Tradeoffs between Time Allocations to Maintenance Activities/Travel and Discretionary Activities/Travel

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by

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Abstract

This paper focuses on the tradeoff in time allocation between maintenance activities/travel and discretionary activities/travel. We recognize that people generally must travel a minimum amount of time in order to allocate one unit of time to the activity. This minimum amount of travel is represented by the travel time price, a ratio obtained by dividing the total amount of time traveling to maintenance or discretionary activities by the total amount of time spent on activities of the same type; it is the time equivalent of the monetary price for performing an activity. Using the San Francisco Bay Area 1996 Household Travel Survey data and applying the Almost Ideal Demand System (AIDS) of demand equations, we found that with respect to the time equivalent of income elasticities of maintenance and discretionary activities, the former is less than unity and the latter is greater than unity. In other words, maintenance activities are a necessity and discretionary activities are a luxury. With respect to the own travel time price elasticities, if the travel time price of performing a certain type of activity increases (for reasons such as traffic congestion), one would reduce the time allocated to that type of activity. Time spent on maintenance activities is less elastic than the time spent on discretionary activities. As for the cross travel time price elasticities (changes in time allocated to activity type i in responses to changes in the time price for activity type j), we found that $\varepsilon_{dm} > 0$ and $\varepsilon_{md} > 0$, suggesting a substitution effect between maintenance and discretionary activities.

Key words: AIDS demand equations, time allocation, travel time price, tradeoff

1. Introduction

Traveling is an integral part of our lives, not only because of the spatial distribution of various activities that we want/need to perform, but also because of our own desire to be connected to the outside world. Because of the different degrees of fixities associated with different types of activities, traveling is often subject to temporal and spatial constraints (Hagerstrand, 1970). In other words, the amount of time available for the performance of an activity with relatively flexible location and duration (e.g., discretionary activities) is limited and depends on the amount of travel time needed to reach the destination. Lower travel time (resulting from shorter distances and/or higher speeds) means that more time is allocated to activities; conversely, higher travel time means that less time is allocated to activities. This is only roughly true, because at least some travel time can be recovered as productive (or at least pleasant) activity time through multitasking – perhaps increasingly so with improvements in information and communication technologies (Lyons and Urry 2005). Given that the assumption of traveling as a derived demand remains a useful first-order approximation for most of our daily travel, lower travel time implies higher utility gained and higher travel time implies lower utility gained. Put another way, as we gain utility from spending our time on activities, travel is the cost that we must endure in order to go to these activity locations.

Even though travel is a disutility to us, we generally cannot reduce our travel time to zero. Our ability to adjust our travel time is constrained by the physical settings of the activities and how fast we can travel (Hagerstrand 1970). Changes in travel time often result from involuntary changes. For example, it might result from either relocation (or addition, withdrawal) of activity opportunities (e.g., relocation of a store) or changes in traffic conditions. Given a change in travel time, individuals must adjust their time allocation to activities, which might take place with or without changes in activity locations. The consequences of a change in travel time can be either short-term or long-term. In the short term, a change in travel time could cause changes in time allocation to activities; in the long term, a change in travel time could trigger changes in residential and/or job locations.

In this paper, we focus on the short-term effect of a change in travel time on the time allocation to activities. As we note in the concluding discussion, our use of cross-sectional data to some extent confounds the effects of short-term and long-term changes. However, such data can be viewed as representing a typical mixture of short-term and long-term effects occurring at any given time, and since (almost by definition) only a relatively small proportion of people are undergoing relevant long-term changes in any random cross-sectional sample, it is fair to view the results as reasonably approximating short-term effects.

Instead of directly analyzing the relationships between travel time and activity duration as many researchers have done (Hamed and Mannering 1993; Pas 1985; 1996; Fujii et al., 1997, cited by Kitamura et al. 1997; Golob and McNally, 1997; Kitamura et al. 1997; Ma and Goulias, 1998; Lu and Pas, 1999; Levinson, 1999; Pendyala and Goulias 2002; Kitamura, 2002; Kuppam and Pendyala, 2001; Pendyala, 2003), we utilize a measure called travel time price. A change in travel time is captured through a change in the travel time price, which is the ratio obtained by dividing the total amount of travel time to a particular type of activity by the actual time expenditure on the activity of the same type. Compared to the direct travel time measure, this travel time price has the advantage of acknowledging the effect of the spatial distribution of activity locations on time allocation (i.e., individuals are not equipped with complete allocation power because of the physical locations of various activities) by establishing a link between time spent on activities and on travel. An increase in the travel time price suggests an increase in the time equivalent cost of performing an activity (either from an increase in travel time or from a decrease in activity duration); and conversely for a decrease in the travel time price. In economic terms, this travel time price can be viewed as the time equivalent of the travel-based monetary price of performing an activity.

In this study, we focus on two types of activities: maintenance and discretionary. Given one's current residential and job locations, we ask: how will a change in the travel time price of performing a maintenance or a discretionary activity affect the actual time expenditure on the activity (maintenance or discretionary)? And how will an increase in the total amount of time available (which is total available time less time spent on commuting and working) affect the time allocation to activities? In economic terms, if we view the travel time price as a price separating various activities, calculation of tradeoffs in time allocation among activities and travel is essentially the same as calculating the own and cross travel time price elasticities of maintenance and discretionary activities, as well as the time equivalent of income elasticities (to examine the effects of a change in total time available on allocation to activities).

