A JOINT ANALYSIS OF TIME USE AND CONSUMER EXPENDITURE DATA: AN EXAMINATION OF TWO ALTERNATIVE APPROACHES TO DERIVING VALUES OF TIME

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ABSTRACT

Time use perspectives in travel behavior research are increasingly gaining attention for their ability to shed light on the underlying temporal processes that affect travel demand and influence behavioral responses to a range of land use and transportation policy actions. This paper offers an examination of time use allocation to work and leisure activities in the context of the monetary expenditures that are incurred for different categories of activities including work, leisure, and other committed expenses (such as housing, food, education, and transportation). A microeconomic model based on consumer choice theory is estimated to model time allocated to work and leisure, and determine the value of time for work and leisure. The model is estimated on a synthesized data set that was created by merging records from the 2008 American Time Use Survey data set with records from the 2008 Consumer Expenditure Survey data set of the United States. The model results show that individuals in the sample data set work until the margin, i.e., until the marginal utility of work is nearly zero, implying that the value of leisure is nearly equal to the wage rate. In addition, a structural equations model system that relates time allocation for work and leisure, and monetary expenditures for leisure, is estimated to draw inferences about relationships among these variables. Comparisons of model results suggest that the models offer vastly different measures of the value of leisure; while the microeconomic model offers a utilitarian measure of the value of leisure, the structural equations model provides a measure of the average relationship between monetary expenditure and time allocation. The paper concludes with a discussion on the implications of the findings from the perspective of applying different models for policy analysis.

Keywords: time use, activity time allocation, value of leisure, value of work, monetary expenditures, microeconomic model, structural equations model

1. INTRODUCTION

Over the past few decades, there has been considerable research on the relationships between time use and travel behavior (Kitamura, 1984). This research stems from the recognition that travel demand is inextricably linked to the amount of time that people allocate to various activities that are distributed in time and space, as well as time spent at home for various purposes (Bhat and Koppelman, 1999; Kitamura et al, 1997). Presumably, as people spend or allocate more time for out-of-home activities, then the time allocated to travel will increase as well. Thus, enhanced understanding of how people allocate time to various activities should provide a basis for better forecasting and simulating activity-travel patterns under a wide range of system scenarios (Pendyala and Goulias, 2002). For example, consider the situation where roadway capacity has been expanded providing a savings in travel time to and from the work place. Then, the question that arises is how individuals will allocate the travel time savings to various activities. If some of the time is allocated to additional out-of-home activity engagement, and consequently travel, then the additional roadway capacity may have induced net new travel not previously existing in the system. The time use approach to travel forecasting provides a strong basis for activity-travel microsimulation, and model systems that aim to simulate activity-travel patterns are increasingly considering activity durations (time use allocation) as explicit measures that need to be modeled within the microsimulation framework.

It is reasonable to expect that the time allocated to activities depends on the marginal utility that individuals derive from participation in various activities. Utility based frameworks have formed the basis of behavioral models in economics for many decades (Winston, 1987; Juster, 1990). The application of the utility-based approach to time use allocation has been the basis of much past research dedicated to modeling time allocation to activities such as work, shopping, social recreation, household maintenance and errands, and eating out. To effectively model time allocation to various activities, it is therefore of interest to evaluate the value of time that individuals attribute to various activities as well as the associated marginal utility values. With such information, it should be possible to more accurately determine how individuals value time (Wardman, 2004) and allocate time among a variety of activities, including those that lead to travel.

Much of the previous work on the analysis and modeling of time use allocation across activities of various types has attempted to do so without explicitly considering monetary expenditures associated with activity engagement. There is a natural connection between activity time use allocation and monetary expenditures; in general, as one spends more time on a certain activity, associated monetary expenditures will go up as well. However, monetary constraints play an important role in shaping time use (Kockelman, 2001). The value of leisure, work, home-stay, and other activities can best be determined by closely tying together the time allocation to these activities with monetary expenditures that people incur in the pursuit of these activities. The monetary expenditures are representative of the willingness-to-pay of individuals as they allocate money to various activities; if a certain activity does not provide any value, and the individual is consequently not willing to spend any money on the activity, then the individual will presumably allocate no time to it. In other words, an integrated examination of monetary and time use expenditures can provide a robust framework for determining time allocation to activities, travel demand under different temporal constraints, and values of activity and travel time. The determination of the value of travel time (savings) is of much interest, for example, in the profession to help calculate user benefits arising from alternative modal investments. Similarly, an understanding of the trade-offs involved in time allocation across activities, monetary expenditures across activities, and between time use and monetary expenditures provides a more holistic perspective on the relationships driving human activity-travel choices and influencing overall quality of life. An individual could, for example, spend a lot of time on free recreational activities outside home (say, at the local public community park) without incurring much monetary expenditure, or spend a lot of time playing golf at an expensive country club (incurring substantive monetary expenditures). Thus, one needs to have knowledge of monetary expenditures to be able to value the benefits that people accrue from activity engagement, and to understand why and how individuals from different socio-economic backgrounds (say, very different income levels) may have activity time allocation patterns that are counter-intuitive. For example, a low income person can spend lots of time at the free community park, while a high income person may spend the same or less amount of time (because this person is busy working many hours of the day to earn the income) at the golf course. There have been several attempts in the recent past to start relating activity travel choices to monetary expenditures (Ferdous et al, 2010; Thakuriah and Liao, 2006); those research efforts have focused on transportation related expenditures and have not necessarily considered the entire range of expenditures that households incur.

