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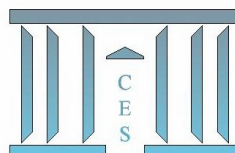
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Anil Alpman* and François Gardes†

Paris School of Economics, Université Paris 1 Panthéon-Sorbonne, CES

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Abstract

This paper is a comment on the analysis of “Time Use During the Great Recession” conducted by Aguiar, Hurst and Karabarbounis. We derive an opportunity cost by exploring the substitution between individual’s time and monetary resources and show that the changes in non-market activities during the Great Recession compensate to some extent the decrease of individuals’ monetary resources.

Keywords: Household Production, Time Allocation, Wealth, Business Fluctuations, Cycles.

JEL: D31, E32, J22.

1 Introduction

In an innovative paper, Mark A. Aguiar, Erik Hurst and Loukas Karabarbounis (2013), AHK hereafter, explore the time allocation of the individuals in the United States during the Great Recession. They find that 50% of the decline in the market work hours during the recession are compensated by an increase in leisure, and 30% by an increase in nonmarket work. As nonmarket work represents roughly 60% of the time devoted to market work, the elasticity of nonmarket work with respect to market work is -0.5 , indicating an important substitution between market work and nonmarket work.

Job search and other income generating activities increase no more than 10% during the Great Recession, suggesting that individuals choose to do non-market

*E-mail: anil.alpman@univ-paris1.fr.

†E-mail francois.gardes@univ-paris1.fr.

activities rather than spending time trying to find a job (which is harder during crises) or to work for a low wage. The results of AHK show therefore that it is crucial to include the time component to assess the welfare effects of crises. As remarked by Mark A. Aguiar and Erik Hurst (2007a), “if leisure time has value, our results suggest that welfare calculations about the growing inequality based solely on changing incomes or changing expenditures may be incomplete.” In addition, in their discussion of the implications of their findings for business cycle models, AHK mention that “home production can make a difference” because “shifts in relative prices cause households to substitute goods and time ... intratemporally between the market and the home sector” and “volatility in goods and labor markets arises because of relative productivity differences between the two sectors”.

The household production model, where the utility and the full income constraint depend on individuals’ times, presents an attractive way to explore welfare changes and the substitutions between time and goods at the individual level while incorporating the time component. For an empirical application, we match the dataset used by AHK with the Consumer Expenditure (CE) survey and estimate the opportunity cost of time as well as the parameters of the utility and the household production functions.

Using these estimations, we are able to value time and explore the intratemporal substitution between goods and time, the variations of individuals’ full expenditures, and the evolution of their utilities during the Great Recession. We can therefore quantify, among others, the welfare implications of individuals’ time allocations described in AHK.

2 Method and Data

Following François Gardes (2014) we assume that the consumer combines time use with monetary expenditures to produce activities that generate utility in a model where the market work time is valued by the consumer’s wage rate, denoted w , whereas time allocated to other activities (e.g., leisure or nonmarket work) is valued by an opportunity cost corresponding to a shadow wage, denoted ω . The opportunity

cost is given by the ratio of the derivatives of the utility function with respect to the total disposable time and to the consumer's income. A detailed presentation of the model and the derivation of the opportunity cost of time is presented in the Appendix.

The model is estimated on a dataset obtained by matching the American Time Use Survey (ATUS) as it was processed by AHK with the Consumer Expenditure (CE) survey. We use the FMLI file which contains households' characteristics, income, and summary level expenditures. Since the data used by AHK informs the weekly time allocation of one individual within the household, we transform households' quarterly expenditures into weekly per capita expenditures using the equivalence scale proposed by the OECD which consist in dividing expenditures by the square root of the family size. We also divide expenditures by the price index to obtain real expenditures. Finally, we drop all individuals above 65 and below 18 as in AHK.

Since the estimation of the opportunity cost requires prior estimates of the production functions' parameters, we define five activities for which the monetary and time inputs can be accurately identified: leisure, housing (including home work), transport, food, and others. We then match the ATUS and the CE survey using the statistical matching procedure proposed by Donald B. Rubin (1986) and developed for Stata by Anil Alpman (2015). When time allocation is informed by the ATUS and the income allocation by the CE survey, and both datasets contain variables in common, Rubin's procedure allows to impute expenditures allocated to activity i as a function of time allocated to i and of the control variables, assuming a partial correlation value of -0.2 between expenditures and time allocated to activity i given the control variables (i.e., state, region, education, age, marital status, number of child, sex, and race).¹

¹See the online Appendix for a detailed description of the dataset, the calibration of the partial correlation value, and the matching procedure.

3 Results

The results indicate (Table 1) that the opportunity cost of time is, on average, 10.65\$, that is, 54% of the real wage rate. Estimates made on french and canadian data produce comparable results (Gardes, 2014).² In addition, Figure 1 shows that the evolution of the opportunity cost follows the economic cycle as predicted by the time allocation theory: during the period of sustained growth (2004-2006), the opportunity cost of time has an increasing trend and its average value over this period is equal to 9.43\$. As the economic activity slows down significantly in 2007, the opportunity cost decreases by 19.4%. It continues to decrease by 15.6% between 2007 and 2008 and reaches its lowest value during the Great Recession in 2009 (i.e., 6.05\$). Over the recovery period (2010-2012), the values of the opportunity cost and of the GDP per capita growth are higher than their crisis values but lower than their values during the sustained growth period: the opportunity cost fluctuates around 7.95\$ between 2010 and 2012.

