

Recent Developments in the Economics of Time Use

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Abstract The proliferation of new datasets and the harmonization of older datasets with the new ones have allowed researchers to make significant progress in our understanding of how individuals allocate their time away from market work. We highlight how these new data can be used to test theories of time use and we review recent developments in long run trends in time use, lifecycle patterns of expenditures and labor supply and the allocation of time over the business cycle.

CONTENTS

Introduction	3
Time Use Data	4
<i>U.S. Historical Time Use Data: 1965-1999</i>	5
<i>U.S. Recent Time Use Data: 2003-2010</i>	8
<i>International Time Use Data</i>	9
Aggregate Trends in Time Use	10

<i>Trends in U.S. Home Production and Leisure</i>	10
<i>Trends in U.S. Leisure Inequality</i>	13
<i>Trends in U.S. Child Care Time</i>	13
<i>Time Use Patterns in Other Countries</i>	15
Lifecycle Consumption and Labor Supply	17
<i>A Lifecycle Model With Intratemporal Substitution</i>	18
<i>Retirement Spending</i>	26
<i>Lifecycle Spending</i>	28
<i>Labor Supply Elasticities</i>	31
<i>Micro Estimates of the Elasticity of Substitution</i>	33
Business Cycles	33
<i>Real Business Cycles with Home Production</i>	35
<i>Time Use over the Business Cycle</i>	38
<i>Macro Estimates of the Elasticity of Substitution</i>	40
Conclusions and Future Research	41

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1 Introduction

How individuals allocate their time away from market work has been a cornerstone of many economic models over the last fifty years. For example, Becker (1965) has put forth a general theory of how one should think about the allocation of time across different activities. Ghez and Becker (1975) have shown the importance of the substitutability of time between market and non-market work in explaining lifecycle profiles of consumption expenditures and work hours. Benhabib, Rogerson, and Wright (1991) and Greenwood and Hercowitz (1991) developed models where the extent to which market expenditures and market work fall during recessions depends on the willingness of households to substitute between market-produced and home-produced goods. Greenwood, Seshadri, and Yorukoglu (2005) have shown that innovations in the market of consumer durables allowed women to increase their labor supply in a model in which home production is an active margin of substitution. Diamond (1982) and Mortensen and Pissarides (1994) emphasize the time allocated to job search in explaining unemployment dynamics.

While all of these models highlight the importance of the time allocated to activities other than market work in explaining a variety of different economic phenomena, the lack of high quality time use data makes it hard to assess systematically many of the key empirical predictions of these models.¹ During the last decade, however, advances in both the collection of new data and the harmonization of older data with the new data have allowed researchers to make

¹This is not to say that these papers did not have empirical content. For example, Ghez and Becker (1975) use data from the Survey of Consumer Expenditures (1960-1961) and the Census (1960) to test several of their hypotheses.

significant progress in our understanding of how individuals allocate their time. The goal of this review is to highlight some of this recent empirical literature that has used the new (or the newly harmonized) time use data sets.

The paper proceeds in five parts. In Section 2, we describe the data that researchers have used to measure time use. In Section 3, we discuss recent developments in analyzing long run trends in time use. In Section 4, we set up a lifecycle model with home production and highlight how recent empirical work has used the predictions of the model to explain patterns of the lifecycle behavior of households. In Section 5, we review recent theoretical and empirical work on the allocation of time over the business cycle. In Section 6, we conclude and identify areas where additional research is needed.

Before proceeding, we stress that our goal is to highlight some of the recent advances in the empirical literature that tests existing theories of time allocation. We do not consider this review to be an exhaustive survey of all the relevant work on time use that has taken place in the last few decades. In this sense our article is complementary to Gronau (1987) who surveys the older (mostly theoretical) literature and to Juster and Stafford (1991) who discuss in more detail issues related to the measurement of time. Additionally, most of our applications are drawn from U.S. data. There is much interesting work being done with time use data in other countries, and we discuss some of this work later.

2 Time Use Data

Micro data on the time individuals spend on market work has been consistently measured since at least the 1960s. For example, in the United States the Current Population Survey (CPS) has collected hours worked in the market for a large

representative sample of the U.S. population starting in 1962. The Panel Study of Income Dynamics (PSID), the Health and Retirement Survey (HRS) and the National Longitudinal Surveys (NLSY) are panel datasets that provide market work hours for a given individual over time.

Micro data on the extent to which individuals allocate their time to activities other than market work has been much more scarce. Both the PSID and the HRS provide some non-diary recall data on certain aspects of non-market time. However, a number of studies have shown that time diaries provide more accurate estimates for non-market time relative to surveys based on recall data.² For instance, Robinson and Godbey (1999) discuss how estimates of time use in studies that focus on recall estimates of time spent in various activities almost always add up to a number that exceeds the total time endowment. We start by reviewing available U.S. time use datasets which are based on time diaries. We then discuss some of the time use data available in other countries.

2.1 U.S. Historical Time Use Data: 1965-1999

Between 1965 and 1999 there were five large nationally representative time use surveys that document how individuals spend their time away from market. The

²An issue with time diaries (when used to conduct individual level analysis) is that a large fraction of individuals have zero values for the time spent in many activities. For example, it is reasonable to assume that most parents spend at least some time on child care, but it has been observed that a relatively large fraction of parents report no time spent on child care on their diary day. Some researchers have advocated Tobit methods to deal with the zeros. Stewart (2009) argues that the zeros in time use data arise from a mismatch between the reference period of the data (the diary day) and the period of interest which is typically much longer. As a result, two-part models and OLS methods may be preferable to Tobit.

surveys were: 1965-1966 Americans' Use of Time; 1975-1976 Time Use in Economics and Social Accounts; 1985 Americans' Use of Time; 1992-1994 National Human Activity Pattern Survey; and the 1998-1999 Family Interaction, Social Capital and Trends in Time Use Study. All surveys used a 24-hour recall of the previous day's activities to record time diary information. All surveys aside from the 1975-1976 survey collect diaries for only one individual per household. Below, we briefly summarize the other salient features of these surveys.

The 1965-1966 Americans' Use of Time was conducted by the Survey Research Center at the University of Michigan. The survey sampled one individual per household in 2001 households in which at least one adult person between the ages of 19 and 65 was employed in a non-farm occupation during the previous year. Of the 2001 individuals, 776 came from Jackson, Michigan. The remainder of the sample was designed to be nationally representative. The time use data were obtained by having respondents keep a complete diary of their activities for a single 24-hour period between November 15 and December 15, 1965, or between March 7 and April 29, 1966.

The 1975-1976 Time Use in Economic and Social Accounts was also conducted by the Survey Research Center at the University of Michigan. The sample was designed to be nationally representative excluding individuals living on military bases. Unlike any of the other time use studies, this study sampled multiple adult individuals in a household (as opposed to a single individual per household). The sample included 2406 adults from 1519 households. The survey collected up to four diaries for each respondent over the course of a year. However, the attrition rate for the subsequent rounds after the first round was high. The 1975-1981 Time Use Longitudinal Panel Study is a longitudinal dataset that combines additional

data collected in 1981 with the earlier 1975-1976 Time Use in Economic and Social Accounts dataset. This combined dataset consists of 620 respondents (and their spouses if they were married at the time of first contact).

The 1985 Americans' Use of Time survey was conducted by the Survey Research Center at the University of Maryland. The sample of 4939 individuals was nationally representative with respect to adults over the age of 18 living in homes with at least one telephone. The survey sampled its respondents from January 1985 through December 1985. Part of the survey design was to compare response rates for individuals who were asked to complete the survey via mail relative to individuals who were asked to complete the survey via telephone interviewing or face-to-face interviewing.

The 1992-1994 National Human Activity Pattern Survey was conducted by the Survey Research Center at the University of Maryland and was sponsored by the United States Environmental Protection Agency. As a result, this survey also asked detailed questions about the location where different time use activities were taking place. The sample was designed to be nationally representative with respect to households with telephones. The sample included 9386 individuals, of whom 7514 were individuals over the age of 18. The survey randomly selected a representative sample for each 3-month quarter starting in October of 1992 and continuing through September of 1994. This survey contained the least detailed demographics of all the time use surveys. Specifically, the survey reports the respondent's age, sex, level of educational attainment, race, labor force status and parental status. Unfortunately, the survey does not report the respondent's marital status, household income, or the number of children present in the household.

