MODELLING TIME ASSIGNED TO ACTIVITIES: ESTIMATION POSIBILITIES FROM A GENERAL FRAMEWORK AND AN AD-HOC DATABASE

Sergio R. Jara-Díaz, Marcela A. Munizaga, Carolina Palma, Paulina Greeven
Departamento de Ingeniería Civil, Universidad de Chile. Casilla 228-3, Santiago, Chile.
jaradiaz@cec.uchile.cl, mamuniza@cec.uchile.cl, cpalma@cec.uchile.cl
http://tamarugo.cec.uchile.cl/~dicidet/

Abstract

In this paper we present the general framework of a model system involving time assigned to activities, goods consumption and discrete choices, including the discussion of the error structure within econometric possibilities which are sufficiently general. We describe the generation and contents of an experimental database, and present the calibration results of some of the modelling possibilities using this database.

Keywords: Time assignment; Value of time
Topic Area: D6 Travel and Shipper Behaviour Research

1. Introduction

Both the microeconomic and econometric foundations of discrete travel choice models, have had remarkable advances within the last few years, contributing to the better understanding of travel behaviour. A closer examination of the specification of modal utility has been particularly fruitful, as it corresponds to the conditional solution of a problem formulated within the framework of consumer theory. In 1978, Train and McFadden derived a modal utility from a consumer behaviour framework that resembles that of Becker (1965). By looking at the general problem Jara-Díaz (1998b) recognised that a common behavioural framework can lead to the simultaneous specification of models of time assignment to activities and travel (mode choice), involving the same type of exogenous information. Thus, activity duration models can add new information for an improved estimation of common parameters. For example, Jara-Díaz and Guevara (2003) formulated a joint model of time assignment to work and mode choice, that permits the calculation of the different components of the subjective value of time, including value of time as a resource, value of time assigned to work, and value of travel time. Jara-Díaz and Guerra (2003) extended the analysis and provided a general framework to model time assignment to all activities. Munizaga et al (2003) adapted the econometric approach of discrete/continuous models based on Lee’s (1983) transformation to estimate the Jara-Díaz and Guevara (2003) model with an error structure that includes correlation between error terms. So far, the empirical examination of the theory has been done using data obtained from the 1991 Santiago O-D survey, which is quite limited to explore the possibilities of the new developments; better and more detailed information is needed to explore both the microeconomic foundations and its econometric challenges. The additional information requirements come mainly from the activities and income structure of the individuals. Even though there are experiences of collecting travel information through an activities approach (Harvey, 2001 among others), a database containing all the information required for a joint model system, such as the one described, is rarely found.

In this paper we present the general framework of a model system, presenting the equations for all activities and discrete choice and including the discussion of the error structure within econometric possibilities which are sufficiently general. We describe the generation and contents of an experimental database, and present the calibration results of some of the modelling possibilities using this database.

2. The general model

The framework proposed by Jara-Díaz and Guevara (2003) using a Cobb-Douglas uitility function was expanded by Jara-Díaz and Guerra (2003), who generated a model system encompassing one equation for each freely chosen activity (including work) and each good consumed. Further, they obtained an indirect utility function involving time mandatorily assigned to unwanted activities as well as their cost. They show that estimating both type of models from the same population makes it possible to obtain very rich information regarding individual preferences and all the values of time as defined in the literature. They point out that unconstrained activities (those that are freely assigned more time than the minimum) must have equal positive marginal utilities, otherwise they would not be undertaken. Besides, 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. The treatment of the constrained activities is similar to that of travel time within the previous model. Let I and R be the sets of all unrestricted and restricted activities respectively. Considering a Cobb-Douglas utility function that includes time assignment to all activities, each with an exponent θ_i , and goods consumption with exponents η_k , first order conditions for all activities yield

$$\frac{\mu}{U} = \frac{A}{\left(\tau - T_w - \sum_{r \in R} T_r^{Min.}\right)} \quad , \tag{1}$$

where μ is the Lagrange multiplier of the time budget constrain, U is the utility level, A is the summation of the exponents over all unrestricted activities, τ is the total time available, T_w is the working time and T_r^{Min} is the minimum time that activity r must be assigned. Note that the denominator is simply the uncommitted time.

Analogously, exogenous minimum consumption levels (fixed expenses) or non work income can be included in the model as well. Fixed income and fixed expenses can be included in a way that is similar to that of travel cost in discrete travel choice models. Let J be the set of goods whose consumption has a minimum (active), letting K denote the unrestricted goods and I_f the fixed income. Then first order conditions over all goods in K yield

$$\frac{\lambda}{U} = \frac{B}{\left(wT_w + \left(I_f - \sum_{j \in J} P_j X_j^{Min.}\right)\right)} \quad , \tag{2}$$

where λ is the Lagrange multiplier of the monetary budget constrain, w is the wage rate, P_j is the price of good j, X_j^{Min} is the minimum level of consumption of good j, and B is the summation over all unrestricted goods of the exponents. Defining

$$G_f = \left(\sum_{j \in J} P_j X_j^{Min.} - I_f \right), \quad T_f = \sum_{r \in R} T_r^{Min.}, \quad \gamma_i = \frac{\theta_i}{(A + B + \theta_w)} \quad \text{and} \quad \varphi_k = \frac{\eta_k}{(A + B + \theta_w)} \tag{3}$$

Jara-Díaz and Guerra get the generalized version of the labour supply model (equation 4), the equations for time assigned to activities (5), for goods consumption (6) and for the indirect utility function (7).