The paper is organized as follows. In Section 2, we discuss the notion of using the travel time price instead of the nominal values of time allocation to activities and travel. We propose our model framework in Section 3. The database used for this study is described in Section 4. Estimation results are presented in Section 5, followed by a discussion in Section 6.

2. Use of Travel Time Price

The travel time price reflects a balancing process between the time spent on travel and activities (Dijst and Vidakovic 2000). During such a balancing process, the choice of allocating time between activities and travel is partly one of preference and partly one of necessity. Due to the spatial separation of various activities, people are not able to allocate time to travel completely as they wish (if they could, under the presumption of a completely negative utility, everyone would allocate zero time to travel). For example, if one wants to go to a recreational park for some fun, he or she will have to travel for a minimum amount of time no matter how much he or she likes or hates travel. The fact that constraints exist within the balancing process is not a new idea. Both DeSerpa (1971) and Evans (1972) associated a minimum amount of traveling time with the amount of time spent at the destination for an activity.

If we observe people's travel time price from day to day, we would expect the travel time price to vary comparatively little for a single individual if the units of time are relatively large (e.g., a week or a month). The variation of the travel time price from day to day for a single individual would be larger; the variation of the travel time price within a group of individuals would be even larger as there exist many individual/household differences (e.g., residential and job locations, lifestyles). We found only two published studies that explicitly used a travel time price concept. Both studies used the term "travel time ratio", instead of travel time price, but the two concepts are similar (although not identical). The denominator of the travel time ratio includes both activity duration and round trip travel time, while for our travel time price, only activity duration is included. In addition, those studies empirically analyzed travel time ratios only for single activities at a time, whereas we combine the travel and activity time across multiple activities of a given type. Using data collected in the Netherlands in 1992, Dijst and Vidakovic (2000) calculated the travel time ratio for work at a fixed address to be 0.18, meaning that an 8-hour work duration is associated with a one-way travel time of 52 minutes. In another study by Schwanen and Dijst (2002), using the 1998 Dutch National Travel Survey, the travel time ratio for work activities was calculated to be around 0.105, meaning 28 minutes (each way) for an 8-hour workday. They also noted that travel time ratios are affected by a wide range of variables such as household and person characteristics and urban/suburban contexts.

Other studies, though not directly calculating a travel time price, reported the amount of travel time associated with an activity of a certain duration. For example, Golob and McNally (1997) found that about 22.6 minutes of travel each way were involved for every eight hours of out-of-home work activity (similar to Schwanen and Dijst's 28 minutes), and about 7.8 minutes of travel each way were involved for every hour of out-of-home maintenance activity, indicating travel time ratios of 0.086 and 0.21 for out-of-home work activities and out-of-home maintenance activities, respectively.

3. Proposed Model

In this section, we propose a framework for modeling the time spent on both activities and travel, incorporating a time constraint. We establish a linear constraint between the time spent on activities and the time spent traveling. Our model, based on Evan's (1972) model of time allocation, is as follows:

Max

$$V(a_m, a_d, a_t)$$

subject to:

$$a_m + a_d + a_t = \tau,$$

$$a_t = b_m a_m + b_d a_d, \qquad b_m, b_d \geq 0,$$

where

a_m is the time spent on maintenance activities,

a_d is the time spent on discretionary activities,

a_t is the time spent on travel,

τ is the total time available minus the time spent on mandatory activities and their associated travel, and

b_m and b_d are the number of units of travel time (generally fractional) associated with one unit of time spent on maintenance and discretionary activities, respectively.

In the above formulation, the first constraint is the total time budget constraint. In the second constraint, we assume a linear equality relating the time allocated to activities and the travel to engage in those activities. The linear specification is probably quite a simplification of reality, nevertheless it serves as a first step toward recognizing the constraint in reality that individuals do not have complete control over their allocation of time to activities and travel.

Our next task is to derive demand functions for the arguments of V from the above model framework. We decided to derive demand functions from a cost function because then the derived demand functions are "first order approximations to any set of demand functions derived from utility-maximizing behavior" (Deaton and Muellbauer 1980, p. 315). There are different ways to derive demand functions from a cost function, such as the Almost Ideal Demand System (AIDS), (Deaton and Muellbauer 1980), the Rotterdam model (Theil 1965, 1976) and the translog model (Christensen, et al. 1975). Compared to other models, Deaton and Muellbauer (1980) cited several advantages of using an AIDS system, including: a) its demand functions can approximate a large variety of demand functions; b) it aggregates well over individuals; and c) the common constraints in microeconomic theory (symmetry, homogeneity) can be tested. Because of these advantages, we decided to use the AIDS model. The derived demand functions for a_m and a_d in the share form are:

$$w_m = \alpha_m + \gamma_{mm} \log p_m + \gamma_{md} \log p_d + \beta_m \log(\tau / P),$$

$$w_d = \alpha_d + \gamma_{dm} \log p_m + \gamma_{dd} \log p_d + \beta_d \log(\tau / P),$$

where

$$p_m = 1 + b_m,$$

$$p_d = 1 + b_d,$$

$$\tau = p_m a_m + p_d a_d,$$

$$w_m = \frac{p_m a_m}{\tau},$$

$$w_d = \frac{p_d a_d}{\tau}, \text{ and}$$

$$\log P = \alpha_0 + \sum_{i=m,d} \alpha_i \log p_i + \frac{1}{2} \sum_{i=m,d} \sum_{j=m,d} \gamma_{ij} \log p_i \log p_j.$$