Since the labor market becomes more attractive for the consumer during growth periods (because of higher wage rates and higher probabilities of finding a job), in theory the opportunity cost of time should increase and, as a consequence, time allocated to market work should also increase. Thus, the time input is expected to be substituted by market goods in the production of activities. Figure 1 shows that our results match the theory: during the period of sustained growth (2004-2006), the geometric weighted mean of expenditures (i.e., m') increases roughly by 11% and reaches its peak in 2006 while the geometric weighted mean of time inputs (i.e., t') reaches the same year its lowest value (during the same period, the market work time also increases according to AHK). Between 2007 and 2009, m' decreases roughly by 9% per year whereas t' increases by 2% and reaches its highest value in 2009. During the recovery period, m' and t' gravitates around a lower and higher trends, respectively, than their pre-crisis trends.

The results of AHK indicate that when market work time decreases by 1%, time

²The analysis of the substitution between time and money conducted by Mark A. Aguiar and Erik Hurst (2007b) allows to derive an opportunity cost which is quite low (39% lower than the minimum wage rate) and significantly lower than our estimates (see the Online Appendix).

Table 1: Descriptive Statistics of Estimated Parameters

Variables	2004	2005	2006	2007	2008	2009	2010	2011	2012
ω	9.51 (0.10)	9.05 (0.10)	9.74 (0.12)	7.85 (0.11)	6.62 (0.08)	6.05 (0.08)	8.10 (0.13)	7.93 (0.12)	7.83 (0.12)
m'	222.82	239.19	247.42	237.84	227.77	216.54	226.74	215.63	221.20
t'	19.44	19.76	19.19	19.82	19.76	20.24	20.03	20.21	20.17
σ	-0.41 (0.04)	-0.48 (0.04)	-0.45 (0.04)	-0.30 (0.04)	-0.35 (0.05)	-0.39 (0.05)	-0.35 (0.04)	-0.24 (0.05)	-0.37 (0.05)
$e_{t'}/t_w$	-0.27	-0.26	-0.29	-0.31	-0.29	-0.28	-0.29	-0.28	-0.27
$e_{t'}/\omega$	-0.07	-0.08	-0.08	-0.13	-0.15	-0.13	-0.13	-0.11	-0.13
y^f	1,859.94	1,895.20	1,947.40	1,802.94	1,646.89	1,546.25	1,748.92	1,678.66	1,706.29
u	106.93	112.65	113.21	112.62	109.26	106.64	109.41	106.94	108.10
GDP per capita growth	2.8	2.4	1.7	0.8	-1.2	-3.7	1.7	1.1	2

Notes: ω is the average opportunity cost of time for the whole population and the standard error of this mean multiplied by 10^2 is in parentheses; m' and t' are the geometric weighted means of monetary and time inputs, respectively; $\sigma = \partial \log(t'/m') / \partial \log(\omega)$ is the elasticity of substitution between time and expenditures with its standard error in parentheses; $e_{t'}/t_w$ and $e_{t'}/\omega$ are the elasticities of t' with respect to the market work time and the opportunity cost of time, respectively; y^f is the full expenditure; and u is the utility. All the variables have been estimated at the individual level and averaged over the population.

allocated to various activities increases, on average, by 0.23%.³ The substitution between monetary and time inputs, on the other hand, can be estimated by the elasticity of substitution σ defined as $\sigma = \partial \log(t'/m') / \partial \log(\omega)$. Our results show that σ is -0.37 on average (Hamermesh [2008] and Gardes et al. [2014] obtain comparable values). Note that σ includes implicitly, through the variation of t' , the substitution between market work time and time allocated to other activities; in addition, σ contains an income effect (through the changes of t_w and the opportunity cost). Thus, along with the elasticities computed by AHK, the value of σ is an additional result which should be accounted for in the analysis of business cycles.

Another important indicator that captures the relation between the monetary and the temporal components is the *full expenditure* (see equation [A3] in the Appendix), 63% of which is constituted by monetary expenditures. Figure 2 shows that

³Using the share of time allocated to each activity (AHK, Table 3, column 1) and the elasticity of time substitution between each activity and the market work time computed by AHK, we calculate the average elasticity of time substitution between the various activities and market work time as $\bar{e} = \sum(e_i t_i) / (\sum t_i)$.

during the sustained growth period, the full expenditure increases by 4.7%; this increase is mainly driven by higher quantities of market goods since expenditures are in real terms. However, the full expenditure decreases by 7.42% between 2006 and 2007, 8.66% between 2007 and 2008, and it reaches its lowest value, 1,546.25\$, during the Great Recession after decreasing by 6.11% between 2008 and 2009. During the recovery period, the full expenditure increases by 13.11% but remains under its pre-crisis values. Note that all these changes are greater than those of the per capita growth rate of GDP.