$$T_w^* = \beta(\tau - T_f) + \alpha \frac{G_f}{w} + \sqrt{\left(\beta(\tau - T_f) + \alpha \frac{G_f}{w} \right)^2 - (2\alpha + 2\beta - 1)(\tau - T_f) \frac{G_f}{w}} \tag{4}$$

$$T_i^* = \frac{\gamma_i}{(1 - 2\beta)} \left(\tau - T_w^* - T_f \right) \qquad \forall i \in I \tag{5}$$

$$X_k^* = \frac{\varphi_k}{P_k (1 - 2\alpha)} \left(w T_w^* - G_f \right) \qquad \forall k \in K \tag{6}$$

$$V = \tilde{\Omega} \left(w T_w^* - G_f \right)^{1-2\alpha} \left(\tau - T_w^* - T_f \right)^{1-2\beta} T_w^{*2\alpha+2\beta-1} \prod_{r \in R} T_r^{Min\, \gamma_r} \prod_{j \in J} X_j^{Min.\, \varphi_j} . \tag{7}$$

Here, $\beta=(B+\theta_w)/2(A+B+\theta_w)$ and $\alpha=(A+\theta_w)/2(A+B+\theta_w)$. Equation 5 establishes the relation of time assigned to activity i (T_i) as a function of the available time, where a parameter (γ_i) to be estimated is introduced for each activity i. In the same way, equation 6 indicates that consumption of good k depends on the available income and on the price of the good, and a parameter (φ_k) can be calibrated for each good equation included. Equation 7 is the general form of the indirect utility function, from where discrete choice models can be derived for those activities or goods which are restricted to the minimum assignment.

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). On the other hand, one can formulate and estimate as many discrete choice models as restricted variables exist, unless one choice determines two or more variables simultaneously. In many cases one does not know exactly which activities (or goods) are restricted, which is something that can be explored empirically.

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 A and B, which can be associated with those of leisure and a generalised good respectively in a fully aggregated goods-leisure-work-restricted activities model.

3. Description of the database

3.1. Design and application of the survey

To cope with the requirements of the recently developed microeconomic model system of time assignment to activities and discrete choices, better, more detailed, and wider information on activities and income structure of individuals is needed. Three types of data are required, dealing with the characteristics of the individuals, of the activities they do, and of the trips they make. The relevant *characteristics of the individuals* are related with the dominant activity (i.e. work, study, others), the work structure (if applicable), and the income they receive, identifying fixed and variable components. *Information on activities*, includes mainly the amount of time assigned to all activities undertaken, defined according to a certain level of aggregation. *Information on trips* includes purpose of the trip, origin and destination, alternative transport modes available, and level of service variables for each of the available alternatives. Time use surveys (activities) have been widely used within and beyond the transport field (Fisher, 2000; United Nations Statistics Division, 2000; Harvey, 2001, among others). But, a database containing all the detailed information required to perform a joint estimation of the described type, is rarely found. In Chile, the only experience of time use survey reported is that of the Sociology Department of the Catholic University (Fisher, 2000). On the other hand, even though in the transport field, the demand surveys are carried out using a travel approach only (DICTUC, 2002), it is possible to derive some information about activities (through the travel purpose). Both time use and travel surveys experiences proved quite useful for our design.

In this section we describe the design and characteristics of a very well documented small sample for experimentation, collected in Santiago, Chile. The objective population was workers within a wide middle income range, who live in a specific corridor that presents a wide variety of transport modes available (Vicuña Mackenna – CBD). So we choose people who lived around that corridor and worked at the CBD (northern extreme of the corridor). We decided to conduct the survey at the work places, seeking approval of the employers first. This strategy made much easier the first approach to the objective population, and contributed to increase the response rate; it is also cheaper than house interviews. The sampling method used is similar to a stages random sampling (Hernández et al, 1996). We contacted 14 institutions or firms located at the CBD and willing to collaborate. At each one we selected a limited number of individuals who lived around the corridor. The sample size was defined balancing the available time and money budget, and the desired aggregation level (Ortúzar, 1994). We wanted a small but accurate sample, and our budget was modest. The sample size was finally decided as 300.

In order to define the activities classification, we considered the experiences reported in United Nations Division (2000). On this basis, we defined a preliminary classification into nine main categories, subdivided into more disaggregate sub-categories. The definition of the sub-categories considered the relative importance within this project and the time use data available for the Chilean population (Fisher, 2000). The final classification consisted of 39 activities, plus the activity defined as travel, disaggregated into 11 transport modes (pure and combined).

After a preliminary process that included two focus group exercises and a pilot survey, the definitive survey was defined. It included a first interview to apply the segmentation and occupation surveys, and to explain and deliver the activities and travel record book. The second visit was set for the following week, when the interviewer would collect the record, would review and solve potential doubts and would apply the income survey.

After a pre-recruitment process, which was different in the different institutions that participated, the project was explained to 399 individuals; 322 of them agreed to answer the segmentation and occupation surveys. 93% of them completed the Activities and Travel Record (300 records). The simultaneous process of coding and preliminary validating the data was very useful to identify and obtain the required feedback. Afterwards, a detailed validation process was carried out, to detect missing or incongruent information. The direct cost of the whole survey was approximately US$10 per respondent.

The cases of missing information were similar to those found in the pilot survey: time of the beginning/ending of some activities, address where the activity was located, omission of a trip (or its details), and details on income information. We decided to call the respondent in all these cases, as there were many cases where only some small detail was required to complete the information. In this process, also the most important information was verified with the respondent. After calling 209 respondents, only four surveys could not be recovered. Finally, a total amount of 10 surveys was discarded, because the income information was not available or because the Activities and Travel record was deficient. So, the usable database consists of 290 observations (a 90% response rate). We have named it the Santiago TASTI (Time Assignment, Travel and Income) database.