In the above system of demand functions, parameters to be estimated include the α_is, β_is, and γ_{ij}s. One advantage of the AIDS system is that the demand functions do not require the assumption of utility maximization. If utility maximizing behavior is not assumed, the budget shares can be viewed as "unknown functions of log p_i and log [τ]" (Deaton and Muellbauer 1980, p. 315). In this case, we relax both the homogeneity and symmetry restrictions: $\sum_j \gamma_{ij} = 0$ (homogeneity constraint, meaning that if we double both price and budget, the quantity demanded will remain the same) and $\gamma_{ij} = \gamma_{ji}$ (symmetry constraint, or $\partial a_i/\partial p_j = \partial a_j/\partial p_i$, meaning that the change in the consumption of the *i*-th good in response to a change in the price of the *j*-th good must equal the change in the consumption of the *j*-th good in response to a change in the price of the *i*-th good). These restrictions are usually imposed to make the model consistent with the utility maximization framework. In the actual estimation of an AIDS model, these restrictions may be checked to see if the demand functions reflect utility maximizing behavior. This represents a significant advantage over many other models because we are not restricted to demand functions based on utility maximization and yet we have the freedom to test the empirical validity of the restrictions that make the model consistent with utility maximization.

4. Data Base

The database used in this study comprises responses to the 1996 San Francisco Bay Area Household Travel Survey. The survey consisted of a two-day activity and travel diary, and questions obtaining data on household and person characteristics as well as vehicle characteristics. The sample contains about 3618 households and 7990 people. On average, per household there are 2.2 people, 1.3 workers and 1.8 vehicles.

The activities that are included under the maintenance and discretionary categories are listed in Table 1. Cases having activities that were coded as "out of area" or "do not know/ refused" or "other" were dropped from our sample. Travel time was also distinguished by activity category. To avoid inconsistent estimates due to the presence of zero value observations, observations with zero values for any one of the four variables of interest (time allocation to maintenance and discretionary activities and to travel for each of those types of activities) were given a random number with uniform distribution between 0 to 0.01 for the variable in question.

[Table 1 insert here]

The travel time price for maintenance activities, b_m, is calculated as the total travel time for all maintenance activities over two days divided by the total time spent on the maintenance activities themselves (whether in-home or out-of-home), and similarly for discretionary activities. For the modeling, the study excluded observations with a travel time price for maintenance activities (b_m) or for discretionary activities (b_d) that was greater than 1. The final sample used for this study comprised 3906 observations.

The average travel time price for maintenance activities (b_m=0.04) is lower than that for discretionary activities (b_d=0.12), which is well expected. The minimum value for the maintenance share is 0.24 while the minimum value for the share of time spent on discretionary activities/travel is close to 0. In other words, for everyone in the sample, at least 24% of their non-work, non-commute time is spent on maintenance activities and associated travel, whereas there are some people who spend essentially no time on discretionary activities/trips. On average, about 3 times as much time is spent on maintenance activities/trips (with a share of 0.74) as on discretionary ones (with a share of 0.26). Note that since both in-home and out-of-home activity time is counted, the travel time price is capturing tradeoffs between in-home and out-of-home activity – as those tradeoffs currently stand across the sample as a whole.

5. Estimation and Statistical Results

The AIDS model can be estimated with standard statistical software; we used SAS. Both symmetry and homogeneity restrictions were tested. We found that both constraints were satisfied, indicating that the null hypothesis that the model is consistent with utility maximization theory is not rejected. The model results are reported in Table 2. The adjusted R^2s of 0.47 for both models are considered a good fit for disaggregate cross-sectional models (Greene, 2003).

Estimates on the socio-demographic variables indicate that females, younger people, the unemployed, non-blacks, and higher-income people spent a larger share of their total available time on maintenance activities and a smaller share of time on discretionary activities than other people do. By way of explaining the latter two results, descriptive analysis showed that compared to other groups, non-blacks spent more time (in absolute terms) and a greater share of their total available time on sleeping, day care/after school care, personal business, and household maintenance/chores. And although people with higher incomes (annual household incomes greater than or equal to $100,000) allocated, on average, less time (in absolute terms) to maintenance activities than others did, the travel time price (b_m) for people with higher incomes is larger than that for others and the total time available, τ, for people with higher incomes is smaller than that for others. Both contribute to the allocation of a larger *share* of the total available time to maintenance activities by people with higher incomes than for others.

The model also shows that not just total travel time for a given activity type, but also the number of trips of that type plays an important role in time allocation, all else equal. Holding total maintenance travel time constant, the more maintenance trips one makes, the more time is allocated to maintenance activities, and similarly for discretionary trips/activities.

