2017

Intertemporal Elasticity of Substitution with Leisure Margin

Juan Du
Old Dominion University

Takeshi Yagihashi
Old Dominion University

Follow this and additional works at: https://digitalcommons.odu.edu/economics_facpubs

Part of the [Recreation Business Commons](#)

Repository Citation

Du, Juan and Yagihashi, Takeshi, "Intertemporal Elasticity of Substitution with Leisure Margin" (2017). *Economics Faculty Publications*. 21.
https://digitalcommons.odu.edu/economics_facpubs/21

Original Publication Citation

Du, J., & Yagihashi, T. (2017). *Intertemporal Elasticity of Substitution with Leisure Margin*. Old Dominion University. Department of Economics. Retrieved from <https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbm9YWtIc2hpZWFnZW50bGd4Ojc2NTIxNzdkYmRhNzlhM2M>

Intertemporal Elasticity of Substitution with Leisure Margin

Takeshi Yagihashi¹ and Juan Du²

This version: September 17, 2017

Abstract

This paper investigates whether leisure time definitions matter in the estimation of the intertemporal elasticity of substitution of consumption (IES) by using a utility specification that allows interaction between consumption and leisure time. We find that the IES estimated using a narrowly defined leisure measure that excludes quasi-leisure activities is larger than that estimated using nonmarket time. The discrepancy is largely driven by the substitution of consumption and several leisure components over the lifecycle. This finding is robust in alternative specifications and holds well for subsamples of higher socioeconomic status. Our results demonstrate the inseparable nature of consumption and time allocation.

Keywords: intertemporal elasticity of substitution, time allocation, labor supply, earnings

JEL code: E21 (Consumption), D91 (Intertemporal household choice), J22 (Time allocation and labor supply)

¹ Corresponding author. Address: Department of Economics, Old Dominion University, 5115 Hampton Boulevard, Norfolk, VA 23529; phone (757) 683-3512; email: tyagih@odu.edu.

² Address: Department of Economics, Old Dominion University, 5115 Hampton Boulevard, Norfolk, VA 23529; phone (757) 683-3543; email: jdu@odu.edu.

I. Introduction

Intertemporal elasticity of substitution (IES) is widely regarded as one of the key mechanisms that influence consumption and saving behavior observed in the aggregate economy. According to Havranek *et al.* (2015), over 300 academic papers have estimated IES during the last four decades, showing a strong and lasting interest in this topic.³ Based on the widely-cited work of Milton Friedman (1957), consumers allocate consumption over their lifetime based on their projected lifetime income and the relative price of consumption over time. IES indicates how strongly consumption responds to changes in the relative price, which is often represented by the market interest rate.

One puzzle in this literature is that the level of consumption exhibits a pronounced hump around mid-life, which is at odds with the traditional life-cycle model that predicts a relatively flat consumption profile over the lifetime. Heckman (1974) argues that once leisure time and consumption are treated as nonseparable components in the utility function, the path of consumption becomes dependent on both the interest rate and the wage rate. Motivated by Heckman's work, many studies estimate the IES while controlling for labor-related variables, and they generally find time allocation is important in understanding consumption allocation.

This paper aims to explore whether the IES estimate is sensitive to how *leisure* time is defined under a nonseparable preference. So far, most studies in this area have used nonmarket time, calculated as total time minus market work, as a proxy for leisure. This approach makes intuitive sense, since nonmarket time is directly linked to the opportunity cost of nonwork. However, two arguments can be made against using nonmarket time as a proxy for leisure. First, nonmarket time includes housework, which most people regard as

³ Havranek *et al.* (2015) conduct a meta-study of 169 published papers on the estimates of IES. Among them, 21 were published in the 1980s, 62 in the 1990s, and 86 during 2000-2014.

quasi-work. The literature on home production (e.g., Baxter and Jermann, 1999) has argued that the main reason for doing housework is not enjoyment, but saving cost on purchasing the corresponding services. Second, some of the nonmarket time, such as education and childcare, are “durable” in nature. The literature on time use (e.g., Kydland and Prescott, 1982) has long noted that time allocation on leisure activities today may generate flow utility in the future. Therefore, using nonmarket time as a proxy for leisure could lead to misjudging the true effect that wages have on today’s leisure because the effect on future utility is not taken into account.⁴

Many microeconomic studies have also questioned the conventional approach of pooling all leisure activities together. Literature on subjective well-being has noted that different leisure activities yield different levels of happiness.⁵ Literature on labor has shown that different leisure components respond differently to the wage rate.⁶ As we will show later (Figure 2), different leisure components fluctuate differently over the lifecycle and their correlation with consumption also varies.

One of the obvious challenges of studying the interaction of consumption and leisure is that there is no dataset that has detailed data on both consumption and leisure for the same individual. The Consumer Expenditure Survey (CEX) has detailed spending data but only records hours of work. The American Time Use Survey (ATUS) has detailed time use data but contains no information on spending. In addition, ATUS does not track individuals over time, which means that we cannot obtain the change in leisure time. To overcome these

⁴ We note that similar argument is often employed in justifying the use of nondurable goods and services as the relevant consumption measure when estimating the IES. This is because the change in durable goods and services spending (e.g., purchase of cars, education, and health care) would not necessarily reflect the contemporaneous effect that interest rate has on these expenditures.

⁵ For example, Kahneman *et al.* (2004) and Krueger (2007) find that time spent on education and childcare is less pleasurable than other leisure activities.

⁶ See, for example, Kimmel and Connelly (2007) for childcare time; Du and Yagihashi (2017) for exercise and medical/personal care time; Biddle and Hamermesh (1990) for sleep time; Du and Leigh (2015) for smoking.

problems, we impute leisure time in the CEX using information in the ATUS, and construct a synthetic panel based on birth-year cohort.⁷ The synthetic panel is constructed from over 50,000 consumer units in the CEX and roughly 90,000 individuals in the ATUS and covers the period from 1996 to 2014, which is sufficiently long to estimate model parameters.

First, we show that IES estimates are sensitive to the leisure measure used under a utility specification that allows nonseparability between consumption and leisure.⁸ Specifically, we consider three leisure measures: nonmarket time, broad leisure, and core leisure. We find that the narrowest leisure measure that excludes both housework and quasi-leisure activities such as childcare and education results in the largest IES estimate of 0.246, whereas nonmarket time yields the smallest estimate of 0.115. We show that the IES estimates are very similar once we shut off the adjustment of the leisure margin. These results suggest that leisure time plays an active role in smoothing consumption over the lifetime. We also conduct sub-sample analysis distinguished by marital status, gender, stock-holding status, and education. We find larger gaps in the IES estimates between core leisure and nonmarket time for the married and those with higher socioeconomic status (college educated, males, stock-holders).

Second, motivated by these findings we examine which time use has the largest impact on the IES estimate. Among the time uses considered (housework, childcare, and education), we find that childcare has the largest impact. Once childcare is excluded, the point

⁷ Another method to combine CEX and ATUS is to merge the two datasets based on cohort and / or demographic groups. This requires first aggregating the ATUS data and then calculate the growth rate. However, Attanasio and Weber (1995) argue that this way of calculating the growth rate would yield biased estimates because lags of the endogenous variables are likely to be correlated with the growth rates of consumption. In addition, working with demographic groups would further reduce the cell size in our sample, which may lead to estimates more sensitive to potential outliers.

⁸ For studies that emphasize the nonseparability, see for example, Aguiar and Hurst (2005), Altonji and Ham (1990), Attanasio (1995), Attanasio and Browning (1995), Attanasio and Weber (1993), Blundell *et al.* (1994, 2016), Browning and Meghir (1991), Ham and Reilly (2002), and Ziliak and Kniesner (2005).

estimate of IES increases from 0.132 to 0.242. While the exclusion of education and housework time has similar effects, the change in the IES estimate is much smaller.

Finally, several robustness analyses are conducted. First, we incorporate joint decision-making of leisure time by couples. Next, we consider the effect of progressive taxation on household income. Although the point estimates differ somewhat from the baseline, the main finding remains largely unchanged under these alternative specifications.

Our results offer new findings and important insights to the literature. First, we show that the distinction between different leisure activities is important in the estimation of IES. Due to the substitution between consumption and quasi-leisure activities (particularly for individuals with higher socioeconomic status), the IES estimate tends to be low when nonmarket time is used in estimation. This result challenges the common practice of treating nonmarket time as the proxy for leisure.

Second, our study uses the King-Plosser-Rebelo form (King *et al.*, 1987; KPR hereafter) for the utility, which is well-known and analyzed in the literature (e.g., Swanson, 2012), but the KPR preference has not been used to estimate IES by previous studies. Past studies in this literature have mostly resorted to either a simple utility specification augmented by labor supply variables (e.g., Attanasio and Weber, 1995) or the Cobb-Douglas form (Jacobs, 2007). The former assumes the correlation between consumption and leisure is only through employment and labor hours, whereas the Cobb-Douglas function imposes restrictions on the substitutability between consumption and leisure, which is less flexible than the KPR function. In addition, the KPR preference allows us to directly test the substitutability between consumption and different leisure components.

Finally, in addition to confirming the general importance of nonseparable preferences in the context of consumption and saving behavior,⁹ we extend previous studies by testing the substitutability between consumption and different leisure components, which allows us to identify the leisure component(s) that has the largest impact on IES estimates.

This paper is organized as follows. In Section II we discuss the theoretical framework. Section III provides details on data and the estimation method. Section IV reports the empirical patterns of predicted time use. We present the main results in Section V and further analysis in Section VI. Conclusions follow in section VII.

II. Theoretical Framework

II.A. Individual's Optimization Problem

In our model, individuals maximize their lifetime utility subject to constraints associated with budget and time. Specifically, their time-separable lifetime utility can be written as

$$\max \sum_{\tau=0}^{\infty} \beta^{\tau} u(C_{t+\tau}, L_{t+\tau}), \quad (1)$$

where C is consumption and L is leisure. $\beta < 1$ is the time discount factor. We follow Becker (1965) and assume that consumption and leisure act as substitutes in producing utility-yielding “commodities” by selecting a period utility function of the King-Plosser-Rebelo form (King *et al.*, 1987):

$$u(C_t, L_t) = \frac{1}{1-\gamma} C_t^{1-\gamma} L_t^{\chi(1-\gamma)}, \quad (2)$$

⁹ See for example, Mankiw *et al.* (1985), Eichenbaum *et al.* (1988), Blundell *et al.* (1994), Attanasio and Weber (1995), Basu and Kimball (2002) Jacobs (2007), and Kilponen (2012).

where γ and χ are curvature parameters associated with consumption and leisure, which are assumed to be nonnegative. These parameters capture how quickly people become “satiated” with increased consumption (when L is fixed) or leisure (when C is fixed). When χ is nonzero, the value of one variable would affect the marginal utility of the other. This parameter also influences the extent of substitutability between consumption and leisure because it enters the cross-partial derivative:

$$u_{CL,t} = \chi(1 - \gamma)C_t^{-\gamma}L_t^{\chi(1-\gamma)-1}. \quad (3)$$

The sign of $u_{CL,t}$ is determined by $\chi(1 - \gamma)$ because consumption and leisure can only take positive values. If $\chi(1 - \gamma)$ is negative, then consumption and leisure are substitutes.

