Time Use During the Great Recession: A Comment

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March 1, 2014

Aguiar, Hurst, and Karabarbounis (2013) show that forgone market work hours during the Great Recession are compensated primarily by an increase in leisure and nonmarket work. By matching the American Time Use Survey with the Consumer Expenditure survey, we explore the consequences of these changes over the opportunity cost of time (with which we value time use), the households’ full income, and finally on households’ welfare.


JEL Classification: D12; D13; E32; J22

I. Introduction

Aguiar, Hurst, and Karabarbounis (2013) explore individuals’ time allocation during the Great Recession by using the American Time Use Survey (ATUS) which is conducted every year since 2003. They find that 50% of the decline in market work hours during the recession are compensated by an increase in leisure, and 30% by an increase in nonmarket work, while job search and other income generating activities increase no more than 10%. Education, health care, and civic and religious activities absorbs slightly more than 10% of this change though the authors point out that it is not clear whether time allocated to health increases as a result of preventive care or as a result of medical shocks associated

with the recession, and whether education increases as a result of temporary lower opportunity cost of time.

The results of Aguiar et al. (2013) indicate that the elasticity of nonmarket work with respect to market work is $-0.5$ (i.e., a 10% fall in market work hours increase nonmarket work hours by 5%), suggesting a high elasticity of substitution between the market work and the home work. This result is an important factor that must be taken into account to explain business cycles.

The findings of Aguiar et al. (2013) are obtained by using the variation of changes in time use across states, which allows them to control for common low frequency trends in time use. They show that, a “naïve” comparison of time allocation before and after the recession is misleading; for example, if the trend of leisure is not controlled for, then one would wrongly conclude that leisure absorbs 80% (rather than 50%) of the decline in market work hours.

In order to combine the changes in households’ time allocation with monetary income changes, we need to calibrate the value of time devoted to home production, leisure or other activities. Defining this value will allow to estimate the change in households’ welfare induced by the decline of market work during the crisis. We present in Section 2 a simple scheme, based on Becker’s model of the allocation of time and Cobb-Douglas domestic production functions, which allows to estimate the opportunity cost of time locally, for each household, together to a welfare index. Section 3 presents the dataset, which combines monetary with time expenditures. Section 4 discusses the results on the evolution of the value of the time component of households activities and the resulting change in their overall welfare.

II. Estimating the Value of Time

Gardes (2014) proposes to combine time use with monetary expenditures (such as those informed by consumer expenditure surveys) in a model that values time allocated to market work by the household’s wage rate net of taxes, denoted $w$, whereas time used in other activities (such as home production or leisure) is valued by an opportunity cost of time corresponding to a shadow wage $\omega$ defined
by the substitution between aggregate monetary expenditure and consumption time: $u'_t / u'_x = \omega / p_x$, with $p_x$ the value of the household’s aggregate monetary consumption. The household divides its monetary income and its total disposable time when not working on the market between a set of activities $i$ (also referred as final goods) which are assumed to be produced by the consumption of units of an aggregate market good (with unit price $p_i$) and an amount of time equal to $t_i = \tau_i x_i$. \(^1\) The full price $\pi_i$ for one unit of the final good (domestic activity) $i$ is written: $p_i x_i + \omega t_i = (p_i + \omega \tau_i) x_i$. The full price and income budget constraint thus writes:

$$\sum_i (p_i x_i + \omega t_i) = wT + V + (\omega - w)(T - t_w) = wt_w + V + \omega \sum_i \tau_i x_i$$

where $V$ denotes other income, $T$ is the total time (for example 24 hours per day), $t_w$ denotes the time allocated to market work, and $wt_w + V + \omega \sum_i \tau_i x_i$ corresponds to the full income.