This paper attempts to shed light on the values of leisure and work time using a microeconomic theory of consumer behavior that was previously developed by Jara-Díaz et al (2008). In addition, values of leisure derived from a structural equations model system estimated on the same data set are compared against those obtained from the microeconomic model system to explore differences and similarities that may exist in the inferences drawn from different modeling approaches. The effort is made possible through an innovative synthesis and merging of two different disaggregate national survey data sets collected in the United States. They are the 2008 American Time Use Survey (ATUS) and the 2008 Consumer Expenditure Survey (CES) data sets. Using a set of socio-economic attributes as matching criteria, records from these data sets are matched against one another using probabilistic matching processes to create an integrated time use – monetary expenditures data set. This disaggregate data set can be used to evaluate values of time for various activities and to study relationships between time allocation and monetary expenditures. The intent is to provide additional evidence on the values of leisure and work and to illustrate the importance of using models founded on microeconomic consumer theory to calculate such values.

The next section provides an overview of the methodologies adopted in the paper. The third section describes the integrated time use – monetary expenditures survey data set prepared for this study. The fourth section summarizes key results from the study effort while the fifth section offers key conclusions.

2. METHODOLOGY

This section presents an overview of the modeling methodology used in this study.

2.1. Microeconomic Consumer Model of Time Allocation and Expenditures

Jara-Diaz et al (2008) expanded the framework developed by Jara-Diaz and Guevara (2003), adapting a De Serpa (1971) like model where time assignment to activities and good consumption are the arguments of utility, including the usual time and income constraints, adding technical constraints where goods required to perform the activities, and activities required to consume goods, have minima necessary. Using a Cobb-Douglas utility form within this formulation, an individual labor supply equation (1) and the equations for time assigned to activities (2) are obtained (Jara-Diaz et al, 2008).

$$T_w^* = \beta(\tau - T_c) + \alpha\frac{E_c}{w} + \sqrt{\left(\beta(\tau - T_c) + \alpha\frac{E_c}{w}\right)^2 - (2\alpha + 2\beta - 1)(\tau - T_c)\frac{E_c}{w}} \quad (1)$$

$$T_i^* = \frac{\gamma_i}{(1-2\beta)}\left(\tau - T_w^* - T_c\right) \qquad \forall i \in A^f \quad (2)$$

These equations establish that time assignment to activities that the individual would like to expend (i.e. those contained in A^f) depend on the wage rate w, on committed expenses E_c (the sum of expenses over all goods which are consumed exactly at the minimum) and on committed time T_c (the sum of time used over all activities that are assigned the minimum). τ is the total time period under consideration (in this analysis, it is 168 hours corresponding to a week). Parameters α, β, and γ_i are normalized from the original utility parameters. Equations (1) and (2) can be used as the basis for the estimation of the parameters involved. Equation (1) includes α and β only. Equation (2) adds one parameter (γ_i) to be estimated for each freely chosen activity i. Because of the restriction on total time, only up to n-1 time assignment equations can be estimated (with n the cardinal of the set of unrestricted activities). When using this model system for econometric estimation, one has to assume *a priori* which activities are restricted, which is something that can be explored empirically. Although α and β can be estimated using equation (1) only, they would be more efficiently estimated together with γ_i using equations (2). Because equations (1) and (2) have exogenous variables in common, they can be correlated ($\rho_{w,i}$). Based on Munizaga et al (2008), a normal error with different standard deviations is assumed for each equation (σ_w and σ_i). The model was estimated by maximum likelihood with full information using software GAUSS 7.0 (maxlik package).