The 1998-1999 Family Interaction, Social Capital, and Trends in Time Use Study, conducted at the University of Maryland Survey Research Center, covers a small scale contiguous state sample of individuals over 18. 1151 individuals were surveyed between March of 1998 and December of 1999. One of the goals of the survey was to measure time spent on social interactions, and in particular the time parents spend with their children.

Despite the fact that each of these time use surveys were conducted during different time periods and had different objectives, the structure of the surveys was very similar.³ As a result, it is easy to harmonize the data across the years. The American Heritage Time Use Study (AHTUS) is a dataset that harmonizes the above five datasets. In addition, the AHTUS dataset has started harmonizing the first waves of the American Time Use Survey.

2.2 U.S. Recent Time Use Data: 2003-2010

The American Time Use Survey (ATUS) was recently developed to provide consistent and periodic data on how U.S. individuals are allocating their time away from market work. The ATUS is conducted by the U.S. Bureau of Labor Statistics (BLS). Covering more than 400 detailed time categories, the ATUS is considered the state of art in time use surveys. Participants in ATUS, which includes children over the age of 15, are drawn from the existing sample of the Current Population Survey (CPS). The individual is sampled approximately 3 months after completion of the final CPS survey. At the time of the ATUS survey, the BLS updates the respondent's employment and demographic information. Respondents are

³John Robinson, currently at the University of Maryland, was the Principal Investigator on all five time use surveys. Given the common Principal Investigator, the survey design was very similar across all the surveys.

surveyed during every month of the year. There were roughly 20000 respondents in the 2003 wave of the ATUS, while the 2004-2010 waves included around 13000 respondents each year. For a more detailed description of the ATUS dataset and the activities that it records see Hamermesh, Frazis and Stewart (2005).

One difficulty in harmonizing the ATUS data to the other historical time use data within the U.S. is that the survey structure and subsequent coding of time use activities are dramatically different. Most of the U.S. time use surveys prior to the ATUS categorized time use into roughly 90 different sub-categories of time use, whereas the ATUS includes over 400 different sub-categories. Individual researchers have taken the raw ATUS data and tried to create classifications that were consistent with the earlier surveys. For an example of harmonizing the various datasets see Aguiar and Hurst (2007a).

2.3 International Time Use Data

Many other developed countries have collected cross sectional time use data during the last forty years. Much of this data can be downloaded from the Multinational Time Use Study (MTUS). The MTUS is an ex-post harmonized cross-time, cross-national comparative time-use database constructed from national random-sampled time-diary studies. Currently, the MTUS encompasses over 60 datasets from roughly 20 countries (including the U.S. studies discussed above). Countries with multiple surveys spanning multiple decades include Australia, Canada, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, and the United Kingdom. Like the U.S. data, most of these surveys are based on 24-hour recall of the prior day's activities. Many of these studies have all adults in a household and multiple consecutive days.

3 Aggregate Trends in Time Use

The recent progress in the measurement of time use in many developed economies has allowed researchers to analyze how time allocated away from market work has evolved over the past few decades. In this section, we review the trends in non-market work (home production), leisure, and child care within the U.S. and a few other developed economies.

3.1 Trends in U.S. Home Production and Leisure

It has been well documented that in the U.S. time spent on market work for men has been falling since the late 1960s while time spent on market work for women has been increasing steadily during this time period.⁴ The harmonization of the historical U.S. time use surveys allows researchers to examine what men and women have been doing with their time more broadly during this time period. In this sub-section, we focus on two broad time use categories: leisure time and non-market work time. As seen from the work surveyed below, two robust features of the data have emerged. First, since the 1960s aggregate non-market work time has fallen sharply. Second, during this time period, leisure time has increased. The extent to which leisure time has increased, however, differs across authors depending on how the leisure activities are defined.

Specifically, non-market work time includes activities like cooking, cleaning, laundry, home maintenance, grocery shopping, and obtaining services (e.g. going to the barber or going to the dry cleaners). Time spent obtaining education or medical services are almost always excluded from the non-market work category. Instead, researchers treat such time as investments (either in human capital or

⁴See, for example, McGrattan and Rogerson (2004).

health). There is some disagreement about the extent to which time spent on child care should be treated as non-market work time. Given this, we choose to treat child care as a separate category and discuss it separately below.

Most researchers define leisure time as the time individuals spend in activities such as watching television, socializing, playing games, talking on the phone, exercising, engaging in sports, using the computer for personal use, going to the movies, etc. Some researchers lump together personal maintenance time into their leisure measures. These categories include time spent eating, time spent sleeping and time spent on personal care. Including these categories into the leisure measure is usually found to make little difference for the trend in leisure time given that the trend in the sum of these personal maintenance categories has been constant since the 1960s, as reported for example by Aguiar and Hurst (2007a).

Juster (1985), Robinson and Godbey (1999), Aguiar and Hurst (2007a) and Ramey and Francis (2009) use the harmonized time use data sets within the U.S. to explore trends in leisure and non-market work time. Robinson and Godbey (1999) is a book length treatise comparing the time use data from the 1965, 1975, 1985, and 1992-1994 surveys. Aguiar and Hurst (2007a) harmonized all the earlier time use surveys with the more recent data from the ATUS. A key finding from their paper is that total non-market work in the U.S. fell by nearly four hours per week between 1965 and 2003 for non-retired individuals between the ages of 18 and 65. For women, the decline in non-market work was over 10 hours per week. Men, on the other hand, actually increased their time spent on non-market work by 4 hours per week during this time period. In the same paper, Aguiar and Hurst documented that between 1965 and 2003 average leisure time in the

U.S. increased by roughly 5 hours per week for non-retired individuals between the ages of 18 and 65. The increase in leisure was slightly higher for men than it was for women (6.2 hours per week versus 4.9 hours per week).

Ramey and Francis (2009) independently harmonized the U.S. time use data and documented trends in leisure and home production for the population as a whole and for men and women separately. Like Aguiar and Hurst (2007a), Ramey and Francis (2009) also found a large decline in aggregate home production time for prime age individuals between 1960 and the early 2000s. Ramey and Francis (2009), however find that there was very little increase in leisure for either prime age men or women during this time period.⁵

The work of Ramey and Francis (2009) provides an additional innovation above and beyond the work of Aguiar and Hurst (2007a). In particular, Ramey and Francis (2009) incorporate the findings of Ramey (2009) into their analysis which allows them to compute trends in non-market work and leisure prior to 1965. This is a very ambitious task given that there are no nationally representative time diaries within the U.S. prior to 1965. The goal of Ramey (2009) is to use non-representative time use surveys conducted within the U.S. prior to 1965 to compute the amount of home production done in the U.S. for an average individual by weighting the non-representative samples appropriately. Using this methodology, Ramey (2009) concludes that between 1900 and 1965, non-market work time for women fell by about 6 hours per week while non-market work time for men increased by about 7 hours per week. Given the Ramey (2009) estimates, Ramey and Francis (2009) state that aggregate leisure increased by an additional

⁵See Ramey (2007) and Aguiar and Hurst (2007c) for a reconciliation of the differences in leisure trends between the two papers. A large part of the debate is whether eating while at market work is consider market work (Aguiar and Hurst) or leisure (Ramey and Francis).

two hours per week for prime aged individuals between 1900 and 1965.

3.2 Trends in U.S. Leisure Inequality

Aguiar and Hurst (2007a, 2009) explore the evolution of other moments of the time use distribution in the U.S. with the aim of documenting the evolution of leisure inequality. They show that between 1965 and 1985, the average time spent on leisure activities for low educated households grew at a rate similarly to the average time spent on leisure activities for high educated households. Between 1985 and 2003, however, the leisure time of low educated households grew substantially while the leisure time of higher educated households actually contracted. Almost all the differences in leisure across education groups was driven by differences in the time allocated to market work across the education groups. The growing leisure inequality mirrors the well documented change in wages and consumption between education groups starting in the early 1980s.⁶

3.3 Trends in U.S. Child Care Time

Parental time spent with children combines elements of parental leisure, parental home production, and parental investments.⁷ For example, when asked to assess the satisfaction they receive from the various activities they perform, individuals consistently rank the time they spend playing with their children and reading to their children as being the most enjoyable (Robinson and Godbey, 1999). Such

⁶See, for instance, Katz and Autor (1999) and Attanasio, Battistin, and Ichimura (2004).