3.2. Socio-economic characterisation of the sample

Out of the 290 workers, 42.4% are female and almost 70% are married individuals (23.5% are single). Around 50% are between 35 and 49 years old, 25% are between 25 and 34 years old, and 20% are 50 or over. Just 5% of the sample belongs to the 20-24 age range. The educational level is mostly “full technical professional” or “university graduate”, which add up to 67% of the sample. 20% of the individuals studies and works (nearly half of them in the 25-34 age range). The percentage of married woman (53%) is smaller than that of married men.

As shown in Figure 1, the percentage of woman surveyed decreases with age, which shows the increasing incorporation of women into the labour market. Regarding educational level, 43% of men are university graduates, while in the case of women the most important proportion belongs to the full technical studies category. These graphs suggest that shorter careers would make women enter the labour market earlier than men, which might help explaining the inverse relation between age and percentage of women working.

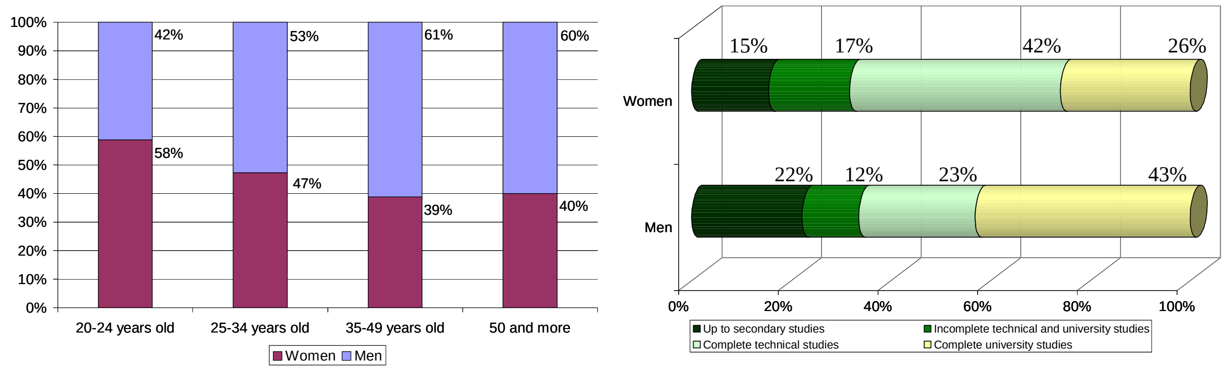

Figure 1: Proportion of the sample according to age, education and gender

Another way to characterise the sample sociodemograficaly is through the variables that describe the individual’s household. The average household size is 3.8 people (mode of 4) and the average of workers in the household is 1.9 (mode of 2). Homes of three, four and five persons are 76% of the sample. It is remarkable that one third of the individuals are the only home supporter (two thirds of which are male).

Almost all the households in the sample own a TV set (99.6%), while 94.8% have telephone and the same percentage own automatic washing machine. On the other hand, within the high income segment (more than 1,160 US$ per month) 84% owns a computer and 60% have Internet connection at home. However, in homes with medium income (580 – 1,160 US$), these percentages fall to 46% and 23% respectively. The same is observed with the availability of Internet at work: 77% for high income people, 60% for medium income, and 55% for low income. In general, the ownership of goods and services grows with income. 62% of surveyed people owns a driver’s license, and 83% of them have a car at home. In the segment of non driver's license holders, only 35% have a car at home. It is worth mentioning that 74% of men surveyed are driver's license holders; in the case of women this proportion is 46% only.

Regarding the working structure, 86.6% of the sample have a formal working contract on their main job. 14% of the respondents have more than one job, and only 10% of them have a working contract on the secondary job. Also, 95% of the persons have a fixed salary in their main job, while in the secondary job this percentage drops to only 27%. In spite of the above, 93% have a fixed entry time in their main job, and 83% in their secondary job. In the main job, 99% of persons declared a fixed work schedule, while in secondary jobs 68% did. In both types of job, most persons surveyed declared to be satisfied with the amount of time dedicated to work in the week.

Income not related to work has some relevance for 39 individuals in the medium (20) and high (19) income segments only. It means 21% (medium) and 11% (high) of their total income. On the other hand, 38 out of these 39 persons who receive non-working income, have only one job. For these individuals, their average working income is US$1,138, while their average total income is US$1,403. Figure 2 shows the number of persons that belong to the different ranges of total income. It can be observed that the frequency decreases with the income range starting from the third interval. 51% of persons receive an income between US$387 and US$968 and 30% between US$968 and US$1,936. The extreme values of the histogram are quite far away, with a maximum above US$3,873, and a minimum slightly less than US$194. It is worth mentioning that income distribution in Chile is quite skewed: the ratio between the average income of the highest and lowest 20% of the population is around 15.3.