In maximizing the lifetime utility (1), individuals face two constraints: the budget constraint and the time constraint. The budget constraint can be expressed as

$$C_t + D_t \leq w_t N_t + (1 + r_t)D_{t-1}, \quad (4)$$

where D_t represents savings that pay a predetermined real interest rate r_{t+1} in the next period, w_t is the real wage rate, and N_t is the time spent on market work. The time constraint is expressed as

$$\bar{T} = N_t + L_t + O_t, \quad (5)$$

where $\bar{T}$ is the total endowed time that is constant and the same across individuals (e.g., 24 hours a day). O_t is the time spent on “other” activities that generate neither utility nor income, which are treated as exogenous. O_t may include quasi-leisure activities and/or housework. Individuals decide how to split time between leisure and work out of the “available” time, $T_t \equiv \bar{T} - O_t = N_t + L_t$. Deriving the first-order necessary conditions and combining them yield a pair of intertemporal efficiency conditions:

$$\left(\frac{C_{t+1}}{C_t}\right)^\gamma \left(\frac{L_{t+1}}{L_t}\right)^{-\chi(1-\gamma)} = \beta(1 + r_{t+1}), \quad (6)$$

$$\left(\frac{C_{t+1}}{C_t}\right)^{-(1-\gamma)} \left(\frac{L_{t+1}}{L_t}\right)^{-[\chi(1-\gamma)-1]} = \beta(1 + r_{t+1}) \frac{w_t}{w_{t+1}}, \quad (7)$$

where equation (6) is the conventional consumption Euler, whereas equation (7) is the leisure Euler, which describes intertemporal substitution of leisure demand.

II.B. Discussion on the KPR Preference

In general, the KPR functional form implies that the secular growth of the wage rate has no effect on time allocation.¹⁰ This is regarded as a desirable property by many macroeconomists to keep their workhorse model consistent with long-run historical data.¹¹ The KPR utility further allows us to examine consumption smoothing behavior when *both* consumption and leisure time are free to adjust. Following Swanson (2012), the intertemporal elasticity of substitution of consumption (IES) with an active leisure margin can be expressed as

$$\theta^{cl} \equiv [\gamma - \chi(1 - \gamma)]^{-1}, \quad (8)$$

which depends on the value of γ and χ . The intertemporal elasticity of *leisure demand* can be expressed as

$$\nu \equiv -[1 - \chi(1 - \gamma)]^{-1}. \quad (9)$$

We note that the elasticity also depends on γ and χ , similar to the IES case.

To gain further insights on how the parameters affect IES, it is useful to consider two limiting cases. First, consider a special case where $\chi = 0$. This would imply $\theta^{cl} = \gamma^{-1} \equiv \theta$.

¹⁰ In our case, the intratemporal efficiency condition is expressed as $u_t^c/u_t^l = C[\chi L^{-1}] = w$, i.e., real wage is proportional to consumption times a function of leisure. This further implies that when the economy is on a balanced growth path, the income effect and substitution effect of an increased wage rate would cancel each other.

¹¹ See, for example, Fujiwara *et al.* (2011), Smets and Wouters (2005, 2007).

Intuitively, $\chi = 0$ corresponds to a scenario in which the interaction between consumption and leisure is suppressed, as the marginal utility of consumption becomes independent of leisure. When χ is positive, θ can be interpreted as the *leisure-held-constant* IES that many studies have estimated.¹² We note that for given nonnegative values of χ , θ^{cl} and θ are positively correlated. Second, when $\gamma = 1$ (log-utility), which is sometimes presumed in the neoclassical growth model, θ^{cl} and θ are both one. Intuitively, under the log-utility the income effect that potentially arises from the change in the wage rate cancels the substitution effect from the change in the interest rate, making the leisure margin totally irrelevant. In summary, for the leisure margin to influence the IES, we need $\chi > 0$ and $\gamma \neq 1$.

Our choice of the KPR functional form is more flexible for the purpose of estimating substitutability between consumption and leisure compared with other functional forms in the literature. One of the widely adopted KPR utilities takes the following functional form:

$$u(C_t, L_t) = \frac{1}{1-\gamma} C_t^{1-\gamma} \exp \left[\frac{\gamma-1}{1+\sigma_N} (\bar{T} - L_t)^{1+\sigma_N} \right],$$

where σ_N is interpreted as the inverse Frisch elasticity of labor supply.¹³ The cross-partial derivative is given as

$$u_{CL,t} = (1-\gamma) C_t^{-\gamma} L_t^{\sigma_N} \exp \left[\frac{\gamma-1}{1+\sigma_N} (\bar{T} - L_t)^{1+\sigma_N} \right],$$

where the sign of $u_{CL,t}$ (and hence the substitutability of C_t and L_t) is solely determined by $1-\gamma$. It should be noted that γ , which is restricted to a positive value, already has the assigned interpretation of (the inverse of) the leisure-held-constant IES. Thus this model specification imposes restrictions on the sign and size of substitutability.

Another popular choice in modeling consumption-leisure interaction is the one

¹² Basu and Kimball (2002) use the term “labor-held-constant” IES to denote IES when labor is kept fixed. Because individuals in our model choose leisure instead of labor, we call it leisure-held-constant IES.

¹³ For related work that applies this functional form, see Attanasio and Weber (1995), Basu and Kimball (2002), and Kilponen (2012).

proposed by Kydland and Prescott (1982) and used by Jacobs (2007) to estimate IES:

$$u(C_t, L_t) = \frac{1}{1-\gamma} [C_t^{\sigma_C} L_t^{1-\sigma_C}]^{1-\gamma},$$

where σ_C is the Cobb-Douglas share parameter of *goods* consumption within the generalized unit of consumption.¹⁴ Under this specification, the cross-partial derivative is given as

$$u_{CL,t} = \sigma_C(1 - \sigma_C)(1 - \gamma) C_t^{\sigma_C(1-\gamma)-1} L_t^{-\sigma_C-\gamma(1-\sigma_C)},$$

where the sign of $u_{CL,t}$ is determined by $\sigma_C(1 - \sigma_C)(1 - \gamma)$. Given that σ_C has the pre-assigned interpretation of relative importance of consumption and needs to be less than unity, this functional form also imposes restrictions on the sign and size of substitutability. In our specification, χ serves as the utility weight of leisure, but unlike σ_C , χ is allowed to vary beyond the unit boundary. Thus our utility specification can circumvent the *conceptual* identification issue that the other two specifications suffer.

III. Data and Estimation Strategy

We estimate the IES using the log-linearized version of equations (6) and (7). These equations contain the growth rate of four variables: consumption, leisure, wage rate, and interest rate. We first describe the data and main variables, and then explain the estimation methodology.

III.A. Consumption and Leisure

Our main data source is the 1996-2014 Consumer Expenditure Survey (CEX) conducted by the Bureau of Labor Statistics. The survey primarily records expenditures of a

¹⁴ For related studies that apply this functional form, see Eichenbaum *et al.* (1988).

given “Consumer Unit (CU)” on a wide variety of items on a quarterly basis.¹⁵ Each household is interviewed five times (four of them available to the public) over the course of one year and three months. In each quarter, the survey replaces 20% of the households with newly selected households. In addition to consumption, the CEX also collects data on wages, earnings, and work hours for each CU member. While consumption data are recorded at the CU level, wage and work time are available at the individual level.

We focus on individuals in their prime working years and restrict our sample to five birth-year cohorts (1951–1955, 1956–1960, 1961–1965, 1966–1970, and 1971–1975). To be eligible for our sample, the individual must appear in both the second and the fifth waves of the interview, because wage and work hours are only available in these two waves. To mitigate measurement errors, households with zero food expenditures and those with negative entries for other nondurable goods are excluded.¹⁶

Nondurable consumption is defined as the sum of consumption on all nondurable goods and services.¹⁷ We convert it into real values using the consumer price index (CPI). We assume the consumption growth rate to be the same for everyone in the same CU, because we cannot distinguish each CU member’s consumption in the CEX. In addition, major consumption decisions are usually made collectively within a household, and it is conceivable that the growth rate does not differ much among CU members. Following Attanasio and Weber (1995), we only consider consumption in the month immediately before the interview

¹⁵ A CU is defined as: (1) two or more people related by marriage, blood, adoption, or other legal arrangement who make joint financial decisions; (2) a person living alone, or sharing a house with others but is financially independent.

¹⁶ Vissing-Jørgensen (2002) and Brav *et al.* (2002) dropped observations based on stricter criteria. In addition to our criterion, they also dropped households whose consumption growth satisfies $C_t / C_{t-1} > 2$ and $C_t / C_{t-1} < 0.5$. We conducted analysis using the stricter criterion, and the results were similar.

¹⁷ Nondurable consumption includes food, alcoholic beverages, tobacco and smoking, apparel and services, household operation, utilities and fuels, gasoline, maintenance and repairs, vehicle-related expenses, public transportation, reading, fees and admissions, maintenance and insurance, baby day care, domestic services, and personal care. Rent, education, and health-related goods and services are not included in our definition.

month. This helps to avoid complicated error structures arising from having monthly spending covering different quarters as well as helping to reduce recall bias.

Leisure time is constructed by combining the CEX and the ATUS. The ATUS is conducted by the US Census Bureau and primarily collects information on how Americans spent their time on a given day, using a diary format. About 50% of the sample is randomly assigned to weekdays and 50% to weekends. Respondents are required to identify the primary activity when multiple activities are performed at the same time; therefore, all activities sum up to 24 hours. Our sample covers the period from 2003M1 to 2014M12. While the CEX and the ATUS are conducted independently, the demographics of the samples are similar in most aspects. Appendix Table A.1 provides the summary statistics of demographic variables from the two datasets, adjusted for sampling weights.

For leisure measures, we largely follow the definitions of Aguiar and Hurst (2007). Our first leisure measure, which we refer to as “core” leisure, consists of time spent on socializing, relaxation, sleeping, eating, and personal care. This measure corresponds to Aguiar and Hurst’s Leisure Measure 2, which the authors regard as their preferred leisure measure. These activities are generally regarded as enjoyable and score high on mean net affects (Kahneman *et al.*, 2004). Some of them may also accompany additional health benefits, such as lowering stress and inducing positive emotions (Pressman *et al.*, 2009). The second leisure measure, which we call “broad” leisure, adds time spent on childcare, education, own medical care, religious/civic activities, and care for others. This measure corresponds to Aguiar and Hurst’s Leisure Measure 4. These activities do not necessarily induce positive emotion (as core leisure activities do), but they are also not regarded as “work” in the broadest sense. Because of this, we refer to these activities as “quasi-leisure.”

The last leisure measure (“nonmarket time”) additionally includes core nonmarket work (household activities and associated travel time), shopping/obtaining goods and services, and other home production, all of which are referred to as housework. Nonmarket time is the typical leisure measure used in the literature. The complete definitions of leisure measures and the corresponding ATUS codes are provided in Appendix Table A.2.