⁷For the purposes of this short review we do not distinguish between time devoted to a child care activity, time in which a child was present, time in which an adult reported responsibility for the care of a child under 12 and general supervisory time. See Folbre, Yoon, Finnoff and Fuligni (2005) for a careful definition of the time spent on child care.

evidence suggests that elements of child care time are akin to leisure. Alternatively, some child care services can be purchased directly from the market. As a result, some elements of child care time are akin to home production.

Kimmel and Connelly (2007) treat child caregiving time distinctly from time spend on home production, leisure and paid market work. Their focus is to identify differential responses of these time use categories to demographics and prices. For instance, the authors find that higher-wage mothers devote more time to caregiving and that paid work time on weekdays responds positively to higher wages, while leisure time and home production weekday time respond negatively to higher wages.

Guryan, Hurst and Kearney (2008) document that the income elasticity of child care time is strongly positive, with richer and higher educated parents spending much more time with their children than poorer and lower educated parents. In all years of the time use surveys, high income parents spend less time on home production relative to lower educated parents. In recent time use surveys, high income parents also allocate less of their time to leisure than low educated parents. The income elasticity of child care time stands in sharp contrast (and is of opposite sign) to the income elasticities of both home production time and leisure time.

Sayer, Bianchi, and Robinson (2004) and Aguiar and Hurst (2007a) document that time spent with children has been increasing in the late 1990s and the 2000s relative to the 1960s, 1970s, and 1980s.⁸ Ramey and Ramey (2010) document that the increase in time spent with children has increased more for high educated

⁸These results could be influenced by classification issues. Because of the way the ATUS is structured, child care may be over-reported compared to earlier time-use surveys.

parents relative to low educated parents. The increasing gap in time spent with children by education has occurred in all categories of child care time: time spent on basic child care, time spent on educational child care, and time spent on recreational child care.

Collectively, these results show that there are interesting patterns in the trends in child care and the response of child care to changing demographics and prices that should be treated as distinct from the responses in either home production or leisure.

3.4 Time Use Patterns in Other Countries

There is much work that also uses international time use data to measure the trends in time use within other countries or to compare the allocation of time across countries.⁹ Early work by Juster and Stafford (1991) provides some cross country analysis of time use. For instance, this work documents that total work hours for men declined substantially in Japan, Norway and the U.S. between the 1960s and the 1980s. This decline was a consequence of a small increase in hours spent on non-market work which was more than fully offset by a large decline in hours spent on market work.

Lee, Kawaguchi and Hamermesh (2011) use time diaries from Japan and Korea to analyze the effects of legislated labor demand shocks on time use. Identification of the effects on time use comes from the fact that the exogenous reduction in legislated work hours is more likely to affect workers who are closer to the constraint. Using time diaries from before and after these shocks, they find

⁹For some additional recent work using international data see the 2005 symposium organized by the *European Economic Review* (Hamermesh and Pfann, 2005).

that the increased time was mostly reallocated to increased leisure and increased personal maintenance, with very little time being absorbed by home production.

Gimenez-Nadal and Sevilla-Sanz (2011) use the Multinational Time Use Study (MTUS) and other country-specific datasets for seven developed countries (Australia, Canada, Finland, France, the Netherlands, Norway and the UK) to examine trends in the allocation of time since the mid-1970s. They conclude that leisure time for men increased by roughly 4 hours per week over the last few decades in Australia, Finland, and the United Kingdom. Conversely, during the last few decades, leisure time for men actually declined in France, the Netherlands, and Norway and remained constant in Canada. They find that in most countries changes in leisure were less pronounced for women relative to men. Additionally, Gimenez-Nadal and Sevilla-Sanz (2011) document that in most countries decreases in men's market work were offset by increases in time spent on non-market work and child care. For women, time devoted to market work increased in almost all countries and time spent on home production decreased.

The proliferation of datasets on time use in various countries has also allowed researchers to look at cross country differences in the allocation of time. Freeman and Schettkat (2005) examine time use data from a number of countries and conclude that there is a very high substitution of time between market and home work across individuals. For instance, they report that in the 1990s Europeans worked 20% more than Americans in the home sector. Similar patterns are documented by Burda, Hamermesh and Weil (2008) who compare the allocation of time within the U.S. to the allocation of time in Germany, Italy and the Netherlands.

Burda, Hamermesh and Weil (2007) use time diary data from 25 countries

and demonstrate a strong gender “iso-work” relationship in various advanced economies. Specifically, while men work more in the market sector than women and women work more in the home sector than men, these differences tend to balance out in a way such that men and women spend approximately the same time on total (market and non-market) work (see also Robinson and Godbey, 1999). Burda, Hamermesh and Weil (2007) argue that the iso-work fact may be explained by a model which incorporates a social norm for leisure. Peer pressure or conformity to common social norms can diminish the incentive to allocate time in response to changing wages and individual tastes. As a result, total work (market plus non-market) time and leisure time become more similar across individuals.

In a cross country study, Alesina and Ichino (2009) use the MTUS dataset for Italy (2002), the U.S. (2003), Spain (2002) and Norway (2000) to estimate how home production affects cross country comparisons in GDP. Specifically, the authors use two methods to estimate the value of home production. The first one assumes that home production time is paid according to the ongoing market wage, while the second one evaluates each hour of home production at the cost at which home services can be bought in the market (measured as the unskilled wage). A robust finding of their analysis is that Italy’s position in terms of GDP with respect to comparable countries would improve considerably if official statistics included the imputed value of home production.

4 Lifecycle Consumption and Labor Supply

The economics literature typically analyzes lifecycle patterns of consumption and work by appealing to models that emphasize only the intertemporal substitution

of goods and time. However, various patterns of consumption expenditure and labor supply over the lifecycle cannot be explained based on intertemporal substitution only. In this section, we start by describing a simple model due to Ghez and Becker (1975) that aims to explain lifecycle expenditures and labor supply by incorporating rich intratemporal substitution patterns between time and goods. We then discuss how the theory can be used to rationalize a number of stylized facts of the lifecycle behavior of households and we review recent developments in the empirics of consumption and labor supply.

4.1 A Lifecycle Model With Intratemporal Substitution

A consumer lives for $t = 1, \dots, T$ periods. The consumer self-insures by borrowing and lending at an exogenous and constant interest rate r . Assets a_{t+1} must exceed some lower bound ϕ . The consumer takes all prices in the economy as given.

The consumer derives utility from N commodities C_i , $i = 1, \dots, N$. We denote the period utility function by $U(C_1, \dots, C_N)$. We denote by β the discount factor. Preferences are additively separable across periods. In every period t , the consumer maximizes the expected discounted sum of utilities:

$$\mathbf{E}_t \sum_{s=t}^T \beta^{s-t} U(C_{1s}, \dots, C_{Ns}) \quad (1)$$

Following Becker (1965), we represent the commodities $C_{it} = f^i(H_{it}, X_{it})$ that enter utility as the outputs of production functions that take time H_{it} and market expenditures X_{it} as inputs.¹⁰ For instance, a commodity may be “watching a television show,” which combines services from a durable (the television), a cable subscription, and time. Similarly, another commodity may be a “meal”

¹⁰For simplicity, we have ruled out “joint production.” That is, a time or market good used to produce commodity i cannot be simultaneously used to produce commodity j with $i \neq j$.

which is produced with groceries and time spent on cooking as inputs. Note that in the former example time and market goods are complements, while in the latter example time and market goods may be substitutes, given the option to purchase food prepared by others. As we shall see, the degree of substitutability between time and market inputs in the production function is a key feature that distinguishes various commodities. We denote the price of market good X_{it} by p_{it} .

Let L_t denote the time the consumer spends working in the market. The consumer earns an exogenous (after-tax) wage w_t per unit of time worked in the market. The consumer also earns an exogenous income T_t in each period (e.g. a transfer from the government). We normalize the total time endowment to 1 in each period.