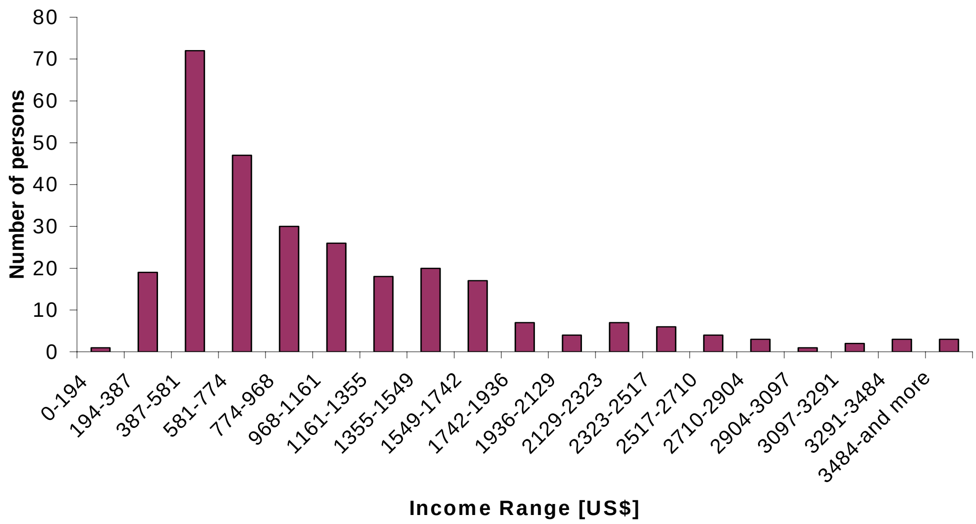

Figure 2: Total income histogram

Figure 3 shows how income relates to other variables. Note that income concentrates within the first two segments for all age groups. Although the maximums differ evidently, the average (larger dot) presents a much lower variance. The income – gender – educational level graph shows that income rises with educational level for both genders, as expected, but incomplete education plays a role. It is important to mention that even though income is higher for men in all categories of educational level, the largest percentage difference is observed in the full university studies one, where the difference reaches 60%.

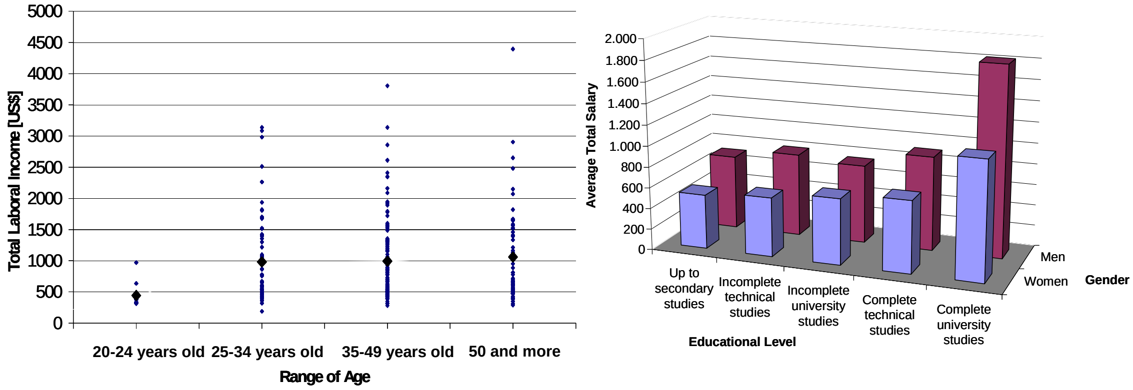

Figure 3: Total salary by age, gender and educational level

3.3. Aggregate description of activities

The average time assigned to each of nine aggregate activities on each day type reported is presented in Figure 4 for the whole sample. This gives a general idea of what activities are the most relevant for this sample of workers. Activities were grouped into: sleeping, personal care, work, shopping and errands, care-taking of others (children or elderly people), study, domestic work, entertainment and travel.

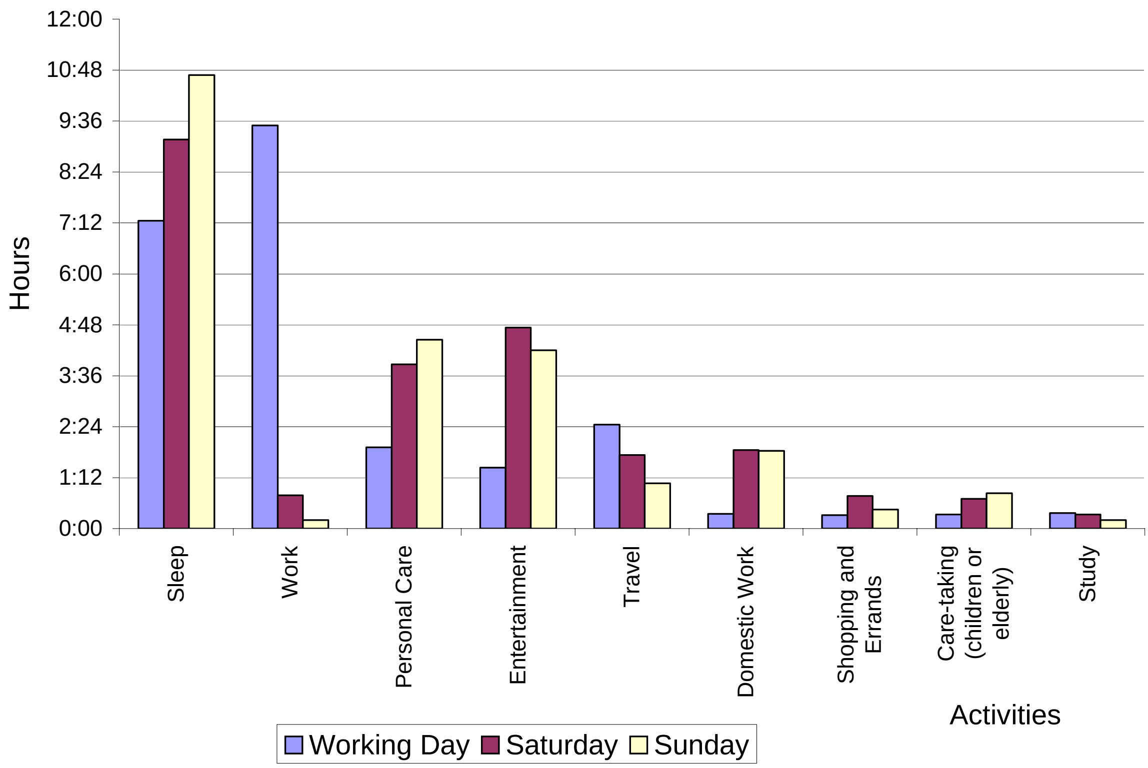

Figure 4: Average time assigned to activities (whole sample)

