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ESTIMATING THE VALUE OF LEISURE FROM A TIME ASSIGNMENT MODEL

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Abstract

A new approach to calculate the value of leisure is developed and applied. This is derived from a consumer behaviour model that includes goods and activities. A system of time assignment equations is explicitly obtained from which the values of both leisure and work can be analytically calculated using econometrically estimated parameters. This framework is applied using detailed data from three samples in diverse settings: Santiago (Chile), Karlsruhe (Germany), and Thurgau (Switzerland). The empirically estimated values of leisure differ from the wage rate and a theoretical justification is provided.

Introduction

We are witnessing an increased interest in the perception of the quality of life by individuals. Many authors have investigated the relations between each of many variables and what is generically called happiness, both at a macro and individual levels (see the very good synthesis by Frey and Stutzer, 2002, and Layard's 2003 lectures). We believe that time assignment theories can make a contribution to a better understanding of individual well-being within the ever evolving work and social environments, as they have since long established theoretical relations among the different values of time. After all, understanding time allocation is just as understanding life itself.

After Becker's (1965) pioneering work, time value was looked at in a single dimension, namely as the opportunity cost of work time equal to the wage rate, a property that followed the absence of work time in utility, criticized soon after by Johnson (1966), Oort (1969) and Evans (1972). By 1971, De Serpa identified three concepts of time value: the value of time *as a resource*, the value of *assigning time* to an activity, and the value of *saving time* in a constrained activity. The first corresponds to the money value of an increase in available time. The second is the ratio between the marginal utility of an activity and the marginal utility of money, i.e. the trade-off between the activity and money at the margin. The third, finally, is the willingness to pay to reduce the (constrained) time assigned to an activity. As evident, this latter value would be zero for each of those activities that are freely assigned more time than the minimum required. De Serpa defined these as *leisure* activities, and they have the property

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of having the same value assigned at the margin, otherwise time would be relocated from the less to the more valuable activities. This single value is exactly the value of time as a resource, which, because of this, is also known as the value of leisure. This value is not only indicative of the pure perception of time, but also is part of the willingness to pay to reduce exogenously constrained activities, which is at the heart of the appraisal of projects in sectors as transport. So far, the value of leisure has never been estimated empirically from consumers' behaviour models with a microeconomic basis that include time assigned to activities. This is the main contribution of this paper.

There have been other attempts at estimating leisure values from other perspectives. For example, Álvarez-Farizo et al. (2001) identify travel time savings with the activity at the destination, which makes them associate the value of leisure time to the value of time assigned to a leisure trip; they used contingent rating to calculate this value. The general association between time assigned to a trip and its purpose at the destination is at least debatable, as the trip time could also be associated with the activity at the origin, an ambiguity that arises precisely because of the lack of a microeconomic consumer behaviour approach. Nevertheless, this is a plausible approach in the particular case of leisure trips. Lee and Kim (2005) make the value of leisure equal to the reservation wage, and develop a method to estimate it by means of a switching regression model with endogenous switching, which is applied to the information collected through interviews about the willingness to reduce the weekly number of hours at work. Using data from 1997 and 1998, they conclude that the Asian crisis induced a non-negligible reduction in the value of leisure. Aguiar (2006) examined the trends in time use and proposed a concept of leisure that uses Becker's (1965) framework, where utility depends on the consumption of commodities, which require time and goods to be produced. Leisure commodities would be those where time cannot be easily substituted by goods. Such definition was then abandoned in favour of the simpler (but less rigorous) concept of an arbitrary time aggregate. It is worth mentioning the theoretical analysis by Shaw (1992), who makes a case for an opportunity cost of an individual's time different from the wage rate.

In this paper we use a general consumer behaviour approach to derive a system of equations to model time assigned to all activities and to estimate the value of leisure and the value of time assigned to work from data sets that include fairly detailed, but not onerous levels of information on activity time assignment. These data sets were collected in the cities of

Karlsruhe, Germany (Axhausen et al., 2002) and Santiago, Chile (Jara-Díaz et al., 2004), and in the Canton Thurgau, Switzerland (Löchl et al., 2005), using different methods and with different levels of detail regarding activities and income. The formulation follows the general framework developed by Jara-Díaz (1998a,b) and expands and corrects the model proposed and used by Jara-Díaz and Guevara (2003), who generated a system of equations for the joint estimation of labour supply and discrete travel choice models, whose estimation was improved later on by Munizaga et al. (2006) to account for correlation between discrete and continuous equations.

The model is presented in the following section and the three data sets are described in section 2. The model system is used to estimate the value of leisure and the value of time assigned to work for the three samples, which are compared using the corresponding wage rates as the reference. In section 3 we conclude that the theoretical possibility of a value of leisure different from the wage rate can actually happen, and that the results suggest that the relative values depend on work schedules, working conditions and committed time.

1. A Model Of Time Allocation

After many years of discussion and contributions from research into home production, labour supply and transport, an implicit agreement has been reached regarding a fairly complete microeconomic formulation of consumer behaviour encompassing not only goods consumption but also time assigned to activities. After Becker (1965), who introduced time as an input to obtain final goods, authors like Johnson (1966), Oort (1969) and De Serpa (1971) included all activity duration as a direct source of utility in a consumer's behaviour framework. The quite elegant piece by Evans (1972) went further to postulate activities as the only source of utility. Later on, and from different perspectives, the consumption-activity model has gradually settled in the literature. Gronau (1986) expanded Becker's framework in this direction, and both Winston (1987) and Juster (1990) adopted this more general approach as well.

In a general model encompassing activities and goods, in which individuals derive utility from what they do as well as from the goods consumed during those activities, three types of relations (restrictions) have to be taken into account. First, a money budget constraint that accounts for all expenses and all types of income. Second, a total time constraint for activity

times limited by social and biological cycles (days, weeks, months). And third, technical constraints that deal with goods consumption and minimum time assignments. Let $T=(T_i)$ be the vector of time assigned to activities, $X=(X_j)$ the vector containing the amount of goods consumed during period t , T_w the time assigned to work, P_j the price of good j , w the wage rate and I income from other sources but work. Let activities and consumption have minima given by T_i^{Min} and X_j^{Min} respectively. Then a general model would look as

$$\begin{array}{ll} \text{Max} & U(T, X) \\ \text{subject to} & \end{array} \quad (1)$$

$$I + wT_w - \sum_j P_j X_j \geq 0 \leftarrow I \quad (2)$$

$$t - T_w - \sum_i T_i = 0 \leftarrow m \quad (3)$$

$$T_i - T_i^{Min} \geq 0 \leftarrow k_i \quad \forall i \quad (4)$$

$$X_j - X_j^{Min} \geq 0 \leftarrow h_j \quad \forall j \quad (5)$$

where the Lagrange multipliers have been included. The analytical solution of this model yields, in general, equations for time use and goods consumption, $T^*(...)$ and $X^*(...)$.