[Table 2 insert here]

Estimates of the parameters β_m and β_d provide information on the time equivalent of income elasticities, referring to the percentage change in the time spent on maintenance and discretionary activities, respectively, in response to a percentage change in the total amount of time available. The time equivalent of income elasticity is calculated as: $e_i = \frac{\beta_i}{w_i} + 1$, where e_i is the time equivalent of income elasticity of good i, and w_i is the budget share of good i. In general, a negative β_i indicates that e_i is between 0 and 1 and thus the i-th good is a necessity; a positive β_i indicates that e_i is greater than 1 and thus the i-th good is a luxury. In our model as shown in Table 2, β_m is negative, meaning that maintenance activities belong to the category of necessary goods (if one had less time, he or she would not decrease the amount of time spent on maintenance activities by as much, proportionally, as the total decrease in time). β_d is positive, meaning that discretionary activities belong to the category of luxury goods (if one had more time, he or she would increase the amount of time spent on discretionary activities by proportionally more than the total increase in time). This is also reflected in two other models estimated for people with different income levels (not shown in this paper). For people whose income falls under $15,000, it was found that their β_d is 0.14, which is slightly higher than for the rest of the sample (0.13). All other estimates are similar. This suggests that for people with low incomes, discretionary activities are even more of a luxury than for people with higher incomes, but not much more so.

Since changes in the full time prices, which are equal to ($1+b_m$) and ($1+b_d$) respectively for maintenance and discretionary activities, would only come from changes in the travel time prices (the b_m and b_d), we calculate and plot the travel time price elasticities directly. To avoid confusion, estimates associated with the γs shown in Table 2 (that is, elasticities with respect to the full time prices) will not be discussed. Our interpretation of the results will concentrate on the calculated own and cross travel time price elasticities described below.

Formulas for the own and cross travel time price elasticities (that is, the percent change in time spent on activity *i* given a percentage change in the travel time price of activity *j*) are: $\varepsilon_{ij} = \frac{\partial \ln a_i}{\partial \ln b_j} = -\delta_{ij} + \frac{\partial \ln w_i}{\partial \ln b_j} = -\delta_{ij} + \frac{1}{w_i} \cdot \frac{\partial w_i}{\partial \ln b_j} = -\delta_{ij} + \frac{b_j}{w_i} \cdot \frac{\partial w_i}{\partial b_j} = -\delta_{ij} + \frac{b_j}{w_i} \cdot \frac{\gamma_{ij} - \beta_i w_j}{1 + b_j}$, where a_i is the amount of time allocated to performing the i-th type of activity; b_j is the amount of time one has to travel in order to perform one unit of time of the j-th type of activity; w_i is the share of time spent on traveling to and performing activity i, $\frac{(1+b_i)a_i}{\tau}$; and δ_{ij} is the Kronecker delta which is equal to 1 when i = j and 0 when i ≠ j. Evaluation of ε_{ij} with the above formula shows that the elasticity (either the own or the cross travel time price elasticity) varies not only with the shares w_m and w_d (which can also be expressed as 1 - w_m), but also with b_j, the travel time price of traveling to perform activity type j. In other words, it is a three-dimensional graph. Figures 1-4 plot the four ε_{ij}s as functions of the cost and share variables, using the estimates of the β_is and the γ_{ij}s in Table 2.

[Figures 1-4 insert here]

The own travel time price elasticities for maintenance and discretionary activities (ε_{mm} and ε_{dd}) are both negative as expected (Figures 1 and 2). In terms of the magnitude, both ε_{mm} and ε_{dd} appear to be smallest when the corresponding travel time price (b_m or b_d) is low. Then, both increase in magnitude as the corresponding travel time price increases. This indicates that when the travel time price of performing either type of activity is low, people adjust their time allocation (in response to a change in the travel time price) to a smaller degree compared to when the travel time price is high. If we interpret the change in the travel time price as coming from the denominator (travel time to activities), this latter observation is quite reasonable. When travel time is high, a given percentage change in travel time constitutes a larger absolute amount of time than when it is low. Further, when travel time is high, the amount of time originally allocated to activities must be relatively lower, and hence the larger absolute amount of time released by the percentage change in travel time constitutes a larger percentage of activity time, than when travel time is originally low and activity time is high.

Figures 1 and 2 also show that the rates of increase of the own travel price elasticities for both maintenance and discretionary activities appear to be quite stable along the axis of the share of maintenance and discretionary (respectively) activities throughout, indicating that the current shares of maintenance and discretionary activities do not appear to play a significant role in their own travel time price elasticities. In addition, although the absolute values of both elasticities are generally greater than 1, the magnitude for maintenance activities is considerably smaller that that for discretionary activities, indicating less scope for adjustment of maintenance activities than for discretionary activities, when the travel time price of the corresponding type of activity increases.

The cross travel time price elasticities of maintenance and discretionary activities with respect to the travel time prices for discretionary and maintenance activities respectively, ε_{md} and ε_{dm}, are positive and increase in magnitude when the travel time prices for discretionary and maintenance activities increase (Figures 3 and 4). That is, an increase in the travel time price of each type of activity leads to an increase in time spent on the other type of activity. A potential two-directional substitution effect between discretionary and maintenance activities may explain this result. People may obtain positive utilities by performing certain maintenance (discretionary) activities. Thus, a reduction in the utility associated with a maintenance (discretionary) activity (due to the increase in the time cost of activity performance) may be partially re-collected by performing more discretionary (maintenance) activities.