Looking at the most basic activities, average sleeping time on a working day is seven hours and fifteen minutes, while on Sundays it rises to eleven hours. Average time assigned to work is 9.5 hours on a working day dropping to less than one hour on weekends. The activity defined as "personal care" presents a pattern that is similar to that of sleeping. The "shopping and errands" activity has a peak on Saturdays, while the "care-taking" activity has it on Sundays. However, both activities present an average of less than one hour on each reported day. Time assigned to "domestic work" is larger on weekends (similar on both days) than on working days. Regarding "entertainment", it peaks on Saturday, with an average of almost five hours of dedication; on Sundays this value decreases to four hours and twelve minutes and on working days to almost an hour and a half. It is worth pointing out that the average weekly time assigned to "entertainment" is fairly stable across age (some 17 hours), except for individuals within the 25-35 years range, who assign more time to entertainment as well as to "care-taking" and "study". In the case of "travel", the daily average on working days is almost two hours and a half, which decreases on Saturdays to one hour and 45 minutes and on Sundays to slightly more than one hour.

3.4. Analysis of the activity pattern

The activity pattern in Figure 5 shows the proportion of the individuals who where engaged in a particular activity at any moment during the day, using five minutes intervals beginning at 6:00 AM. For clarity, activities have been aggregated into five: personal care (including sleeping and home meals), work (including eating breaks), domestic work, entertainment, and others (including transport).

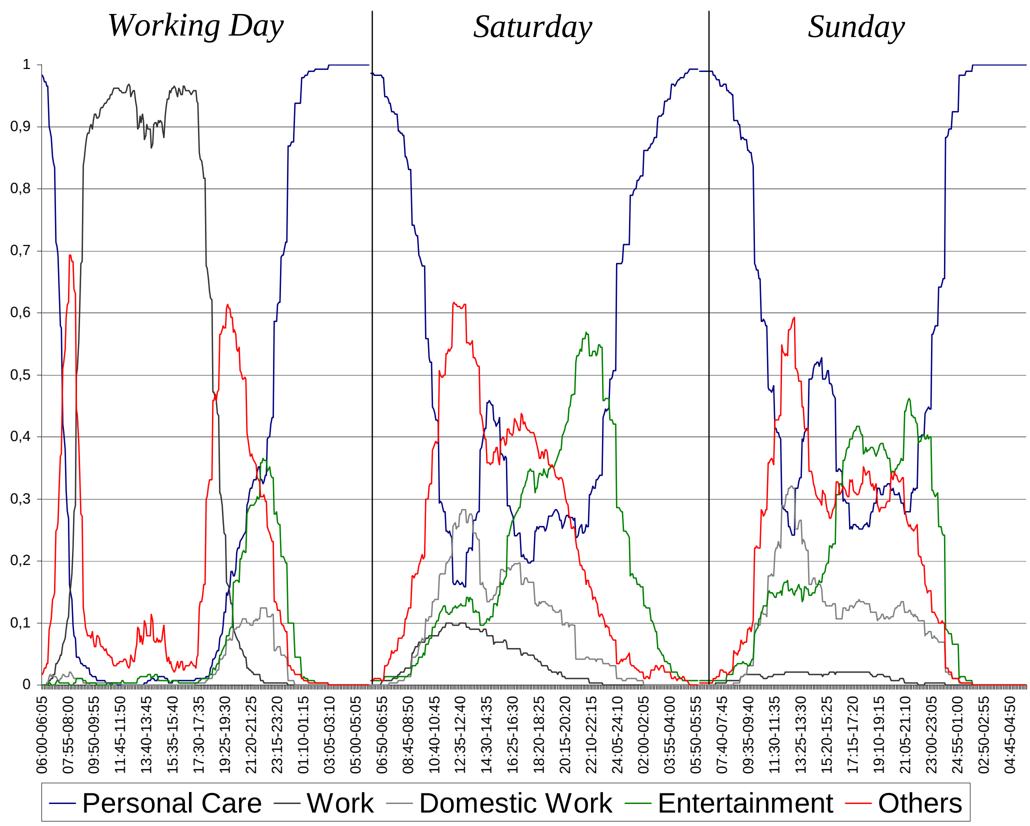

Figure 5: Activity pattern for the whole sample, on the three reported days

The activity pattern on working days is quite neat, as most people is simultaneously engaged in the same activity type. The work and resting patterns show evident substitution. Activities such as entertainment and domestic work concentrate in the evening and "others", that includes travel, study, care-taking and shopping and errands, has two large peaks and a small one at lunch time.

Saturdays and Sundays present some similarities and some differences. On both days the predominant activities are personal care, entertainment and domestic work. These activities have a similar behaviour on both weekend days, though “entertainment” has a higher peak on Saturday and the curve decreases later. On the other hand, “domestic work” increases during the morning on both weekend days, with a maximum before lunchtime. As expected, “work” has some relevance only on Saturday.

The separate patterns for domestic work and entertainment by age and gender are shown in Figure 6, where the proportions are relative to the corresponding universe. On working days these activities are concentrated in the evening, with a relatively scarce presence of men engaged in “domestic work”, showing a pronounced peak in the activity “entertainment”. On weekends, this gender pattern persists. There is a larger proportion of men dedicated to “entertainment” than to “domestic work” all day long, with great differences during the afternoon. On the other hand, women in the sample are more dedicated to “domestic work” than to “entertainment” during the morning and midday, and only since 16:00 hours “entertainment” begins to dominate, but “domestic work” maintains relevance.