We obtain nonmarket time directly from the CEX by using total hours in a year minus the product of hours worked per week and weeks worked per year. For core and broad leisure, we estimate the fraction of nonmarket time spent on these activities by using the ATUS and predict core and broad leisure using the same variables in the CEX. Specifically, we define the fraction of time spent on leisure relative to nonmarket time as

$$l_i \equiv \frac{L_i}{\bar{T} - N_i}. \quad (10)$$

We apply a fractional logistic regression (Papke and Wooldridge, 1996) to predict l for each individual i on a given day. The advantage of the fractional regression compared with Least Square regressions is that it takes into account boundary values and restricts the fitted values to be between 0 and 1, which avoids generating implausible values for the fraction of time use. We provide details of this method in Appendix A.¹⁸ The estimation model is specified as

$$l_{day,it} = \beta_c + \beta_s single_{day,it} + \beta'_{nc} nchild_{day,it} + \beta'_v V_{day,it} + dyear_t + \varepsilon_{it}, \quad (11)$$

where $l_{day,it}$ represents the fraction of leisure time for individual i . The variable $single_{it}$ represents dummy variable for marital status and the vector $nchild_{it}$ represents the number of children for different age groups (0-2 years old, 3-6 years old, 7-18 years old). The vector V

¹⁸ Mullahy and Robert (2010) use a similar model to examine the effect of education on time use. The goodness of fit and accompanying tests of appropriate functional form are presented in Appendix Table A.3.

includes other socioeconomic and demographic characteristics, which are gender, age, age squared, race (white, black, hispanic, other), education (less than high school, high school diploma, college degree), self-employment, occupation (manager and professional, administrative, sales, protective services, personal care services, other services, laborer, construction, and farming)¹⁹, regional dummies (Northeast, Midwest, South, West), and an indicator as to whether the interview was conducted during the summer months (June, July, and August). Variable $dyear$ represents the interview year dummies. We estimate equation (11) separately for weekdays ($day = wd$) and weekends ($day = we$).

We predict individual's leisure time in the CEX using estimated coefficients of equation (11) for different leisure measures. We then transform each leisure measure into an annual measure based on the weeks worked as reported in the CEX. The CEX records how many hours each member of the CU worked during a given week (N_{week}) and how many weeks they worked in the past year (H_{year}). Using this information, we compute leisure time for the work week and the nonwork week separately.²⁰ Leisure time i during an average work week is then computed as

$$L_{work,i} = 5 \left(24 - \frac{N_{week,i}}{7} \right) l_{wd,i} + 2 \left(24 - \frac{N_{week,i}}{7} \right) l_{we,i}, \quad (12)$$

whereas leisure time during an average nonwork week is computed as

$$L_{nonwork,i} = 7 \times 24 l_{we,i}. \quad (13)$$

Annual measure for leisure time i is calculated as the sum of leisure time during the work and the nonwork weeks as

$$L_{year,i} = H_{year} L_{work,i} + (52 - H_{year}) L_{nonwork,i}. \quad (14)$$

¹⁹ The occupation codes do not match exactly across the two datasets. The ATUS has 22 categories while the CEX has 18 categories. See Appendix Table A.4 for the matching of the occupation codes between the two datasets.

²⁰ Since the CEX does not provide the breakdown of how work hours are split between weekdays and weekends, we take an agnostic stance and evenly split work hours into seven days.

III.B. Wage Rate and Interest Rate

Each CU member in the CEX is interviewed about their gross pay in the last pay period and the period that this payment covers (one week, two weeks, month, quarter, and year). CU members are also asked about their wages and salary income before deductions over the past twelve months. Our first wage measure is constructed by dividing the gross pay by the corresponding work hours during the reference period. This is our preferred measure, because it closely represents the wage rate paid at the time of the interview. For the second measure, we use annual wage and salary earnings divided by annual work hours. Whenever the first wage measure is missing, we replace the missing with the second wage measure.²¹ Our sample is restricted to those with positive hourly wages in both the second and fifth interviews.

For the nominal interest rate, we use the 3-month treasury bill rate, which is common in the IES literature.

III.C. Estimation

To estimate parameters γ and χ , we use the synthetic cohort approach, which can capture cohort fixed effects arising from each generation's common lifetime experience.²² Following the convention in the literature (e.g., Attanasio and Weber, 1995), we construct cohorts based on birth years, and the interval of a cohort is set to five years (1951–1955,

²¹ Ham and Reilly (2002) use a similar approach when constructing the wage rate in the CEX.

²² Other advantages are described in Chamberlain (1984) and Hayashi (1987). For examples of the synthetic cohort approach, see Attanasio and Weber (1995), Ghez and Becker (1975), and Rupert *et al.* (2000).

1956–1960, 1961–1965, 1966–1970, and 1971–1975). Thus the age range in our sample is 21–45 in 1996 and 39–63 in 2014. We then linearize equations (6) and (7) as follows:

$$\begin{aligned} \frac{1}{I} \sum_i \Delta \ln(C_{i,t+1}) = & \beta_{0,c} + \theta r_{t+1} + \chi(\theta - 1) \frac{1}{I} \sum_i \Delta \ln(L_{i,t+1}) \\ & + \beta_{z,c}' \frac{1}{I} \sum_i \Delta \ln(z_{i,t+1}) + \varepsilon_{c,t+1}, \end{aligned} \quad (15)$$

$$\begin{aligned} \frac{1}{I} \sum_i \Delta \ln(C_{i,t+1}) = & \beta_{0,l} + \left(\frac{\theta}{\theta - 1} - \chi \right) \left[\frac{1}{I} \sum_i \Delta \ln(L_{i,t+1}) \right] \\ & + \frac{\theta}{\theta - 1} \left[\frac{1}{I} \sum_i \Delta \ln(w_{i,t+1}) - r_{t+1} \right] \\ & - \beta_{z,l}' \frac{1}{I} \sum_i \Delta \ln(z_{i,t+1}) + \varepsilon_{l,t+1}, \end{aligned} \quad (16)$$

where $\theta \equiv 1/\gamma$ is the leisure-held-constant IES and I is the number of observations of a cohort in a given quarter (“cell size”). The interest rate and the wage rate are both adjusted for inflation using the CPI. Vector z consists of demographic variables and seasonal dummies. Demographic variables include the number of adults (*adults*), the number of children less than age 18 (*children*), marital status (*single*), whether the spouse works full time (*spouse fulltime*), and the spouse’s nonmarket hours (*spouse nonmkt*).²³ The inclusion of spouse-related variables follows Attanasio and Weber (1995).

We note that cohort-based growth rates for consumption are obtained by first taking the growth rate for each respondent between the second and the fifth interview (9-month period), and then taking the average of these growth rates for a given cohort in each quarter.²⁴ Cohort-based growth rates for wages and leisure are obtained using the same procedure. By aggregating in this way, we can reduce the bias caused by serially correlated errors. This

²³ Spouse nonmarket hours are calculated as total hours available in a year (8736 hours = 24hrs × 7days × 52weeks) minus annual work hours, which is the product of hours worked per week and weeks worked per year. This number is multiplied by 0.75 for the 9-month period that consumption is measured.

²⁴ We note that even though our sample consists of those having positive wages in the second and fifth waves, an individual could still exit and enter the labor market between the two waves. Our measure of annual nonmarket time may capture some of the changes due to these entries and exits.

approach also ensures that the growth rate is constructed using the same individual across two periods so that any change in consumption growth is not caused by changes in sample composition due to lifetime events, such as marriage, divorce, and childbirth.

Equations (15) and (16) are jointly estimated using the Generalized Methods of Moments (GMM). Identification is achieved using lagged variables as instruments. Specifically, we include the second, third, and fourth lags of the endogenous variables (consumption growth, leisure growth, nominal interest rate, inflation, and labor income growth), the second and third lags of the number of CU members (adults, children, and adults older than 64), age, age squared, and three seasonal dummies. Four observations are lost for each cohort because four lags are used to construct instruments. The total number of observations is 360 ($= 5 \times (76 - 4)$).

The average cell size in our sample is larger than 100 for all cohorts (see Table 1), which helps to reduce the risk of a spurious MA(1) error structure induced by limited cell size.²⁵ The fact that one CU member only appears once in the sample helps to reduce autocorrelation within cohorts over time. To further mitigate the problem, we apply a weight matrix that controls for both autocorrelation (for one year) and potential heteroscedasticity arising from different cell sizes (i.e., the number of observations for each cohort in a quarter is different). Finally, clustered standard errors are applied at the cohort and year-quarter level.

III.D. Check on Concavity/Substitutability

We conduct statistical tests on the concavity of the utility function. For the utility function to be concave, the estimated parameters must satisfy three conditions: (1) u_{CC} is

²⁵ A spurious MA(1) structure in the error term would generally make the first lagged endogenous variables invalid instruments. See Attanasio and Weber (1995) for more details.

negative; (2) u_{LL} is negative; (3) $u_{CC} u_{LL} - (u_{CL})^2$ is nonnegative. In our model, this is equivalent to $\gamma > 0$, $\{\chi(1 - \gamma) - 1\}\chi < 0$, and $\chi\gamma + \chi^2\gamma - \chi^2 \geq 0$. If one of these null hypotheses is rejected at the 1% significance level, the concavity assumption is violated. We also conduct hypothesis tests on whether consumption and leisure act as substitutes in generating utility. Specifically, we examine the sign of the cross-elasticity of equation (3), which depends on the sign of $\chi(1 - \gamma)$. If the null $\chi(1 - \gamma) \leq 0$ is rejected, the substitutability assumption is violated. Both tests serve as a check on the plausibility of the point estimates of γ and χ .

IV. Empirical Patterns

IV.A. Summary Statistics

Table 1 shows cohort summary statistics. On average, Americans spend roughly 6 hours on work and 18 hours on nonmarket time per day. Within nonmarket time, core leisure time occupies 15 hours, while the remaining 3 hours are spent on activities that are neither market work nor core leisure, such as housework, childcare, and education. Housework is about 1.3-1.5 hours per day, with longer hours for older cohorts. Childcare time is the highest for the middle-aged cohorts, at about 1-1.2 hours per day.

Figure 1 shows the time series of three leisure measures averaged across employed individuals with positive wages. We confirm that core leisure measure is trending upwards during 1996-2014, which is consistent with the findings in Aguiar and Hurst (2007). Core and broad leisure have smaller variability over time compared with nonmarket time, which varies more with the business cycle.

Figure 2 presents the life-cycle profile of selected variables, plotted in five-year intervals. Each line represents the average of each cohort. All leisure measures except for nonmarket time are predicted. Consumption and wage rate are obtained directly from the CEX. We see a mild U-shape for nonmarket time, broad leisure, and core leisure. This is expected, as work time tends to be high in the middle ages and low for the very young and the very old. It should be noted that housework, childcare, and education have different lifecycle patterns from the aggregate leisure measures: housework peaks around ages 46-50, childcare around 31-35, and education around 21-25. The bottom panels of Figure 2 show that consumption peaks around the middle ages, while wage rate exhibits an increasing trend until close to retirement.²⁶ Since leisure time is linked to the opportunity cost of nonwork, wage rate is likely to influence the individual's time allocation at any given point in time as well as over lifetime.

IV.B. Comparing Predicted Outcomes with those in ATUS

Next we examine whether the predicted leisure time are comparable in levels with those reported in ATUS. These results are shown in Table 2. The predicted values are somewhat larger than the ATUS counterparts. This is mostly driven by nonmarket time because nonmarket time is larger in the CEX and multiplying it with a fraction causes all leisure measures to be larger. We note that nonmarket time in the CEX is calculated based on annual work hours, whereas in the ATUS it is measured daily. In the last two columns of Table 2, we calculate the ratio of disaggregated leisure time to nonmarket time. These ratios are much closer than levels.