In this model, the value of time as a resource is given by μ/I , the value of time assigned to an activity i is $(\partial U / \partial T_i) / I$ and the value of saving time in an activity i is k_i / I . From the first order conditions on activities and work time two well-known important relations regarding the values of time are obtained, namely

$$\frac{k_i}{I} = \frac{m}{I} - \frac{\partial U / \partial T_i}{I} \quad \text{and} \quad (6)$$

$$\frac{m}{I} = w + \frac{\partial U / \partial T_w}{I} \quad (7)$$

Equation (6) shows that the value of saving time in activity i equals the value of time as a resource minus the value of time assigned to that activity. The interpretation is straightforward: if an activity is assigned the minimum necessary, the willingness to pay to reduce that exogenous minimum is the value of the liberated time - that can be assigned to other activities - minus the value of time assigned to what is being reduced. If the activity in question is freely assigned more time than the minimum, the multiplier k_i is nil, which means that unconstrained activities must have equal positive marginal utilities (all equal to μ); if they were different, the individual would reassign time from the less valuables to the others. As

these are leisure activities by definition in a DeSerpa framework, μI is the value of leisure. On the other hand, the right hand side of equation (7) includes the wage rate, which is the money value of the goods that can be bought with a unit time worth of work, and the money value of the marginal utility of a unit time at work, which is the value of assigning time to work. These two components add up to the total value of work. Therefore, equation (7) establishes that the value of leisure should be equal to the total value of work. Intuitively, this equality arises because if the value of leisure was larger (smaller) than the total value of work, the individual would diminish (increase) time at work. For short, at the margin the pleasure from freely assigning time to leisure equals the money reward from work plus the pleasure (or displeasure) of working.

To turn the preceding framework into an analytically workable model, let utility in equation (1) be given a Cobb-Douglas form whose properties are exposed below. If W is a positive constant, j_j and q_i are the exponents associated with good j and activity i respectively, then

$$U = \Omega T_w^{q_w} \prod_i T_i^{q_i} \prod_j X_j^{j_j} \quad . \quad (8)$$

The problem formed by equations (8), (2), (3), (4) and (5) corresponds to the expansion of the more limited framework proposed by Jara-Díaz and Guevara (2003), where only one technical constraint regarding minimum travel time was imposed as the emphasis was on the value of travel time savings. Let us derive the demand functions.

Let A^f be the set of freely chosen activities, A^r the set of activities assigned the minimum required T_r^{Min} , G^f the set of freely chosen goods, and G^r the set of goods of which the minimum required X_j^{Min} is consumed.

The first order conditions for goods are

$$\frac{j_j U}{X_j} - I P_j = 0 \quad \forall j \in G^f \quad (9)$$

$$\frac{j_j U}{X_j^{Min}} + h_j - I P_j = 0 \quad \forall j \in G^r \quad (10)$$

For activities but work

$$\frac{\mathbf{q}_i^U}{T_i} - \mathbf{m} = 0 \quad \forall i \in A^f \quad (11)$$

$$\frac{\mathbf{q}_i^U}{T_i^{Min.}} + \mathbf{k}_i - \mathbf{m} = 0 \quad \forall i \in A^r \quad . \quad (12)$$

Finally, the first order condition for work is

$$\frac{\mathbf{q}_w^U}{T_w} + \mathbf{l}_w - \mathbf{m} = 0 \quad (13)$$

Note that every unpleasant activity will be assigned the exogenous minimum, because the sign of its marginal utility is the same irrespective of duration under this specification. This does not mean that an activity that is assigned the minimum time is necessarily unpleasant, because the optimal time assignment could be less than the exogenous minimum. As the value of time as a resource is positive, the exponents of the uncommitted activities, i.e. those in A^f , should be positive as indicated by equation (11). This is not the case for work because there is a money reward attached to it, as established by equation (13), which clearly shows that \mathbf{q}_w could be negative, positive or zero, an important analytical property indeed as it carries the sign of the marginal utility of labour. On the other hand, equation (9) shows that the exponents of freely chosen goods are also positive.

First order conditions (11) for all activities in A^f plus constraints (3) and (4) yield

$$\frac{\mathbf{m}}{U} = \frac{\Theta}{\left(\mathbf{t} - T_w - \sum_{i \in A^r} T_i^{Min.} \right)} \quad , \quad (14)$$

where $\Theta > 0$ is the summation of the (positive) exponents \mathbf{q}_i over all unrestricted activities. Note that the denominator is simply the uncommitted time. Similarly, if $\Phi > 0$ is the summation of the (positive) exponents \mathbf{j}_j over all unrestricted goods, first order conditions (9) over all goods in G^f plus constraints (2) and (5) yield

$$\frac{\mathbf{l}}{U} = \frac{\Phi}{\left(wT_w + \left(I - \sum_{j \in G^r} P_j X_j^{Min.} \right) \right)} \quad . \quad (15)$$

Define committed expenses $E_c = \left(\sum_{j \in G^r} P_j X_j^{Min.} - I \right)$ and committed time $T_c = \sum_{i \in A^r} T_i^{Min.}$.

Dividing equation (13) by U and replacing equations (14) and (15) in the resulting expression, a second order equation for T_w is obtained, namely

$$\frac{\mathbf{q}_w}{T_w} + w \frac{\Phi}{(wT_w - E_c)} - \frac{\Theta}{(t - T_w - T_c)} = 0 \quad . \quad (16)$$

From this one gets

$$T_w^* = \frac{(\Phi + \mathbf{q}_w)(t - T_c) + (\Theta + \mathbf{q}_w) \frac{E_c}{w} \pm \sqrt{\left((\Phi + \mathbf{q}_w)(t - T_c) + (\Theta + \mathbf{q}_w) \frac{E_c}{w} \right)^2 - 4\mathbf{q}_w(t - T_c) \frac{E_c}{w}}}{2(\Theta + \Phi + \mathbf{q}_w)} \quad . \quad (17)$$

Solving equation (16) for $\mathbf{q}_w=0$, the solution for the optimal work hours coincide with the limit of equation (17) when \mathbf{q}_w approaches 0 only for the + sign of the square root, which is the valid solution. Equation (17) has the same structure as the one obtained by Jara-Díaz and Guevara (2003) but it is more general, as it includes committed expenses and committed time as explanatory variables instead of travel cost and travel time (which are included in T_c and E_c respectively).