The evolutions between 2006 and 2009 of the components of the full expenditure show that the monetary and the time expenditures have decreased by 10.28% (i.e., 120.64\$) and 20.60% (i.e., 280.52\$), respectively, while the time allocated to various activities (i.e., $\sum t_i$) has increased by 1.92%. According to these results, the decrease of monetary expenditures during the Great Recession is induced by lower quantities of market goods whereas the decrease of the time expenditure is induced by the decrease of the opportunity cost of time, which leads to an increase of the time allocated to various non-market activities. Indeed, the elasticity of t' with respect

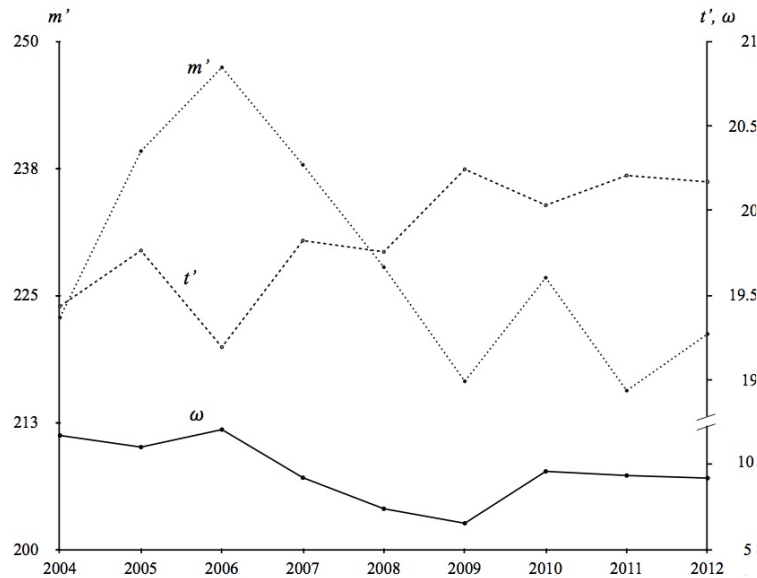


Figure 1: The opportunity cost of time (w) and the geometric weighted means of monetary (m') and time (t') inputs.

to the opportunity cost (when the market work time and individual characteristics are controlled for) is -0.08 between 2004 and 2006, -0.14 between 2007 and 2009, and -0.12 between 2010 and 2012. In addition to the forgone market work time, the decrease of the opportunity cost of time is therefore an important factor explaining the increase of the time allocated to various activities during the Great Recession. (Note that our estimations indicate that the elasticity of t' with respect to the market work time is -0.28 , which is very similar to the average weighted elasticity, -0.23 , computed using the elasticities informed in AHK).

The decrease of the cost of time and the possibility to substitute time to market goods when market work time decreases should imply that the evolution of the time component during the Great Recession reduces the negative impact of the crisis on individuals' welfares. The latter is explored by estimating the indirect utility, which is a function of time and expenditures (see equation [A2] in the Appendix). Note that the evolution of the utility (see Figure 2), on average, is very much as expected: during the period of sustained growth (2004-2006), utility increases while it decreases slightly as the economic activity slows down in 2007. When the growth rate of the GDP per capita becomes negative in 2008, the utility decreases significantly. During the Great Recession, the utility continues to decrease (-2.4% between 2008 and

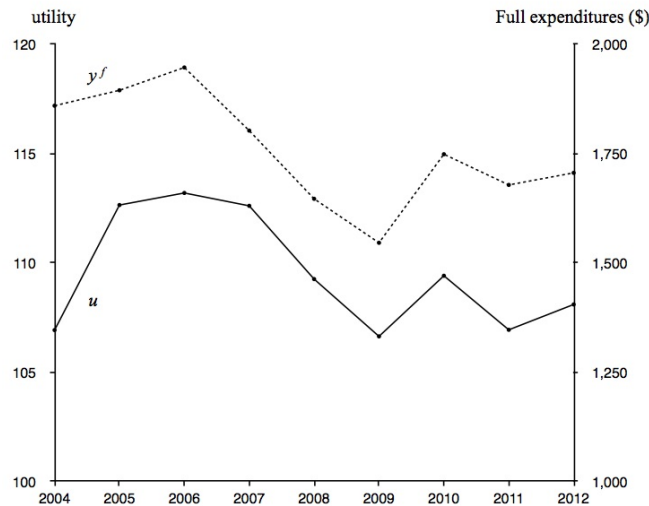


Figure 2: The utility (u) and the Full Expenditure (y^f)

2009) and it reaches its lowest value (which is slightly below its 2004 level). Within the recovery period (2010-2012) the utility fluctuates at a higher level than the crisis but it remains lower to its pre-crisis level. We find that the elasticities of the utility with respect to m' and t' are 0.64 and 0.44, respectively. Finally, if t' was fixed at its 2006 value, the decrease rate of the utility would have been roughly 33% stronger. Therefore, the time component attenuates indeed the negative impact of the crisis.

4 Conclusion

Our findings add to the results and discussions of AHK mainly in three points. First, we provide empirical evidence that changes in the opportunity cost of time, which affect relative prices, leads market goods to be substituted by time intratemporally: the elasticity of the substitution between expenditures and time with respect to the opportunity cost is -0.37 on average. Second, the decrease of the opportunity cost induces indeed a higher volatility in the labor market since the elasticity of the geometric weighted mean of time allocated to various activities (other than market work time) with respect to the opportunity cost is -0.13 during the Great Recession. Third, the evolutions of the allocation and the cost of time reduce the negative impact of the crisis: the decrease rate of the utility during the Great Recession would have been roughly 33% higher if changes in the allocation of time were ignored.

In addition, our findings suggest that, on average, 48% of the increase of the time allocated to non-market activities are explained by the decrease of the opportunity cost of time and 52% by the forgone market work hours. As mentioned by AHK, this decomposition is important for understanding how much of the time allocated to human capital during the Great Recession “contributes to the long-run stock of human capital.”