In order to simplify the derivation of the opportunity cost of time, a Cobb-Douglas form is chosen both for the utility and the domestic production functions of the final goods $Q_i$ which depend on the monetary and time inputs. \(^2\) Under these assumptions, the optimization program is (all variables correspond to a household $h$ which index is omitted in the equations):

$$(2) \max_{m_i, t_i} u(Q) = \Pi_i a_i Q_i^{\gamma_i} \quad \text{with} \quad Q_i = m_i^{\alpha_i} t_i^{\beta_i}$$

subject to the full income constraint (1).

Note that $T - t_w = T_d = \sum_i t_i$ and that both, the market wage and the shadow wage (i.e., the opportunity cost of time $\omega$) appear in the budget equation: as mentioned, the shadow wage corresponds to the valuation of the total disposable

\(^1\)The production of the final good $i$ is modelled, as concerns time use, by a Leontief technology based on the amount of market good used in this production (or equivalently based on the amount of the final good, as each unit of final good necessitates, assuming the absence of economy of scale, the same consumption of the market good).

\(^2\)Their parameters will be estimated on each point (for each household in the dataset), so that this specification just supposes the constancy of each household’s elasticities of the domestic productions in the utility, and the two factors in the production functions.
time when not working on the market and not sleeping, and it differs from the
market wage $w$ whenever there exist some imperfection on the labor market or if
the disutility of labor is smaller for domestic production.

In order to estimate the opportunity cost for time, the utility function is re-
written:

\[
(3) \quad u(Q_i) = \Pi_i a_i Q_i^{\gamma_i} = \Pi_i m_i^{\alpha_i \gamma_i} \left( \Pi_i t_i^{\beta_i \gamma_i} \right) \sum_i \alpha_i \gamma_i
\]

\[
= am' \sum_i \alpha_i \gamma_i \sum_i \beta_i \gamma_i
\]

with $m'$ and $t'$ the geometric weighted means of the monetary and time inputs
with weights $(\alpha_i \gamma_i) / (\sum \alpha_i \gamma_i)$ and $(\beta_i \gamma_i) / (\sum \beta_i \gamma_i)$. Deriving the utility over the
total disposable time when not working on the market (i.e., $T - t_w$) and dividing
it by the derivative of the utility with respect to the monetary income $Y$ gives
the opportunity cost of time:

\[
(4) \quad \omega = \frac{\partial u}{\partial T_d} / \frac{\partial u}{\partial Y} = \left( \frac{\partial u}{\partial t'} / (\partial m' / (\partial Y) \right) / \left( \frac{\partial u}{\partial t} / (\partial m / \partial Y) \right) = \frac{m' \sum_i (\beta_i \gamma_i) \partial t' / (\partial T_d)}{t' \sum_i (\alpha_i \gamma_i) \partial m' / \partial Y}
\]

All parameters of the utility function are estimated locally (for each household)
so that the household’s welfare will depend both on the set of parameters and on
its monetary and time expenditures $m_i$ and $t_i$. In order to calculate the parameters ($\alpha$, $\beta$, and $\gamma$) of the utility and domestic production functions, Gardes (2014)
considers the substitutions which are possible, first between time and money re-
sources for the production of some activity, second between money expenditures
(or equivalently time expenditures) concerning two different activities. The sub-
stitution between time and money in the domestic production function of activity
$i$ generates the first order condition:

\[
(5) \quad \alpha_i = \frac{m_i}{\omega t_i + m_i} \quad \text{and} \quad \beta_i = \frac{\omega t_i}{\omega t_i + m_i}
\]

\footnote[3]{Note that it is sufficient to examine the implication of two over these three types of substitution.}
under the constraint of a constant economy of scale for each production function:

\[ \alpha_i + \beta_i = 1, \]

while the substitution between times \( t_i \) and \( t_j \) in the domestic production of two different final goods \( i \) and \( j \) implies another condition between the parameters of the domestic production functions and the utility function:

\[ \gamma_i = \gamma_i \frac{t_i \alpha_i}{t_j \alpha_j} \]  

(6)

The estimation of parameters \( \alpha, \beta, \) and \( \gamma \) allows to estimate both, the opportunity cost of time \( \omega \) and the welfare index \( u(Q_i) \).