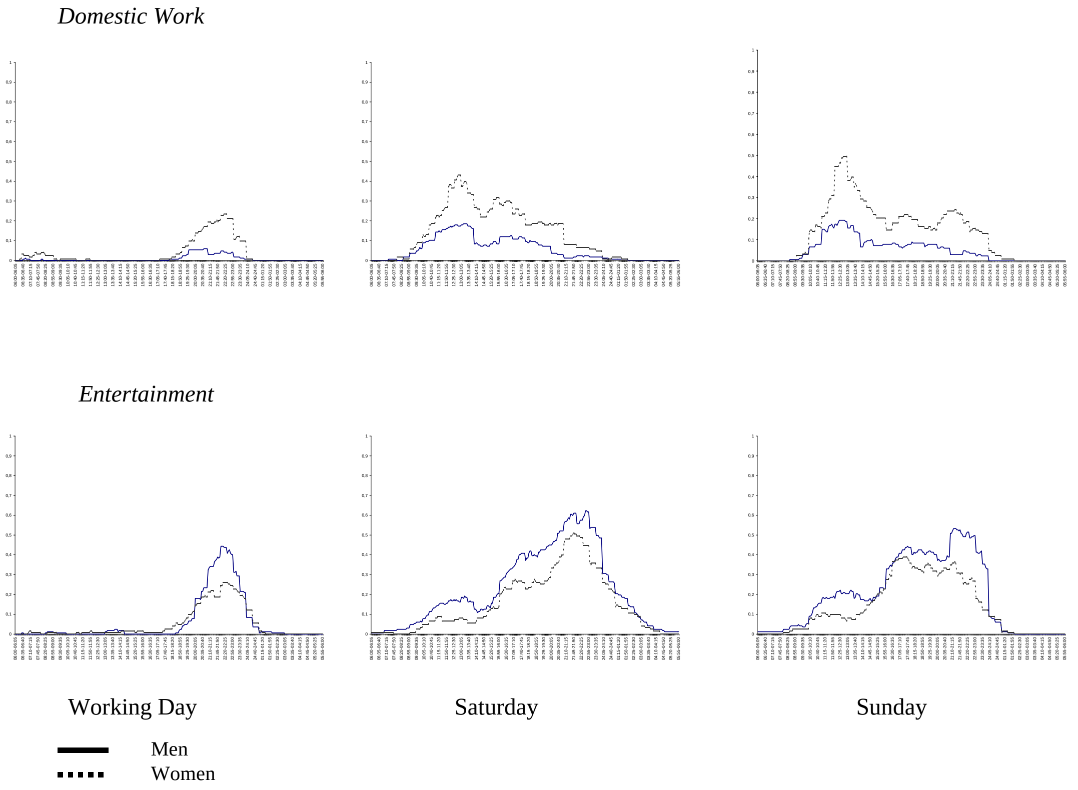

Figure 6: Patterns of domestic work and entertainment, by gender

In Figure 7, we present patterns for the work, travel and study activities, considering two aggregate age ranges (less than 35, and 35 and over) on working days. Regarding the “work” patterns, there are three differences: the “young” arrive later and leave earlier, and assign time to other activities during lunchtime. The “study” activity, which is done mostly after working hours, is clearly present only in the younger segment. Probably this explains part of the difference between “travel” patterns. In the older segment, there is a well defined peak, immediately after work, while for the younger two peaks are observed. The same happens if we divide the sample between people with incomplete university studies and the rest.

Finally, in Figure 8 we show the "personal care" and "entertainment" patterns for both Saturday and Sunday by age. Similar patterns of dedication to the activity "personal care" (which includes sleeping hours) and "entertainment" are observed, though the younger individuals in the sample carry out entertainment activities until later at night on Saturdays and get up later on Sunday mornings, with a gap of around an hour and a half. However, this difference is not observed on Sunday night, when most of people go to sleep at about the same time.