Given the purpose of this paper, we discussed the implications of our findings for the average individual. Yet, the responses of individuals to the Great Recession are conditional on characteristics such as age, marital status, employment status, gender, and number of child. Such a study is left for future research.

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Appendix

Following Gardes (2014), we assume that the consumer’s utility is given by $u(Q) = \prod_i a_i Q_i^{\gamma_i}$ where Q_i is the activity i produced by the combination of monetary (m) and time (t) inputs: $Q_i = b_i m_i^{\alpha_i} t_i^{\beta_i}$ where $m_i = x_i p_i$ with x_i the quantity of the market good i and p_i its price. A Cobb-Douglass structure has been assumed both for the utility and for the production functions in order to simplify the derivation of the optimization program. The parameters are estimated locally (i.e., for each observation in the dataset), so that this specification assumes simply constant substitution between time and monetary resources in a neighborhood of each individual’s equilibrium point.

Combining the utility and the production functions allows to express the utility in terms of inputs:

$$u(m, t) = \prod_i a_i b_i \left(\prod_i m_i^{\frac{\alpha_i \gamma_i}{\sum \alpha_i \gamma_i}} \right)^{\sum \alpha_i \gamma_i} \left(\prod_i t_i^{\frac{\beta_i \gamma_i}{\sum \beta_i \gamma_i}} \right)^{\sum \beta_i \gamma_i} \quad (\text{A1})$$

$$= a m'^{\sum \alpha_i \gamma_i} t'^{\sum \beta_i \gamma_i} \quad (\text{A2})$$

where m' and t' are geometric weighted means of the monetary and time inputs. When there exist some imperfections on the labor market, w may differ from the opportunity cost of time ω such that the full expenditure writes:

$$\sum_i^n (p_i x_i + \omega t_i) = wT + (\omega - w)(T - t_w) + V \quad (\text{A3})$$

where t_w is time allocated to market work, $T = \sum t_i + t_w$ is total time, and V is non-market income less savings. The optimization program consist in maximizing equation (A2) subject to equation (A3).

Denoting the monetary income by $Y = wt_w + V$, the opportunity cost of time is given by

$$\omega = \frac{\frac{\partial u}{\partial t'} \frac{\partial t'}{\partial T}}{\frac{\partial u}{\partial m'} \frac{\partial m'}{\partial Y}} = \frac{m' \sum \beta_i \gamma_i \frac{\partial t'}{\partial T}}{t' \sum \alpha_i \gamma_i \frac{\partial m'}{\partial Y}} \quad (\text{A4})$$

The substitution between time and money in the production function of activity i generates the following first order conditions:

$$\alpha_i = \frac{m_i}{\omega t_i + m_i} \quad \text{and} \quad \beta_i = \frac{\omega t_i}{\omega t_i + m_i} \quad (\text{A5})$$

under the constraint of a constant economy of scale for each production function, that is, $\alpha_i + \beta_i = 1$.

Consider now the substitution between times t_i and t_j in the production functions of two different activities i and j : this substitution implies another condition between the parameters of the utility and the production functions:

$$\frac{\gamma_i}{\gamma_j} = \frac{\beta_j t_i}{\beta_i t_j} = \frac{a_j m_i}{a_i m_j} \quad (\text{A6})$$

All other substitutions between monetary and time ressources devoted to different activities can be derived from equations (A5) and (A6).

Equation (A6) implies for all activities:

$$m_i\gamma_j = m_j\gamma_i + \omega\gamma_i t_j - \omega\gamma_j t_i \quad (\text{A7})$$

Equation (A7) can be estimated as a system of $(n - 1)$ equations for $j = 1$ and $i = 2, 3, \dots, n$ under the constraint of $\sum \gamma_i = 1$ or fixing γ_j as the full budget share of one of the activities, for instance food. In this system, ω and γ_j are over-identified.

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Anil Alpman and François Gardes

Paris School of Economics, Université Paris 1 Panthéon-Sorbonne, CES

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Online Appendix

I. Introduction

This appendix provides a step-by-step guide explaining the construction of the dataset used in Alpman and Gardes (2015) and how to reproduce the results discussed in that paper. The main folder *ce_atus* contains all the necessary files for this task and it is organized as shown in Table 1.

Table 1: Main Folder Organization

Main folder	Sub 1
ce_atus	atus
	ce
	ce_atus
	ce_atus_matched
	do-files and documents
	TU_CE_2014.dta

To obtain the intermediate and final datasets, all the necessary do-files are contained in the folder *do-files and documents*. The organization of the latter is shown in Table 2.

II. The American Time Use Survey (ATUS)

The American Time Use Survey (ATUS) provides microdata about individuals' time allocations.¹ The survey reports the time allocated to various activities that the respondents have carried out during 24 hours, starting at 4 a.m. the day before the interview and ending at 4 a.m. the day of the interview. A detailed description of the ATUS is provided by Aguiar et al. (2013).

¹ <http://www.bls.gov/tus/home.htm> (last accessed the 21st of January 2014).