We begin by computing the shares of the monetary and time expenditures in the full prices (\( \alpha \) and \( \beta \) respectively) using the market wage rate given by the data as the opportunity cost of time. The shares of both inputs allows to derive the elasticity of the commodities in the utility function (i.e., \( \gamma \)). In the second step, we compute the geometric weighted means of the monetary and time inputs, 

\[ m' = \Pi i \frac{(\alpha_i \gamma_i) / (\sum_i \alpha_i \gamma_i)}{P_i} \]

(\( i \)) and 

\[ t' = \Pi i \frac{(\beta_i) / (\sum_i \beta_i)}{P_i} \],

respectively. Finally, we take the derivative of \( t' \) with respect to all disposable time except the market work time, and the derivative of \( m' \) with respect to monetary income:

\[ m' = \phi_0 + \phi_1 \sum_i m_i + \phi_n Z_n + \epsilon \]  

(7)

\[ t' = \psi_0 + \psi_1 \sum_i t_i + \psi_n Z_n + \mu \]  

(8)

where \( \phi \) and \( \psi \) are parameters to be estimated, \( \phi_1 \) and \( \psi_1 \) are the parameters of interest, \( Z_n \) is a vector of individuals' characteristics, and \( \epsilon \) and \( \mu \) are the error terms. The opportunity cost of time is calculated using the following equation:

\[ \omega = \frac{m' (\sum_i \beta_i \gamma_i) \psi_1}{t' (\sum_i \alpha_i \gamma_i) \phi_1} \]  

(9)
III. The Data

To estimate the opportunity cost of time and the full income we match the ATUS with the Consumer Expenditure (CE) survey. The ATUS provides detailed microdata on a yearly basis about how Americans spend their time. The survey reports each activity that the respondents have carried out during the 24 hours the day before their interview (for a more detailed description of the ATUS see Aguiar et al., 2013). On the other hand, the CE survey is a quarterly survey conducted by the Bureau of Labor Statistics which informs in detail households’ monthly expenditure (and weekly expenditure for frequently purchased items). Each quarter contains roughly between 5,000 and 7,000 respondents.

To match the ATUS with the CE survey, we assign each respondent in both datasets to a cell according to their age, education, and family situation. $C_{ijk}$ is defined as the cell of age group $i$, education level $j$, and family situation $k$ where $i \in I = \{20-30; 31-40; 41-50; 51-60; 60-71\}$, $j \in J = \{\text{high school or less; university without bachelor; bachelor; master or more}\}$, and $k \in K = \{\text{not married and no child; married without child; with child}\}$. Therefore, respondents are distributed among 60 cells given their characteristics. We compute the mean of each time category for all cells in the ATUS and we attribute those values to the corresponding cells in the CE survey to obtain the matched CE-ATUS database. For example, in the ATUS, the mean market work time of the cell $C_{111}$ in 2005 is 35.26 hours/week. This value is attributed to all individuals aged between 20 and 30, with a high school diploma or less, not married, and with no child in the CE survey.

Once both datasets are matched we proceed in two steps: first, we classify disposable time (i.e., total time minus market work time and sleeping time) into five groups: health time, leisure time, home work time, food time, transport time. We classify monetary expenditure along the same groups which allows to compute the opportunity cost of time for each individual of the CE-ATUS database. In the second step, time allocation is classified into seven main categories as in
Aguiar et al. (2013): market work, other income-generating activities, job search, child care, nonmarket work (including core home production, home ownership activities, obtaining goods and services, and others care), leisure (including TV watching, socializing, sleeping, eating and personal care, and other leisure), and other (including education, civic and religious activities, and own medical care). Each category includes the transport time related with it.