In sum, the negativity of ε_{mm} and ε_{dd} found in this study is mostly consistent with a number of studies in the literature which identified a negative relationship between time allocation to different types of activities and travel (e.g., Levinson 1999; Golob and McNally 1997; Lu and Pas 1999; Fujii et al. 1997, cited by Kitamura et al. 1997; Kuppam and Pendyala 2001). The positivity of ε_{md} and ε_{dm}, while not surprising, identifies a substitution effect between activity types *tied to a change in the travel time price of one type*, which to our knowledge has not been previously identified in this form.

6. Discussion

In this paper, we developed and estimated a simple model of the tradeoff behavior between maintenance activities/travel and discretionary activities/travel, including both in-home and out-of-home activities. Using 3906 responses to the 1996 San Francisco Bay Area Household Travel

Survey, the empirical answers to our initial research questions are as follows. With respect to the time equivalent of income elasticities of maintenance and discretionary activities, we found the former to be less than unity and the latter to be greater than unity. That is, if one had a certain amount of additional time, one would increase the amount of time allocated to maintenance activities disproportionally less, but would increase the amount of time devoted to discretionary activities disproportionally more. In other words, maintenance activities are a necessity and discretionary activities are a luxury.

With respect to the own travel time price elasticities, if the travel time price of performing either type of activity increases (for reasons such as traffic congestion), one would reduce the time allocated to that type of activity itself. The negativity of the own travel time price elasticities for both maintenance and discretionary activities is consistent with the negative slope often observed in the demand curve for goods. As expected, the time spent on maintenance activities is less elastic than the time spent on discretionary activities.

As for the cross travel time price elasticities (changes in time allocated to activity i in responses to changes in the time price for activity j), we found both $\varepsilon_{md} > 0$ and $\varepsilon_{dm} > 0$, indicating that maintenance and discretionary activities are substitutes.

The present work can shed light on the tradeoff between in-home and out-of-home maintenance and discretionary activities. If people can and are willing to substitute nearly all their out-of-home activities with similar in-home activities (so that the travel time prices b_m and b_d become close to zero), we observe that the magnitudes of the own travel time price elasticities for both types of activities become the smallest (close to -1). In other words, the two elasticities become equal to each other and a percentage increase in the travel time price will result in an equal percentage reduction in the time allocation to the corresponding activity. When the travel time prices for maintenance (b_m) and discretionary activities (b_d) are close to zero, the cross travel time price elasticities for discretionary and maintenance activities are also close to zero, suggesting that an increase in the travel time price for maintenance or discretionary activities will not initiate any change in the time allocation to discretionary or maintenance activities, respectively.

There is still more to be investigated. For example, the consumption of goods and consumption of time are probably interrelated with each other. A detailed discussion of the inter-relationship between time and money is available from a more extended version of the paper (Chen and Mokhtarian, 2005). The conceptual differences between time and money (Leclerc, et al. 1995) call for alternative model frameworks to be developed (other than the modified classical microeconomic models) for better incorporation of goods consumption and time allocation, as well as for the collection of information on monetary budget and goods consumption from the same sample as that providing time allocation information. As it is, most Metropolitan Planning Organizations (MPOs) in the U.S. collect information on time allocation to every activity (generally defined) and trip, but little or no monetary information related to goods consumption (except of travel). Conversely, programs such as the U. S. Consumer Expenditure Survey (http://www.bls.gov/cex/home.htm) collect data on monetary expenditures across all types of goods and services, but no information regarding time expenditures on activities and travel.

It is also important to understand that what is estimated in our paper (as is the case for any single model over an entire sample) are general population average relationships, for the spatial and demographic characteristics of the population from which our sample is drawn. The stability of the travel time prices as well as the estimated parameters over time, space and different populations calls for future investigation. The travel time prices as well as the parameters of the model could in fact be expected to vary by demographic traits (e.g., in this study we found that the time equivalent of income elasticity of discretionary activities for people with household incomes below $15,000 is slightly larger than that of the rest of the sample) and geographic characteristics (e.g., the travel time price may be higher in rural areas than in urban ones). Travel time prices may also change over time. For example, with increasing use of Information and Communication Technologies (ICT), people may substitute many of their out-of-home activities with in-home activities (e.g., shopping activities, going to the bank). These changes will likely change the travel time prices for various kinds of activities (e.g., the travel time price for maintenance activities may be reduced).

Furthermore, this study strictly dealt with intra-person time allocation and shed no light on inter-person time allocation. However, inter-person time allocation (in particular between household members) is probably relevant to intra-person time allocation. Therefore, incorporation of the inter-dependence between household members into a time allocation study should be one of the next steps for future research.

Lastly, the dataset used in this study is a cross-sectional dataset, containing responses from multiple individuals at a single point of time. Although the tradeoffs identified in this paper are described as intra-person tradeoffs, they are actually derived from inter-person comparisons based on the strong assumptions that behavior is symmetric and reversible (Kitamura 1990; i.e., the behavior of a person whose travel time price *changes* from, say, b_{m1} to b_{m2} is the same as that of an otherwise identical person whose travel time price is *currently* b_{m2}). Furthermore, the use of a cross-sectional dataset does not allow us to distinguish between the consequences of short-term and long-term changes present in the sample. For example, some effects may be the result of the combination of a change in job/home location and a change in the time allocation to maintenance/discretionary activities/travel. Correction of this potential problem calls for a panel dataset collection that tracks individuals' time-use behavior as well as their long-term choices (home/job location choices) over time.