The sources of uncertainty in the model are the spot wage w_t , the vector of market goods prices $p_t = [p_{1t}, \dots, p_{Nt}]$ and the income transfer T_t . We denote the exogenous state vector by $s_t = (w_t, p_t, T_t)$. The exogenous state vector follows a Markov process whose transition probabilities may vary over the lifecycle. Specifically, we denote by $\pi_t(s'|s)$ the probability that in period $t+1$ the state is $s_{t+1} = s'$ conditional on the state being $s_t = s$ in period t .

This model nests as special cases the standard neoclassical model of consumption (see, for instance, Attanasio and Weber, 2010) and the standard neoclassical model of labor supply (see, for instance, Blundell and MaCurdy, 1999). Specifically, the standard model is obtained when there are only two-commodities and the first commodity is produced only with market expenditures (“consumption”) and the second commodity is produced only with time (“leisure”).

We can represent the consumer’s optimization problem in recursive form. In

any period $t < T$ the consumer solves:

$$V_t(a_t, s_t) = \max_{\{H_{it}\}, \{X_{it}\}, L_t, a_{t+1}} U(C_{1t}, \dots, C_{Nt}) + \beta \int V_{t+1}(a_{t+1}, s_{t+1}) \pi_t(s_{t+1}|s_t) ds_{t+1} \quad (2)$$

subject to the constraints:

$$C_{it} = f^i(H_{it}, X_{it}) \quad (3)$$

$$L_t + \sum_{i=1}^N H_{it} \leq 1 \quad (4)$$

$$\sum_{i=1}^N p_{it} X_{it} + a_{t+1} \leq w_t L_t + (1+r)a_t + T_t \quad (5)$$

$$a_{t+1} \geq \phi \quad (6)$$

To solve this problem, we substitute constraint (3) into the objective function (2). Also, denote by θ_t the multiplier on constraint (4), by λ_t the multiplier on constraint (5) and by μ_t the multiplier on constraint (6). To simplify the exposition we are assuming that the consumer is in an interior equilibrium with $L_t > 0$, $H_{it} > 0$ and $X_{it} > 0$ for all commodities $i = 1, \dots, N$.¹¹ The first-order conditions associated with this problem are:

$$\{H_{it}\} : \frac{\partial U}{\partial C_{it}} \frac{\partial C_{it}}{\partial H_{it}} = \theta_t \implies \frac{\partial U / \partial C_{it}}{\partial U / \partial C_{jt}} = \frac{\partial C_{jt} / \partial H_{jt}}{\partial C_{it} / \partial H_{it}}, \forall i, j = 1, \dots, N \quad (7)$$

$$\{X_{it}\} : \frac{\partial U}{\partial C_{it}} \frac{\partial C_{it}}{\partial X_{it}} = \lambda_t p_{it} \implies \frac{\partial U / \partial C_{it}}{\partial U / \partial C_{jt}} = \frac{p_{it}}{p_{jt}} \frac{\partial C_{jt} / \partial X_{jt}}{\partial C_{it} / \partial X_{it}}, \forall i, j = 1, \dots, N \quad (8)$$

$$L_t : \theta_t = \lambda_t w_t \implies \frac{\partial C_{it} / \partial H_{it}}{\partial C_{it} / \partial X_{it}} = \frac{w_t}{p_{it}}, \forall i = 1, \dots, N \quad (9)$$

¹¹Because the consumer optimizes at an interior point we use the terms “wage” and “opportunity cost of time” interchangeably. If the consumer chooses to not work, however, the opportunity cost of time, now given by the marginal rate of technical substitution between time and expenditures, exceeds the real wage. All our results below can be easily generalized to the case in which the consumer does not work, with the difference that one has to use the marginal rate of technical substitution as the appropriate measure of the opportunity cost of time (instead of the wage).

$$a_{t+1} : \lambda_t - \mu_t = \beta(1 + r_t) \int \lambda_{t+1} \pi_t(s_{t+1}|s_t) ds_{t+1} \quad (10)$$

The first-order condition (7) states that the consumer allocates time across different commodities in a way that equalizes the marginal rate of substitution between different commodities (the ratio of the marginal utilities) to the ratio of the marginal products of time in the production of these commodities. Similarly, the first-order condition (8) states that the consumer allocates expenditures across different commodities in a way that equalizes the marginal rate of substitution between different commodities to the ratio of the marginal products of expenditure in the production of these commodities adjusted by the relative price of inputs. The first-order condition (9) states that the consumer supplies labor in the market up to the point where the real wage is equalized to the marginal rate of technical substitution between time and expenditure (which for each good equals the ratio of the marginal products). Finally, the first-order condition (10) characterizes the intertemporal allocation of resources. We note that all previous conditions hold regardless of the specific assumption one makes on the structure of asset markets (complete markets, incomplete markets, borrowing constraints etc.).

For given marginal value of resources λ_t , wage w_t and vector of prices $p_t = [p_{1t}, \dots, p_{Nt}]$, equations (7) and (8) define a system of $2N$ equations in $2N$ unknowns.¹² Additionally, the time constraint is one more equation that can be used to solve for labor supply L_t and the production functions provide solutions for the commodities C_{it} . Denote the solution of this system by:

$$H_{it}(\lambda_t, w_t, p_t); L_t(\lambda_t, w_t, p_t); X_{it}(\lambda_t, w_t, p_t); C_{it}(\lambda_t, w_t, p_t), \forall i = 1, \dots, N \quad (11)$$

We examine how time H_{it} and L_t , expenditures X_{it} and the production of

¹²This is after substituting $\theta_t = \lambda_t w_t$ from equation (9) to equation (7).

commodities C_{it} respond when the wage w_t or the marginal value of resources λ_t vary over the lifecycle. To simplify the exposition and to get a sharper intuition for the results, we will assume that the utility function $U(C_1, \dots, C_N)$ is separable across commodities, and that the production technology $C_{it} = f^i(H_{it}, X_{it})$ is characterized by constant returns to scale.

First, we consider variations of the opportunity cost of time w_t holding constant λ_t and p_t . We use the following notation. We define the λ_t -constant elasticity of time H_{it} and L_t , expenditures X_{it} and the production of commodities C_{it} with respect to the opportunity cost of time as:

$$\varepsilon_{Hw}^i = \frac{\partial H_{it}}{\partial w_t} \frac{w_t}{H_{it}}, \quad \varepsilon_{Lw} = \frac{\partial L_t}{\partial w_t} \frac{w_t}{L_t}, \quad \varepsilon_{Xw}^i = \frac{\partial X_{it}}{\partial w_t} \frac{w_t}{X_{it}} \quad \text{and} \quad \varepsilon_{Cw}^i = \frac{\partial C_{it}}{\partial w_t} \frac{w_t}{C_{it}} \quad (12)$$

We define the elasticity of the output of commodity C_{it} with respect to some input as:

$$\varepsilon_{CH}^i = \frac{\partial C_{it}}{\partial H_{it}} \frac{H_{it}}{C_{it}} \quad \text{and} \quad \varepsilon_{CX}^i = \frac{\partial C_{it}}{\partial X_{it}} \frac{X_{it}}{C_{it}} \quad (13)$$

By constant returns to scale, we have $\varepsilon_{CX}^i + \varepsilon_{CH}^i = 1$ for all commodities $i = 1, \dots, N$. Additionally, the elasticities of output with respect to inputs coincide with the implicit income shares of these inputs in the production of output.