²⁶ While the major driver for this observed hump-shaped pattern in consumption is household size, other factors such as liquidity constraints, income uncertainty, and work-related expenses also matter. For more on this topic, see, for example, Aguiar and Hurst (2013), Attanasio *et al.* (1999), Carroll (1994), and Hubbard *et al.* (1995).

Next, we compare the life-cycle profile of leisure time in the CEX and the ATUS. To account for the differences in cohort, year, and household characteristics, we estimate the following regression,

$$\ln L_{i,t} = \rho_0 + \rho'_{da} dagegr_{i,t} + \rho'_{dc} dcohort_{i,t} + \rho_s single_{it} + \rho'_{df} dfamsize_{i,t} + \rho_{nc} nchild_{it} + \rho'_y dyear_t + \varphi_{i,t}, \quad (17)$$

where *dagegr* is a vector of five-year age dummies (base = 41-45 years old), *dcohort* is a vector of birth-year cohort dummies (base = those born in years 1951-55), and *dfamsize* is family size dummies (base = 1).²⁷ We restrict individuals in our sample to those who are employed and between 21 and 63 years old in both datasets. For the CEX sample, we use only information from the second wave to keep it consistent with the cross-section nature of the ATUS.

The three left panels of Figure 3 plot the estimated regression coefficients of age ρ_{da} for three leisure measures (nonmarket, broad, and core). We observe that the lifecycle profiles generated using the predicted leisure measures closely track those in the ATUS. There are some noticeable differences among the older and young age groups: the CEX leisure time is higher for the younger group and lower for the older group. This could be due to relatively small number of employed young and old individuals, for whom the age coefficients are less precisely estimated.

The right panels of Figure 3 plot the regression coefficients of cohort ρ_{dc} . The predicted leisure time in the CEX again tracks the leisure in ATUS fairly closely, especially for core leisure. We observe an upward trend for all three leisure measures, indicating

²⁷ Because the CEX sample (1996-2014) is longer than the ATUS sample (2003-2014), the regression for the CEX sample has more year dummies and cohort dummies.

younger cohorts have more leisure time than older cohorts. The increase in leisure time for younger cohorts is a bit steeper in ATUS than in the CEX.

Appendix Table A.5 further reports the regression results related to household characteristics. Overall, our results confirm existing studies' finding that household characteristics are among the key determinants of individuals' time allocation.

IV.C. Relationship between Consumption and Leisure

To quantify the direct dependency of leisure time on consumption, we estimate the following estimation model similar to the one used in Aguiar and Hurst (2013),

$$\Delta Share_{i,t} = \delta_0 + \delta_c \Delta \ln C_{i,t} + \delta_w \Delta \ln(w_{i,t}) + \delta_n \Delta \ln(nonmkt_{i,t}) + \delta_z' \Delta z_{i,t} + dyear_t + dseason_s + \varepsilon_{i,t} \quad (18)$$

where *Share* is the percentage of nonmarket time spent on specific leisure time (e.g., broad/core leisure) and *nonmkt* is the nonmarket time.²⁸ The vector *z* collects socioeconomic and demographic characteristics (*single*, *spouse fulltime*, *spouse nonmkt*, *dfamsize*, *nchild*) and *dseason* is the vector of seasonal dummies. For this exercise, we restrict our sample to those who are born between 1951 to 1975 to be consistent with the later analyses. The regression is run for the overall sample and for each cohort separately.

Table 3 reports the estimates of δ_c for different leisure measures. The estimates for each cohort are largely consistent with the overall sample, so we mainly discuss the results for the overall sample. The estimate of δ_c is negative for broad leisure and positive for core leisure, suggesting broad leisure is a substitute of consumption whereas core leisure is a

²⁸ Note that we explore the effect of consumption on how leisure time is allocated conditional on a given level of nonmarket time, whereas Aguiar and Hurst (2013) has explored the effect of labor supply on how consumption is allocated conditional on a given level of spending. Unlike their model, we utilize the short-panel nature of the CEX data to account for the unobserved characteristics of individuals.

complement to consumption. The estimate of δ_c is negative and statistically significant for childcare and education, but for housework it is negative but statistically insignificant. For exercise (a component of core leisure), the estimate of δ_c is consistently positive across cohort. While these results do not establish a causal relationship between leisure and consumption, it is suggestive that consumption-leisure association depends on the leisure measure used.

Appendix Table A.6 shows the estimated coefficients of other variables for the overall sample. Most of the coefficients make sense in terms of sign and statistical significance.²⁹ The results again confirm that household characteristics are an important determinant of time allocation, in addition to consumption and wage rate.

V. IES Estimates

IV.A. The Elasticity of Consumption

Table 4 reports the IES estimates for different leisure measures. The second column shows the result for nonmarket time. The IES estimate θ^{cl} is 0.115 and the leisure-held-constant IES θ is estimated to be 0.303. The gap between the θ^{cl} and the θ estimates arises because of the substitution between consumption and nonmarket time, as indicated by the positive substitutability parameter χ of 2.334.

The next and the last columns show the IES estimates for broad and core leisure. For broad leisure, the estimates of θ^{cl} and θ are close to those estimated using nonmarket time. We note that the difference between broad leisure and nonmarket time is housework, which

²⁹ For example, higher wage rate leads to less housework (cf. opportunity cost) but more exercise time that improves longevity and leads to higher lifetime income. Being single reduces time spent on housework and childcare. Also, having *young* children increases the time spent on childcare and housework while substantially reducing the core leisure time.

suggests that housework does not appear to have a large impact on IES. However, when core leisure is used, the estimate of θ^{cl} rises to 0.246, with χ estimated to be 0.458.

In the fourth and fifth columns, we further examine which leisure component causes the difference in θ^{cl} between broad and core leisure by excluding education and childcare one at a time.³⁰ The largest change in the IES estimate occurs when childcare is excluded: θ^{cl} increases from 0.132 to 0.242. When education is excluded, we also see an increase in the estimate of θ^{cl} , but the magnitude is smaller (change from 0.132 to 0.159). The change in the estimate of χ can be used to infer the substitutability between each leisure component and consumption. The estimate of χ is 0.641 when childcare is excluded and 1.572 when education is excluded. This result implies that time spent on childcare is more substitutable with consumption compared with education. Many households with children are likely to trade off between certain types of consumption (vacation trips, hobbies, and luxuries) and spending more time with children. In addition, there are many market-based options available for childcare (daycare, baby-sitters), which allow parents to substitute purchased services for their own time.

V.B. The Elasticity of Leisure Demand

The second row of Table 4 shows the estimates of the Frisch elasticity of leisure (ν). In all cases, the sign of the Frisch elasticity is negative, meaning that a higher wage rate reduces leisure demand. The elasticity estimate is -0.157, -0.182, and -0.509 for nonmarket time, broad leisure, and core leisure, respectively. As the substitutability between goods and time becomes lower from nonmarket to core leisure (χ decreases from 2.334 to 0.458), the

³⁰ In additional analysis, we also excluded medical care time from broad leisure. The results do not make much difference from broad leisure.

marginal utility of leisure becomes less affected by consumption, and consequently more affected by the wage rate.

In the same table, we also find that when childcare is excluded from broad leisure, the elasticity becomes -0.449, compared with -0.182 for broad leisure. Again, this may be related to childcare time having greater substitutability with consumption. When education is excluded, the elasticity of leisure is -0.236, which is not much different from broad leisure.

V.C. Discussion

Past studies have mostly estimated the *labor*-held-constant IES for consumption by adding labor variables in their estimation. For example, Attanasio and Weber (1995) use a utility specification in which the marginal utility of consumption depends linearly on several labor supply variables such as the spouse's work status and household labor income. They find a lower IES estimate when spousal- and labor-related variables are controlled for, indicating the spouse's leisure time and income can be used as an additional consumption smoothing tool.³¹ Our results are consistent with their findings in that sense.

Basu and Kimball (2002) use an extended version of Attanasio and Weber's (1995) model and further impose an optimality condition that the real wage must equal the marginal rate of substitution between leisure and consumption. They estimate the IES to be somewhat higher than ours (0.67). It should be noted that Basu and Kimball (2002) assume that the ratio of labor income to consumption spending stays constant over time, whereas our method does not impose such a restriction.³²

³¹ For example, the point estimate of IES falls from 0.341 to 0.149 in the sample of 1981-1990 and from 0.480 to 0.331 for the shorter subsample of 1982-1990.

³² In addition, Basu and Kimball (2002) utilize an aggregate time series, which does not distinguish employed and unemployed. We use a cohort-based time series constructed from individual-level data who are employed. Finally, their sample period is 1982-1999 whereas ours is 1996-2014.

Both studies adopt the “basic” KPR utility specifications in which the sign of $(1 - \gamma)$ determines consumption-leisure substitutability. Jacobs (2007) and Eichenbaum *et al.* (1988) instead use the Cobb-Douglas utility specification that involves an additional share parameter, which affects the consumption-leisure substitutability. Their results imply that consumption and nonmarket time act as substitute, consistent with our finding.³³ Our study additionally explores the relationship between subsets of leisure activities and consumption, which is not examined in previous studies.³⁴

With regard to θ^{cl} , there are no studies that produce comparable estimates. However, there are two related studies. Low (2005) extends Heckman’s (1974) model by introducing uncertainty and a precautionary motive of work. Low finds that the consumption profile becomes less responsive to exogenous shocks once labor is allowed to vary. Our finding is consistent with his in the sense that labor serves as an additional adjustment margin to consumption fluctuations. The difference is that our result does not depend on the existence of uncertainty. Another related study is Rupert *et al.* (2000), who find a larger labor supply elasticity when home production is explicitly controlled for. This is consistent with our finding that when housework is excluded from nonmarket time, the absolute value of the elasticity of leisure demand becomes larger. In addition, we show that the elasticity further increases when we focus on a narrower set of leisure activities that exclude childcare and/or education.

³³ In Jacobs (2007), leisure-held-constant IES is estimated to be between 0.318 and 0.492 when the linearized Euler equation is used (Table 2 of their paper). In Eichenbaum *et al.* (1988), leisure-held-constant IES is estimated to be between 0.855 and 6.937 when the baseline model is used (Table 1 of their paper).

³⁴ One exception is found in the work of Dotsey *et al.* (2014). They estimate the elasticity of substitution parameter between consumption and leisure, using a leisure measure that is conceptually close to our core leisure. As with our result, they find that consumption and leisure are gross substitutes. Note however that they preset the labor-held-constant IES to a constant value (0.67) when estimating the elasticity parameter.

There are several explanations for our results. First, when individuals can maneuver a broader range of activities, it often results in a higher consumption-leisure substitutability and a lower IES. Second, it is possible that time spent on sleeping, eating/drinking, and relaxation, all of which are included in core leisure, cannot be easily substituted by consumption, as compared with other activities, such as childcare. In addition, some of the core leisure activities (e.g., taking yoga classes, reading novels) require *both* goods and time, making goods-time substitution more difficult. In sum, our analysis suggests that it is the nature of time use rather than the sheer volume that explains the differences in the IES estimates.

The estimated elasticity of leisure demand is empirically plausible when compared with labor supply elasticity in the literature. To convert the elasticity of leisure demand into labor supply elasticity, we multiply ν with the sample average of the leisure-labor ratio (calculated from Table 1), which we interpret as labor supply elasticity evaluated at the steady-state.³⁵ The implied labor supply elasticity is around unity, which is within the plausible range of the estimates found in the literature, but it is on the higher end.