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Table 1: List of Activities Classified as Maintenance and Discretionary

Maintenance Activities	Discretionary Activities
Shopping	Recreation/rest
Meals/preparation	Recreation/play
Sleep	Amusement at home
Day care/after school care	Visiting
Personal service	Entertainment
Medical service	Religion/civic[2] services
Professional business	Civic /volunteer services
HH/personal service	Amusement outside home
HH/maintenance chores	Hobbies
HH/obligation and family care	Exercise/athletics
Sick/ill	Computer
Waiting	Get ready[1]
Morning routine	
Evening routine	
Get ready[1]	
Hygiene	
Diary	

[1] The code for “get ready” is not for getting ready in the morning and in the evening, which mainly involves personal hygiene activities and hence belongs to the maintenance category. Here, “getting ready” is interpreted as getting ready for the next activity and thus can be classified as either a maintenance or a discretionary activity, depending on the type of the next activity.
[2] In the data dictionary for the 1996 MTC household travel survey data, this is called “religion/civil services”, which we took to be a typographical error.

Table 2: Estimation Results of the AIDS Model for Time Allocation[1]

Variable	Estimate	t-ratio	p-value
Maintenance			
Intercept (α_m)	1.79	40.38	<0.01E-2
Ln(1+b_m)[4] (γ_{mm})	-0.24	-25.13	<0.01E-2
Ln(1+b_d)[5] (γ_{md})	0.24	25.13	<0.01E-2
Ln(τ/P)[6] (β_m)	-0.13	-22.57	<0.01E-2
Male	-0.03	-9.85	<0.01E-2
Age	-0.04E-2	-4.71	<0.01E-2
Employed (1 if employed and 0 otherwise)	-0.01	-3.21	0.13E-2
Black	-0.03	-3.91	<0.01E-2
Highinc (1 if household income is ≥ $100,000)	0.01	2.64	0.84E-2
Number of maintenance trips	0.02	25.99	<0.01E-2
Number of discretionary trips	-0.03	-40.32	<0.01E-2
Adjusted R-squared: 0.47			
Discretionary			
Intercept (α_d)	-0.79	-40.38	<0.01E-2
Ln(1+b_m)[4] (γ_{dm})	0.24	25.13	<0.01E-2
Ln(1+b_d)[5] (γ_{dd})	-0.24	-25.13	<0.01E-2
Ln(τ/P)[6] (β_d)	0.13	22.57	<0.01E-2
Male	0.03	9.85	<0.01E-2
Age	0.04E-2	4.71	<0.01E-2
Employed (1 if employed and 0 otherwise)	0.01	3.21	0.13E-2
Black	0.03	3.91	<0.01E-2
Highinc (1 if household income is ≥ $100,000)	-0.01	-2.64	0.84E-2
Number of maintenance trips	-0.02	-25.99	<0.01E-2
Number of discretionary trips	0.03	40.32	<0.01E-2
Adjusted R-squared: 0.47			
Constraint Tests			
Adding up	2.19E-10	0.00	1.00
Symmetry	-3.42E-11	-0.00	1.00
Homogeneity (m)[2]	-22.26	-1.08	0.28
Homogeneity (d)[3]	22.26	0.40	0.69

[1] Both symmetry and homogeneity constraints are imposed and satisfied. [2] Homogeneity constraint for maintenance activities. [3] Homogeneity constraint for discretionary activities. [4] b_m is the travel time price for maintenance activities. [5] b_d is the travel time price for discretionary activities. [6] τ is total available time minus time spent on mandatory activities and their associated travel; and

$$\log P = \alpha_0 + \sum_{i=m,d} \alpha_i \log p_i + \frac{1}{2} \sum_{i=m,d} \sum_{j=m,d} \gamma_{ij} \log p_i \log p_j .$$

Figure 1: Own Travel Time Price Elasticity of Time Spent on Maintenance Activities, as a Function of Travel Time Price for Maintenance Activities (b_m) and Share of Time Spent on Maintenance Activities/Travel (w_m)