To compute the wage rate, Aguiar et al. (2013) use the weekly earnings variable that they divide by the usual weekly hours of work variable, both informed in the ATUS. This variable, which we denote $w_2$, is our preferred wage rate indicator. Since the CE survey does not contain a similar variable, we transform the income after tax variable (informed in the CE survey) such that we obtain $w_2$: we multiply the yearly average of income after tax variable by yearly average ratio $w_2/(\text{income after tax})$, and we call this variable $w_1$. The latter is used to compute the opportunity cost of time and it differs slightly from $w_2$ because of missing observations (see Table 1).

Finally, the CE-ATUS database contains respondents aged between 20 and 71 (against 18 and 65 in Aguair et al., 2013), and it includes the years 2011 and 2012 while the year 2003 is unavailable in the CE survey. Despite these differences, the next section shows that our results are very close to those of Aguiar et al. (2013) when we reproduce their estimates.

IV. Results

A. CE-ATUS database

In this section we briefly compare the results of Aguiar et al. (2013) with the findings that we obtain when we replicate their main estimates on the CE-ATUS database. Aguiar et al. (2013, Table 3, column 1) report that individuals allocate on average 79.2% and 13.3% of their time when they do not work on the market to leisure and nonmarket work, respectively. Using the CE-ATUS database we find 79.1% for leisure and 13.9% for nonmarket work. When controlling for the
Table 1—Opportunity Cost of Time and The Wage Rate

<table>
<thead>
<tr>
<th>Year</th>
<th>$\omega$</th>
<th>$w_1$</th>
<th>$w_2$</th>
<th>$w_1$</th>
<th>$w_2$</th>
<th>$w_1$</th>
<th>$w_2$</th>
<th>$w_1$</th>
<th>$w_2$</th>
<th>Average</th>
</tr>
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<tr>
<td>2005</td>
<td>14.86</td>
<td>18.30</td>
<td>19.84</td>
<td>15.51</td>
<td>18.55</td>
<td>20.27</td>
<td>22.39</td>
<td>22.13</td>
<td>22.90</td>
<td>18.75</td>
</tr>
<tr>
<td>2006</td>
<td>15.94</td>
<td>19.30</td>
<td>20.27</td>
<td>15.51</td>
<td>20.55</td>
<td>22.59</td>
<td>22.39</td>
<td>22.13</td>
<td>22.90</td>
<td>18.75</td>
</tr>
<tr>
<td>2007</td>
<td>16.83</td>
<td>20.01</td>
<td>22.59</td>
<td>16.75</td>
<td>21.37</td>
<td>23.29</td>
<td>23.29</td>
<td>23.29</td>
<td>21.60</td>
<td>18.75</td>
</tr>
<tr>
<td>2008</td>
<td>16.75</td>
<td>20.01</td>
<td>22.59</td>
<td>17.35</td>
<td>21.05</td>
<td>23.29</td>
<td>23.29</td>
<td>23.29</td>
<td>21.60</td>
<td>18.75</td>
</tr>
<tr>
<td>2009</td>
<td>16.75</td>
<td>20.01</td>
<td>22.59</td>
<td>17.35</td>
<td>21.05</td>
<td>23.29</td>
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<td>23.29</td>
<td>21.60</td>
<td>18.75</td>
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<tr>
<td>2010</td>
<td>17.54</td>
<td>20.01</td>
<td>22.59</td>
<td>17.35</td>
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<td>23.29</td>
<td>23.29</td>
<td>23.29</td>
<td>21.60</td>
<td>18.75</td>
</tr>
<tr>
<td>2011</td>
<td>17.54</td>
<td>20.01</td>
<td>22.59</td>
<td>17.35</td>
<td>21.05</td>
<td>23.29</td>
<td>23.29</td>
<td>23.29</td>
<td>21.60</td>
<td>18.75</td>
</tr>
<tr>
<td>2012</td>
<td>17.54</td>
<td>20.01</td>
<td>22.59</td>
<td>17.35</td>
<td>21.05</td>
<td>23.29</td>
<td>23.29</td>
<td>23.29</td>
<td>21.60</td>
<td>18.75</td>
</tr>
</tbody>
</table>