One of the advantages of the model system as derived here is that data can be accommodated to different degrees of aggregation in the variables, because adding activities does not change the structure of the model. But the most interesting property of the model is that it allows the empirical estimation of the value of leisure and the value of assigning time to work. As shown by Jara-Díaz et al (2008), the value of leisure *VL* for an individual with preferences represented by α and β, with a wage rate w and exhibiting committed expenses E_c and committed time T_c can be calculated as:

$$VL = \frac{1-2\beta}{1-2\alpha}\frac{\left(wT_w^* - E_c\right)}{\left(\tau - T_w^* - T_c\right)} \quad (3)$$

As the value of leisure equals the total value of work, given by the wage rate plus the value of assigning time to work *VW*, the latter happens to be given by (Jara-Díaz et al, 2008):

$$VW = \frac{2\alpha + 2\beta - 1}{1-2\alpha}\frac{\left(wT_w^* - E_c\right)}{T_w^*} \quad (4)$$

Finally, note that the equality representing each individual equilibrium regarding time assignment can be presented controlling for differences in the wage rate. This can be done simply by noting that $VL = VW + w$, which can be re-written as:

$$\frac{VL}{w} + \left(-\frac{VW}{w}\right) = 1 \quad (5)$$

2.2. *Structural Equations Model*

A typical structural equations model with G endogenous variables is defined by a matrix equation system, as shown in following equation:

$$Y = BY + \Gamma X + \varepsilon \Rightarrow Y = (I - B)^{-1}(\Gamma X + \varepsilon) \tag{6}$$

where Y is a column of endogenous variables, B is a matrix of parameters associated with right-hand-side endogenous variables, X is a column vector of exogenous variables, Γ is a matrix of parameters associated with exogenous variables, and ε is a column vector of error terms associated with endogenous variables.

Structural equations systems are estimated by covariance-based structural analysis, also called the method of moments, in which the difference between the sample covariance and the model implied covariance matrices is minimized. The fundamental hypothesis for the covariance-based estimation procedures is that the covariance matrix of the observed variables is a function of a set of parameters, $\Sigma = \Sigma(\theta)$ where Σ is the population covariance matrix of observed variables, θ is a vector that contains the model parameters, and $\Sigma(\theta)$ is the covariance matrix written as a function of θ. The relationship between Σ and $\Sigma(\theta)$ is basic to an understanding of identification, estimation, and assessment of model fit. The matrix $\Sigma(\theta)$ has three components: the covariance matrix of Y, the covariance matrix of X and Y, and the covariance matrix of X. Let Φ equal the covariance matrix of X and Ψ equal the covariance matrix of ε. Then it can be shown that:

$$\Sigma(\theta) = \begin{bmatrix} (I - B)^{-1}(\Gamma\Phi\Gamma' + \Psi)(I - B)^{-1'} & (I - B)^{-1}\Gamma\Phi \\ \Phi\Gamma'(I - B)^{-1'} & \Phi \end{bmatrix} \tag{7}$$

Before estimating model parameters, it is first necessary to ensure that the model is identified. Model identification in simultaneous structural equations systems is concerned with the ability to obtain unique estimates of the structural parameters. The identification problem is typically resolved by using theoretical knowledge of the phenomenon under investigation to place restrictions on model parameters. The restrictions usually employed are zero restrictions where selected endogenous variables and certain exogenous variables do not appear on the right hand side of certain equations and selected error correlations are specified to zero. There are several rules that can be used to check whether a structural equation model system is identified. Detailed discussions on these identification rules may be found in Bollen (1989).

The unknown parameters in B, Γ, Φ, and Ψ are estimated so that the implied covariance matrix $\hat{\Sigma}$ is as close as possible to the sample covariance matrix S. In order to achieve this, a fitting function to be minimized, $F(S, \Sigma(\theta))$, is defined. The fitting function has the properties of being a scalar, greater than or equal to zero, equal to zero if and only if $\Sigma(\theta)$ = S, and continuous in S and $\Sigma(\theta)$.

Available methods for parameter estimation include maximum likelihood (ML), unweighted least squares (ULS), generalized least squares (GLS), scale-free least squares (SLS), and asymptotically distribution-free (ADF). Each of these methods minimizes the fitting function and leads to consistent estimators of θ. In this paper, the ML method of estimation may be employed as all time use and expenditure endogenous variables may be treated as continuous in nature. The fitting function that is minimized in the ML method of estimation is shown in Equation (8):

$$F_{ML} = \log|\Sigma(\theta)| + \text{tr}\,(S\,\Sigma^{-1}(\theta)) - \log|S| - (G + K) \tag{8}$$

where G is the number of excluded endogenous variables on the right-hand side of the model and K is the number of included exogenous variables on the right-hand side of the model. The asymptotic covariance matrix for the ML estimator $\hat{\theta}$ is obtained by substituting $\hat{\theta}$ for θ in the following expression which allows conducting tests of statistical significance for the parameter estimates $\hat{\theta}$.

$$\left(\frac{2}{N-1}\right)\left\{E\left[\frac{\partial^2 F_{ML}}{\partial\theta\,\partial\theta'}\right]\right\}$$

3. DATA SET AND SAMPLE COMPOSITION

In order to conduct an analysis of the value of time, very detailed information about time use and expenditure characteristics are desired at an individual level. Time use information is generally desired at the activity episode level and expenditure information is desired at the level of the individual good, commodity, or service. While there are data sets that provide detailed information about time use and expenditure at the individual level, these data sets are collected largely independently. Data sets that tie detailed information about time use choices to household and individual expenditure decisions are not readily available. One can use intelligent data stitching techniques to generate a synthetic data set of time use and expenditure by combining independent datasets. One such approach has been applied in this study to create a synthetic dataset of time use and expenditure for single person households, in which the individual is employed. For detailed time use data, the American Time Use Survey dataset was used and for consumer expenditure data, the interview portion of the Consumer Expenditure Survey data set was used. Both datasets from the year 2008 were selected so that temporal consistency existed in the merged data set.

