Online Supplement to

"A Microeconomic Theory-based Latent Class Multiple Discrete-Continuous Choice Model of Time Use and Goods Consumption"

Sebastian Astroza, Abdul R. Pinjari, Chandra R. Bhat *(corresponding author)*, Sergio R. Jara-Díaz

Estimation process

A number of different empirical specifications were explored, with different sets of explanatory variables, different functional forms of variables, and different groupings. All the demographic variables available in the data were considered for characterizing the latent segments as well as the baseline preference specification. These variables include respondents' gender, age, presence of children in the household, income level, marital status, level of education, race, household size, household location (urban or rural area), and dwelling type (renter or owner). The final specification was based on the presence of adequate observations in each category of explanatory variables, a systematic process of rejecting statistically insignificant effects, combining effects when they made sense and did not degrade fit substantially, and judgment and insights from earlier studies. To identify the appropriate number of latent segments (G), we estimated the model for increasing values of G until we reached a point where an additional segment did not significantly improve model fit. The evaluation of model fit was based on the Bayesian Information Criterion (BIC):

$$\text{BIC} = -L(\boldsymbol{\theta}) + 0.5 \cdot R \cdot \ln(N),$$

where $L(\boldsymbol{\theta})$ is the log-likelihood value at convergence, R is the number of parameters estimated and N is the number of observations. The model with the number of segments corresponding to the lowest value of BIC is considered to provide the market segmentation that best fits the data. In our analysis, the three-segment model provided the least BIC value. The log-likelihood value at convergence for this model was -8,486.12 and, with 85 model parameters, the BIC was 8723. The BIC values for the model with one (*i.e.*, no latent segmentation), two, and four segments were 8810, 8793, and 8804, respectively. The log-likelihood value for the naïve model with no latent segmentation, and only alternative-specific constants in the baseline marginal utility and satiation parameters, was -15,757.84. The Rho-squared value of our final model specification with respect to this naïve model is 0.462.

Selection of the estimation sample

This section describes the methodology used to select the estimation sample.

Original database

The LISS database for year 2012 includes about 5500 respondents who reported information about their time use and expenditure. Among these respondents, approximately 2600 are workers. Respondents reported

(1) the time allocated to 13 activities during the past seven days before the survey, and
(2) the average monthly expenditure (in euros) in 30 categories, considering as reference the past 12 months.

Selection of workers and construction of activities, expenditures and income
- Selected respondents who worked at least than 1 hour per week.
- Selected workers who live in one-worker households (the respondent is the only worker in the household). This allows assigning all personal and household expenditures to the only worker in the household, without making assumptions regarding how the household expenditures are shared among income producers.
- The LISS panel considers 13 activities, including work and travel time to/from work. Three of these activities (helping parents, helping family members and helping non-family members) were combined into one (helping friend and family). Then, in addition to work and travel to/from work, only 9 activities are considered in the analysis.
- Selected workers who reported expenditure in at least one expenditure category.
- The database includes the monthly average gross and net income of the worker. For the analysis, only net income is considered. Henceforth, net income is referred as income.
- To achieve consistency between activity durations and expenditures, monthly expenditures and monthly income are divided by 4 to obtain weekly expenditures and weekly income, respectively.
- Income is grouped into work income and non-work income.
  - Work income is obtained from working (for an employer or independently) and it is used to compute the wage.
  - Non-work income corresponds to the money received from pensions, insurances, annuities, governmental support, scholarships and others non-work related sources.

$Income = wT_W + I_{NW}$

Consistency of data
- Removed workers who slept, on average, less than 4 hours per day (28 hours per week): individuals who reported sleeping less than that may have underestimated their sleeping time and, therefore, misestimated other times uses.
- Removed from the sample individuals that reported extremely high activity durations (for example, some people reported working 168 hours per week = 24 hours per day), and other inconsistencies.
- Removed observations with missing or incomplete data.
- In some cases the total expenditures (on household, person and children related categories) are larger than the respondent´s net income.
  - If the difference between total expenditures and income is larger than 20% the worker´s income, the observation is removed from the sample.

- If the difference between total expenditures and income is smaller than 20% the worker´s income, the difference is added to the worker´s non-work income (I_{NW}). Then, in these cases, the difference between total expenditures and income is zero.
- Respondents who spent less than 2 euros per day were removed from the sample, along with those workers whose wage was less than 3 euros/hour (the minimum hourly wage in Netherlands was about 8.4 euros in 2012).

After this selection process, the estimation sample has **1193** workers.

Association between activities and expenditure

To associate expenditures to the previous relevant activities (the 5 activities that require expenditure), the 30 expenditure categories available in the LISS panel data were studied in detail to asses those that matched the description of the activities. Not all the expenditure categories were used.