Table 2: The do-files and documents Folder

Sub 1	Sub 2
do-files and documents	1. instructions.do, 1.1 merge atus.do, 1.2 time categories.do, 2.1 destrung.do, 3. recode.do, 4. matching.do, 5. opportunity_cost_2004_2012 6. results.do 7. appendix.do

Table 3 shows the organization of the *atus* folder: *1_original_files* contains the files as downloaded from the internet site of the Bureau of Labor Statistics (BLS). To use the data contained in these files, it must be “extracted”; to do so, use the do-files provided by the BLS (see do-files in column 5 of Table 3). Then, informations contained in the various extracted files must be regrouped. For this, we use the do-files provided by Aguiar et al. (2013), which we have saved under the name *1.1 merge atus* in the *do-files and documents* folder. After the merging procedure, the data of Aguiar et al. (2013) are obtained by running the *1.2 time categories* do-file. This do-file was originally written by Aguiar et al. (2013); however, we add 7 new time categories (see Table 4). The purpose of these new time categories is to identify the monetary counterpart of the time allocated to an activity. For instance, we create the total transport time category so that we identify the counterpart of transport expenditures as the total time allocated to transport (thus, we remove transport time related with other activities). The resulting file, *atus_04_12.dta*, contained in the folder *5_atus_04_12*, allows to reproduce the results of Table 1 and 2 in Aguiar et al. (2013).

III. The Consumer Expenditure Survey (CE)

The Consumer Expenditure (CE) Survey, which consists of the *Quarterly Interview Survey* and the *Diary Survey*, provides microdata regarding individuals’ income allocations (i.e., their expenditures).² The Interview survey contains data on monthly expenditures, income, and households’ characteristics, while the Diary Survey contains data on weekly expenditures of frequently purchased items, income, and households’ characteristics. Both of these surveys include various files for each quarter.

² <http://www.bls.gov/cex/home.htm> (last accessed the 21st of January 2014).

Table 3: atus Folder Organization

Sub 1	Sub 2	Sub 3	Sub 4	Sub 5
atus	1_original_files	2004	atusact_2004	atusact_2004.dat, atusact_2004.do, ...
			atuscps_2004	...
			atusresp_2004	...
			atusrost_2004	...
			atussum2004	...
			atuswho_2004	atuswho_2004.dat, atuswho_2004.do, ...
	
		2012	atusact_2012	atusact_2012.dat, atusact_2012.do, ...
		
			atuswho_2012	atusact_2012.dat, atusact_2012.do, ...
	2_extracted_data	2004	act_2004.dta, cps_2004.dta, resp_2004.dta, rost_2004.dta, sum_2004.dta, who_2004.dta	
		
		2012	act_2012.dta, ..., who_2012.dta	
	3_merged_data	atus_2004.dta, ..., atus_2012.dta		
	4_time_groups	atus_2004.dta, ..., atus_2012.dta		
	5_atus_04_12	atus_04_12.dta		

Table 4: New Time Categories

Main	codes
time_market_work	05-01; 05-02
time_home_work	02-01; 02-03; 02-04; 02-05; 02-08; 02-09; 02-99; 09-01; 09-02; 09-04
time_leisure	12; 13
time_food	02-02; 07-01-01 07-01-03; 11
time_transport	07-01-02; 09-05 18 (<i>17 for the year 2004</i>)
time_health	01-03; 08-04
time_personal_care	01-02; 01-04 01-99; 08-05

We use the FMLI file contained in the Interview survey; the former is "a file with characteristics, income, and summary level expenditures for the household" (<http://www.bls.gov/cex/pumhome.htm>). Table 5 shows the organization of the *ce* folder: the *1_original_data* folder contains the CE survey as downloaded from the internet site of the BLS. To be used in Stata, the data must be “destringed”; to do so, use the do-file *2.1 destring*. The “destringed” data is saved in the folder *2_destringed*. The do-file *2.1 destring* also appends the different quarters and years. The appended dataset, that is, *ce_04_12.dta* file, is saved in the folder *3_ce_04_12*.

Table 5: ce Folder Organization

Sub 1	Sub 2	Sub 3	Sub 4	Sub 5
ce	1_original_data	2004	diary04	...
			expn04	...
			intrvw04	fml041x.dta, fml042.dta, fml043.dta, fml044.dta, fml051.dta, ...
	
		2012	diary12	...
			expn12	...
			intrvw12	fml121x.dta, fml122.dta, fml123.dta, fml124.dta, fml131.dta, ...
	2_destringed	2004	fml041x.dta, fml042.dta, fml043.dta, fml044.dta, fml051.dta	
		
		2012	fml121x.dta, fml122.dta, fml123.dta, fml124.dta, fml131.dta	
		ce_2004.dta, ce_2005.dta, ce_2006.dta, ce_2007.dta, ce_2008.dta, ce_2009.dta, ce_2010.dta, ce_2011.dta, ce_2012.dta,		
	3_ce_04_12	ce_04_12.dta		

IV. Recoding

To prepare the ATUS and the CE survey for the matching procedure, we recode the control variables and generate the variables of interest. Table 6 presents the organization of the *ce_atus* folder (not to be confused with the main folder). To obtain the *ce_atus_appended.dta* file, the 3. *recode* do-file must be used.

The control variables that we use during the matching procedure are *region*, *state*, *edu* (i.e., education), *age*, *married*, *num_child* (i.e., the number of child), *male*, and *black*. The education variable is equal to 1 for lower than high school, 2 for high school diploma, 3 for some university without the bachelor degree, 4 for bachelor degree, and 5 for master or more. In the ATUS, Iowa (19), New Mexico (35), North Dakota (38), Vermont (50), and Wyoming (56) are dropped because these States are not included in the CE survey and it would therefore create a mismatch.