V.D. Subsample Analysis

In this subsection, we examine whether our main results apply to the subsamples. We select several sampling criteria (marital status, gender, stock-holding, and education) that are relevant to consumption-leisure choices and also have been studied extensively in the literature.³⁶ We estimate the consumption and leisure Euler equations jointly for a pair of subsamples (for example, married and singles), which allows us to test whether the difference

³⁵ For related studies, see Browning *et al.* (1999), Domeij and Floden (2006), Heckman and MaCurdy (1980).

³⁶ For example, Attanasio and Paiella (2011) and Gorbachev (2011) study the effect of financial market participation on IES, whereas Attanasio and Borella (2014) study how IES varies by education. Apps and Rees (2005), Bishop *et al.* (2009), Blau and Kahn (2007), and Kumar and Liang (2016) provide evidence on how men and women differ in labor supply behaviors.

in the IES estimates of the two subsamples are statistically significant. Yagihashi and Du (2015) use a similar method to examine the relationship between IES and risk aversion. We use two leisure measures for this exercise, core leisure and nonmarket time.

The results are shown in Table 5. Married individuals are found to have notably larger IES than singles, and the difference is statistically significant for both leisure measures. A larger IES estimate for the married could reflect household characteristics such as home ownership and spouse earnings, which facilitate better access to the financial market. We also find that the IES for stockholders far exceeds that for non-stockholders.³⁷ This finding is consistent with previous studies that individuals who actively manage their financial assets tend to have a larger IES than those who do not.³⁸ For the gender and education subsamples, differences in IES are somewhat less obvious. Women have a larger IES than men in both measures. College-educated individuals have a larger IES estimate than lesser-educated individuals, consistent with the finding in Attanasio and Borella (2014). The difference is statistically insignificant when nonmarket time is used and significant at the 5% level when core leisure is used.

Just as with our earlier finding, the IES estimate is larger when core leisure is used as opposed to nonmarket time in all subsamples. The largest difference occurs for married individuals: the IES estimate is 0.101 for nonmarket time and 0.276 for core leisure. For singles, the two leisure measures almost result in no difference in the IES estimates (0.054 for nonmarket time and 0.064 for core leisure). This could be because married individuals on average spend more time on childcare than singles, which can potentially be substituted by

³⁷ To define stockholding status, we follow Cogley (2002) to include not only those who reported a positive value for their stockholding, but also those who made investment in a private retirement account or IRA and those who reported positive income from interest and dividend. By including these additional categories, we have 61.09% of the sample categorized as stockholders.

³⁸ See, for example, Attanasio and Browning (1995), Blundell *et al.* (1994), Guvenen (2006), and Vissing-Jorgenson (2002).

market-based options. The large gap in the IES estimates between the two leisure measures is also seen for stockholders, the college-educated, and males. These results indicate that the adjustment at the leisure margin plays a larger role for individuals with higher socio-economic status, who can afford market-based options.

VI. The Role of Family Characteristics

Throughout our analysis, we assume that individuals in the same household share the same consumption growth, but leisure time is determined individually. However, it is possible that leisure time is also jointly determined within the household. Schirle (2008) and others show that adults' labor supply decisions often depend on their spouse's labor-related decisions. In addition, a spouse's leisure time is significant in our baseline specification. In this section, we further explore the role of family characteristics and taxation on consumption smoothing.

VI.A. The Role of a Spouse's Leisure

To take into account a spouse's time use, we redefine L as a "composite" leisure that is produced as follows:

$$L_{i,t} = L_{p,i,t}^\alpha L_{s,i,t}^{1-\alpha}, \quad (19)$$

where $L_{p,i,t}$ is individual i 's own leisure, $L_{s,i,t}$ is the spouse's leisure, which is exogenously determined, and α is the weight for one's own leisure and $\alpha < 1$. In this specification, a spouse's leisure enters the individual's utility directly. We assume that within a given period a couple jointly minimizes the opportunity cost associated with time, i.e., $w_p L_p + w_s L_s$. The optimality condition implies that α equals the share of one's own labor income within the

household. Further details of this specification and the linearized Euler equations are provided in Appendix B.

Table 6 shows the estimation result for nonmarket time, broad leisure, and core leisure.³⁹ First, the leisure-held-constant IES estimate θ becomes smaller than the baseline for all leisure measures. For nonmarket time and broad leisure, the estimate becomes negative. Second, the substitutability parameter χ becomes larger for all leisure measures. The estimates of θ^{cl} have lower values relative to the baseline.

One possible interpretation of the increase in χ is that a spouse's leisure time can serve as an additional adjustment channel between consumption and one's own leisure. For example, a spouse can take up some of the household chores and childcare-related responsibilities, which provides the individual more flexibility in combining consumption and leisure. Higher substitutability further implies that individuals become less dependent on the financial market to smooth consumption, which is consistent with the lower values of θ^{cl} .

We also confirm that using core leisure results in a larger estimate for θ^{cl} than other leisure measures (0.104 for core leisure, -0.019 for broad leisure, and -0.006 for nonmarket time), just as in the baseline and subsample analysis. The larger estimate for core leisure is due to lower values of θ and the higher values of χ . We note that the concavity condition and the substitutability condition are rejected for nonmarket time and broad leisure but are satisfied in the case of core leisure. This demonstrates the robustness of core leisure across different model specifications.

VI.B. The Role of a Progressive Tax System

³⁹ Because a spouse's leisure time L_S is explicitly incorporated in optimization, we exclude the spouse variables (*single*, *spouse fulltime*, *spouse nonmkt*) in estimation.

In the baseline specification, we included several demographic variables (e.g., number of children, marital status), some of which appeared to be highly significant. Controlling for these variables can also account for the unobserved tax effect on time allocation. Under a progressive income tax system, the tax rate is mostly determined through household-level characteristics such as joint household income, number of household members who are working, marital status, and the number of dependents. Tax rate can be important in estimating the IES because it poses a penalty for working longer hours. Here, we attempt to obtain a direct estimate of the after-tax income and account for the tax effect on labor in estimating IES.

We start by approximating the US tax system using the approach in Heathcote *et al.* (2010, 2014), in which each household's income after tax is modeled as

$$Inc_{Aft} = (1 - T)(w_p N_p + w_s N_s)^{1-\varphi}, \quad (20)$$

where income before tax is defined as the sum of a couple's labor income $w_p N_p + w_s N_s$, φ is the parameter that captures the progressivity of the tax system, and T is the tax rate when the tax system is proportional.⁴⁰ The linearized version of equation (20) allows us to obtain an estimate for φ . Specifically, we regress the (log of) after-tax income Inc_{Aft} upon the (log of) before-tax income using the Ordinary Least Squares. After-tax income is computed as before-tax CU income net of federal, state, and social security taxes. These taxes are simulated jointly using TAXSIM 9.0 software provided by the National Bureau of Economic Research.⁴¹ Our estimate for φ is 0.081, which is not far from Heathcote's estimates. Further

⁴⁰ For households with more than two adults, we ignore the income generated by non-spouse adults. For single-earner households, $w_s N_s$ is equal to zero.

⁴¹ For simplicity, we treat each CU as a single tax unit and do not consider cases in which CU members file their taxes separately. The income used as input in the tax simulation is the sum of all members' labor income, self-employment income, and incomes from other sources such as rent, alimony, child support, estates, trusts, royalties, interest, social security, and

details of this approach and the linearized Euler equations that incorporates the effect of φ are provided in Appendix C.

Table 7 shows the IES estimates for different leisure measures. First, we observe a moderate and uniform increase in θ for all leisure measures compared with the baseline. Second, estimates for χ are lower for all leisure measures. The lower χ implies that the leisure demand responds more negatively (or labor responds more positively) to the increase in the wage rate once the tax effect is explicitly accounted for. Consequently, the leisure margin plays a lesser role in smoothing consumption. This can be confirmed through the increase in θ^{cl} for all leisure measures relative to the baseline.

Finally, we confirm that using core leisure results in a larger estimate for θ^{cl} than other leisure measures (0.330 for core leisure, 0.160 for broad leisure, and 0.154 for nonmarket time). Since the estimates of θ remain similar for all leisure measures (0.346-0.364), we conclude that the gap of θ^{cl} is mainly driven by the lower values of χ (0.164 for core leisure, 1.947 for broad leisure, and 1.907 for nonmarket time).

VI.C. The Role of Additional Income Sources

Studies have repeatedly shown that the presence of a secondary earner in the household provides indirect insurance against unforeseen lifetime events that negatively impact the primary earner (Low, 2005).⁴² To check the robustness of our results, we re-estimate the IES by including two alternative income measures as controls: (a) before-tax labor income of all CU members less the income of the individual and (b) after-tax total

transfer income. We largely follow the code and procedures provided by Lorenz Kueng on the NBER website: <http://users.nber.org/~taxsim/to-taxsim/cex-kueng/cex.do>.

⁴² Blundell *et al.* (2016) specifically examine the effect of working spouses as an insurance against wage shocks. They find that wives' labor supply would increase by 1.7 percentage points for a permanent 10% decrease in husbands' wages. See also Stephens (2002), which examines how the labor supply of wives changes in response to the husbands' job losses.

income of all CU members. The income measure (a) is obtained directly from the CEX, whereas the income measure (b) is obtained using TAXSIM 9.0, as described in the previous subsection.

In Appendix Table A.7, we confirm that using nonmarket time yields a smaller estimate of θ^{cl} than core leisure. The estimates of θ^{cl} and ν remain almost unchanged from the baseline. Income measure (a) is statistically significant, but income measure (b) is borderline significant. Overall, the results suggest that controlling for income from other household members or after-tax household income has little impact on the IES estimates.

VII. Conclusions

This paper provides estimates for the intertemporal elasticity of substitution (IES) in a model framework that assumes nonseparability between consumption and leisure. As distinct from earlier studies that focus on labor hours or nonmarket time, our paper explores how subsets of leisure measures affect the IES estimates by jointly estimating consumption and leisure Euler equations. We incorporate time diary data to construct detailed leisure measures, which enables us to explore the effect of different leisure components on the IES estimates.

Our main finding is that the IES estimates are highly sensitive to the leisure measure used. The IES estimated using nonmarket time is smaller than that estimated using core leisure, which excludes housework and quasi-leisure activities (e.g., childcare, education). The difference in the IES estimates is largely driven by the quasi-leisure activities that are substitutes of consumption. We conduct several robustness analyses that account for potential misspecifications in estimation, and find similar results. Another interesting finding is that for individuals with higher socioeconomic status, the distinction of leisure measures yields a

larger difference on the IES estimates. Our result indicates any public policy that targets particular demographics and/or time use could have unintended effects on individuals' consumption and financial decisions.

One limitation of this paper is that we follow the dichotomic treatment of time allocation (income-generating work versus leisure), which has long been the norm in the literature. Future models would likely benefit from incorporating multiple time uses in the utility maximization process. Another extension is to allow leisure of durable nature to enter the model. Longitudinal data on time use would be called for to test the empirical relevance of such a model.