We define the intratemporal elasticity of substitution between time H_{it} and expenditures X_{it} in the production of good C_{it} as:

$$\sigma^i = d \ln \left(\frac{X_{it}}{H_{it}} \right) / d \ln \left(\frac{\partial C_{it} / \partial H_{it}}{\partial C_{it} / \partial X_{it}} \right) = \varepsilon_{Xw}^i - \varepsilon_{Hw}^i \quad (14)$$

The last equality of equation (14) follows from the first-order condition (9). Finally, we define the elasticity of intertemporal substitution for commodity i as:

$$\gamma^i = - \frac{\partial U / \partial C_{it}}{C_{it} (\partial^2 U / \partial C_{it}^2)} \quad (15)$$

Note that the intertemporal elasticity of substitution γ^i , the intratemporal elasticity of substitution σ^i and the shares ε_{CH}^i and ε_{CX}^i are allowed to vary by

commodity i . To ease the notation we have assumed that these parameters are stable over time, but it is straightforward to generalize our analysis to the case under which these parameters vary over time.¹³

Differentiating the first-order condition (8) with respect to w_t (holding constant λ_t) and manipulating the resulting expression yields:¹⁴

$$\frac{\partial C_{it}}{\partial X_{it}} \left(\varepsilon_{CH}^i \varepsilon_{Hw}^i + \varepsilon_{CX}^i \varepsilon_{Xw}^i \right) - \gamma^i H_{it} \frac{\partial^2 C_{it}}{\partial X_{it} \partial H_{it}} \left(\varepsilon_{Hw}^i - \varepsilon_{Xw}^i \right) = 0 \quad (16)$$

Using the facts that $\sigma^i = \varepsilon_{Xw}^i - \varepsilon_{Hw}^i$ and $\varepsilon_{CX}^i + \varepsilon_{CH}^i = 1$, equation (16) can be solved for the λ -constant elasticity of expenditures with respect to the wage:¹⁵

$$\varepsilon_{Xw}^i = \varepsilon_{CH}^i \left(\sigma^i - \gamma^i \right) \quad (17)$$

Equation (17) states that expenditures for commodity i increase with the wage if the intratemporal elasticity of substitution between time and goods is greater than the intertemporal elasticity of substitution in consumption. The intuition is that as the wage increases, the consumer substitutes away from time and towards market inputs to achieve a given level of consumption. This is a movement along the production isoquant and is parameterized by σ^i . However, the fact that time is costlier in the current period relative to other periods causes the consumer to shift consumption to a period in which the cost of producing consumption (time plus market goods) is lower. This a parallel movement towards a lower production isoquant and is parameterized by γ^i . The magnitude of the change in expenditures also depends on the share of time in production. In the limiting

¹³Note that we have also assumed that the production of commodity C_{it} is characterized by a stable production function $f^i(H_{it}, X_{it})$. It is conceivable that the efficiency with which time and expenditures are combined into the production of final goods also changes over time.

¹⁴We use the fact that for a linear homogeneous function $f(x_1, x_2)$ we have $f_{11} = -x_2 f_{12} / x_1$.

¹⁵We use the fact that for a linear homogeneous function $f(x_1, x_2)$ we have: $f_{12} = (f_1 f_2) / (\sigma f)$.

case in which consumption uses only expenditures as inputs, movements in the opportunity cost of time have no effect on expenditures.

The λ -constant elasticity of time in each commodity with respect to the wage equals:

$$\varepsilon_{Hw}^i = \varepsilon_{Xw}^i - \sigma^i = -\left(\varepsilon_{CX}^i \sigma^i + \varepsilon_{CH}^i \gamma^i\right) \quad (18)$$

The elasticity is always negative. As the opportunity cost of time increases, the consumer substitutes both intratemporally away from current time towards current expenditures (parameterized by σ^i) and intertemporally away from current time towards time in other periods (parameterized by γ^i).

Using the time constraint (4) we can obtain the λ -constant elasticity of labor supply with respect to the wage:

$$\varepsilon_{Lw} = -\sum_{i=1}^N \left(\varepsilon_{Hw}^i \frac{H_{it}}{L_t} \right) = \sum_{i=1}^N \left(\left(\varepsilon_{CX}^i \sigma^i + \varepsilon_{CH}^i \gamma^i \right) \frac{H_{it}}{L_t} \right) \quad (19)$$

Since the time constraint holds along the optimal path, the elasticity of labor supply with respect to the wage is a weighted average of the elasticities of time allocated in the production of the various commodities. Since the latter are all negative, the λ -constant elasticity of labor supply is always positive.

Finally, totally differentiating the production functions, we obtain the λ -constant elasticity of consumption of commodity i with respect to the wage:

$$\varepsilon_{Cw}^i = \varepsilon_{CH}^i \varepsilon_{Hw}^i + \varepsilon_{CX}^i \varepsilon_{Xw}^i = -\gamma^i \varepsilon_{CH}^i \quad (20)$$

The elasticity of commodity i with respect to the wage is a weighted average of the elasticity of expenditures with respect to the wage and the elasticity of time with respect to the wage. Recall that both elasticities are driven by both intertemporal and intratemporal substitution. In both cases, intertemporal substitution causes a decrease of the inputs when the opportunity cost time increases.

Intratemporal substitution, on the other hand, tends to increase expenditures and to decrease time when the opportunity cost of time increases. Equation (20) shows that these effects cancel out in a way that only the effects of intertemporal substitution remain. Holding constant the marginal value of resources λ_t , when the opportunity cost of time increases consumption of commodity i falls as long as the commodity uses time as an input in its production.

Next, we consider variations of the marginal value of resources λ_t , holding constant the wage w_t and the price vector p_t . We use the following notation. We define the w_t -constant elasticity of time H_{it} and L_t , expenditures X_{it} and the production of commodities C_{it} with respect to the marginal value of resources as:

$$\varepsilon_{H\lambda}^i = \frac{\partial H_{it}}{\partial \lambda_t} \frac{\lambda_t}{H_{it}}, \varepsilon_{L\lambda} = \frac{\partial L_t}{\partial \lambda_t} \frac{\lambda_t}{L_t}, \varepsilon_{X\lambda}^i = \frac{\partial X_{it}}{\partial \lambda_t} \frac{\lambda_t}{X_{it}} \text{ and } \varepsilon_{C\lambda}^i = \frac{\partial C_{it}}{\partial \lambda_t} \frac{\lambda_t}{C_{it}} \quad (21)$$

Differentiating the first-order condition (8) with respect to λ_t and manipulating the resulting expression yields:

$$\left(\varepsilon_{CH}^i \varepsilon_{H\lambda}^i + \varepsilon_{CX}^i \varepsilon_{X\lambda}^i \right) - \gamma^i \frac{\partial^2 C_{it}}{\partial X_{it}^2} \frac{X_{it}}{\partial C / \partial X_{it}} \left(\varepsilon_{X\lambda}^i - \varepsilon_{H\lambda}^i \right) = -\gamma^i \quad (22)$$

Differentiating the first-order condition (9) with respect to λ_t we obtain $\varepsilon_{X\lambda}^i - \varepsilon_{H\lambda}^i = 0$. Substituting $\varepsilon_{X\lambda}^i = \varepsilon_{H\lambda}^i$ into equation (22) we can solve for the w_t -constant elasticities of expenditures, time, labor supply and consumption of commodities with respect to λ_t :

$$\varepsilon_{C\lambda}^i = \varepsilon_{X\lambda}^i = \varepsilon_{H\lambda}^i = -\gamma^i \quad (23)$$

$$\varepsilon_{L\lambda} = - \sum_{i=1}^N \left(\varepsilon_{H\lambda}^i \frac{H_{it}}{L_t} \right) = \sum_{i=1}^N \left(\gamma^i \frac{H_{it}}{L_t} \right) \quad (24)$$

Equation (23) shows that when lifetime resources increase (a decrease of λ) for reasons other than changes in wages and prices, consumption of commodity i increases. The consumer increases the production of commodity i by increasing

both inputs by the same percent. Intuitively, this follows because the opportunity cost of time w_t/p_{it} is being held constant and therefore the marginal rate of technical substitution in the first-order condition (9) must also remain constant. With constant returns to scale, this can happen when both inputs increase proportionally as we move to a higher isoquant. Finally, equation (24) shows that when lifetime resources increase, labor supply decreases, as the consumer increases the time allocated in the production of all other commodities.

We now use these theoretical insights to examine a number of issues related to lifecycle expenditures and labor supply.

4.2 Retirement Spending

The workhorse model of consumption over the lifecycle, the permanent income hypothesis, posits that individuals allocate their resources in order to smooth their marginal utility of consumption across time (see e.g. Attanasio (1999) for a review). If the marginal utility of consumption depends only on measured consumption, this implies that individuals will save early in their lifecycle in order to maintain a smooth level of consumption at retirement. Hamermesh (1984) was the first to observe that retirees' savings are insufficient to sustain consumption throughout the rest of their lives. If households enter into retirement with low accumulated wealth, their consumption must decline sharply at retirement.