On the other hand, from equations (11) and (14) we get an expression for the time assigned to freely chosen activities given by

$$T_i^* = \frac{\mathbf{q}_i}{\Theta} (t - T_w^* - T_c) \quad \forall i \in A^f \quad . \quad (18)$$

Similarly, combining equations (9) and (15) an expression is obtained for the demand for freely chosen goods given by

$$X_j^* = \frac{\mathbf{j}_j}{P_j \Phi} (wT_w^* - E_c) \quad \forall j \in G^f \quad . \quad (19)$$

These equations establish that time assignment and goods consumption depend on the wage rate w , on committed expenses E_c , on committed time T_c , and on individuals' preference parameters. Further analyses of the obtained equations reveal some properties that are

associated with the Cobb-Douglas form. Note that equation (19) can be easily turned into expenses in good j by moving price to the left hand side, a modification that permits trivial goods aggregation. It is simple to verify that the coefficients of uncommitted time out of work and available income in equations (18) and modified (19) respectively are proportions that add up to one. As shown below, E_c plays an important role in these equations.

Let us define normalized utility parameters as $\mathbf{b}=(\mathbf{F}+\mathbf{q}_w)/2(\mathbf{Q}+\mathbf{F}+\mathbf{q}_w)$, $\mathbf{a}=(\mathbf{Q}+\mathbf{q}_w)/2(\mathbf{Q}+\mathbf{F}+\mathbf{q}_w)$, $\mathbf{g}_i=\mathbf{q}_i/(\mathbf{Q}+\mathbf{F}+\mathbf{q}_w)$ and $\mathbf{d}_k=\mathbf{j}_k/(\mathbf{Q}+\mathbf{F}+\mathbf{q}_w)$. As \mathbf{Q} and \mathbf{F} are positive, both \mathbf{a} and \mathbf{b} are less than 0.5, which will prove useful later on. Using these definitions in equations (17), (18) and (19) a simplified individual labour supply model (equation 20) and the corresponding equations for time assigned to activities (21) and for goods consumption (22) are obtained as

$$T_w^* = \mathbf{b}(t - T_c) + \mathbf{a} \frac{E_c}{w} + \sqrt{\left(\mathbf{b}(t - T_c) + \mathbf{a} \frac{E_c}{w} \right)^2 - (2\mathbf{a} + 2\mathbf{b} - 1)(t - T_c) \frac{E_c}{w}} \quad , \quad (20)$$

$$T_i^* = \frac{\mathbf{g}_i}{(1 - 2\mathbf{b})} (t - T_w^* - T_c) \quad \forall i \in A^f \quad \text{and} \quad (21)$$

$$X_j^* = \frac{\mathbf{d}_j}{P_j(1 - 2\mathbf{a})} (wT_w^* - E_c) \quad \forall j \in G^f \quad . \quad (22)$$

The resulting system explains time assignment and goods consumption in an integrated fashion, involving transformations of the coefficients that accompany the marginal utilities of discretionary activities and consumption. Note that normalization has been done adding over the exponents of all uncommitted consumption and activities (including labour). By defining the ratio between committed expenses and the maximum possible income $e_c = E_c/w(t - T_c)$, equation (20) turns into

$$T_w^* = (t - T_c) [(\mathbf{b} + \mathbf{a}e_c) + \sqrt{(\mathbf{b} + \mathbf{a}e_c)^2 - e_c(2\mathbf{a} + 2\mathbf{b} - 1)}] \quad . \quad (23)$$

Varying e_c from 0 to 1 makes optimal work time T_w^* move from $2\mathbf{b}(t - T_c)$, a fraction of available time, to $(t - T_c)$, as expected. This analysis also highlights the importance of committed expenses in the labour equation, as they are generally different from zero and justify the presence of the wage rate in the resulting model system, overcoming one of the limitations induced by the Cobb-Douglas form, namely that time assigned to work would be

independent of the wage rate if E_c was zero. Note also that changes in goods prices have an effect in optimal (uncommitted) expenses and/or time assignment only if they occur in prices of committed goods, which operate through E_c . These properties make model (20)-(22) more than an extension of that obtained by Jara-Díaz and Guevara (2003), including activities and consumption equations and more reasonable explanatory variables.

Equations (20) to (22) can be used as the basis for the estimation of the parameters involved. Equation (20) includes α and \mathbf{b} only. Equation (21) adds one parameter (\mathbf{g}) to be estimated for each freely chosen activity i . In the same way, equation (22) adds one parameter (\mathbf{d}_k) for each goods consumption equation included. Because of the restrictions on consumption and time, only up to $n-1$ time assignment or good consumption models can be estimated (with n the cardinal of the corresponding set of unrestricted activities or goods). When using this model system for econometric estimation, one has to assume *a priori* which activities (or goods) are restricted, which is something that can be explored empirically. Although α and \mathbf{b} can be estimated using equation (20) only, they might be more efficiently estimated together with \mathbf{g} and \mathbf{d}_k using equations (21) and (22). Note that, depending on the available information, one can choose to estimate the whole system of equations or a subset, as for example labour supply and activities, as we will do in the next section.

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 (or goods) does not change the structure of the model. This can be observed directly from the definition of both \mathbf{Q} and \mathbf{F} , which are summations over unrestricted activities and goods respectively. 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. Dividing equation (14) by (15) and using the definitions of \mathbf{a} and \mathbf{b} one gets the following expressions of the value of leisure

$$\frac{\mathbf{m}}{\mathbf{l}} = \frac{\Theta \left(wT_w^* - E_c \right)}{\Phi \left(\mathbf{t} - T_w^* - T_c \right)} = \frac{1 - 2\mathbf{b} \left(wT_w^* - E_c \right)}{1 - 2\mathbf{a} \left(\mathbf{t} - T_w^* - T_c \right)} \quad (24)$$

On the other hand, recalling that the marginal utility of work time is given by $U\mathbf{q}_w/T_w$ and using equation (15) to solve for U , the value of time assigned to work happens to be given by

$$\frac{\partial U / \partial T_w}{I} = \frac{\mathbf{q}_w}{\Phi} \frac{(wT_w^* - E_c)}{T_w^*} = \frac{2\mathbf{a} + 2\mathbf{b} - 1}{1 - 2\mathbf{a}} \frac{(wT_w^* - E_c)}{T_w^*} \quad (25)$$

The definitions of \mathbf{Q} , \mathbf{F} and \mathbf{q}_w provide intuition for these results, as the value of leisure in equation (24) increases with the relative importance of leisure activities in utility and with what we have called the **expenditure rate** within the goods/leisure framework, defined as the ratio between uncommitted income and uncommitted time available to spend it. Similarly, the value of work in equation (25) increases with its relative importance in utility.