References

- Altonji, Joseph and John C. Ham (1990), "Intertemporal substitution, exogeneity, and surprises: estimating life cycle models for Canada," *The Canadian Journal of Economics*, 23(1), 1-43.
- Aguiar, Mark and Erik Hurst (2005), "Consumption versus expenditure," *Journal of Political Economy*, 113(5), 919-948.
- Aguiar, Mark and Erik Hurst (2007), "Measuring Trends in Leisure: The Allocation of Time Over Five Decades," *The Quarterly Journal of Economics*, 122(3), 969-1006.
- Apps, Patricia and Ray Rees (2005), "Gender, time use, and public policy over the life cycle," *Oxford Review of Economic Policy*, 21(3), 439-461.
- Attanasio, Orazio P (1995), "The intertemporal allocation of consumption: theory and evidence," *Carnegie-Rochester Conference Series on Public Policy*, 42, 39-89.
- Attanasio, Orazio P., James Banks, Costas Meghir, and Guglielmo Weber (1999), "Humps and bumps in lifetime consumption," *Journal of Business & Economic Statistics*, 17(1), 22-35.
- Attanasio, Orazio P. and Margherita Borella (2014), "Modeling movements in individual consumption: A time-series analysis of grouped data," *International Economic Review*, 55(4), 959-991.

Attanasio, Orazio P. and Martin Browning (1995), "Consumption over the Life Cycle and over the Business Cycle," *The American Economic Review*, 85(5), 1118-1137.

Attanasio, Orazio P. and Monica Paiella (2011), "Intertemporal consumption choices, transaction costs and limited participation in financial markets: Reconciling data and theory," *Journal of Applied Econometrics*, 26, 322-343.

Attanasio, Orazio P. and Guglielmo Weber (1993), "Consumption growth, the interest rate and aggregation," *The Review of Economic Studies*, 60(3), 631-649.

Attanasio, Orazio P. and Guglielmo Weber (1995), "Is Consumption Growth Consistent with Intertemporal Optimization? Evidence from the Consumer Expenditure Survey," *Journal of Political Economy*, 103(6), 1121-1157.

Basu, Susanto and Miles S. Kimball (2002), "Long-run labor supply and the elasticity of the intertemporal substitution for consumption," working paper, University of Michigan.

Baxter, Marianne and Urban J. Jermann (1999), "Household production and the excess sensitivity of consumption to current income," *The American Economic Review*, 89(4), 902-920.

Becker, S. Gary (1965), "A theory of the allocation of time," *The Economic Journal*, 75(299), 493-517.

Biddle, Jeff E. and Daniel S. Hamermesh (1990), "Sleep and the allocation of time," *Journal of Political Economy*, 98(5), Part 1, 922-943.

Bishop, Kelly, Bradley Heim, and Kata Mihaly (2009), "Single women's labor supply elasticities: Trends and policy implications," *Industrial and Labor Relations Review*, 63(1), 146-168.

Blau, Francine D. and Lawrence M. Kahn (2007), "Changes in the Labor Supply Behavior of Married Women: 1980-2000," *Journal of Labor Economics*, 25(3), 393-438.

Blundell, Richard, Martin Browning, and Costas Meghir (1994), "Consumer demand and the life-cycle allocation of household expenditures," *Review of Economic Studies*, 61, 57-80.

Blundell, Richard, Luigi Pistaferri, and Itay Saporta-Eksten (2016), "Consumption Inequality and Family Labor Supply," *American Economic Review*, 106(2), 387-435.

Brav, Alon, George M. Constantinides, and Christopher C. Geczy (2002), "Asset pricing with heterogeneous consumers and limited participation: Empirical evidence," *Journal of Political Economy*, 110(4), 793-824.

Browning, Martin and Costas Meghir (1991), "The Effects of Male and Female Labor Supply on Commodity Demands," *Econometrica*, 59(4), 925-51.

Browning, Martin, Lars Peter Hansen, and James J. Heckman (1999), "Micro Data and General Equilibrium Models," in *Handbook of Macroeconomics*, 1A, edited by John B. Taylor and Michael Woodford, 543-633. Elsevier: North Holland

Carroll, Christopher D. (1994), "How does future income affect current consumption?" *The Quarterly Journal of Economics*, 109(1), 111-147.

Chamberlain, Gary (1984), "Panel data," in *Handbook of Econometrics*, 2, edited by Zvi Griliches and Michael D. Intriligator, Amsterdam: North Holland.

Cogley, Timothy (2002), "Idiosyncratic risk and the equity premium: Evidence from the Consumer Expenditure Survey," *Journal of Monetary Economics*, 49, 309-334.

Domeij, David and Martin Floden (2006), "The labor-supply elasticity and borrowing constraints: why estimates are biased," *Review of Economic Dynamics*, 9(2), 242-262.

Dotsey, Michael, Wenli Li, and Fany Yang (2014), "Consumption and time use over the life cycle," *International Economic Review*, 55(3), 665-692.

Du, Juan and J. Paul Leigh (2015), "Effects of wages on smoking decisions of current and past smokers," *Annals of Epidemiology*, 25: 575-582.

Du, Juan and Takeshi Yagihashi (2017), "Health capital investment and time spent on health-related activities," *forthcoming in Review of the Economics of the Household*.

Eichenbaum, Martin S., Lars Peter Hansen, and Kenneth J. Singleton (1988), "A time series analysis of representative agent models of consumption and leisure choice under uncertainty," *Quarterly Journal of Economics*, 103(1), 51-78.

Friedman, Milton (1957), 'A theory of the consumption function,' Princeton University Press, Princeton, New Jersey.

Fujiwara, Ippei, Yasuo Hirose, and Mototsugu Shintani (2011), "Can news be a major source of aggregate fluctuations? A Bayesian DSGE approach," *Journal of Money, Credit and Banking*, 43(1), 1-29.

Ghez, Gilbert, Gary S. Becker (1975), 'The allocation of time and goods over the life cycle,' NBER Books, National Bureau of Economic Research, Cambridge, Massachusetts.

Gorbachev, Olga (2011), "Did household consumption become more volatile?" *The American Economic Review*, 101(5), 2248-2270.

Guvenen, M. Fatih (2006), "Reconciling conflicting evidence on the elasticity of intertemporal substitution: A macroeconomics perspective," *Journal of Monetary Economics*, 53(7), 1451-1472.

Ham, John C. and Kevin T. Reilly (2002), "Testing intertemporal substitution, implicit contracts, and hours restriction models of the labor market using micro data," *The American Economic Review*, 92(4), 905-927.

Havranek, Thomas, Roman Horvath, Zuzana Irsova, and Marek Rusnak (2015), "Cross-country heterogeneity in intertemporal substitution," *Journal of International Economics*, 96, 100-118.

Hayashi, Fumio (1987), "Tests for liquidity constraints: A critical survey and some new results," in *Advances in Econometrics Fifth World Congress*, 2, edited by Truman F. Bewley, Amsterdam: North-Holland (for Econometric Soc.)

Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L. Violante (2010), "Unequal we stand: An empirical analysis of economic inequality in the United States, 1967-2006," *Review of Economic Dynamics*, 13, 15-51.

Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L. Violante (2014), "Consumption and labor supply with partial insurance: An analytical framework," *The American Economic Review*, 104(7), 2075-2126.

Heckman, James J. (1974), "Life cycle consumption and labor supply: An explanation of the relationship between income and consumption over the life cycle," *The American Economic Review*, 64(1), 188-194.

Heckman, James J. and Thomas E. Macurdy (1980), "A life cycle model of female labour supply," *The Review of Economic Studies*, 47(1), 47-74.

Hubbard, R. Glenn, Jonathan Skinner, and Stephen P. Zeldes (1995), "Precautionary saving and social insurance," *Journal of Political Economy*, 103(2), 360-399.

Jacobs, Kris (2007), "Consumption-leisure nonseparabilities in asset market participants' preferences," *Journal of Monetary Economics*, 54, 2131-2138.

Kahneman, Daniel, Alan B. Krueger, David Schkade, Norbert Schwarz, and Arthur Stone (2004), "Towards national well-being accounts," *The American Economic Review*, 94(2), 429-434.

Kimmel, Jean and Rachel Connelly (2007), "Mothers' time choices: caregiving, leisure, home production, and paid work," *The Journal of Human Resources*, 42(3), 643-681.

Kilponen, Juha (2012), "Consumption, leisure and borrowing constraints," *The B.E. Journal of Macroeconomics*, 12: Iss.1 (Topics), Article 10, 1-23.

King, Robert G., Charles I. Plosser, and Sergio T. Rebelo (1988), "Production, growth and business Cycles: I. The basic neoclassical model," *Journal of Monetary Economics*, 21, 2-3, 195-232.

- Krueger, Alan B. (2007), "Are we having more fun yet? Categorizing and evaluating changes in time allocation," *Brookings Papers on Economic Activity*, 2, 193-215.
- Kumar, Anil and Che-Yuan Liang (2016), "Declining female labor supply elasticities in the U.S. and implications for tax policy: Evidence from panel data", *National Tax Journal*, 69(3), 481-516.
- Kydland, Finn E. and Edward C. Prescott (1982), "Time to build and aggregate fluctuations," *Econometrica*, 50(6), 1345-1370.
- Low, Hamish (2005), "Self-insurance in a life-cycle model of labour supply and savings," *Review of Economic Dynamics*, 8, 945-975.
- Mankiw, Gregory N., Julio J. Rotemberg, and Lawrence H. Summers (1985), "Intertemporal Substitution in Macroeconomics," *Quarterly Journal of Economics*, 100(1), 225-251.
- Mullahy, John and Stephanie A. Robert (2010), "No time to lose: time constraints and physical activity in the production of health," *Review of Economics of the Household*, 8, 409–432.
- Papke, Leslie E., Jeffrey M. Wooldridge (1996), "Econometric Methods for Fractional Response Variables with an Application to 401(K) Plan Participation Rates," *Journal of Applied Econometrics*, 11(6), 619-632.
- Pressman, D.Sarah, Karen A. Matthews, Sheldon Cohen, Lynn M. Martire, Michael Scheier, Andrew Baum, and Richard Schulz (2009), "Association of enjoyable leisure activities with psychological and physical well-being," *Psychosomatic Medicine*, 71, 725-732.
- Rupert, Peter, Richard Rogerson, and Randall Wright (2000), "Homework in labor economics: home production and intertemporal substitution," *Journal of Monetary Economics*, 46, 557–579.
- Schirle, Tammy (2008), "Why have the labor force participation rates of older men increased since the mid-1990s?" *Journal of Labor Economics*, 26(4), 549-594.
- Smets, Frank and Rafael Wouters (2005), "Comparing Shocks and Frictions in US and Euro Area Business Cycles: A Bayesian DSGE Approach," *Journal of Applied Econometrics*, 20, 161-183.
- Smets, Frank and Rafael Wouters (2007), "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach," *The American Economic Review*, 97(3), 586-606.
- Stephens, Melvin Jr. (2002), "Worker displacement and the added worker effect," *Journal of Labor Economics*, 20(3), 504-537.
- Swanson, Eric T. (2012), "Risk aversion and the labor margin in dynamic equilibrium models," *The American Economic Review*, 102(4), 1663-1691.

Vissing-Jørgensen, Annette (2002), “Limited asset market participation and the elasticity of intertemporal substitution,” *Journal of Political Economy*, 110(4), 825-853.

Yagihashi, Takeshi and Juan Du (2015), “Intertemporal elasticity of substitution and risk aversion: are they related empirically?” *Applied Economics*, 47 (15): 1588-1605.