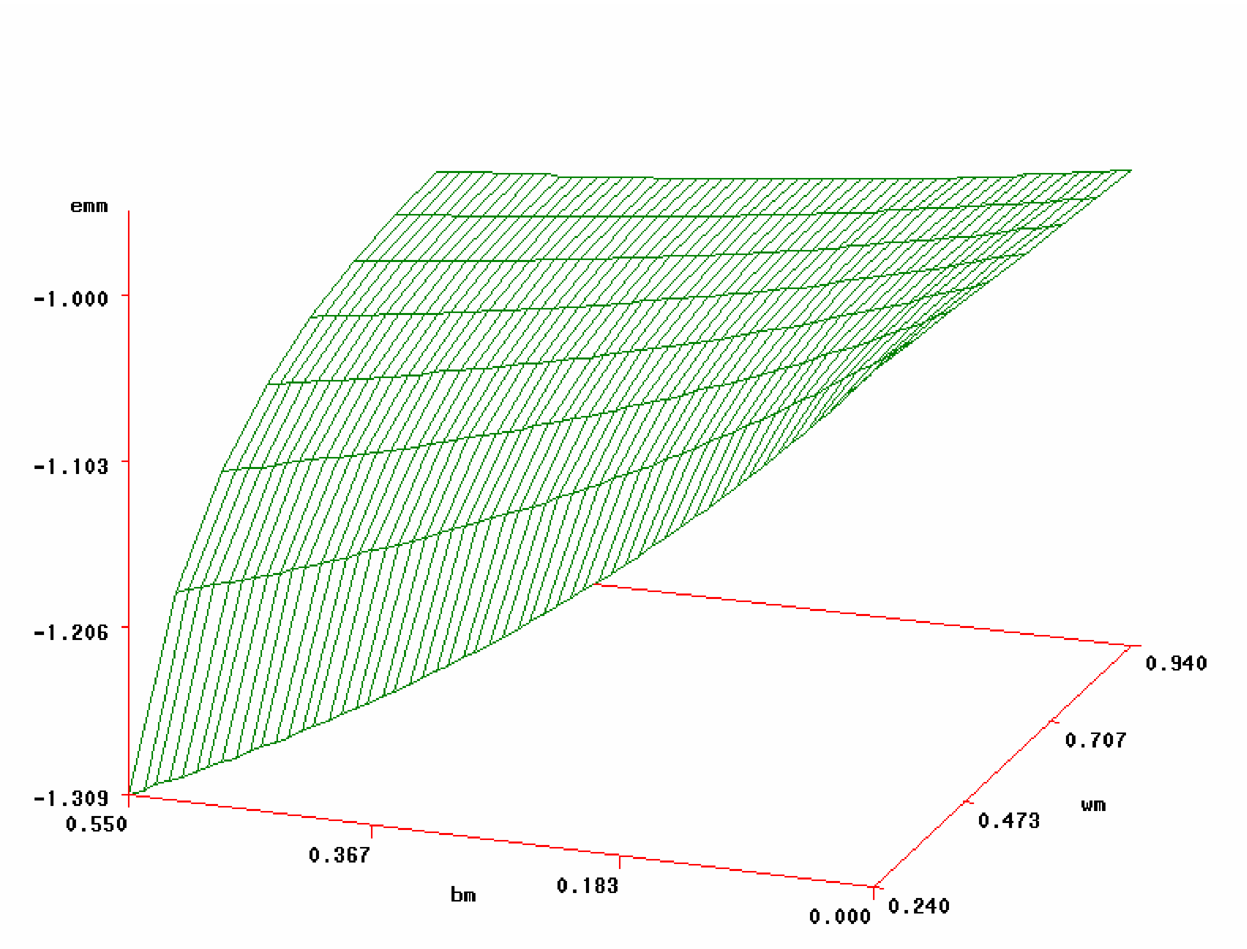

Figure 2: Own Travel Time Price Elasticity of Time Spent on Discretionary Activities, as a Function of Travel Time Price for Discretionary Activities (b_d) and Share of Time Spent on Discretionary Activities/Travel (w_d)