The "retirement consumption puzzle" refers to the fact that household expenditure falls discontinuously upon retirement. Banks, Blundell and Tanner (1998) look at the consumption smoothing of British households around the time of retirement. Controlling for factors that may influence the marginal utility of consumption (such as family composition and age, mortality risk, labor force

participation), they find that consumption falls significantly at retirement. Bernheim, Skinner, and Weinberg (2001) find that total food expenditure declines by 6-10% between the pre-retirement and the post-retirement period, which leads them to conclude that households do not use savings to smooth consumption with respect to predictable income shocks. Haider and Stephens (2007) use subjective retirement expectations as an instrument to distinguish between expected and unexpected retirements and find a decline in food expenditures ranging from 7-11% at retirement.

Aguiar and Hurst (2005) argue that tests of the lifecycle model typically equate consumption with expenditure. However, as stressed by the model above, consumption C_{it} is the output of a home production process which uses as inputs both market expenditures X_{it} and time H_{it} . Equations (17) and (18) show that when the relative price of time falls, individuals will substitute away from expenditures towards time spent on home production. Since retirees have a lower opportunity cost of time than their pre-retired counterparts, time spent on the production of commodities should increase during retirement. If this is the case, then the drop in expenditure does not necessarily imply a large decrease of actual consumption at retirement.

To test this hypothesis, Aguiar and Hurst (2005) explore how actual food consumption changes during retirement. Using data from the Continuing Survey of Food Intake of Individuals, a dataset conducted by the U.S. Department of Agriculture which tracks the dollar value, the quantity, and the quality of food consumed within U.S. households, they find no actual deterioration of a household's diet as they transition into retirement. To test the hypothesis that retirees maintain their food consumption relatively constant despite the declining food

expenditures, Aguiar and Hurst (2005) use detailed time diaries from the National Human Activity Pattern Survey and from the American Time Use Survey and show that retirees dramatically increase their time spent on food production relative to otherwise similar non-retired households. That retirees allocate more time to non-market production has been also shown by Hurd and Rohwedder (2006) and Schwerdt (2005).

In light of these evidence, Hurst (2008) concludes that the retirement puzzle “has retired.” That is, even though it is a robust fact that certain types of expenditures fall sharply as households enter into retirement, standard lifecycle models with home production are able to explain this sharp fall because retirees spent more time producing goods.¹⁶ Additionally, as we discuss in the next section, declines in expenditures are mostly limited to two types of consumption categories: work related items (such as clothing and transportation expenditures) and food (both at home and away from home). When expenditures exclude food and work related expenses, the measured declines in spending at retirement are either close to zero or even increasing.

4.3 Lifecycle Spending

The literature on spending over the lifecycle is also large. The typical finding has been that consumption follows a hump-shaped pattern over the lifecycle with consumption being low early in the lifecycle, peaking at middle age and falling sharply at retirement. Some authors have argued that the lifecycle profile represents evidence against the forward-looking consumption smoothing behavior

¹⁶Hurst (2008) also discusses how health shocks that lead to early retirement can help reconcile the fact that actual consumption falls for a small fraction of households upon retirement.

implied by permanent income models, particularly since the hump in expenditures tracks the hump in labor income (as documented by Carroll and Summers, 1991). This view interprets expenditure declines in the latter half of the lifecycle as evidence of poor planning. Other authors argue that the hump-shaped profile of consumption reflects optimal behavior if households face liquidity constraints combined with a need to self-insure against idiosyncratic income risks (see, for example, Zeldes 1989, Deaton 1991, Carroll 1997, Gourinchas and Parker 2002). Households build up a buffer stock of assets early in the lifecycle, generating the increasing expenditure profile found during the first half of the lifecycle. The decline in the latter half of the lifecycle is then attributed to impatience once households accumulate a sufficient stock of precautionary savings.

However, Aguiar and Hurst (2008) demonstrate that there is tremendous heterogeneity in the lifecycle patterns of expenditures across different spending categories. In particular, some categories (e.g. food and transportation) display the familiar hump-shaped profile over the lifecycle, but other categories display an increasing (e.g. entertainment) or decreasing (e.g. clothing and personal care) profile over the lifecycle. This heterogeneity cannot be captured by the standard lifecycle model of consumption that emphasizes only the intertemporal substitution of goods and time.

The heterogeneity in the lifecycle profiles of various expenditures is compatible with the Ghez and Becker (1975) model of lifecycle expenditures. We can use equation (17) to illustrate this point. Food consumption has a relatively low intertemporal elasticity of substitution and a relatively high intratemporal elasticity of substitution. It should therefore be more likely to covary positively with the opportunity cost of time. On the other hand, time and market goods are

difficult to substitute in the production of entertainment and entertainment has a relatively high intertemporal elasticity of substitution. As a result, we should expect expenditures on entertainment to rise as the opportunity cost of time falls. If the opportunity cost of time decreases as workers enter into retirement, then we expect food consumption to decrease and entertainment expenditures to increase upon retirement.

We summarize our discussion by stressing that the standard model of consumption focuses only on the fact that expenditures respond to movements in lifetime resources, abstracting from movements in the opportunity cost of time. That is, the standard model emphasizes only the elasticity $\varepsilon_{X\lambda}^i$ in equation (23) and assumes that $\varepsilon_{Xw}^i = 0$ in equation (17). This would not be an issue if time is a small share of consumption inputs. However, since time is an empirically prominent input in the production of various commodities, an analysis that abstracts from movements in the opportunity cost of time confounds price and income effects. This is analogous to models of labor supply, where it has long been recognized that wage changes yield both substitution and income effects. To illustrate this point consider equations (20) and (23) which show the response of consumption C_{it} with respect to w_t and λ_t respectively. If shocks to λ_t (income effects) dominate when consumers are close to retirement then we expect a decrease in expenditures, time allocated in home production and consumption. If, however, shocks to w_t (substitution effects) dominate, then the increased time in home production causes an increase in the production of final commodities.

4.4 Labor Supply Elasticities

Most attempts to obtain estimates of the labor supply elasticity are based on models in which any time not spent on the market is allocated to leisure (see, for instance, Blundell and MaCurdy, 1999, for a review of the standard neoclassical labor supply model). To map the standard model of labor supply into our framework, consider the simple case with only two commodities. The first commodity, “consumption,” is produced only with market expenditures, $c(H^1, X^1) = X^1$. The second commodity, “leisure,” is produced only with time $l(H^2, X^2) = H^2$. Under this case, the λ_t -constant elasticities of consumption, leisure and labor with respect to the wage are $\varepsilon_{cw} = 0$, $\varepsilon_{lw} = -\gamma$, and $\varepsilon_{Lw} = \gamma(1 - L_t)/L_t$ respectively, where $\gamma = -U_l/U_{ll}$. There is a rich literature that tries to estimate the elasticity of intertemporal substitution in labor supply (related to the parameter γ).

To understand the implications of introducing home production into the standard neoclassical labor supply model for the measurement of the elasticity of labor supply, now consider a simplified version of our model with three (instead of two) goods and $\gamma^i = \gamma$. Except for consumption and leisure, there is also a third good called “home commodity” which is produced according to a function $h(H^3, X^3)$ that uses both time and expenditures as inputs. Under this modification of the standard model, the λ_t -constant elasticity of labor supply with respect to the wage becomes:

$$\varepsilon_{Lw} = \gamma \frac{l_t}{L_t} + \left(\varepsilon_{hX}^3 \sigma^3 + \varepsilon_{hH}^3 \gamma \right) \frac{h_t}{L_t} \quad (25)$$

If both the two-good model and the three-good model have the same equilibrium level of labor supply L_t , then in the model with home production labor sup-

ply is more elastic with respect to variations of the wage that leave the marginal value of resources constant when $\sigma^3 > \gamma$. To see this note that:

$$\varepsilon_{Lw} = \gamma \frac{l_t}{L_t} + \left(\varepsilon_{hX}^3 \sigma^3 + \varepsilon_{hH}^3 \gamma \right) \frac{h_t}{L_t} > \gamma \frac{l_t}{L_t} + \left(\varepsilon_{hX}^3 \gamma + \varepsilon_{hH}^3 \gamma \right) \frac{h_t}{L_t} = \gamma \frac{1 - L_t}{L_t} \quad (26)$$

The main lesson is that augmenting the neoclassical model of labor supply with home production changes the measured responsiveness of labor supply to variations of the wage. Alesina, Ichino and Karabarbounis (2011) adopt preferences such that the elasticity of labor supply is increasing in the amount of time spent on home production.¹⁷ They argue that intrahousehold bargaining that favors men can explain why men take less home duties than women. This, in turn, explains the well documented gender gap in labor supply elasticities. In addition, since men engage in more home production and women engage in less home production relative to the 1960s, models in which the elasticity of labor supply is increasing in the time spent on home production imply that the elasticities of labor supply of men and women have converged relative to the 1960s. This seems indeed to be the case (see, for example, Blau and Kahn, 2007).