Ziliak, James P. and Thomas J. Kniesner (2005), “The effect of income taxation on consumption and labor supply,” *Journal of Labor Economics*, 23(4), 769–796.

Appendix A: Fractional Logistic Regression

Our IES estimates depend partly on how well leisure time is predicted in the ATUS. In Appendix A.1, we present the summary statistics for the CEX sample (1996-2014) and the ATUS sample (2003 – 2014) by employment status. The overall sample size of the CEX is about two times larger than the ATUS, but the demographics of the two datasets are remarkably similar after adjusting for sampling weight. For example, the average age of the employed sample is about 42 years old and 51-52% of the sample are males. 62% of the CEX employed sample is college educated, whereas 64% of the ATUS employed sample is college educated. The CEX has slightly more Whites and less Hispanic than the ATUS (71% in CEX vs. 68% in ATUS for Whites; 12% in CEX and 14% in ATUS for Hispanics). The CEX consists of more married individuals with more older children than the ATUS.

In addition to comparing summary statistics, we take extra steps to test the fit of the functional form in the regressions that predict leisure fractions. For fractional regressions, the most popular functional form for the conditional mean is the logistic distribution. But each leisure fraction has its own distribution across weekdays and weekends. To identify the most appropriate distribution that fits each leisure measure, we tested five link functions with two statistics often used in the literature. The first statistics is RESET test (Ramsey, 1969). The second statistics is GGOFF, which is proposed by Ramalho *et al.* (2011) to test the goodness-of-functional-form for the conditional mean. Ramalho *et al.* (2011) show that GGOFF performs better than RESET in terms of size and power.⁴³ Under the null hypothesis that the conditional mean specification is appropriate, a test statistics with a small p-value would reject the null.

⁴³ We use version 1 of GGOFF in the Ramalho and Ramalho (2011). Results are similar when using other versions of the test.

Five link functions (Cauchit, Logit, Probit, Log-Log, Complementary Log-Log) are tested for each leisure measure. In Table A.3, we report the functional form selected for each leisure measure and the corresponding test statistics. For core leisure, we do not reject the null hypothesis at the 5% level of significance for both weekday and weekend, suggesting the functional form is appropriate. For broad leisure, we do not reject the null hypothesis for weekend, but for weekdays none of the five link functions appear to fit the distribution well. We select the Cauchy distribution that has the smallest test statistics among all. Results for additional leisure measures are provided in the last two columns.

Appendix B: Including Spouse's Leisure in Time Allocation

We assume that a “composite” leisure represented by L consists of one's own leisure and the spouse's leisure, as described in the main text,

$$L = L_p^\alpha L_s^{1-\alpha}.$$

In other words, an individual internalizes the spouse's leisure time when deciding his / her own time use. Parameter α represents the weight of one's own leisure in the composite leisure. According to the cost minimization principle, α is equal to one's own income share in a two-earner household. If the person is single or has a non-working spouse, α is automatically set to unity and $L = L_p$. Thus, both singles and married individuals can be included in the same estimation. The physical time constraint is expressed at the individual level as,

$$N_t + L_{p,t} + O = T \tag{B.1}$$

where $L_{p,t}$ is own leisure. Consequently, the “discretionary time” is redefined as

$$\bar{L} \equiv T - O = N_t + L_{p,t}. \tag{B.2}$$

The set of first-order necessary conditions that describe the intertemporal substitution in consumption and leisure are modified as,

$$C_t^{-\gamma} L_t^{\chi(1-\gamma)} = \beta E_t \left[(1 + r_{t+1}) C_{t+1}^{-\gamma} L_{t+1}^{\chi(1-\gamma)} \right], \quad (\text{B.3})$$

$$\frac{-\chi C_t^{1-\gamma} L_t^{\chi(1-\gamma)-1} \left(\frac{\alpha L_t}{L_{p,t}} \right)}{w_t} = \beta E_t \left[(1 + r_{t+1}) \frac{-\chi C_{t+1}^{1-\gamma} L_{t+1}^{\chi(1-\gamma)-1} \left(\frac{\alpha L_{t+1}}{L_{p,t+1}} \right)}{w_{t+1}} \right], \quad (\text{B.4})$$

and the implied Frisch elasticity of leisure is

$$\nu = [1 - \alpha\chi(1 - \gamma)]^{-1}. \quad (\text{B.5})$$

The linearized version of Equations (B.3) and (B.4) are

$$\begin{aligned} \frac{1}{I} \sum_i \Delta \ln(C_{i,t+1}) &= \beta_c + \theta r_{t+1} + \chi(\theta - 1) \frac{1}{I} \sum_i \Delta \ln(L_{i,t+1}) \\ &\quad + \theta_c' \frac{1}{I} \sum_i \Delta \ln(z_{i,t+1}) + \varepsilon_{c,t+1}, \end{aligned} \quad (\text{B.6})$$

$$\begin{aligned} \frac{1}{I} \sum_i \Delta \ln(C_{i,t+1}) &= -\beta_c + (-\chi) \left[\frac{1}{I} \sum_i \Delta \ln(L_{i,t+1}) \right] + \frac{\theta}{\theta - 1} \left[\frac{1}{I} \sum_i \Delta \ln(w_{i,t+1}) + \frac{1}{I} \sum_i \Delta \ln(L_{p,i,t+1}) - r_{t+1} \right] - \\ &\quad \theta_l' \frac{1}{I} \sum_i \Delta \ln(z_{i,t+1}) + \varepsilon_{l,t+1}, \end{aligned} \quad (\text{B.7})$$

where the growth rate of the composite leisure for each individual i is calculated as

$$\Delta \ln(L_{i,t+1}) = \alpha_i \Delta \ln(L_{p,i,t+1}) + (1 - \alpha_i) \Delta \ln(L_{s,i,t+1}).$$

Finally, the *average* Frisch elasticity of leisure is calculated as

$$\bar{\nu}_\alpha = [1 - \bar{\alpha}\chi(1 - \gamma)]^{-1}, \quad (\text{B.6})$$

where $\bar{\alpha}$ is the sample average of α_i across all individuals included in estimation.

Appendix C: Optimization Under a Progressive Tax System

Following Healthcote *et al.* (2014), the budget constraint under the progressive taxation system can be expressed as,

$$C_t + D_t \leq Inc_{Aft,t} + (1 + r_t) D_{t-1}. \quad (\text{C.1})$$

The first-order condition with respect to labor becomes

$$-\chi C_t^{1-\gamma} L_t^{\chi(1-\gamma)-1} = -\lambda \frac{\partial Inc_{Aft,t}}{\partial N_t} = -\lambda(1-T)(1-\varphi)(Inc_{Bef,t})^{-\varphi} w_t. \quad (C.2)$$

The intertemporal efficiency condition with respect to leisure becomes

$$\frac{-\chi C_t^{1-\gamma} L_t^{\chi(1-\gamma)-1}}{(Inc_{Bef,t})^{-\varphi} w_t} = \beta E_t \left[(1+r_{t+1}) \frac{-\chi C_{t+1}^{1-\gamma} L_{t+1}^{\chi(1-\gamma)-1}}{(Inc_{Bef,t+1})^{-\varphi} w_{t+1}} \right], \quad (C.3)$$

and the implied Frisch elasticity of leisure is

$$v_t = -\frac{1-\varphi}{1-\chi(1-\gamma)+\varphi(L_t/N_t)}, \quad (C.4)$$

where the ratio L_t/N_t depends on which leisure measure is used. The linearized version of

Equation (C.3) becomes

$$\begin{aligned} \frac{1}{l} \sum_i \Delta \ln(C_{i,t+1}) &= -\beta_c + \left(\frac{\theta}{\theta-1} - \chi \right) \left[\frac{1}{l} \sum_i \Delta \ln(L_{i,t+1}) \right] \\ &+ \frac{\theta}{\theta-1} \left[\frac{1}{l} \sum_i \Delta \ln(w_{i,t+1}) - \varphi \frac{1}{l} \sum_i \Delta \ln(Inc_{Bef,t+1}) - r_{t+1} \right] \\ &- \theta_l' \frac{1}{l} \sum_i \Delta \ln(z_{i,t+1}) + \varepsilon_{l,t+1}, \end{aligned} \quad (C.5)$$

where the term with φ in the front is an addition to the original intertemporal efficiency condition.

Finally, the average Frisch elasticity of leisure is calculated as

$$\bar{v}_{L/N} = -\frac{1-\varphi}{1-\chi(1-\gamma)+\varphi(\bar{L}/\bar{N})} \quad (C.7)$$

where $\bar{L}/\bar{N}$ is the sample average of $L_{i,t}/N_{i,t}$ across all individuals included in estimation.

Appendix References

Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L. Violante (2014), “Consumption and labor supply with partial insurance: An analytical framework,” *American Economic Review*, 104(7), 2075-2126.

Papke, Leslie E., Jeffrey M. Wooldridge (1996), “Econometric methods for fractional response variables with an application to 401(K) Plan participation rates,” *Journal of Applied*

Econometrics, 11(6), 619-632.

Ramvalho, Esmeralda A. and Joaquim J.S. Ramalho (2011), “Alternative estimating and testing empirical strategies for fractional regression models,” *Journal of Economic Surveys* 25(1), 19–68.

Ramsey, James B. (1969), “Tests for specification errors in classical linear least-squares regression analysis,” *Journal of the Royal Statistical Society: Series B (Methodological)*, 31(2), 350-371.

Table 1 Cohort Summary Statistics

Birth-year	1951-1955	1956-1960	1961-1965	1966-1970	1971-1975
age in 1996	41-45	36-40	31-35	26-30	21-25
age in 2014	59-63	54-58	49-53	44-48	38-43
<i>Time use (hrs/day), consumption, wage rate</i>					
Work time	5.7	5.7	5.7	5.6	5.6
Nonmarket time	18.3	18.3	18.3	18.4	18.4
Leisure: broad	16.8	16.8	16.8	17.0	17.1
less education	16.3	16.3	16.3	16.4	16.5
less childcare	16.0	15.8	15.6	15.6	15.7
Leisure: core	15.3	15.2	15.0	15.0	15.0
Consumption	2,210.58	2,289.36	2,310.62	2,215.38	2,107.50
Wage rate	35.18	34.48	30.39	31.34	28.04
<i>Other socioeconomic and demographic characteristics</i>					
# of adults	2.25	2.25	2.17	2.11	2.07
# of children below18	0.54	0.88	1.23	1.37	1.32
Single	0.27	0.27	0.27	0.29	0.33
Spouse, full time	0.49	0.50	0.50	0.49	0.46
Spouse, nonmkt. time	5,329.22	5,297.63	5,299.94	5,312.46	5,308.25
CU income	77,563.12	80,202.27	78,628.72	74,541.12	71,345.25
Observations	10,635	12,286	12,242	10,772	7,847
ave. cell size	140	162	161	142	103

Note: The sample consists of those who have positive wages in both the second and the fifth waves of the interview in the Consumer Expenditure Survey. Sample period is 1996Q1-2014Q2. Average cell size is the number of observations for a given cohort in each quarter, and it is calculated as the total number of observations for a given cohort divided by the number of quarters (74 quarters). Leisure and work time are calculated at the daily basis for convenience of understanding. Consumption is defined as average nondurable consumption per CU over one month, valued in 2014 dollar. Wage rate is average hourly wage valued in 2014 dollar. Spouse's full-time work status is equal to one if the spouse works full time and zero otherwise. Spouse nonmarket time is spouse's nonmarket hours over one year, which is zero for single individuals. CU income is (before-tax) labor income per CU over one year valued in 2014 dollar.