The 2008 American Time Use Survey (ATUS) data set contains information about how individuals spend their time engaging in various activities on a pre-assigned day of the week. The sample is drawn by selecting and interviewing a randomly designated person from the households that have completed their final month of interviews for the Current Population Survey (CPS). Eligible respondents must be at least 15 years of age. Selected persons are interviewed on the day following the assigned day and they report the activities they performed from 4 AM on the assigned day until 4 AM on the day of the interview. In 2008, about 12,723 individuals provided detailed time use information for a 24 hour period. In addition to activity engagement information, there is also information about the location of the activities, the accompanying individual(s), and a host of socioeconomic and demographic characteristics about the respondent and the household.

The Consumer Expenditure Survey (CES) collects information on the buying habits of American consumers. The survey has two components – one is a diary survey which is administered for two consecutive one-week periods and the other is an interview survey which records expenditures of consumers during each quarterly period. In the diary survey, participants are asked about small and frequent expenditures that cannot be easily recalled, whereas in the interview survey larger and longer-term expenditures which can be easily recalled are recorded. Dollar amounts of the purchases (both goods and services) made during the survey period are recorded by the respondents irrespective of whether or not payment is made at the time of purchase. In 2008, the interview survey comprised of nearly 7000 respondents on a rotating panel basis for every quarter.

As noted above, ATUS collects time use data from only one individual in a household over the course of a day. In contrast, the interview portion of the consumer expenditure survey provides information about quarterly consumer expenditure patterns of households. As can be seen, there is a difference in both the unit of analysis and the time dimension of the datasets. In the ATUS, the unit of analysis is an individual whereas in the CES, the household is the unit of analysis. With respect to the time dimension, ATUS collects time use data for a day while CES collects quarterly expenditure information. In order to combine the two datasets in a consistent fashion, only single person households were considered in the analysis. Further the analysis was limited to employed individuals because the aim of this paper is to estimate the value of leisure time by modeling time allocation to work and leisure, while considering both income and time constraints. An analysis period of a week was considered appropriate as many time use and expenditure patterns are likely to follow weekly cycles. In order to facilitate a weekly analysis, a synthetic weekly time use and expenditures dataset was constructed from the daily time use survey data set. A weekly expenditure data set was constructed by applying a naïve scaling approach on the quarterly data. For creating the weekly time use dataset, individuals that reported their time use patterns on a Sunday were selected and time use patterns for Monday through Saturday were generated by appending records of individuals that reported time use patterns on other days of the week. In order to select the individual whose records will be appended, a candidate respondent pool was selected based on matching of seven socioeconomic characteristics of interest, namely, gender, age, employment status, race, college status, family income, and employment category. From the candidate pool, a respondent was randomly selected to append time use records for a particular day. If no records were found to match the seven attributes of interest, then the first six were considered, and the process was repeated. The threshold value for identifying the candidate pool was three attributes. A synthetic time use data set was thus generated.

In order to synthesize a dataset that contained both time use and expenditure data for a week, a procedure similar to that for creating the weekly time use dataset was employed. However, in this process, six socioeconomic variables, namely, gender, age, employment status, race, college status, and family income were used as matching criteria. The reference dataset was the synthetic weekly time use data, and expenditure records were appended from the CES based on a matching of the above six variables. The data stitching procedure resulted in a data set comprised of 332 individuals with complete weekly time use and expenditure data.

Table 1 provides a descriptive snapshot of the sample used in this study. The sample consists of 332 single adults who work outside the home. Total weekly expenditures amount to just about $380 with a little over $200 allocated to committed expenses. Committed expenses include such items as education, shopping, housing rent and mortgage, utilities and telecommunications, transportation, health care, and household maintenance services. As expected, housing and transportation are the top two expenditures among committed expenses with communications and education being the smallest expenditures. Household maintenance and health care are also substantive pieces of committed expenses. Food expense at home is more than food expenses for eating out, which is in turn higher than expenditures for shopping. However, there may be many shopping expenditures captured in other categories (e.g., eating out, food at home which involves shopping for eating at home as well).