Empirically, Rupert, Rogerson and Wright (2000) construct a synthetic cohort from the cross section of three time use surveys to estimate a structural model of lifecycle consumption and labor supply with home production. They show that estimates of the intertemporal labor supply elasticity based on models that take home production explicitly into account are significantly larger than the estimates found in empirical studies that ignore home production. As we discuss

¹⁷A similar result also holds in this more general model. To be more precise, under the assumption $\sigma^3 > \gamma$ and holding constant the equilibrium level of labor supply L_t , equation (25) shows that the λ_t -constant elasticity of labor supply with respect to the wage increases in the fraction of time devoted to home production h_t as opposed to leisure l_t .

in Section 5, the result that labor supply responds more in models that explicitly take into account the home sector has important theoretical implications about the comovement of macroeconomic aggregates over the business cycle.

4.5 Micro Estimates of the Elasticity of Substitution

Our discussion above indicates that the degree to which households are willing to substitute intratemporally between expenditures X_{it} and time H_{it} is important in understanding various patterns of consumption and labor supply. Estimates of this elasticity σ can be obtained by estimating variations of equation (9). Rupert, Rogerson and Wright (1995) use data from the Panel Study of Income Dynamics (PSID). Most of their estimates point out for an elasticity that exceeds 1. Aguiar and Hurst (2007b) use data from the American Time Use Survey. Assuming that the relevant opportunity cost of time is the marginal rate of technical substitution between time and goods in the shopping technology, they find a value of around 1.8. Using PSID data, Gelber and Mitchell (2009) find that, in response to tax shocks, the elasticity of substitution between market and home goods is around 1.2 for single men and as high as 2.6 for single women. Finally, using consumer-level data on hours, wages, and consumption expenditure from the PSID and metro-level data on price indices p_i from the U.S. Bureau of Labor Statistics (BLS), Gonzalez Chapela (2011) estimates a lifecycle model with home production and finds a value of σ in the production of food of around 2.

5 Business Cycles

One of the most important contributions of the economics of time is in improving our understanding of aggregate fluctuations. The first wave of dynamic general

equilibrium models, pioneered by Kydland and Prescott (1982), assumed that total time is allocated into only two activities, market work and leisure. There are good reasons why introducing a third activity, time spent on home production, can make a difference for these models. First, when individuals derive utility both from market-produced goods and from home-produced goods, volatility in goods and labor markets can arise because of relative productivity differences between the two sectors, and not just because of productivity shocks in the market sector. Second, relative price changes cause households to substitute goods and time not only intertemporally between periods but also intratemporally between the market and the home sector. Intratemporal substitution introduces a powerful amplification channel which is absent from the standard real business cycle model. In fact, in his review of the home production literature Gronau (1997) writes that "... the greatest contribution of the theory of home production in the past decade was in its service to the better understanding of consumption behavior and changes in labor supply over the business cycle."

The first papers to introduce home production into the stochastic neoclassical growth model were Benhabib, Rogerson and Wright (1991) and Greenwood and Hercowitz (1991). We start by describing briefly the Benhabib, Rogerson and Wright (1991) model and some of its main results and extensions.¹⁸ Then, we discuss empirical tests of these models. We stress that, as opposed to the empirics on time use trends and time use over the lifecycle, the empirical literature on the allocation of time over the business cycle is still in its very early stages of development. This reflects the lack of a long time series dataset that can be used

¹⁸For a model detailed presentation and a review of the early literature, see Greenwood, Rogerson and Wright (1995).

to measure time use at business cycle frequencies.

5.1 Real Business Cycles with Home Production

In the Benhabib, Rogerson and Wright (1991) model, time is discrete and the horizon is infinite, $t = 0, 1, 2, \dots$. The market sector is similar to the standard real business cycle model (see e.g. King and Rebelo, 1999). There is a representative household who provides labor services N_t^m and capital services K_{t-1}^m to a competitive, profit-maximizing producer. Final market goods are produced according to the Cobb-Douglas technology:

$$Y_t = \exp(z_t^m) (K_{t-1}^m)^{\alpha_m} (N_t^m)^{1-\alpha_m} \quad (27)$$

where z_t^m denotes an exogenous technology shock in the market sector and $\alpha_m \in (0, 1)$.

The model departs from the standard real business cycle model by introducing a home sector in which goods can be produced. In the home sector, the household good is produced according to a Cobb-Douglas technology that combines time in household activities (N_t^h) with household capital goods (K_{t-1}^h):

$$C_t^h = \exp(z_t^h) (K_{t-1}^h)^{\alpha_h} (N_t^h)^{1-\alpha_h} \quad (28)$$

where z_t^h denotes an exogenous technology shock in the home sector and $\alpha_h \in (0, 1)$.

The representative household has preferences defined over bundles of aggregate consumption C_t and leisure L_t :

$$\mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \quad (29)$$

where $\beta \in (0, 1)$ is the discount factor. The utility function is specified as:

$$U(C_t, L_t) = \frac{(C_t^{1-b} L_t^b)^{1-\gamma} - 1}{1-\gamma} \quad (30)$$

with $\gamma > 0$ and $b \in (0, 1)$. The difference relative to the standard real business cycle model is that here aggregate consumption is a basket of both market-produced goods and home-produced goods:

$$C_t = \left((1-a)(C_t^m)^\rho + a(C_t^h)^\rho \right)^{\frac{1}{\rho}} \quad (31)$$

where $a \in (0, 1)$ and $\epsilon = 1/(1-\rho) > 0$ denotes the elasticity of substitution between market and home consumption goods. To be precise, the elasticity of substitution $\epsilon = 1/(1-\rho) > 0$ in the utility function (31) is not the same object as the elasticity of substitution σ between time and expenditures studied in Section 4. At the limit when $\alpha_h \rightarrow 0$, that is when the home good is produced only with time and not with capital, the two elasticities are equal to each other. Typically, the parameter α_h is calibrated to a low value (e.g. 0.08 in Benhabib, Rogerson and Wright (1991)), so quantitatively the two elasticities are quite similar.

In the beginning of period t , the household owns a total stock of capital K_{t-1} and invests a total of X_t in new capital goods. Total investment X_t is allocated between the two sectors, $X_t = X_t^m + X_t^h$. We note that capital goods are produced exclusively in the market sector, but they can be used as inputs either in market or in home production. The law of motion for capital stock $j = m, h$ is:

$$K_t^j = X_t^j + (1-\delta)K_{t-1}^j \quad (32)$$

Let w_t is the competitive wage and r_t is the competitive rental rate of market capital that the household receives from the firm. The household chooses sequences of consumption, leisure, market and home work and capital stocks to maximize utility subject to the budget constraint and the time constraint:

$$C_t^m + X_t = w_t N_t^m + r_t K_{t-1}^m \quad (33)$$

$$L_t + N_t^m + N_t^h = 1 \quad (34)$$

Finally, the resource constraint for the aggregate economy is:

$$Y_t = C_t^m + X_t \quad (35)$$

To close the model we specify a stochastic process for the technology shocks

$$Z_t = [z_t^m, z_t^h]':$$

$$Z_t = \mathbf{R}Z_{t-1} + \nu_t \quad (36)$$

where $\nu_t \sim \mathbf{N}(0, \mathbf{\Sigma})$.

The competitive equilibrium of the model is defined as a sequence of quantities and prices such that households maximize their utility subject to the budget constraint, the time constraint and the available technology in the home sector, firms maximize their profits subject to the available technology in the market sector and all markets clear.

Benhabib, Rogerson and Wright (1991) show that the real business cycle model with home production performs better than the standard real business cycle model along a number of dimensions. Specifically, in a calibrated version of their model, one of the main findings is that home production increases the volatility of labor and consumption relative to output. This is because home production introduces an additional margin of substitution towards which market work and market consumption can be directed following exogenous technology shocks. Second, the introduction of technology shocks in the home sector lowers significantly the correlation of productivity with labor hours. This is because technology shocks in the home sector shift the labor supply schedule and tend to create a negative correlation between productivity and hours. This tends to offset the positive correlation induced by technology shocks in the market sector which shift the labor demand schedule.