2. Description Of The Data

This new microeconomic model system of time assignment to activities requires detailed information on activities and income structure of individuals. We present three such data sets collected in quite different settings. One is the relatively small city of Karlsruhe, Germany, with 290 thousand inhabitants in 174 km². The second is a south-east corridor (360 thousand inhabitants in 70 km²) in Santiago, Chile, a capital city with 5.5 million inhabitants in 868 km². The third is the Canton Thurgau, Switzerland, a region with 228 thousand inhabitants in 991 km².

The data sets differ in the collection methods and in their levels of detail. The German and Swiss data were based on a six-weeks travel diary and personal interviews at home. In Karlsruhe 159 individuals older than six years participated, of which 90 are workers (MOBIDRIVE: Axhausen et al., 2002). The Swiss sample consists of 230 individuals, of which 126 are workers (THURGAU: Löchl et al., 2005). The Chilean data is based on a three day activity diary (workday and weekend) and personal interviews at the work place with 290 downtown workers (TASTI: Jara-Díaz et al., 2003). Table 1 summarizes the general characteristics of each sample of workers. We assume that our samples have achieved their long run equilibrium regarding work by adjusting schedules and salaries through job search and negotiation; note that we have included all types of work arrangements observed in the data, such as full or part time and even self employed workers.

Besides the difference in national income *per capita*, German and Swiss households are smaller in size. A smaller proportion of workers have more than one work in the German

sample compared with the Chilean sample (this analysis cannot be done for the Swiss sample because the question was formulated in a different manner). Swiss and German workers work nearly one day less per week than their Chilean counterparts. Compared with both Chilean and German samples, the Swiss one has more men, more one worker households and more married people.

Table 1. Aggregate description of the workers in the samples.

Characteristic	Santiago	Karlsruhe	Thurgau
Gender [% women]	42.4	46.7	37.3
Marital status [% married]	67.6	63.3	74.6
Most frequent age range and its share (%)	35-49 (47.9)	= 50 (37.8)	35-49 (39.7)
Average household size	3.8	2.5	2.5
One worker households [%]	32.8	48.1	62.4
Mobile phone ownership [%]	73.5	51.1**	n.a.
e-mail access [%]	47.2	47.8**	n.a.
Individuals with more than one work [%]	14.1	5.6	19.8 ⁺
Average working hours per week	45.2	32.5	36.5
Average workers income [US\$/month]***	867.7	-	-
Average household income [US\$/month]***	-	2,546	6,922
Share of full time workers	100.0	63.3	77.8
Sample size (diary duration)	290 (3 days)	90 (6 weeks)	126 (6 weeks)
Country indicators*			
Life expectancy at birth (years)	76.4	78.3	80.5
GNI per capita [US\$/year]	4,360	25,270	40,680

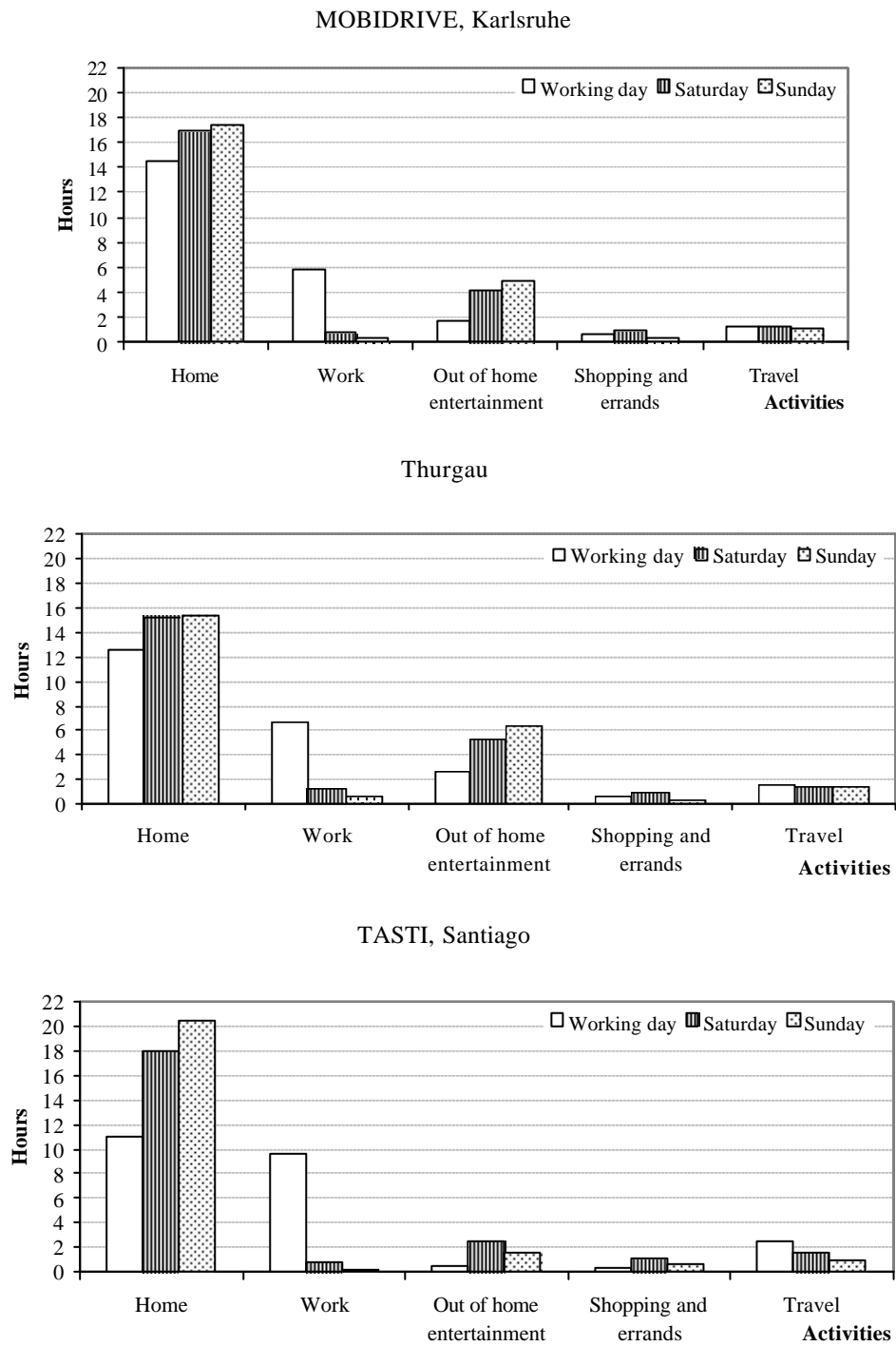
n.a. no information available

* Source: World Bank web page, 2003. ** Household information, not individual.