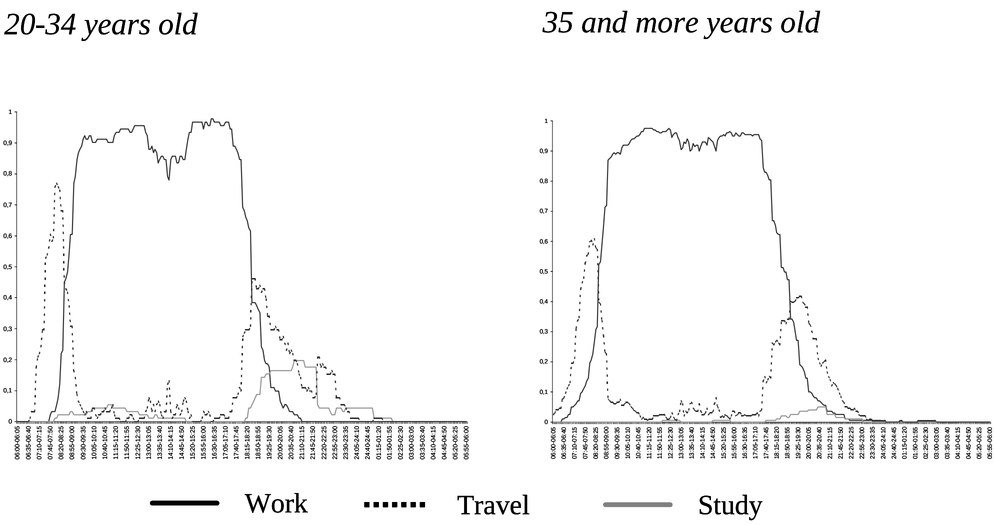

Figure 7: Work, study and travel patterns by age segment, on working days

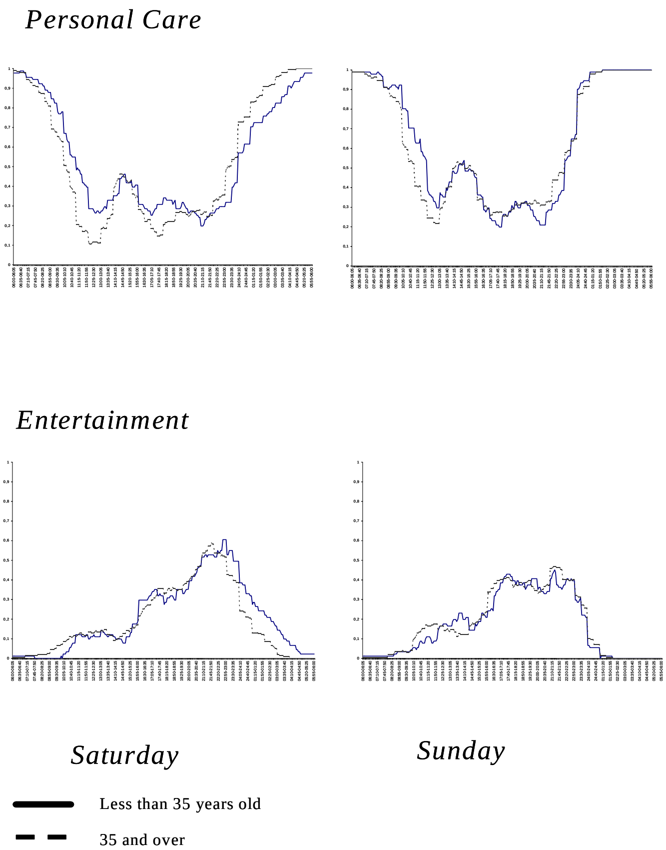

Figure 8: Personal care and entertainment, by age on Saturday and Sunday

4. Model Estimation

4.1. Specification and error structure

A wide variety of particular cases of the general model presented in section 2 can be estimated using this database. We will now present the case of a weekly based model developed aggregating the information into six categories: work, personal care, sleep, entertainment, domestic work-shopping-and-errands, and travel. The last two activities will be considered unpleasant activities, which will be restricted to the minimum, so the observed time allocated to them add to T_f as explained earlier. Time assigned to work is modelled through equation 4 (re-written as 8), personal care and entertainment will be considered as activities that are freely assigned time until their marginal utility equals the value of time as a resource, so their time assignment is modelled by equation 5 (re-written as 9 and 10 respectively). The remaining activity (sleep) is not modelled, as it can be obtained from the time budget constrain. The equations system, is then:

$$T_w^* = \beta\left(\tau - T_f\right) + \alpha\frac{G_f}{w} + \sqrt{\left(\beta\left(\tau - T_f\right) + \alpha\frac{G_f}{w}\right)^2 - \left(2\alpha + 2\beta - 1\right)\left(\tau - T_f\right)\frac{G_f}{w}} \tag{8}$$

$$T_{p\_care}^* = \frac{\gamma_1}{\left(1 - 2\beta\right)}\left(\tau - T_w^* - T_f\right) \tag{9}$$

$$T_{entertainment}^* = \frac{\gamma_2}{\left(1 - 2\beta\right)}\left(\tau - T_w^* - T_f\right) \tag{10}$$

The three equations of this model could in fact be estimated separately. Equation 8 allows to calibrate α and β using information on the time assigned to work, the total time available, the time assigned to the restricted activities (travel, domestic work, shopping and errands), the expenditure on those restricted activities and the wage rate. All the explanatory variables, except the expenditure in restricted activities (G_f), are directly observed in the database. In the case of G_f, it includes expenses in travel, which are available in the database; expenses in domestic work, which can reasonable be assumed to be small; and expenses associated to the shopping and errands activity, which are not available in the database so we are not able to include them. Equation 9 allows to calculate $\gamma_1/(1\text{-}2\beta)$ using information about the time dedicated to personal care, work and the restricted activities, and the total time available. The same happens with entertainment.

To be able to estimate this model system, either jointly or separately, 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. If the parameters are assumed to be deterministic, then both groups of errors can be assumed to add to a Normal additive error term, because it comes from different independent sources. Nevertheless, there are no reasons to assume homoscedasticity among equations, and the presence of common components is expected to cause correlation. For example, the T_f variable measurement error will contribute to the error term of the three equations, causing correlation. Also, the β parameter appears in the three equations, with the same consequence. Furthermore, as shown in section 2, α and β 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 α

and β will be inherently correlated. For the results presented bellow, we calibrated the model with a full information maximum likelihood procedure, allowing for correlation and heteroscedasticity. We consider the possibility of explicit incorporation of taste variation in future stages of this research.

The most interesting results to observe from the model calibration are the different components of the value of time (see Jara-Díaz 2001). From α and β it is possible to calculate the value of time as a resource, which is the ratio between the Lagrange multipliers of the time and income constraints (μ and λ respectively), as established in equation (11) derived by dividing (1) into (2)

$$\frac{\mu}{\lambda}=\left(\frac{1-2\alpha}{1-2\beta}\right)\cdot\left(\frac{Available\ Income}{Available\ Time}\right)\ . \tag{11}$$

The value of assigning time to work can be calculated as the value of time as a resource (μ/λ) minus the value of the wage rate. As said before, the value of assigning time to the other activities which are not restricted to the minimum is by construction equal to the value of time as a resource. Finally, if a mode choice model is also calibrated for the same population, it is possible to calculate the value of travel time savings (*VTTS*). With this information, the value of assigning time to travel can also be obtained.