Table 1: Association of expenditures to activities

Activity	Expenditure
Household chores	Average weekly <u>household</u> expenditure in cleaning the house or maintaining the garden, divided by the number of adults in the household *Assumption*: all adults in the household participate in household chores, and those chores are distributed equally among adults.
Personal care	Average weekly personal expenditure in eating at home. *Assumption*: Some respondents did not declare their expenditure in this category, but they reported the household expenditure in eating at home (for all household members). Then, for those respondents with missing data, this expenditure was computed as the household expenditure divided by the household size. The assumption is that all household members consume the same (this was validated by computing the proportion of personal expenditure in eating at home, compared to the total household expenditure which, in average, was consisted with this assumption).
	Average weekly personal expenditure in food and drinks outside the house
	Average weekly personal expenditure in personal care products and services
	Average weekly personal expenditure in medical care and health costs NOT covered by insurance
Education	Average weekly personal expenditure in (further)schooling
Activities with children	Expenditure per week for children living at home in: - food and drinks outside the house - cigarettes and other tobacco products - clothing - personal care products and services - medical care and health costs NOT covered by insurance - leisure time expenditure - (further)schooling - donations and gifts - other *Assumption*: every expense in children is associated with the time spent with them. This is not necessarily true: a parent can buy food and drinks outside the house for the children, but not spend time while the children eat. Or he/she can purchase a movie ticket and not go with the children to the cinema. I do not think we can identify the expenditures associated with these activities, so I considered everything.
Leisure	Average weekly personal expenditure in leisure time expenditure

Then, the time allocation to the previous activities, along with the corresponding expenditure is presented in Table 2.

Table 2: Time allocation and expenditures

Activity	Participation (%)	Duration (hours/week)				Expenditure (euros/week)			
		Mean	St. Dev.	Min.	Max.	Mean	St. Dev.	Min.	Max.
Work-related activities									
Work	100,0	33,4	13,7	1,0	100,0	-	-	-	-
Time traveling to and from work	94,0	4,5	4,8	0,0	60,0	-	-	-	-
Activities that do not require expenditure									
Helping family and friends	57,6	4,3	7,0	0,0	81,3	-	-	-	-
Sleeping and resting	100,0	58,8	11,4	28,0	119,2	-	-	-	-
Administrative chores and family finances	86,6	2,7	3,4	0,0	50,0	-	-	-	-
Activities that require expenditure									
Restricted activities, restricted expenditure									
Household chores	97,8	12,1	9,9	0,0	90,0	5,8	9,7	0,0	107,5
Personal care	100,0	9,1	5,8	0,5	49,0	96,9	66,5	0,0	1005,0
Education	24,7	1,8	5,6	0,0	87,7	1,4	7,4	0,0	125,0
Free activities, restricted expenditure									
Activities with children	31,2	4,5	9,3	0,0	65,0	5,7	18,6	0,0	166,3
Leisure	99,8	31,9	16,1	0,0	102,0	10,2	18,7	0,0	375,0
Activities with unknown expenditure									
Other activities	42,5	5,0	10,0	0,0	71,0	-	-	-	-
Number of observations	1195								

Table 3: Income and wages

Variable	Mean	St. Dev.	Min.	Max.
Income (euros/week)				
Work income	478,1	262,4	15	3.500
Non-work income	284,6	314,9	0	2.125
Total income	762,7	363,9	152	3.500
Wage (euros/hour)	18,0	24,0	3,1	387,5

APPENDIX A: ACTIVITIES DESCRIPTION

Below is the description of the disaggregate activities in the original survey.

1) **paid work** (in employment or as self-employed; do NOT include the time spent traveling to and from work, but DO count overhours)

2) **traveling to and from work or to and from school**

3) **household chores** (such as cleaning, laundry, shopping, cooking, gardening, odd jobs, car washing, etc; but not personal care or care for children or parents, for example)

4) **personal care** (such as washing, dressing, eating, visiting the hairdresser, seeing the doctor, etc.)

5) **activities with own children** (such as washing, dressing, playing, reading, taking child to see doctor, taking child to school/hobby activities, etc.)

6) **helping parents** (for instance assistance with administrative chores, washing, dressing, taking someone to see the doctor, etc.)

7) **helping other family members** (for instance assistance with administrative chores, washing, dressing, seeing the doctor, tending to the grandchildren, etc.)

8) **helping non-family members** (for instance assistance with administrative chores, washing, dressing, seeing the doctor, association work, voluntary work, babysitting, etc.)

9) **leisure time activities** (such as watching TV, reading, sports activities, hobbies, computer as hobby, visiting family or friends, travelling, going out, walking the dog, cycling, holiday, sex, etc.)

10) **(continued) education** (day or evening courses, professional courses, language course or other course, doing homework, etc.)

11) **administrative chores and own family finances**

12) **sleeping and resting** (sleeping, lazing, thinking, meditating, being ill, etc.)

13) **other activities not mentioned above** (e.g. church attendance)