***One dollar = 634.94 pesos (average 2001) = 1.863 DM (average September 1999) = 1.345 CHF (average 2003). ⁺ Individuals reported to have an additional occupation.

Regarding activities, Figure 1 shows average time assignment for working and the two weekend days, grouped into five comparable activity types. Grouping was constrained mostly by MOBIDRIVE and THURGAU classifications as TASTI was much more disaggregate (39 activities). Recall that the Cobb-Douglas form imposes that activity times in the model have to be strictly positive, which induces the need for some aggregation.

Figure 1. Average duration of activities for workers



We can appreciate important differences among samples. Chileans assign more time to work (nearly 10 hours) and to travel in the city (2.5 hours) during a working day. Individuals in the Swiss and German samples work almost 7 and 6 hours on a working day respectively, and travel slightly more than 1 hour. Work time drops to approximately 1 hour on Saturday and 30 minutes on Sunday for all three samples. Travel time decreases on weekends, notably for the Chilean sample. Larger differences are present in the time assigned to home and out of home entertainment. Swiss allocate systematically 1 hour more than their German counterparts to out of home entertainment every day, which is at the expense of time at home. The Chileans assign more time to being at home on weekends and less on workdays. All the three samples reveal similar relatively low assignments of time to shopping and errands.

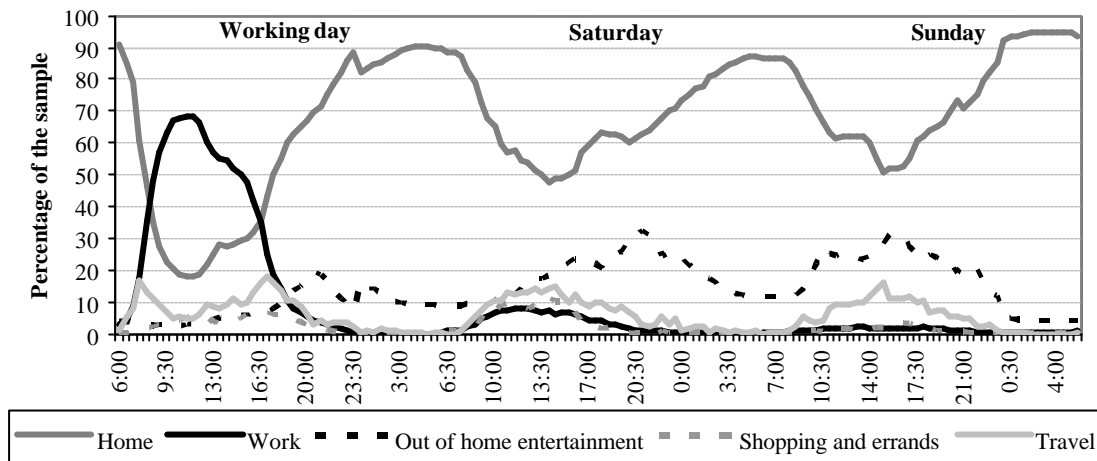
Figure 2 shows the complete activity patterns for all three samples. These patterns represent the proportion of individuals who were engaged in a particular activity at any moment during the day. It is apparent that the work-home patterns differ during the working day and that out of home entertainment is more intense in the German and Swiss cases for all three days. The most noticeable working day difference takes place at lunch time, since in the German case the workers stay at the work place during this time, whereas many of their Swiss counterparts go home for lunch (Chileans go somewhere nearby). Shopping and errands are concentrated strongly during Saturday morning for all three samples.

Note that little can be advanced from this comparative description regarding expected values of leisure and work time. For example, one would expect a larger marginal utility of work for the German sample, as they work less, but also a smaller marginal utility of income because their incomes (and purchasing power) are higher. Hence their ratio –and therefore the values of work and leisure– is difficult to assess *a priori*.

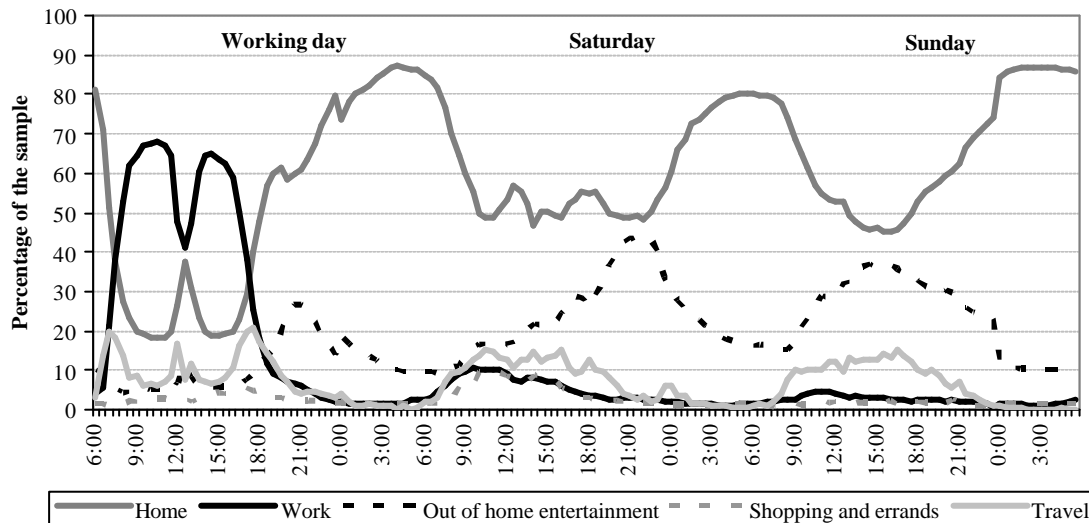
All the information needed to calibrate equations (20) and (21) is directly available in the databases, except for the committed expenditure (E_c), and the wage rate in MOBIDRIVE and THURGAU. In both samples the income information recorded was at household level and expressed in ranges which requires the imputation of the wage rate for each worker inside a household. A wage rate model was estimated using the available information in the *Einkommens- und Verbrauchserhebung 2000* survey (Bundesamt für Statistik, 2000). This survey has information about incomes and expenses for the representative Swiss household. Since the idea is to find a model for the individual wage rate, only one person households were used, because in that case the household income is the personal income. The wage rate