Since the CE is a quarterly survey, the monthly expenditures cover 3 months. Given the date of interview, some expenditures may have been carried out during the quarter of the interview and some others may have been carried out during the previous quarter, see Table 7. For example, if the survey was conducted in April 2005, the expenditures of the previous 3 months are recorded as a previous quarter expenditure (informed by the *_pq* suffix). However, if the survey was conducted in March 2005, the expenditures of January and February took place in the current quarter (informed by the *_cq* suffix) while expenditures conducted in December of the previous year are coded as previous quarter expenditures.

Thus, the total expenditures on the previous 3 months are previous quarter expenditures plus current quarter expenditures. Since the data used by Aguiar et al. (2013) informs weekly time allocation of one individual of the household, we transform households' quarterly expenditures into weekly (i.e., dividing by 12) per capita expenditures using an equivalence scale proposed by the OECD that consist in dividing expenditures by the square root of the family size. Finally, we also divide expenditures by the price index to obtain real expenditures.

Table 6: *ce_atus* Folder organization

Sub 1	Sub 2
<i>ce_atus</i>	<i>atus_recoded.dta</i> , <i>ce_atus_appended.dta</i> , <i>ce_recoded.dta</i>

Table 7: The Recording of Expenditures

	Oct. (2004)	Nov. (2004)	Dec. (2004)	Jan. (2005)	Feb. (2005)	March (2005)	April (2005)	May (2005)	June (2005)
Ex. 1						x	x	x	Inter.
Ex. 2				x	x	x	Inter.		
Ex. 3			x	x	x	Inter.			
Ex. 4	x	x	x	Inter.					

We also transform the nominal wage rate informed in the dataset of Aguiar et al. (2013) into a real wage rate. Our key expenditure categories are presented in Table 8. Finally, as in Aguiar et al. (2013), we drop all individuals above 65, below 18, and for whom `unclassified_paper > 0`

V. Matching

We match the ATUS and the CE survey using the statistical matching procedure proposed by Rubin (1986). When time allocation is informed by the ATUS and income allocation by the CE survey, and both datasets contain variables in common, the procedure of Rubin allows to impute expenditures for activity i as a function of time allocated to activity i and of the control variables. In Stata, we use the `smpred` and `smmatch` programs written by Alpman (2015); the latter shows that, when the partial correlation between two variables to be matched given the control variables is different than zero,

Table 8: Expenditure Categories

Variable new name	Formula (with the name in the CE survey dataset)
total_exp	totexppq+ totexpcq
total_house = total_housing + domestic_service	(housspq+ houscq)+(dmsxccpq+ dmsxcccq)
total_leisure = entertain + trip + alcohol_beverage + pet_toys + reading + tobacco	(entertpq + entertcq) + (ttotalp + ttotalc) + (alcbevpcq + alcbevccq) + (pettoypq + pettoycq) + (readpq + readcq) + (tobaccpq + tobaccqcq)
total_food	foodpq+ foodcq
total_transport	transpq + transcq
total_other	total_exp - (total_house + total_leisure + total_food + total_transport)

Rubin's procedure yields better results than assuming that the variables to be matched are conditionally independent (which is the case in most statistical matching procedures).

In France, the elasticity of the geometric weighted mean of time input with respect to (w.r.t. hereafter) the opportunity cost is -0.16 when estimated directly using the INSEE 2000 dataset (Gardes, 2014). The weighted average elasticity of time allocated to various activities (e.g., food and home work) is -0.166, which is very close to the previous estimate. On the other hand, the elasticity of the monetary input w.r.t. the opportunity cost, which is computed by the weighted average of the elasticities estimated for each activity (Gardes, 2014, Table 3) is 0.305. The resulting marginal propensity of time over money computed by the ratio between these two elasticities corrected by the ratio of their average values is -0.103 in France. The elasticity of the time input w.r.t. the opportunity cost can be derived by dividing the elasticity of the monetary input w.r.t. the opportunity cost of time over the elasticity of the monetary input w.r.t. the time input. This ratio is -0.51, which is higher, in absolute value, than the direct estimate -0.16. With this method the marginal propensity of time over money is -0.34. In Canada, the partial correlation between the time and the monetary input is -0.11 for food, -0.20 for leisure, -0.21 for housing, and -0.03 for other expenditures. Thus, the average partial correlation of these activities which represent 82% of the total full expenditure is -0.16. Therefore, by taking the average of the values observed for France and Canada, we assume a partial correlation of -0.2 between time and expenditures allocated to activity i given the control variables (i.e., state, region, education, age, marital status, number of child, sex, and race).

Table 9: ce_atus_match Folder Organization

Sub 1	Sub 2
ce_atus_match	ce_atus_2004.dta, ce_atus_2004.dta, ce_atus_2006.dta, ce_atus_2007.dta, ce_atus_2008.dta, ce_atus_2009.dta, ce_atus_2010.dta, ce_atus_2011.dta, ce_atus_2012.dta, ce_atus_2003_2012.dta

Therefore, among other, we match:

- *total_house* as a function of *time_home_work* and control variables
- *total_leisure* as a function of *time_leisure* and control variables
- *total_food* as a function of *time_food* and control variables
- *total_transport* as a function of *time_transport* and control variables
- *total_other* as a function of *time_other* and control variables
- *total_exp* as a function of *real_hour_wage* and control variables (assuming a partial correlation value of 0.5)