Entertainment expenses amount to just under $20 per week; insurance is a substantive expense in the United States and this is reflected in the descriptive statistics. Miscellaneous expenses account for just about $25 per week. Interestingly, the weekly expenses are substantively lower than weekly income, which is reported to be about $1000. One must account for the fact that this income is gross income that does not account for taxes, social security contributions, and retirement contributions that usually come out of the paycheck. As such, the true net weekly income is likely to be considerably lower. The average wage rate amounts to just about $30 per hour (calculated by dividing weekly income by weekly hours worked, and averaging across the sample).

In terms of time use, a vast majority of the time is spent at home (more than four of the seven days of the week). Out of home committed time amounts to just under 20 hours per week. Transportation accounts for nine hours per week while eating out accounts for a little over four hours per week. Total work duration amounts to an average of just about 38.5 hours per week consistent with the nature of the sample. Out of home recreational pursuits account for just about 8.4 hours per week, which amounts to an average of about one hour per day, although it is expected that the hours may be most concentrated on non-working days (such as weekend days). The statistics in the table are also shown for the individuals who actually report non-zero values for each of the attributes. Most expenditures are reported by a substantive portion of the sample; an exception is education for which expenses are reported only by seven individuals. For entertainment, 300 of the 332 individuals report a positive leisure expenditure, and 329 individuals report spending a positive amount of time for out of home leisure. Thus, there are a few individuals who pursue only free recreational leisure activities that incur no expenditure at all (such as visiting a local public community park for sports and recreation).

Table 2 provides descriptive statistics by market segment, but removes those records that had some missing data and wherein monetary expenditures exceeded income. The clean sample included 324 records; statistics for this sample are shown in the table. In general, women spend less time at work, more time at home, and more time doing shopping and errands than male counterparts. This is found to hold true across all age and income groups. With respect to entertainment, however, it is found that males spend more time for leisure than females, once again a trend that holds true across all age and income groups. Another interesting trend is that the wage rate is higher for women than men, consistently across age and income groups, except for the first age group where the average wage rates are rather similar. The average committed expenses increase with income (as expected), but do not appear to increase with age. In the middle income group, women spend less on committed expenses than men, but in the high income group, women spend considerably more than men. It appears that women may be undertaking more shopping than men in the highest income bracket, a category that falls within the purview of committed expenses.

4. MODEL ESTIMATION RESULTS

This section presents a description of the results obtained from the estimation of the two model systems.

4.1. Structural Equations Model System

Results of the structural equations model system are presented in Table 3. The model provides an acceptable fit with a χ^2 value of 6.222 with six degrees of freedom and a *p*-value of 0.399 indicating that the model cannot be rejected at the 0.05 level of significance. As noted earlier, all estimations are performed on weekly time use and expenditure data. Three endogenous variables are included in the structural equations model, thus constituting a three-equation system. The three endogenous variables represent the time allocated to work (out of home), the time allocated to leisure (out of home), and the monetary expenditures on leisure activities (out of home). There are three intercepts corresponding to these three endogenous variables, with the one for monetary expenditures for leisure activities statistically insignificant and therefore considered to be zero. The intercepts for the other two endogenous variables are significant, with a value of 2654 for work and 1019 for recreation. Both of these may be considered baseline time expenditures in minutes per week. This translates to about 400 minutes of work per day and 150 minutes of leisure per day. These figures are consistent with the nature of the sample, which is exclusively composed of single adults who work outside the home.

The table first shows the effects of exogenous variables on the three endogenous variables. The focus here is on interpreting the total effects, which is a combination of the direct regression effect and the indirect effect of one variable on another. The indirect effect represents an influence that a variable may have on another, but through an intermediary (mediating) variable. The total effect may be considered as the overall effect of any variable on another. In addition to a few socio-economic variables representing gender and age, several other variables are treated as exogenous. The amount of committed expenses (as defined in the previous section) and the amount of time allocated to committed activities (defined in the previous section) are also treated exogenous. Males, on average, are found to work about 247 more minutes per week than females (about 40 more minutes per day). Males are also found to spend more time on out of home leisure activities, averaging about 70 more minutes per week than females on such leisure pursuits. Interestingly, however, it appears that males spend a modestly lower sum (just about three dollars less per week) on leisure pursuits than females even though they allocate more time to such activities. Age does not have a significant impact on work duration, but does significantly impact leisure activity duration. As age increases, the leisure activity duration drops, suggesting that younger individuals allocate more time to fun and leisure than older individuals. As a consequence, it appears that older individuals also spend less money on out of home leisure activities; however, the age effect on out of home leisure expenses is statistically insignificant.