Figure 2. Activity patterns for workers

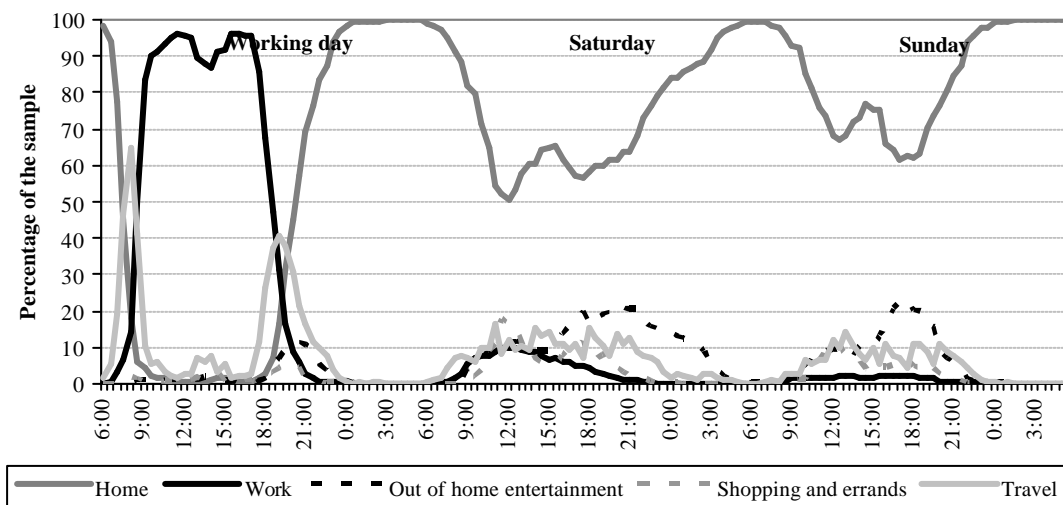
MOBIDRIVE, Karlsruhe



Thurgau



TASTI, Santiago



was calculated from the weekly working hours that individuals reported and their labor income. Four explanatory variables were included: Age, Gender, Education and Work schedule. Self-employed individuals were not considered, because their income is frequently missing or underreported and their working hours are difficult to assign. This way to calculate the wage rate made us exclude from the final sub-sample households with retired people (no work hours), with apprentices (incomplete education) and/or self employed members, which reduced the German and Swiss sample sizes substantially.

To generate the committed expenses E_c we used the information available in the databases complemented with additional information. For Mobidrive and Thurgau we included travel, cost of season tickets for public transport, insurance and tax for cars, and rents or mortgages. In the case of TASTI E_c was approximated using information from the Fifth Survey on Family Budget conducted by the National Statistical Institute (INE) during 1996 – 1997, which includes expenses, income and socio-demographic characteristics of each home. The expenses regarded as mandatory were: housing, water, gas and electricity; domestic service; medical expenses; communications; school. This was added to travel cost, which was directly available. Income from non work sources was deducted.

3. Model And Results

We estimated the activity model system represented by equations (20) and (21) only, as neither sample included precise data on goods expenditure. As stated earlier, up to $n-1$ freely chosen activities can be estimated in the system.

The final sub-samples were constructed excluding individual weeks that reported zero values for the time assigned to the modelled activities (work, personal care and entertainment for TASTI, and work and out of home entertainment for the other two), and those that presented missing or incorrect values (wage rate, rent/mortgage). In the case of the Swiss sample there were individuals that did not report a day for some weeks (reported as holiday, for instance), such that weekly time assignment was impossible to reproduce; those weeks were excluded as well. The Swiss sample had to be further reduced because trips were sometimes inconsistently reported. The final sub-samples of workers for MOBIDRIVE and THURGAU exhibit similar working time, much lower than in the Chilean sample.

Time assigned to work is modelled through equation (20); personal care and entertainment (TASTI) or out-of-home entertainment (MOBIDRIVE, THURGAU) were identified as activities that are freely assigned time until their marginal utility equals the value of time as a resource, modelled by equation (21). The work and free activities equations of this model could in fact be estimated separately. Equation (20) allows to calibrate \mathbf{a} and \mathbf{b} using information on the time assigned to work, the time assigned to the restricted activities (travel, domestic work, shopping and errands in the case of TASTI), the expenditure on those restricted activities and the wage rate. With \mathbf{a} and \mathbf{b} , one can obtain the value of leisure and the value of assigning time to work, by using equations (24) and (25). However, estimating equations (21) simultaneously with equation (20) might increase the efficiency of the estimates of \mathbf{a} and \mathbf{b} and permits estimation of \mathbf{g} .

To be able to estimate this model system an error structure must be assumed. The error sources to be considered in the definition of the error structure are: measurement errors in all the observed variables, differences among individuals, specification errors and the randomness inherent to human nature. We can separate them into two groups: measurements errors that affect all the observed variables, and the rest, that affects all the model parameters. Both groups of errors can be assumed to add to a Normal additive error term, because they arise from different independent sources. As there are no reasons to assume homoscedasticity among equations, we included the standard deviations \mathbf{s}_i in the calibration process. Because of the presence of common error sources among equations, correlation coefficients \mathbf{r}_{ij} were also included. For example, the T_c variable measurement error will contribute to the error term of all activity equations, causing correlation. Also, the \mathbf{b} parameter appears in these equations, with the same consequence. Furthermore, as shown in section 2, \mathbf{a} and \mathbf{b} depend on the same parameters of the original direct utility function, so if there are differences among individual tastes, not explicitly considered within the model, then \mathbf{a} and \mathbf{b} will be inherently correlated. We calibrated the model with a full information maximum likelihood procedure, allowing for both correlation (represented by the correlation coefficients \mathbf{r}_{ij}) and heteroscedasticity (represented by standard deviations \mathbf{s}_i), which were included in the multivariate normal likelihood function. \mathbf{r}_{ij} is adimensional, while \mathbf{s}_i has the units of the dependent variables, i.e. minutes per week. The results of the calibration process are presented in Table 2.

