. When they allocate more time to relatives they also allocate less time with others and slightly less time traveling alone. However, when they allocate more time for others, they do not spend less time with relatives or alone but they travel for shorter time with relatives.

Table 8 Total effects between altruism and companionship (arrow from quadrant 1a to 1b and arrow from quadrant 2a to 2b)

		WOMEN					
		Activity			Travel		
WOMEN		ALONE	WREL	WOTHER	ALONE	WREL	WOTHER
Activity	SELF						3.335
	REL	-0.073	0.574	0.188		0.065	0.038
	OTHER	-0.040	0.393	0.543			0.256
Travel	SELF				0.885	-0.140	
	REL			-0.000		0.685	0.165
	OTHER						
		MEN					
		Activity			Travel		
MEN		ALONE	WREL	WOTHER	ALONE	WREL	WOTHER
Activity	SELF	0.329		-0.142	-0.006*		
	REL	0.114*	0.660	-0.334	-0.019		
	OTHER			0.591	0.038	-0.037	
Travel	SELF						
	REL		0.000		0.120	0.748	0.084*
	OTHER						

* significance levels lower than 95% and higher than 90%

Table 9 contains the answers to the more fundamental questions of interaction between men and women in these households. The top portion of the table shows the total effects from time allocation of women to the time allocation of men (arrow from quadrant 1a to quadrant 2a in Figure 1). The bottom half shows the total effects from the time allocation indicators of men to the time allocation indicators of women (arrow from

quadrant 2a to quadrant 1a in Figure 1). Remarkably many total effects of the top half are zero and the effects that are not zero are very small. The only total effect of a marked magnitude is from the time allocation for self of women to the travel allocation for self by men. The overall indication from these total effects seem to be that of a conduct of "parallel lives" in which women engage in activities (as reflected by the relationships among all the indicators in the previous tables) without imposing substantial time allocation constraints on men. Although many coefficients of the effects of Table 9 are significantly different than zero, their size is very small. This indicates the existence of a threshold. Women that engage in activities for relatives pose limitations on men's activity participation only when their daily total duration in these activities is very long but even in that case with a small impact on men's activity and travel.

This is clearly opposite to the second half of Table 9 in which we see that when men allocate more time to activities for relatives they release constraints for women who in turn can dedicate more time in activities and travel for persons outside the relatives' social network. In addition, when men dedicate more time in activities for others, women in those same household dedicate less time. The size of the total effects also shows there is a substantial influence indicating time allocation of men functions as a strong binding constraint on the time allocation of women and it functions as a strong release of constraints.

Table 9 Total effects of altruistic interaction between women and men (arrows between quadrants 1a and 2a)

WOMEN	MEN	Activity			Travel		
		SELF	REL	OTHER	SELF	REL	OTHER
Activity	SELF			0.000	0.182		
	REL	0.033	-0.008	-0.008	0.001	-0.001	0.000
	OTHER				-0.001	0.004	
Travel	SELF						
	REL			0.000	0.004		
	OTHER						

MEN	WOMEN	Activity			Travel		
		SELF	REL	OTHER	SELF	REL	OTHER
Activity	SELF			-0.815	-0.849*		-0.533
	REL			3.442	-1.991	-0.571*	2.083
	OTHER			-3.532			
Travel	SELF						
	REL						7.461
	OTHER						

There is a clearly asymmetric relationship in expressions of altruism between women and men possibly as a reflection of lack in flexibility (or lack of willingness to accommodate other's needs) for men's tasks that are not influenced by what women do. In contrast, there is substantial flexibility in women's time allocation. The variables analyzed here are heavily influenced in an inhibitory and enabling way by what men do in a day. It should be noted, however, that we cannot detect and analyze why this is

happening and what type of negotiations and considerations may take place within the dyads.

These findings point out that models not accounting for asymmetric relationships between men and women within the same household fail to account for different roles and different schedule flexibilities by persons that take one of these different roles. Similar relationships are found in companionship (Table 10). Again women influence men's time allocation with relatives or others only at very high levels of time allocation while many of men's total effects are greater than one implying that for one more minute of time with relatives they "cause" 3.442 more women's minutes with others.

Table 10 Total effects of companionship interaction between women and men (arrows between quadrants 1b and 2b)

		MEN					
		Activity			Travel		
WOMEN		ALONE	WREL	WOTHER	ALONE	WREL	WOTHER
Activity	ALONE				-0.002	0.001	0.010
	WREL	0.017	-0.000		0.002	-0.001	-0.000
	WOTHER	-0.011			-0.003	0.003	
Travel	ALONE						
	WREL		-0.000				
	WOTHER						

		WOMEN					
		Activity			Travel		
MEN		ALONE	WREL	WOTHER	ALONE	WREL	WOTHER
Activity	ALONE			1.687	-3.542	0.560	0.527
	WREL		-2.197	3.918	-0.951	-0.812	1.228
	WOTHER	0.000		-1.302	-1.534	2.623	
Travel	ALONE						
	WREL						
	WOTHER						

SUMMARY AND CONCLUSIONS

In this paper, using data from 366 households residing in Centre County Pennsylvania, human interaction within and outside the household is analyzed. The analysis differentiates between altruism and companionship and between men and women. Using path analysis gender-roles in time allocation are extended beyond the typical average allocation of time revealing lack of substantial influence of men's time allocation to activities by women's time allocation to activities. Women's time allocation has some influence on men's time allocation but only when women engage in activities for a considerable amount of time in a day. This is accompanied by exactly the opposite influence by men's scheduling that heavily influence women's time allocation. The same template of gender-dependent influence repeats in altruism and in companionship.

The second major finding is that travel is not emerging as a cause but as an outcome supporting once again the practice in activity-based models of considering travel demand as derived from the need to participate in activities. It should also be noted that travel is a very small fraction of the total daily time allocation and does not function as a constraint in budgeting time for activities with and for relatives and other persons.

The relationship between altruism and companionship is different between men and women. On one hand, men appear to be "rationing" their time and allocate time either to relatives or to others. On the other hand, women seem to be doing it all at the same time when they need to allocate time to activities for relatives or others. For example, when they engage in activities for relatives they also engage in more time with relatives and with others and when they engage in more time in activities for others they tend to also allocate more time to activities with relatives and with others.

From the overall path model we also find there are a few variables that function as the "primitive" source and they are not influenced by any of the other 22 variables considered here. They are: the total amount of activity time for one's self and the total amount of activity time for relatives by women. A third variable, although it is not a true "primitive," total amount of activity time for one's self by men is only slightly influenced by the time allocation of women. Implications for subsequent modeling include hierarchy of variable prediction in a cascade that goes from women's altruism, proceeds to men altruism, and men's companionship and then women's companionship. In addition, blocks of variables of activity participation determine travel engagement.

Although the cause-effect arrows are clearly shown by the total effects tables, the analysis here is not sufficient to help us create predictive regression models. First, additional explanatory variables are needed to determine many of the variables including the two "primitives." Second, a more detailed analysis is needed to understand the binding constraints imposed by men's activity time allocation. Other studies claimed work schedule of men to be a controlling factor (Cao and Chai, 2007, and review of literature therein). This can be done by a closer examination of the types of activities these men and women engage and the persons that make up the group of relatives and others. Third, as the analysis in Kato and Matsumoto, 2007, shows, we also need to include the time allocation of children (and other adults in a household) to gain a clearer perspective of time allocation. Since the analysis in this paper is the first time we analyze altruism and companionship at this level of detail all the above mentioned extensions are left as future tasks.

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