Weekly income appears to impact monetary expenditures on leisure activities significantly, but the effect is rather small. It appears that a hundred dollar increase in income would be associated with an only one dollar increase in leisure expenditures. It is possible, however, that individuals may allocate additional income to paying off debt, increasing expenditures on capital items (such as housing and vehicles) that enhance their lifestyle, or put more into savings. Also, it should be noted that the income used in the model is gross income before-taxes. Considering that a substantive portion of any increase in income is paid out in taxes, the ability to increase leisure expenditures in the short term maybe truly limited. Also, time constraints may prevent an individual from being able to allocate more time to leisure activities even if the individual can monetarily afford to engage in more leisure activities. This is consistent with the finding reported in the next section where it is noted that individuals in this sample work to the maximum, all the way until the marginal utility of work is close to zero.

Out of home committed time use, which consists of time allocated to education, shopping, household maintenance, personal care, food preparation and eating at home, eating out, and transportation, negatively impacts work time. Indeed, every additional minute of out of home time commitment is associated with a 0.4 minute reduction in work time, suggesting that people trade-off work hours against household commitment time. On the other hand, it is found that out of home commitment time is positively impacting out of home leisure time. It appears that there is more of a complementary relationship here; those who spend more time for committed activities also spend more time for leisure activities. Indeed, out of home committed time has a positive impact on the monetary expenditures for leisure activities (although the effect is small in magnitude, it is statistically significant). This complementary relationship is further corroborated by the positive impact that out of home committed expenditure has on leisure expenditure. It appears that these activities "go together" (for example, eating out and leisure, shopping and leisure, and so on), thus leading to the complementary relationship. The usual trade-off is found between work and leisure activity engagement. Every additional minute of time allocation to work is associated with a 0.1 minute drop (ratio of 1:10) in out of home recreational time use. In turn, there is a small, but significant, effect on leisure monetary expenditures as well.

Out of home recreational time use is found to affect leisure monetary expenditures with a total effect of 0.06. This suggests that every 100 minutes of out of home leisure activity is associated with a $6 expenditure, thus suggesting a willingness to pay for leisure activities at just about $3.60 per hour. This value is quite low, and does not represent a value that is comparable to the value of leisure obtained from the microeconomic theory-based model (presented in the next section), which is viewing the value of leisure in terms of the marginal utility of work. The structural equations model system is only capturing the change of leisure monetary expenditure per unit change in leisure activity duration; it is not capturing the utility derived from additional time allocation to leisure. This is an important distinction that must be noted in the context of user benefit assessment when evaluating infrastructure projects. User benefits should be calculated based on the value of leisure derived from the utility formulation, as it is this value that truly depicts the welfare that a person derives from additional leisure time. On the other hand, the structural equations model may be able to offer useful information if one were interested in merely determining the willingness to pay for an additional unit of leisure time, or the average monetary expenditures per unit of leisure activity time allocation ($3.60 per hour in this case).

4.2. Microeconomic Model of Time Allocation

Table 4 contains the results for the values of leisure and work, both in absolute value (obtained from equations 3 and 4) and relative to the wage rate (the two elements in equation 5), calculated from the microeconomic model applied to various segments according to age, gender and income. Unfortunately, cross-segmentation combining these three socio-economic variables is not possible due to the scarce number of observations. Nevertheless, all leisure values are positive, as theoretically required. Recall that no sign is theoretically expected or imposed for the value of work. As most of the values of leisure are larger than the wage rate, the corresponding values of work are positive as imposed by equation (5). This suggests that individuals work not only for the money, but also extract some pleasure from it - youngsters more than elders and men more than women, although men work more than women in both age groups. One must keep in mind that all individuals in the sample are workers living alone, so that other elements such as having or receiving secondary income, or having children, are not present.

When it comes to income levels, the average value of leisure increases with income, very likely the effect of marginal utilities of income (MUI) that decrease with income; as the MUI is in the denominator of time values, the (always positive) effect of leisure time in utility is magnified when it is turned into money values. However, all values in this segmentation are not different from zero at a 95 percent significance.

The main conclusion is that for every segment the marginal valuation of work is NOT statistically different from zero. This is quite interesting as it suggests that individuals work until this marginal value is close to zero, assigning different amounts of time to leisure (either at home or out of home) in spite of different wages. This indicates that leisure is valued at the wage rate. Note that the γ parameter (which reflects preference for leisure at home) varies very little across segments (0.67 to 0.72). Recalling data regarding time at Work and Out of Home Entertainment (OHE) by income segment and gender, one notices that among men, low income men work more on average, but among women, it is the high income individuals that work more. OHE is assigned more time by middle income men and middle and high income women, which might explain why middle income persons are the only ones that exhibit negative marginal valuation of work (but not statistically different from zero). Cross-segmentation would be desirable to capture the effect of gender, age and income separately.