Table 2. Parameter estimates

Parameter	Santiago		Karlsruhe		Thurgau	
	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
α	0.303	34.4	0.432	23.8	0.396	19.9
β	0.098	35.5	0.090	10.6	0.086	12.1
γ Personal care	0.181	48.4	-	-	-	-
γ Entertainment	0.155	28.9	0.116*	10.5	0.183*	22.0
σ Work [min]	396.01	22.5	605.38	15.7	740.40	25.5
σ Personal care [min]	415.06	22.5	-	-	-	-
σ Entertainment [min]	611.09	22.5	1030.46*	15.7	1170.71*	25.5
ρ Work – P. Care	-0.253	-4.3	-	-	-	-
ρ Work – Entertainment	-0.288	-5.0	-	-	-0.227	-4.3
ρ P. Care – Entertainment	-0.515	-11.1	-	-	-	-
LR (full vs. no correlation)	168.9 > 7.8 = $\chi^2(5\%, 3)$		2.2 < 3.8 = $\chi^2(5\%, 1)$		17.1 > 3.8 = $\chi^2(5\%, 1)$	
Log-likelihood	-5653.99		-2006.57		-5357.30	
Sample size	253 individuals		26 individuals		75 individuals	
	(253 weeks)		(124 weeks)		(325 weeks)	

* Out of home entertainment

In each case we report the estimators of \mathbf{a} , \mathbf{b} and \mathbf{g} , and those of the standard deviation of each equation, s_i , and the correlation among the error terms, \mathbf{r}_{ij} . It can be seen that for Santiago, the more general specification with three correlation terms happened to be the best, being by far superior to the no correlation specification - which is equivalent to calibrating the equations independently - according to the Likelihood Ratio (LR) test. In the cases of Karlsruhe and Thurgau, as there are two equations, there is only one possible correlation term. The LR test shows that for Thurgau the joint estimation is better, while for Karlsruhe, the increase in likelihood does not justify to include a correlation term, and the independent version is preferred.

The coefficients obtained are quite attractive intuitively, with both \mathbf{a} and \mathbf{b} less than 0.5 for all three samples, as expected from the theoretical derivation of the model. First, note from equation (15) that \mathbf{I} is proportional to Φ and that, from the definition of \mathbf{a} , Φ is proportional to $1-2\mathbf{a}$, which means that the smaller \mathbf{a} for the Chilean sample reflects a larger \mathbf{I} *ceteris paribus*. This was to be expected as Chileans exhibit lower incomes. Something similar

occurs regarding b with the marginal utility of time as a resource, μ , which in this case is smaller for the Swiss sample. Nothing can be inferred from these observations on the value of leisure, though, as it is obtained from the ratio of μ/l .

Before reporting and analyzing the values of leisure and work, it is convenient to recall the basic equality in a De Serpa like model, firstly pointed out by Oort (1969), which establishes the individual equilibrium between the value of leisure and the total value of work, which includes the wage rate (equation 7). In order to make comparisons between countries, the differences in income should be taken into account. Dividing by w , we can rewrite equality (7) between the values of work and leisure at the margin as

$$\frac{\mu/\lambda}{w} + \frac{-(\partial U / \partial T_w)/\lambda}{w} = 1 \quad . \quad (26)$$

This means that the proportions of the values of leisure and time assigned to work (with a minus sign) with respect to the wage rate, should add up to one.

In Table 3 we report the main results, which are the average values of time in US\$/hour and as a percentage of the corresponding wage rate calculated for each sample. Note that these results are calculated for each individual-week, as shown by equations (24) and (25), which involve available income, available time and work time. The reported values are the averages across observations.

Table 3. Average Values of Time [US\$/hour]

	Santiago			Karlsruhe			Thurgau		
Value of	Value	t-stat	% wage	Value	t-stat	% wage	Value	t-stat	% wage
Leisure μ/λ	2.9	24.1	65.9	12.7	4.0	119.8	26.7	5.6	87.8
Work $(\partial U / \partial T_w)/\lambda$	-1.5	-15.3	34.1	2.1	0.7	19.8	-3.7	-0.8	12.2
Average wage rate	4.4	-	100.0	10.6	-	100.0	30.4	-	100.0

***One dollar = 634.94 pesos (average 2001) = 1.863 DM (average September 1999) = 1.345 CHF (average 2003).

The first important observation is that the value of leisure is positive (as expected) and significantly different from the wage rate for all three samples, and that the value of time assigned to work is negative for two samples (Santiago and Thurgau) and slightly positive for

Karlsruhe, although not significantly different from zero for both Thurgau and Karlsruhe. This is not a minor point, particularly because the presence of work in utility has been challenged in practice by suggesting that the wage rate is the only “opportunity cost” of leisure.

The variation among the values of the marginal utility of work in money terms is not as large as that among the values of leisure, which exhibit very large differences. It is worth noting that these estimated values of leisure rank from 2.9 to 26.7 US\$/hour, which encompasses the values estimated with other methods briefly described in the introduction. Around the same period, Lee and Kim (2005) obtained 9.6 US\$/hour using the reservation wage approximation in Korea, and Álvarez-Farizo et al. (2001) obtained a figure close to 6 US\$/hour in Spain for leisure travel.

In our samples, leisure is much more valuable to the Swiss individuals than to Germans, who come on top of the Chileans¹. Equation (26) facilitates the view of these values as a proportion of the corresponding wage rates in Table 3. Grossly speaking, the Chilean sample reflects marginal values of leisure and work that approximates 66% and 34% respectively, while the Swiss and German samples approximate completely different proportions, 88% and 12%, and 120 and (-)20 respectively. This means that in relation with their own income, the dislike for work is remarkably larger for the Chileans and the contrary happens regarding the appreciation of leisure.

The interpretation for these strikingly different relative values of leisure and work are not straightforward, as many variables are involved including not only marginal utilities for work and leisure but also the wage rate and the marginal utility of income. But the fact is that, in the samples, Germans devote less time to work and more time to leisure than Chileans, with the Swiss in between, which means that the equilibrium reflected by equations (24) and (25) takes place at different points in the time space. Although we do not have a detailed description of other activities for the German and Swiss samples, which would help understanding this picture, we do know that Chileans exhibit longer travel times (2.4 hours) than both Swiss (1.7

¹ Recalling that this value represents the money equivalent of the marginal utility of freely chosen activities, it makes sense to compare these subjective values with the reported subjective well-being in various countries from the World Values Survey, reproduced in Frey and Stutzer (2002). In a 1 to 10 scale that represents average satisfaction with life, Switzerland shows 8.02, Germany reaches 7.12 and Chile 6.92, exactly the same order we have obtained for the value of leisure with our samples within the same countries. The geographical settings are quite different, though.

hours) and Germans (1.3 hours) during weekdays. Actually, the total amount of time assigned to committed activities (T_c) in TASTI almost doubles the values for both MOBIDRIVE (the smallest) and THURGAU. On the other hand, to understand the numerical results obtained, the qualitative aspects of the time assigned to work and leisure should be better understood as well. For example, in a survey conducted by a provincial University, 40% of workers in Santiago have answered that their greatest fear is to lose their jobs (newspaper La Tercera, August 9, 2004). In an interview, the former director of the regional branch of the International Labour Organization said that only one third of the Chilean workers have access to a “decent job”, defined as one with a formal contract, with health, unemployment, maternity and retirement coverage (magazine Mensaje, August 2004). According to Layard (2003), job insecurity has a negative impact on subjective happiness, with an effect larger than that arising from a reduction in income by 33% relative to the average. Thus, unstable jobs and low quality of work might help explaining the different values. We believe the quality of leisure could play an important role also, but we do not have enough elements to study that aspect yet, which is indeed a primary candidate for further research. Another element that might play a role in these differences is the fact that the Chilean TASTI sample was obtained in a corridor within Santiago, the capital city of Chile, a megacity with a 5.5 million population very different from Karlsruhe, a small city, and Thurgau, a low density Canton.