4.2. Results

We report the results of calibrating equations 8, 9 and 10 for a sub-sample of the TASTI database in Table 1. This sub-sample was constructed excluding individuals that reported zero values for the time assigned to work, personal care or entertainment and those that presented missing or incorrect values in the travel expenditure, and we calibrated the model system for all these individuals as well as for gender-age segments . The reported results are obtained with the full information maximum likelihood procedure. In each case we report the original α, β and γ_i estimators, plus the estimators of the standard deviation of each equation and the correlation among the error terms of the three equations. In all cases in which the most general possible specification would result in some non significant correlation terms, then those correlation terms were eliminated and the best specification was found using the likelihood ratio test. So, we also report the likelihood ratio test for the model reported against one with no correlation parameters (LR no correlation) and the likelihood ratio test for the most general model against the reported model (LR full correlation). The critical values of the chi-squared distribution are 3.84 and 5.99 for one and two degrees of freedom respectively at the 95% confidence level. Finally, we report the values of time in units of US$/hour calculated for two different income groups. The income segmentation for this purpose was defined in such a way that each subgroup has a reasonable number of observations.

It can be seen from Table 1 that reasonable values are obtained. The standard deviations of the error terms reported could seem too high at first sight, but we must remember that the units of the dependent variable are minutes per week, so the values obtained are reasonable. There is, as expected, a significant correlation effect. The comparison of the values of time among groups shows that women tend to have smaller values of time as a resource, and also people who are 35 and over have smaller values than the younger segment. Obviously, all the values of time are smaller for the lower income group, due to the effect of the marginal utility of income (which is expected to be higher for that group). In all the classifications defined, people dislike assigning time to work (negative values of time); which means they probably would not assign time to that activity (or would assign less) if it wasn't paid. Older people show to dislike this activity more than younger ones. This is observed both for males and females, but in the case of females, there are larger differences, especially in the high income group. So, the differences in behaviour observed in the statistical analysis of the database are reflected into significantly different parameter estimations.

Table 1: calibration of the time assignment model system

	All	Female <35	Female >= 35	Male< 35	Male >= 35
Sample size	262	42	74	41	105
Parameters calibrated:					
α	0.1682	0.2798	0.1370	0.2165	0.1283
	(13.7)	(12.5)	(6.8)	(6.5)	(3.4)
β	0.1470	0.1390	0.1490	0.1396	0.1533
	(79.6)	(29.0)	(40.7)	(39.1)	(52.5)
γ_1	0.1596	0.1636	0.1656	0.1506	0.1572
	(50.9)	(20.3)	(28.9)	(20.091)	(31.6)
γ_2	0.1365	0.1365	0.1179	0.1571	0.1389
	(29.1)	(9.8)	(14.5)	(13.1)	(19.6)
σ_{work}	489.8	473.5	500.0	359.1	468.5
	(22.9)	(9.2)	(12.2)	(9.1)	(14.5)
$\sigma_{p\text{-}care}$	400.4	407.2	375.0	392.3	409.9
	(22.9)	(9.2)	(12.2)	(9.1)	(14.5)
$\sigma_{entertainment}$	592.1	687.3	528.2	637.6	570.5
	(23.6)	(9.8)	(12.9)	(9.1)	(14.3)
$\rho_{work\text{-}p.care}$	-	-	-	-	-
$\rho_{work\text{-}ent.}$	-0.2665	-0.3955	-0.3321	-	-0.2994
	(-5.9)	(-4.2)	(-3.9)		(-4.3)
$\rho_{p.care\text{-}ent.}$	-0.6193	-0.6818	-0.5880	-0.6580	-0.6136
	(-16.8)	(-9.1)	(-8.0)	(-7.4)	(-10.8)
Mean Log-Likelihood	-22.5237	-22.4735	-22.3632	-22.2867	-22.4550
LR(no correlation)	24.4631	39.7989	47.5844	23.2592	58.7170
LR(full correlation)	0.0063	0.0212	0.1956	2.2841	1.1080
μ/λ low income	1.41	1.96	1.21	1.61	1.36
(<870 US$/month)	(26.0)	(9.7)	(16.8)	(8.6)	(10.0)
μ/λ high income	3.94	4.15	3.43	4.87	3.80
(>870 US$/month)	(26.0)	(9.7)	(16.8)	(8.6)	(10.0)
VT_w low income	-1.57	-1.02	-1.68	-1.38	-1.65
(<870 US$/month)	(-34.4)	(-5.4)	(-27.2)	(-8.4)	(-13.3)
VT_w high income	-4.90	-2.88	-5.37	-4.89	-5.04
(>870 US$/month)	(-34.4)	(-5.4)	(-27.2)	(-8.4)	(-13.3)
Wage rate lo-income	2.96	2.97	2.90	2.99	3.00
Wage rate hi-income	8.89	7.53	8.79	9.78	8.83

5. Summary and Conclusions

We have reported the process of developing a model, identifying the data requirements for that model, going through the effort of actually collecting the data required, understand and describe the data gathered, estimate the model system, and interpret the results. The calibration process can be considered successful from the econometric point of view, as we obtained significant parameter estimators for all the relevant parameters. The inclusion of correlation proved to be an improvement in statistical terms. The microeconomic interpretation of the results is also auspicious, as the values of time obtained are coherent with the intuition gained by the statistical description of the sample, and we believe we can indeed understand people better by calibrating this type of models. The simultaneous estimation of discrete travel choice models (as in Jara-Díaz and Guevara, 2003) is pending.

We have identified some possible extensions for this work. On the information availability side we can mention the calibration of this model with other databases, ideally including goods or expenditure information. On the econometric side, the possibility of including taste variations assuming random coefficients, which can be explored using a kernel approach, and the inclusion of the mode choice model, using a discrete-continuous approach, are probably the next steps.

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