5. CONCLUSIONS

Travel behavior is closely linked with how people spend time, and how people value the time spent at various activities. Travel demand is derived from the inherent personal desire and need to undertake activities that are distributed in time and space. However, both money and time are constraints that inevitably influence the amount of time that can be allocated to various activities, including transportation. In this context, there is much interest in being able to model the time allocation to various activities, as such models would presumably offer rich insights into the behavioral processes that shape travel demand. This paper focuses on the allocation of time to work and leisure activities while considering both time and income constraints. A microeconomic model presented previously by Jara-Diaz et al (2008), which is based on consumer choice theory, is applied in this paper to derive the value of leisure based on the time allocated to work and leisure activities. The importance of deriving such values of time is of natural interest in the transportation planning and policy arena where professionals are constantly interested in computing user benefits accruing from an investment in a transportation improvement. If a transportation system improvement provides the opportunity for individuals to spend more time for leisure pursuits, then the utility derived by the impacted individuals may be reflective of the user benefits accrued. The model is applied to a synthesized data set that merges time use data records from the 2008 American Time Use Survey with household expenditure records from the 2008 Consumer Expenditure Survey of the United States. The analysis is limited to single person households, in which the person is employed, to control the data merging process.

It is found that the value of leisure is positive, and the marginal utility of work is not statistically significantly different from zero. This suggests that individuals in the sample work until the margin, i.e., until the marginal utility of work is close to zero. This means that individuals in the sample work not just for monetary gain, but also because they derive some pleasure from the activity. In addition, as the data is derived from the year 2008, when an economic recession was beginning to take deep root in the United States and around the world, it is possible that individuals worked more out of fear of losing their jobs. Single adults may be prone to working more also because they do not have other household obligations and responsibilities. The value of leisure in this case is therefore equal to the wage rate, suggesting that the value of leisure for individuals in this sample is considerably higher than that for individuals in the Chilean, Swiss, and German data sets analyzed by Jara-Diaz et al (2008).

In addition, a structural equations model system was estimated to further learn about the nature of relationships among time allocation to work and leisure, committed time use and expenditures, and leisure expenditures. The results provide plausible and intuitive results and the model shows an acceptable goodness of fit. The model provides values that may be interpreted as the change in expenditure with respect to a change in time use; the analysis shows that the average values of such trade-offs are very different from values that one derives from a microeconomic model. While the microeconomic model is offering utility-based values suitable for computing user benefits, the structural equations model appears to be offering willingness to pay measures that could be equally useful from a policy planning standpoint. For example, in an economic crisis cities may desire to implement user charges for local public community parks (that may have been free in the past). What is an acceptable charge for the use of such public parks? According to the structural equations model, people may be willing to pay up to $3.60 per hour of use of the park. On the other hand, the actual utility derived by the individual from spending an additional hour in the park may be equal or close to the wage rate (as suggested by the microeconomic model). Another example is that the typical cost of a movie ticket in the United States is about $8 (for a two hour). That translates to about $4 per hour, a value consistent with that obtained in the structural equations model. Thus the figures obtained from the structural equations model appear more consistent with willingness-to-pay values as opposed to utilitarian values of time. Overall, the paper shows that time use analysis can provide valuable information for public policy planning, and values of time derived from such analysis can be used for evaluating transportation projects and computing willingness to pay measures.

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Table 1. Summary Profile of Expenditure and Time Use Characteristics

	Across the entire sample		Across non-zero observations	
	Mean	N	Mean	N
Expenditures (in US$)				
Total Expenditure	379.55	332	379.55	332
Committed Expenditures	207.03	332	207.03	332
Housing	74.25	332	76.08	324
Household Maintenance	28.82	332	37.97	252
Utilities	21.12	332	23.07	304
Communications	8.93	332	9.59	309
Transportation	41.79	332	42.83	324
Healthcare	29.01	332	34.78	277
Education	3.10	332	147.03	7
Food at home	33.42	332	33.52	331
Eating out	23.48	332	28.25	276
Shopping	12.57	332	18.06	231
Leisure and Entertainment	18.66	332	20.65	300
Personal Care	2.50	332	3.88	214
Personal Insurance	56.80	332	56.80	332
Other	25.09	332	37.19	224
Time Use				
Total Time Use	7 days	332	7 days	332
In-home	4 day 5.6 hr	332	4 day 5.6 hr	332
Out-of-home Committed Time	0 day 19.5 hr	332	0 day 19.5 hr	332
Household Maintenance	0 day 1.6 hr	332	0 day 1.8 hr	295
Education	0 day 0.2 hr	332	0 day 3.6 hr	18
Personal Care	0 day 1.4 hr	332	0 day 1.9 hr	242
Food at home	0 day 0.2 hr	332	0 day 0.6 hr	98
Shopping	0 day 2.3 hr	332	0 day 2.4 hr	322
Eating out	0 day 4.3 hr	332	0 day 4.3 hr	332
Transportation	0 day 9.0 hr	332	0 day 9.0 hr	332
Other	0 day 0.6 hr	332	0 day 1.2 hr	159
Out-of-home Work	1 day 14.5 hr	332	1 day 14.5 hr	332
Out-of-home Leisure	0 day 8.4 hr	332	0 day 8.4 hr	329