Note: $\omega$ is the opportunity cost of time. $w_2$ is the wage rate obtained by dividing the weekly earnings variable by the usual weekly hours of work variable, both informed on the ATUS. $w_1$ is obtained by multiplying the average income after tax variable (informed in the CE survey) each year by the yearly average of the ratio $w_2$/income after tax. $w_1$ is therefore the wage rate in the CE-ATUS database.

common low frequency trends in time use by using the variation of changes in time use categories across states, Aguiar et al. (2013, Table 3, column 6) finds that 54% of the forgone working hours are allocated to leisure and 30% to nonmarket work. Replicating the same estimates on the CE-ATUS database yields 55% for leisure and 28% for nonmarket work. Finally, the elasticity of leisure time with respect to market work time is $-0.15$ (i.e., 10% decrease in the market work time increases leisure time by 1.5%) and that of nonmarket work time is $-0.5$ according to Aguiar et al. (2013). These elasticities are $-0.157$ for leisure and $-0.456$ for nonmarket work when we compute them using the CE-ATUS database.

The similar results that we obtain by replicating the estimates of Aguiar et al. (2013) on the CE-ATUS database indicate that the matched database is reliable. Moreover, it also shows that the findings of Aguiar et al. (2013) are robust to the exclusion of the year 2003 and to the inclusion of the years 2011 and 2012.

B. The opportunity cost of time

Our estimates show that on average the opportunity cost of time is roughly 80% of the market wage rate. The opportunity cost of time for the United States is slightly higher than that of France, which is roughly 65% (Gardes, 2014). Gardes (2014) explains that the wage rate differs from the opportunity cost of time when there are some imperfections on the labor market. Thus, the difference between the opportunity cost in the United States and in France may arise because the American labor market has less imperfections. Figure 1 shows that the opportu-
nity cost of time and the wage rate have parallel evolutions although the wage rate has increased slightly faster: between 2004 and 2012 the opportunity cost of time has increased by 18.66% while the wage rate has increased by 25.83%.

We find that the elasticity of the opportunity cost of time with respect to the market wage rate is 0.95, that is, when the market wage rate increases by 10%, the opportunity cost of time increases by 9.5%. Gardes (2014) finds that this elasticity is 0.85 for France.

Table 1 gives the opportunity cost of time for each year: the opportunity cost of time has decreased by 0.62% between 2004 and 2005, and by 0.47% between 2010 and 2011. However, during the recession, the opportunity cost of time has decreased by 2.23%. Figure 2 shows that the opportunity cost of time gravitates near its linear trend prior to the recession while there is a sharp decrease in 2009 and a catch-up effect in 2010.

These findings are consistent with the theory, and the parallel evolutions of the wage rate and the opportunity cost of time indicates that individuals assess their opportunity cost of time on their wage rate. Moreover, it appears that, in addition to the wage rate, individuals assess their opportunity cost of time on factors such as unemployment or the probability of finding a stable job.
the recession, the opportunity cost of time decreases faster than the wage rate while in 2011 the market wage rate decreases faster than the opportunity cost. An explanation could be that during the recession in 2009 the wage rate as well as the probability of finding a stable job has decreased. As a result we observe a stronger decrease of the opportunity cost of time than the decrease of the market wage rate. However, in 2011 the decrease of the wage rate does not seem to have implied the degradation of other factors (according to the World Bank, the GDP of the United States has increased by 1.8% in 2011, and Figure 2 shows that the market work time is over its trend in 2011). In consequence, the opportunity cost of time in 2011 decreases only by 0.47% while the wage rate decreases by roughly 1.5%.

C. Evolution of time categories in monetary value

Figure 3 shows the evolution of time allocation in quantity and in monetary value, that is, leisure time and nonmarket work time have been multiplied by the opportunity cost of time whereas work time on the market has been multiplied by the wage rate $w_1$. The evolutions of time allocation in monetary value are quite different than their evolutions in quantity: we observe that the trends of market
work, leisure, and nonmarket work are increasing in value. This is because the market wage rate as well as the opportunity cost of time have an increasing trend between 2004 and 2012. For example, the decreasing trend of nonmarket work in quantity is compensated by the increase of the opportunity cost which leads therefore to an increasing value of the nonmarket work time. More precisely, between 2004 and 2012, the value of market work time has increased by 25.7%, the value of leisure by 21.1%, and that of nonmarket work by 5.3%.