However, the model also produces some notable discrepancies relative to the

data. As Greenwood and Hercowitz (1991) show, the model produces a counterfactual negative correlation between investment in the market sector and investment in the home sector. This is because in a two sector frictionless model, resources tend to flow to the most productive sector. In general, this implies that investment does not increase in both sectors simultaneously following a technology shock in one of the sectors. Greenwood and Hercowitz (1991) show that introducing highly correlated technology shocks between the home and the market sector and increasing the complementarity of time and capital in the production of home goods helps address this discrepancy. Chang (2000) shows that adjustment costs in the accumulation of capital help resolve the investment anomaly when time and capital are substitutes in the production of home goods.

The home production model has been used successfully to address a number of additional business cycle regularities. McGrattan, Rogerson and Wright (1997) augment the home production model with fiscal policy and discuss how to estimate the model using maximum likelihood methods. Canova and Ubide (1998) show that home production helps lower the international correlation of consumption. Baxter and Jermann (1999) show how home production can generate “excess sensitivity” of consumption to predictable income changes. Karabarbounis (2011) discusses the determination of real exchange rates in a model with a home sector and shows that home production helps to explain why real exchange rates are uncorrelated with the ratio of consumption across countries.

5.2 Time Use over the Business Cycle

Models of aggregate fluctuations with home production typically assume a high degree of substitution of time at business cycle frequencies in order to match

business cycle facts. For instance, in their most preferred specification, Benhabib, Rogerson and Wright (1991) set the elasticity of substitution between market and home goods equal to $\varepsilon = 1/(1 - \rho) = 5$. Even though a strong incentive to substitute time intratemporally is central to models with home production, the lack of a long dataset covering the time use of individuals for many years has prevented a systematic analysis of time use at business cycle frequencies.¹⁹ Here we describe some initial attempts to measure the allocation of time over the business cycle.

Burda and Hamermesh (2010) use time diaries from four countries to study the relationship between unemployment and home production. In general, they find that the unemployed spend very little of their additional time on home production activities. However, focusing on U.S. data from the ATUS (2003-2006), they show that individuals residing in metro areas with temporarily high unemployment levels allocate a large fraction (around 75%) of a given decrease of market work to home production.

Aguiar, Hurst and Karabarbounis (2011) explore ATUS data between 2003 and 2010 to measure how foregone market work are allocated to alternate time uses both during the non-recessionary period and during the recent recession. Given the short time series of the dataset, they argue that simply comparing time spent on a given time use category prior to the recession with time spent on

¹⁹Ramey (2009) and Ramey and Francis (2009) provide a comprehensive and very long dataset with annual observations of aggregate hours spent on home production. Karabarbounis (2011) used this dataset to argue that the home sector is countercyclical to market output. However, this provides only indirect evidence for the cyclical behavior of home production because most of the annual observations for hours in home production in the Ramey (2009) and Ramey and Francis (2009) dataset are imputed based on the aggregate employment rate.

that time use category during the recession confounds the business cycle effects on time use. The reason is that during the pre-recessionary period (2003-2008), home production and leisure display noticeable trends which are extensions of the trends that started in the 1960s and which we discussed above. Instead, they identify the business cycle effects on time use from the cross state variation with respect to the severity of the recessions. Looking at the cross state differences in the changes of market work allows to control for a common low frequency trend in time use. Using this identification strategy, the main finding is that that roughly 25-30% of the foregone market work hours are allocated to increased home production and around 5% to increased child care. Leisure activities absorb a total of around 50-55% of the foregone market work hours, with sleep and television watching accounting for more than 30% of the foregone market work hours. Finally, Aguiar, Hurst and Karabarbounis (2011) show that investments in education, civic activities and health care absorb an important fraction of the decrease in market work hours (more than 10%), whereas job search absorbs a relatively small fraction of the decrease in market work hours. The latter finding is not surprising, given how little time unemployed spent searching for a job (Krueger and Mueller, 2010).

5.3 Macro Estimates of the Elasticity of Substitution

Based on aggregate U.S. data and likelihood methods, McGrattan, Rogerson and Wright (1997) estimate the elasticity of substitution between market and home goods, $\varepsilon = 1/(1 - \rho)$, to be slightly less than 2, while Chang and Schorfheide (2003) estimate it to be around 2.3. Karabarbounis (2011) estimates an elasticity of substitution of around 3.4. This parameter is identified from the requirement

that the home production model produces a labor wedge with cyclical and long-run moments that match the moments of the labor wedge observed in the data.

Aguiar, Hurst and Karabarbounis (2011) assess quantitatively whether the business cycle model of Benhabib, Rogerson and Wright (1991) generates movements in the allocation of time over the business cycle that are consistent with the evidence they document from the ATUS data (2003-2010). Specifically, they use their estimate of the fraction of foregone market work that is reallocated towards home production in the data to identify the elasticity parameter ϵ . In a version of the model in which sleep, eating and personal care are excluded from leisure activities, an elasticity of around 2.0-2.5 produces a reallocation of market hours to home hours in the model that matches the actual behavior of households in the data at business cycle frequencies. In a version of the model in which these activities are included in leisure, the estimated elasticity increases to 3.5-4.0. This is because estimates from the U.S. states sample show that sleep is one of the least elastic time use categories in the data.

6 Conclusions and Future Research

In this review we argued that the proliferation of new datasets and the harmonization of older data has allowed researchers to make significant progress in our understanding of how individuals allocate their time away from market work. We highlighted how these new data can be used to test older theories of time allocation and to better inform us about a variety of economic phenomena including long run trends in hours in various countries, lifecycle patterns of consumption, labor supply elasticities, and the business cycle behavior of macroeconomic aggregates.

This strand of research has produced a number of important results. First, non-market work (home production) is falling in the U.S. over time dramatically. Leisure time is increasing, but the extent to which leisure is increasing depends on the classification of activities. Studies from other countries confirm that home production time is decreasing over time for women, whereas the results for leisure are mixed. Second, child care should be treated separately from home production or leisure given its differential response to changes in prices, income and demographics. Third, there are rich cross country differences in the allocation of time other than market work. These differences have been used to improve our understanding of the effects of taxation and labor market institutions on market work time. Fourth, models that emphasize the intratemporal substitution of time and goods (as opposed to models that emphasize only the intertemporal substitution) predict that spending is falling in retirement because retirees, given their low opportunity cost of time, are substituting away from expenditures and towards time in the production of final goods. Indeed, the evidence shows that retired people spend more time in home production and less expenditures in food consumption relative to similar non-retired people. Fifth, intratemporal substitution of time and goods helps us understand why some spending categories are decreasing over the lifecycle (e.g. clothing), others are increasing (e.g. entertainment) and others display the familiar hump-shaped profile (e.g. food). Sixth, incorporating home production has deepened our understanding of gender differences in labor supply elasticities and can help researchers estimate more reliably the elasticity of labor supply. Seventh, dynamic general equilibrium models with home production are successful in amplifying the volatility of hours and expenditure over the business cycle, as long as the elasticity of substitution between

market-produced and home-produced goods is sufficiently high. Eight, various micro and macro estimates of the elasticity of substitution between time and expenditures (or between market-produced and home-produced goods) point out towards a high value (around 2).

Among those topics, the least well developed area is the study of the allocation of time at business cycle frequencies. Given that, at the time of this writing, the American Time Use Survey (ATUS) covers only 8 years of data, standard statistical methods that macroeconomists use to filter time series and make them amenable to business cycle analysis are not yet applicable. We expect that these methods will become increasingly popular in the next decade among researchers working on time use and business cycles.

We reviewed some of the estimates of the key behavioral parameter that governs the willingness of households to substitute intratemporally. Although the identifying assumptions differ across studies, many estimates are in general consistent to each other. However, like the returns to market work, it is possible that the returns to non-market work change during recessions. Under this scenario, it may not be appropriate to use the elasticities of substitution estimated during non-recessionary periods to predict the joint movements of market work, non-market work, and expenditure during recessions. An important area of future research would be to assess the returns to non-market work during recessions.

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