Table 2. Characteristics of Time Use and Monetary Expenditures by Market Segment

	25-39 years old		40-64 years old		Low Income (0-659 USD/wk)		Medium Income (660-1049 USD/wk)		High Income (at least 1050 USD/wk)		Total
Characteristic	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	
Sample size	71	49	102	102	56	53	45	59	72	39	324
Average time (hrs/wk)											
Work	42.96	39.45	45.15	39.46	45.02	38.14	43.90	38.34	43.88	42.94	42.02
Home	96.93	99.58	96.40	100.50	96.30	103.27	96.23	100.39	97.11	95.73	98.29
Shopping and errands	2.77	4.26	3.73	4.48	3.11	4.12	3.54	4.89	3.39	4.06	3.84
Out of home leisure	9.99	9.15	8.22	6.87	8.87	6.85	9.73	7.95	8.52	8.12	8.32
Travel	9.16	9.36	8.65	8.84	9.03	8.26	8.56	9.03	8.92	9.99	8.93
Average wage rate ($/hr)	25.65	24.37	27.28	34.96	10.98	20.03	20.09	29.65	42.85	49.99	28.90
Average committed expense ($/wk)	240.94	195.96	191.99	199.86	127.84	125.92	222.53	157.97	271.08	358.82	205.80

Table 3. Structural Equations Model Estimation Results

Endogenous Variable	Intercept	Effect	Age	Male	Out-of-home Committed Time Use	Out-of-home Work Time Use	Out-of-home Recreation Time Use	Committed Expenses	Weekly Income
Out-of-home Work Time Use	2653.987	Total		247.633	-0.408				
		Direct		247.633	-0.408				
		Indirect		0.000	0.000				
Out-of-home Recreation Time Use	1019.034	Total	-125.775	68.957	0.148	-0.102			
		Direct	-125.775	94.300	0.106	-0.102			
		Indirect	0.000	-25.343	0.042	0.000			
Out-of-home Leisure/Entertainment Expenditure	-15.045[b]	Total	-11.158	-3.124	0.009	-0.006	0.060	0.045	0.011
		Direct	-3.667[b]	-7.231[a]	0.000	0.000	0.060	0.045	0.011
		Indirect	-7.491	4.107	0.009	-0.006	0.000	0.000	0.000

N = 332; χ^2 = 6.222 with 6 degrees of freedom; p-value = 0.399; RMSEA = 0.011; CN = 895

[a] Significant at the 90 percent confidence level.

[b] Not significant but included in the model.

All other variables are significant at 95 percent confidence level.

Table 4. Results of Estimation of Microeconomic Model of Consumer Time Allocation and Monetary Expenditure

	Individuals within the range 25-64 years old									
	Low Income (0-659 USD/wk)		Medium Income (660-1049 USD/wk)		High Income (at least 1050 USD/wk)		Women		Men	
Sample size	109		104		111		151		173	
Parameter	Est.	t-stat	Est.	t-stat	Est.	t-stat	Est.	t-stat	Est.	t-stat
α	0.41	14.35	0.36	9.10	0.45	15.42	0.40	12.24	0.45	26.71
β	0.11	14.18	0.11	13.85	0.14	26.34	0.11	17.32	0.13	31.80
γ_{Home}	0.72	47.27	0.72	48.93	0.67	67.07	0.72	57.73	0.67	83.45
σ_{Work}	9.59	14.76	9.83	14.41	9.70	14.90	10.20	17.37	9.45	18.60
σ_{Home}	10.22	14.60	0.56	14.36	9.45	14.89	10.27	17.21	9.43	18.55
$\rho_{Work\text{-}Home}$	-0.88	-40.64	-0.88	-39.25	-0.85	-31.45	-0.89	-50.63	-0.86	-43.06
Log-likelihood	-6.68		-6.64		-6.73		-6.72		-6.66	
$\rho_{a\text{-}b}$	0.87		0.84		0.77		0.85		0.76	
	Average values of time (USD/Hr)									
Parameter	Est.	t-stat	Est.	t-stat	Est.	t-stat	Est.	t-stat	Est.	t-stat
Leisure	18.60	3.34	20.96	3.71	112.43	1.77	35.98	3.12	58.51	3.38
Work	3.22	0.54	-4.54	-0.78	67.08	1.05	4.46	0.37	31.90	1.80
Average wage rate	15.38		25.51		45.36		31.52		26.61	
Leisure/wage rate (%)	120.95		82.18		247.88		114.16		219.88	
Work/wage rate (%)	20.95		-17.32		147.88		14.16		119.88	