5. Synthesis And Conclusions

Understanding the hidden values behind the way individuals assign their time to activities is a relevant task. The modeller-observer has to take into account that some of these activities are constrained from above, *i.e.* they can not be assigned less than a certain minimum, even if the individual wanted. But there are activities to which the individual assigns time freely; these are the leisure activities whose value reflects the unconstrained appreciation of time. In the present hectic world individuals would like to reduce committed time in order to enjoy leisure, which justifies the emergence of new analyses to explain its evolution (Aguilar and Hurst, 2006), its value (Álvarez-Farizo et al, 2001) or its demand (Couprie, 2007).

On the other hand, the individual has to earn an income that requires time assigned to work, and this assignment is not only dependent on the money reward but also on the satisfaction (or dissatisfaction) that work causes. In this paper we have derived a modelling framework that

rescues and integrate the theoretical contributions on these issues along many years of research from different perspectives. The most important property of the resulting model system is that it permits the empirical estimation of the value of leisure.

The theoretical microeconomic framework developed to model time assignment to activities and to calculate the values of leisure and work developed here, has been shown to be perfectly suited to account for the preceding elements and to analyze different types of samples collected in very different environments. We have used three data sets of workers living along a corridor in a South American megacity, in a small European city and in a mostly rural European conurbation. The application was made using sub-samples of smaller size due to the many restrictions imposed by the information requirements. The calibrated model systems yield credible results both in absolute and comparative terms. The estimated values of leisure are significantly different from the corresponding wage rates. Results also show that work time is a relevant element in utility. Moreover, its inclusion in utility does not preclude obtaining a negligible marginal utility as a particular case.

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References

- Aguiar, M. and Hurst, E. (2006). ‘Measuring trends in leisure: the allocation of time over five decades’, National Bureau of Economic Research Working Paper 12082.
- Alvarez-Farizo, B., Hanley, N. and Barberán, R. (2001). ‘The value of leisure time: a contingent rating approach’, *Journal of Environmental Planning and Management*, vol. 44, pp. 681-699.
- Axhausen, K., Zimmermann, A., Schönfelder, S., Rindsfuser, G. and Haupt, T. (2002). ‘Observing the rhythms of daily life: a six-week travel diary’, *Transportation*, vol. 29, pp. 95-124.
- Becker, G. (1965). ‘A theory of the allocation of time’, *The Economic Journal*, vol. 75, pp. 493-517.

- Couprie, H. (2007). 'Time allocation within the family: welfare implications of life in a couple', *The Economic Journal*, vol. 117, pp. 287-305.
- DeSerpa, A. (1971). 'A theory of the economics of time', *The Economic Journal*, vol. 81, pp. 828-846.
- Evans, A. (1972). 'On the theory of the valuation and allocation of time', *Scottish Journal of Political Economy*, vol. 19, pp. 1-17.
- Frey, B. and Stutzer, A. (2002). *Happiness and Economics*, Princeton University Press.
- Gronau, R. (1986). 'Home production - a survey', in (Ashenfelter, O. and Layard, R., eds.), *Handbook of Labour Economics, Vol. I*. Amsterdam: North Holland, pp. 273-304.
- Jara-Díaz, S.R. (1998a). 'A general micromodel of users' behaviour: basic issues', in (Ortúzar, J. de D., Hensher, D. and Jara-Díaz, S.R., eds.), *Travel Behaviour Research: updating the state of play*. Oxford: Pergamon, 19-33.
- Jara-Díaz, S.R. (1998b). 'Time and income in travel choice: towards a microeconomic activity framework', in (Gärling, T., Laitila, T. and Westin, K. eds.), *Theoretical Foundations of Travel Choice Modelling*. Oxford: Pergamon, 51-73.
- Jara-Díaz, S.R., Munizaga, M. and Palma, C. (2004). 'The Santiago TASTI (Time Assignment Travel and Income) survey', presented at the Triennial International Conference on Transport Survey Methods, San José, Costa Rica.
- Jara-Díaz, S.R. and Guevara, A. (2003). 'Behind the subjective value of travel time savings: the perception of work, leisure and travel from a joint mode choice - activity model'. *Journal of Transport Economics and Policy*, vol. 37, pp. 29-46.
- Johnson, M. (1966). 'Travel time and the price of leisure', *Western Economic Journal*, Spring, vol. 4, pp. 135-145.
- Juster, F. (1990). 'Rethinking utility theory', *The Journal of Behavioural Economics*, vol. 19, pp. 155-179.
- Layard, R. (2003). 'Happiness: has social science a clue? Lionel Robbins Memorial Lectures', London School of Economics March 3-4-5. <http://cep.lse.ac.uk/layard/>
- Lee, K. and Kim, I. (2005). 'Estimating the value of leisure time in Korea', *Applied Economics Letters*, vol. 12, pp. 639-641.
- Löchl, M., Axhausen, K.W. and Schönfelder, S. (2005). 'Analysing Swiss longitudinal travel data', paper presented at the 5th Swiss Transport Research Conference, Ascona, March.
- Munizaga, M., Correia, R., Jara-Díaz, S.R. and Ortúzar, J. de D. (2006). 'Valuing time with a joint mode choice-activity model', *International Journal of Transport Economics*, vol. 33, pp. 69-86.
- Oort, O. (1969). 'The evaluation of travelling time', *Journal of Transport Economics and Policy*, vol. 3, pp. 279-286.
- Shaw, W. D. (1992). 'Searching for the opportunity cost of an individual's time', *Land Economics*, vol. 68, pp. 107-115.
- Winston, G.C. (1987). 'Activity Choice: a new approach to economic behaviour', *Journal of Economic Behavior and Organization*, vol. 8, pp. 567 - 585.