The matching procedure is performed using the *4. matching* do-file (the *smpred* and *smmatch* programs must first be installed). First, expenditures on activity *i* are predicted as a function of time allocated to activity *i* and of the control variables. Then, given the predicted values and conditional on a second group of control variables, observations in the ATUS and CE survey are matched (see Rubin [1986] and Alpman [2015] for more detail on the matching step) and the observed value of the match is imputed for the missing value. To reduce the time of the matching step, the second group of control variables are region, age_group (equal to 1 if age<30, 2 if 29<age<41, 3 if 40<age<51, and 4 if age>50), child_group (equal to 1 if number of child=0, 2 if number of child=1, 3 if number of child between 2 and 4, and 4 if number of child > 4) education, married, male, and black. On an average computer (e.g., 2.9GHz 2 core processor and 8GB of RAM), the do-file *4. matching* takes roughly 35 hours to be completed. The matched datasets are saved in the folder *ce_atus_match* folder (see Table 9).

Table 10 provides descriptive statistics of CE survey while Table 11 provides descriptive statistics of the imputed values on the dataset used to estimate the opportunity cost of time. Table 12 shows that the Rubin's matching procedure does not affect significantly the average values of imputed expenditures.

Table 10: Descriptive Statistics, CE Survey

Year	total exp	leisure exp	house exp	food exp	transport exp	other exp
2004	579.19	71.82	190.52	80.44	117.01	106.31
2005	589.94	70.28	192.74	79.92	119.64	111.46
2006	605.88	73.96	207.93	82.26	116.74	112.52
2007	610.60	71.05	208.69	92.87	112.95	111.62
2008	606.70	73.13	205.36	92.89	111.84	109.41
2009	590.97	69.50	205.54	89.69	98.04	108.12
2010	568.38	67.23	196.70	88.50	95.67	101.54
2011	558.62	63.26	191.57	87.12	98.80	98.44
2012	576.83	66.54	192.55	89.14	106.88	102.85

Notes: The highest 1% of total and house expenditures, and the lowest 5% of leisure expenditures were dropped

Table 11: Descriptive Statistics of Expenditures, Matched Dataset

Year	total exp	leisure exp	house exp	food exp	transport exp	other exp
2004	565.40	83.20	189.37	81.39	132.99	110.84
2005	589.80	77.34	197.55	82.16	131.47	121.79
2006	589.78	79.41	205.33	81.42	123.55	119.86
2007	579.85	72.85	200.78	92.57	124.53	118.96
2008	580.14	76.80	201.55	92.82	118.86	114.52
2009	580.22	73.81	203.94	91.45	106.55	116.29
2010	534.94	72.29	188.85	87.94	104.82	107.34
2011	538.28	65.87	184.64	87.66	102.97	106.94
2012	555.99	72.18	190.10	90.18	116.67	115.82

Notes: The highest 1% of transport expenditures, and the highest 10% of other expenditures were dropped

Table 12: Ratio (CE Survey)/(Matched Dataset)

Year	total exp	leisure exp	house exp	food exp	transport exp	other exp
2004	2.4%	-13.7%	0.6%	-1.2%	-12.0%	-4.1%
2005	0.0%	-9.1%	-2.4%	-2.7%	-9.0%	-8.5%
2006	2.7%	-6.9%	1.3%	1.0%	-5.5%	-6.1%
2007	5.3%	-2.5%	3.9%	0.3%	-9.3%	-6.2%
2008	4.6%	-4.8%	1.9%	0.1%	-5.9%	-4.5%
2009	1.9%	-5.8%	0.8%	-1.9%	-8.0%	-7.0%
2010	6.3%	-7.0%	4.2%	0.6%	-8.7%	-5.4%
2011	3.8%	-4.0%	3.8%	-0.6%	-4.0%	-8.0%
2012	3.7%	-7.8%	1.3%	-1.2%	-8.4%	-11.2%

VI. Opportunity Cost

We begin by estimating the following system using a non-linear seemingly unrelated regressions model:

$$\begin{cases} m_2\gamma_1 = m_1\gamma_2 + \omega\gamma_2t_1 - \omega\gamma_1t_2 \\ m_3\gamma_1 = m_1\gamma_3 + \omega\gamma_3t_1 - \omega\gamma_1t_3 \\ \dots \\ m_n\gamma_1 = m_1\gamma_n + \omega\gamma_nt_1 - \omega\gamma_1t_n \end{cases}$$

We define γ_1 as the full budget share of food, which requires the wage rate of individuals. Therefore, we lose units for which the wage rate is not observed.

This estimation yields a unique ω (see Table 13), and the γ of each activity (Table 14). Note that the $\sum \gamma$ is roughly equal to one for each year. Using the estimated ω , the α and the β corresponding to each activity is estimated using the following equations (see Table 15 and 16):

$$\alpha_i = \frac{m_i}{\omega t_i + m_i} \quad \text{and} \quad \beta_i = \frac{\omega t_i}{\omega t_i + m_i}$$

Using α and the β , we compute m' and t' . Using the latter, we finally compute the individual opportunity cost using the equation

$$\omega = \frac{\frac{\partial u}{\partial m'} \frac{\partial t'}{\partial T}}{\frac{\partial u}{\partial m'} \frac{\partial m'}{\partial Y}} = \frac{m' \sum \beta_i \gamma_i \frac{\partial t'}{\partial T}}{t' \sum \alpha_i \gamma_i \frac{\partial m'}{\partial Y}}$$