As the similar increase between 2004 and 2012 of the value of leisure and non-market work, the decline of the opportunity cost of time during the recession leads the value of leisure time and the value of nonmarket work to decline similarly: both have decreased roughly by 1.5% when we control for the linear trend and we normalize leisure and nonmarket work by their average. Therefore, individuals reallocate their time such that the evolution of leisure and nonmarket work in monetary value is rather similar. This suggest that the relative prices are quiet stable which could explain why we observe an income effect and almost no
substitution effects.

D. Changes in Households’ Welfare

The welfare is computed by calculating the utility in equation (3) and it is graphed in Figure 4. As expected, the welfare index decreases during the recession. We can also see from Figure 4 that the recession had a lasting effect on the utility since in 2010 and 2011 we observe a decline in the welfare index. The figure shows that the welfare loss is the strongest for couples, especially for couples with child. The welfare loss during the recession is induced by a lower monetary income (see Figure 3) as well as a lower time income. Figure 5 shows that, as a result of lower time and monetary income, the full income decreases in 2009, inducing therefore a utility loss.

However, recall that a 1% decrease in the wage rate decreases the cost of leisure and nonmarket work roughly by the same percentage. In addition, our results in Table 2 indicate that the elasticities of the value of nonmarket work and of leisure with respect to market work hours are 0.48 and 0.97, respectively. More specif-
Figure 5. Time Income (left) and Full income (right).

ically, since the elasticity of substitution between market work and nonmarket work is relatively high (−0.45), and that a decrease of the wage rate decreases almost equally the cost of time, a 1% decrease of work time decreases the value of nonmarket work only by 48% while the value of leisure decreases roughly by 1% (since the elasticity of substitution between leisure and market work is lower, namely −0.157). Therefore, the welfare loss induced by the loss of income is partially compensated by a decrease of the opportunity cost and by the reallocation of time, especially by the substitution of market work time with nonmarket work.

<table>
<thead>
<tr>
<th></th>
<th>derivative with respect to the market work time</th>
<th>derivative w.r.t. the wage rate</th>
<th>elasticity w.r.t. the market work time</th>
<th>elasticity w.r.t. the wage rate</th>
</tr>
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<tbody>
<tr>
<td>ω</td>
<td>.</td>
<td>0.766</td>
<td>.</td>
<td>0.96</td>
</tr>
<tr>
<td>Leisure</td>
<td>−0.55</td>
<td>.</td>
<td>−0.157</td>
<td>.</td>
</tr>
<tr>
<td>Nonmarket work</td>
<td>−0.28</td>
<td>.</td>
<td>−0.456</td>
<td>.</td>
</tr>
<tr>
<td>ω*Leisure</td>
<td>52.7</td>
<td>.</td>
<td>0.97</td>
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<tr>
<td>ω*Nonmarket work</td>
<td>4.6</td>
<td>.</td>
<td>0.48</td>
<td>.</td>
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</table>
V. Conclusion

Using the model of Gardes (2014) we have estimated the opportunity cost of time for each household which allows to derive the full prices and therefore the value of home production and leisure. Our results indicate that home production and leisure, in value, have similar evolutions suggesting the existence of a strong income effect and rather stable relative prices. The changes in households’ time allocation observed by Aguiar et al. (2013) are partially compensated by changes in the value of nonmarket work and leisure which modify the welfare implications of the recession. In addition, the estimated elasticity of leisure in value with respect to market work time is higher in absolute value than the elasticity estimated by Aguiar et al. (2013) which implies larger effects on the volatility of business cycles.

References


Data