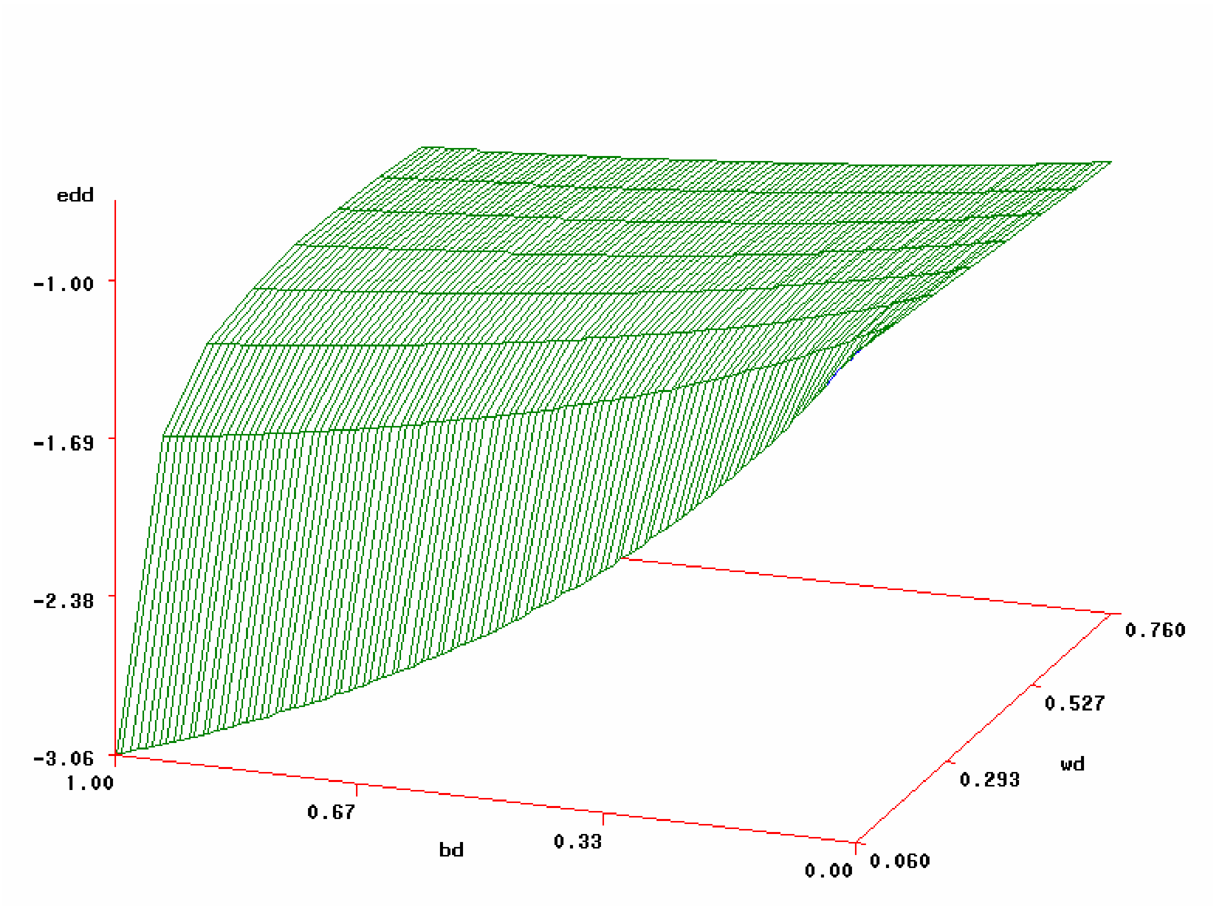

Figure 3: Cross Travel Time Price Elasticity of Time Spent on Maintenance Activities, as a Function of Travel Time Price for Discretionary Activities (b_d) and Share of Time Spent on Maintenance Activities/Travel (w_m)

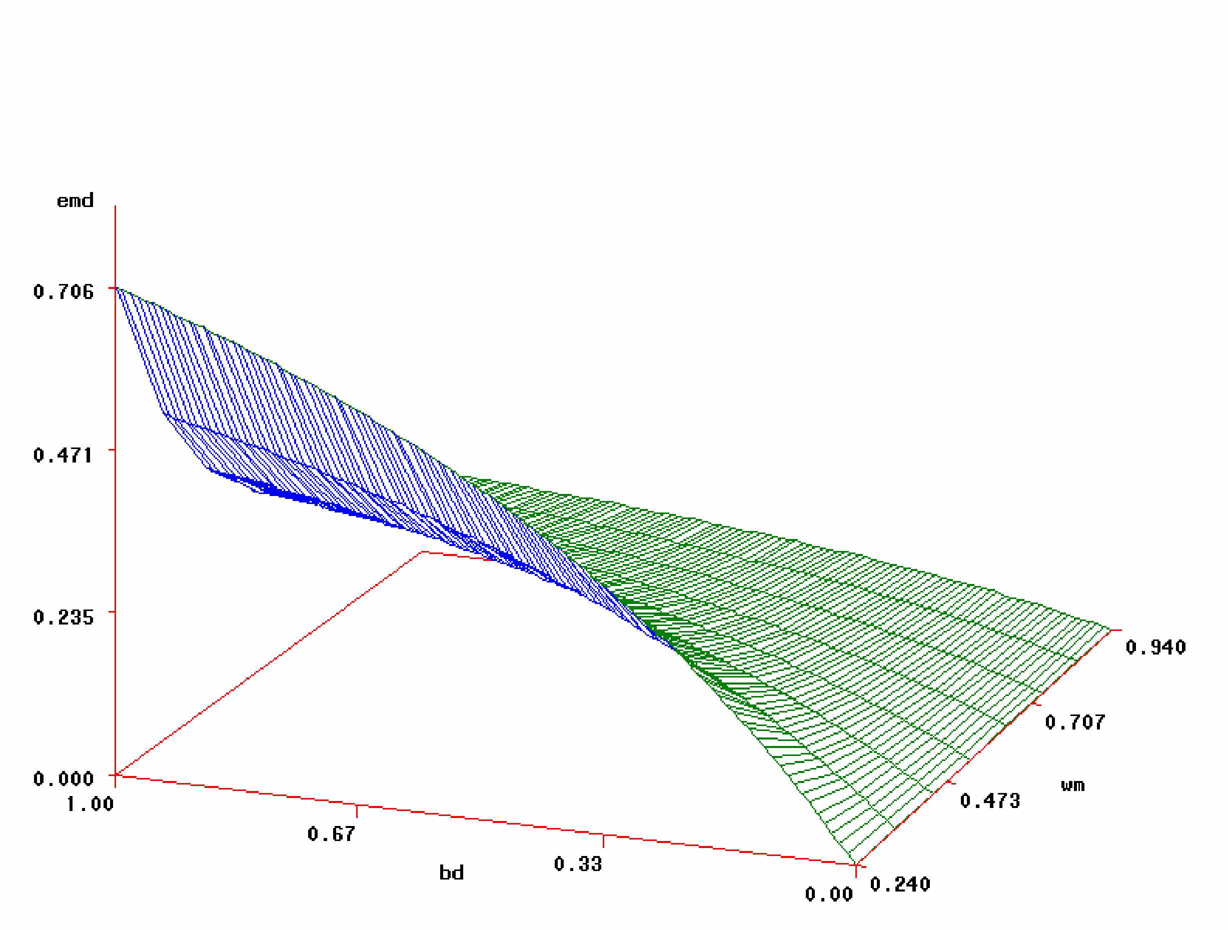

Figure 4: Cross Travel Time Price Elasticity of Time Spent on Discretionary Activities, as a Function of Travel Time Price for Maintenance Activities (b_m) and Share of Time Spent on Discretionary Activities/Travel (w_d)