Table 13: First-step Opportunity Cost

year	First Step Opportunity Cost
2004	6.057
2005	5.689
2006	6.227
2007	4.857
2008	5.266
2009	4.769
2010	4.864
2011	4.874
2012	4.921

Table 14: Values of γ

year	leisure	house work	food	transport	other	$\sum \gamma$
2004	0.24	0.22	0.12	0.27	0.22	1.07
2005	0.22	0.25	0.12	0.27	0.26	1.12
2006	0.25	0.26	0.12	0.27	0.26	1.17
2007	0.21	0.24	0.13	0.24	0.24	1.05
2008	0.22	0.24	0.12	0.24	0.22	1.04
2009	0.21	0.25	0.12	0.22	0.24	1.04
2010	0.22	0.23	0.13	0.23	0.25	1.05
2011	0.21	0.23	0.12	0.22	0.25	1.03
2012	0.21	0.23	0.12	0.22	0.26	1.04

The value of $(\partial t'/\partial T)/(\partial m'/\partial Y)$ in the previous equation is reported in Table 17. Because of possible measurement errors due to the matching, we assign to the periods of growth (2004 to 2007) the average of these years (i.e., $1.27=[1.3+1.48+0.84+1.47]/4$); to the period with negative growth the average of 2008 and 2009 (i.e., 1.05); and to the recovery period the average of the years 2010 and 2012 (i.e., 1.32).

We keep only individuals that have positive time and income allocations to leisure, home work, transport, food, and other activities to compute the α and the β . This procedure does induce a significant decrease in the number of observations (most of the observations that are lost are due to the missing values of the wage rate). Nevertheless, the average values of the key variables do not change significantly: the statistics provided in Table 11, which do not contain individuals having 0 allocation to these 5 activities or individuals for whom the wage rate is not observed, remain similar to those of Table 10.

Table 15: Values of α

year	leisure	house work	food	transport	other
2004	0.44	0.71	0.53	0.62	0.58
2005	0.44	0.72	0.54	0.65	0.62
2006	0.43	0.74	0.52	0.62	0.62
2007	0.46	0.75	0.60	0.67	0.67
2008	0.46	0.75	0.58	0.67	0.62
2009	0.45	0.76	0.60	0.65	0.64
2010	0.48	0.76	0.58	0.66	0.64
2011	0.44	0.75	0.59	0.65	0.63
2012	0.43	0.75	0.58	0.66	0.66

Table 16: Values of β

year	leisure	house work	food	transport	other
2004	0.56	0.29	0.47	0.38	0.42
2005	0.56	0.28	0.46	0.35	0.38
2006	0.57	0.26	0.48	0.38	0.38
2007	0.54	0.25	0.40	0.33	0.33
2008	0.54	0.25	0.42	0.33	0.38
2009	0.55	0.24	0.40	0.35	0.36
2010	0.52	0.24	0.42	0.34	0.36
2011	0.56	0.25	0.41	0.35	0.37
2012	0.57	0.25	0.42	0.34	0.34

Table 17: $(\partial t'/\partial T)$ and $(\partial m'/\partial Y)$

year	$\partial t'/\partial T$	$\partial m'/\partial Y$	$(\partial t'/\partial T)/(\partial m'/\partial Y)$
2004	0.09	0.07	1.30
2005	0.11	0.07	1.48
2006	0.08	0.10	0.84
2007	0.11	0.07	1.47
2008	0.08	0.08	1.01
2009	0.08	0.07	1.10
2010	0.09	0.06	1.67
2011	0.08	0.06	1.27
2012	0.11	0.10	1.02

VII. Opportunity Cost of Time in Aguiar and Hurst (2007)

In their analysis of the substitution between shopping time and expenditures, Aguiar and Hurst (2007, p.1536) define the opportunity cost of time, denoted μ , as

$$\mu = -Q \frac{\partial p}{\partial s}$$

where Q is the quantity of a composite market good, p is its price, and s is the time input. Denoting expenditure on Q as $X=pQ$, the opportunity cost can be written as

$$\mu = -E_{p/s} \frac{\partial X}{\partial s}$$

where $E_{p/s}$ is the elasticity of p w.r.t. s . This equation can be easily interpreted: $E_{p/s}$ indicates the decrease of the price due to an increase of shopping time and X is the amount of expenditure to which the “price gain” applies.

From Aguiar and Hurst (2007, p.1557), $X=16.25\$$ per week (65\$ per month) which corresponds to 20% of the total grocery expenditures reported in the PSID while the mean shopping time, s , is 58.29 minutes, or 0.9715 hour, per week for individuals aged 25 to 29,

(Aguiar and Hurst, Table 1, p.1540). Furthermore, Aguiar and Hurst (2007, p.1548) find an elasticity between price and the frequency of shopping trips that is between 7 and 10 percent. Thus, the opportunity cost would be 1.67\$.

While the opportunity cost derived from Aguiar and Hurst (2007) differs significantly from our estimates and it is 39% of the federal minimum wage (1993-1995), its evolution with respect to age, that is, the decline of the opportunity cost that begins when individuals reach 35-39 years old (Aguiar and Hurst, 2007, Figure 4), corresponds to the observations made on french surveys by Gardes (2014) with the model that we use in Alpman and Gardes (2015).

VIII. Reproducing the Results

The results presented in Alpman and Gardes (2015) can be reproduced using the do-file 6. *results.do* and the Tables presented in this appendix can be obtained by using the do-file 7. *appendix.do*.

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