Table 2 Comparison of Predicted Values (CEX) vs. Actual Values (ATUS)

	Predicted values, CEX (min/day)	Actual values, ATUS (min/day)	Fraction of nonmarket time, CEX (%)	Fraction of nonmarket time, ATUS (%)
Nonmarket time	1,132.48 (129.39)	1,088.05 (279.93)	100.00	100.00
Leisure: broad	1,045.60 (118.25)	974.04 (245.81)	92.33	89.52
less education	1010.97 (113.51)	965.48 (244.87)	89.27	88.73
less childcare	982.21 (121.11)	942.57 (248.43)	86.73	86.63
Leisure: core	938.97 (114.85)	899.82 (239.86)	82.91	82.70
Observation	210,861	84,996	210,861	84,996

Note: Samples are restricted to those between 21-64 years old employed individuals. All statistics are adjusted using sample weights. The predicted values in the CEX are obtained using the constructed 9-month value (measured in hours) divided by 270 to obtain daily value and multiplied by 60 to convert to minutes. For each dataset, we calculate the fraction of nonmarket time by using each leisure component divided by nonmarket time.

Table 3 Relationship between Consumption and Disaggregated Time Use

	Overall Sample	By birth-year cohort:				
		1951-55	1956-60	1961-65	1966-70	1971-75
<i>Aggregate leisure measures</i>						
Broad leisure	-0.007 (0.008)	-0.023 (0.021)	-0.038** (0.017)	-0.0005 (0.018)	-0.004 (0.021)	-0.000 (0.020)
Core leisure	0.067*** (0.009)	0.045** (0.020)	0.079*** (0.018)	0.089*** (0.021)	0.085*** (0.025)	0.045 (0.029)
<i>By specific time use</i>						
Housework (quasi-work)	-0.005 (0.005)	0.007 (0.013)	0.009 (0.010)	-0.014 (0.011)	-0.003 (0.014)	-0.005 (0.014)
Childcare (quasi-leisure)	-0.050*** (0.010)	-0.0122 (0.015)	-0.031** (0.014)	-0.059*** (0.021)	-0.081*** (0.026)	-0.034 (0.033)
Education (quasi-leisure)	-0.010*** (0.002)	-0.006*** (0.002)	-0.013*** (0.003)	-0.015*** (0.003)	-0.009* (0.005)	-0.015 (0.010)
Exercise (core leisure)	0.035*** (0.003)	0.029*** (0.008)	0.047*** (0.008)	0.041*** (0.008)	0.035*** (0.009)	0.021** (0.010)

Note: The numbers reported is the coefficient of nondurable consumption in equation (18) for different measures. A negative coefficient indicates substitution between consumption and leisure. A positive coefficient indicates complementary relationship between consumption and leisure. Regressions are run for the overall sample and for each cohort separately. Standard errors clustered at the individual level are included in the parentheses. ***, ** and * represent statistical significance at the 1%, 5%, and 10% level, respectively.

Table 4 Baseline Estimates

Leisure measure	Nonmarket Time	Leisure: Broad	less education	less child-care	Leisure: Core
θ^{cl}	0.115*** (0.000)	0.132*** (0.000)	0.159*** (0.000)	0.242*** (0.000)	0.246*** (0.000)
ν	-0.157*** (0.000)	-0.182*** (0.000)	-0.236*** (0.000)	-0.449*** (0.000)	-0.509** (0.040)
θ	0.303*** (0.000)	0.325*** (0.000)	0.327*** (0.000)	0.343*** (0.000)	0.322*** (0.000)
χ	2.334*** (0.000)	2.166*** (0.000)	1.572*** (0.000)	0.641** (0.023)	0.458 (0.120)
$\Delta \ln (adult)$	-0.030 (0.484)	-0.018 (0.700)	-0.036 (0.433)	-0.040 (0.403)	-0.050 (0.338)
$\Delta \ln (children)$	-0.055*** (0.000)	-0.053*** (0.002)	-0.056*** (0.001)	-0.050*** (0.002)	-0.058*** (0.000)
$\Delta single$	0.327*** (0.000)	0.336*** (0.000)	0.367*** (0.000)	0.386*** (0.000)	0.319*** (0.000)
$\Delta spouse fulltime$	-0.112 (0.178)	-0.183* (0.060)	-0.111 (0.178)	-0.126 (0.164)	-0.024 (0.788)
$\Delta spouse nonmkt$	-1.975*** (0.000)	-2.164*** (0.000)	-2.040*** (0.000)	-2.059*** (0.000)	-1.890*** (0.000)
Sargan criterion	60.054 (0.617)	59.025 (0.653)	59.928 (0.621)	60.290 (0.608)	59.872 (0.623)
Concave utility?	Yes	Yes	Yes	Yes	Yes
C and L are substitutes?	Yes	Yes	Yes	Yes	Yes

Note: θ^{cl} and ν are constructed based on the estimated coefficients, as explained in the main text. For the null hypotheses $H_0: \theta^{cl}=0$ and $H_0: \nu=0$, we use Wald-type of tests and the delta method to estimate the standard errors. The number in the parentheses represents the p-value for the test. ***, ** and * represent statistical significance at the 1%, 5%, and 10% level, respectively. The instruments include the second, third, and fourth lags of consumption growth, leisure growth, nominal interest rate, inflation, and labor income growth, and the second and third lag of the number of adults, children, and elderly (those older than 64), number of earners, single status, whether the spouse works full-time, spouse's nonmarket time, average age, age squared, and three seasonal dummies. In addition to the variables presented in the table, three seasonal dummies are also included.

Table 5 Subsample Analysis

Parameter estimates	IES for Group 1, θ_1^{cl}	IES for Group 2, θ_2^{cl}	H ₀ : $\theta_1^{cl} - \theta_2^{cl}$ $\neq 0$	Sargan criterion
<i>By marital status (Group 1=Single, Group 2=Married)</i>				
Non-market time	0.054*** (0.000)	0.101*** (0.000)	37.57*** (0.000)	64.417 (0.999)
Leisure: core	0.064*** (0.000)	0.276*** (0.000)	31.28*** (0.000)	64.894 (0.9996)
<i>By gender (Group 1=Male, Group 2=Female)</i>				
Non-market time	0.088*** (0.000)	0.224*** (0.000)	19.05*** (0.000)	65.310 (0.9993)
Leisure: core	0.196*** (0.000)	0.267*** (0.000)	6.26** (0.012)	65.539 (0.9993)
<i>By stock holding (Group 1=Hold stock, Group 2=Do not hold stock)</i>				
Non-market time	0.150*** (0.000)	0.045*** (0.000)	116.87*** (0.000)	63.788 (0.9996)
Leisure: core	0.312*** (0.000)	0.048*** (0.000)	47.07*** (0.000)	63.979 (0.9997)
<i>By education (Group 1= College educated, Group 2=High school and less)</i>				
Non-market time	0.073*** (0.000)	0.084*** (0.000)	0.70 (0.401)	63.746 (0.999)
Leisure: core	0.189*** (0.000)	0.087*** (0.000)	4.73** (0.030)	61.811 (0.999)

Note: For each pair of subsamples (group1 and group 2), four equations are jointly estimated. For example, consumption and leisure Euler equations for singles are jointly estimated with the consumption and leisure Euler equations for married individuals. The control variables include the number of adults and the number of children. The first two columns of numbers present the IES estimates for the two groups. The third column of numbers shows test statistics for the null hypothesis $\theta_1^{cl} - \theta_2^{cl} = 0$. The last column presents the Sargan's criterion for each pair of subsamples. ***, ** and * represent statistical significance at the 1%, 5%, and 10% level, respectively. P-values are included in parentheses.

Table 6 Alternative Specification When Spouse Leisure is Considered in Optimization

Parameter estimates	Nonmarket Time	Broad leisure	Leisure: core
θ^{cl}	-0.001*** (0.000)	-0.019*** (0.000)	0.104*** (0.000)
$\bar{v}_\alpha$	0.001*** (0.000)	0.031*** (0.000)	-0.235** (0.003)
θ	-0.002*** (0.000)	-0.081*** (0.000)	0.179*** (0.000)
χ	2.848*** (0.000)	3.047*** (0.000)	0.874** (0.016)
$\Delta \ln(adult)$	0.001*** (0.001)	-0.030*** (0.000)	0.070*** (0.001)
$\Delta \ln(children)$	0.000*** (0.000)	0.017*** (0.000)	-0.041*** (0.000)
Sargan criterion	60.514 (0.421)	59.513 (0.457)	59.290 (0.465)
Concave utility?	No	No	Yes
C and L are substitutes?	No	No	Yes

Note: θ^{cl} and $\bar{v}_\alpha$ are constructed based on the estimated coefficients. For the null hypotheses $H_0: \theta^{cl} = 0$ and $H_0: \bar{v}_\alpha = 0$, we use Wald-type of tests and the delta method to estimate the standard errors. Because the spouse's leisure time is explicitly incorporated in the optimization process, we do not control for the spouse variables in Table 3. ***, ** and * represent statistical significance at the 1%, 5%, and 10% level. P-values are included in parentheses. The instruments include the second, third, and fourth lags of consumption growth, the corresponding leisure growth, nominal interest rate, inflation, and labor income growth, and the second and third lags of the number of adults, children, and elderly (those older than 64), number of earners, average age, age squared, and three seasonal dummies. In addition to the variables presented in the table, three seasonal dummies are also included.

Table 7 Alternative Specification that Incorporates the Effect of Tax in Optimization

Parameter estimates	Nonmarket Time	Broad leisure	Leisure: core
θ^{cl}	0.154*** (0.000)	0.160*** (0.000)	0.330*** (0.000)
$\bar{v}_{L/N}$	-0.191*** (0.000)	-0.197*** (0.000)	-0.630*** (0.004)
θ	0.346*** (0.000)	0.359*** (0.000)	0.364*** (0.000)
χ	1.907*** (0.000)	1.947*** (0.000)	0.164 (0.569)
$\Delta \ln (adult)$	-0.006 (0.896)	0.004 (0.942)	-0.028 (0.632)
$\Delta \ln (children)$	-0.064*** (0.000)	-0.060*** (0.003)	-0.067*** (0.001)
$\Delta single$	0.250*** (0.000)	0.252*** (0.000)	0.230*** (0.000)
$\Delta spouse fulltime$	-0.204** (0.036)	-0.278** (0.015)	-0.108 (0.273)
$\Delta spouse nonmkt$	-2.301*** (0.000)	-2.494*** (0.000)	-2.230*** (0.000)
Sargan criterion	59.945 (0.621)	58.640 (0.666)	59.520 (0.635)
Concave utility?	Yes	Yes	Yes
C and L are substitutes?	Yes	Yes	Yes

Note: θ^{cl} and $\bar{v}_{L/N}$ are constructed based on the estimated coefficients. For the null hypotheses $H_0: \theta^{cl} = 0$ and $H_0: \bar{v}_{L/N} = 0$, we use Wald-type of tests and the delta method to estimate the standard errors. ***, ** and * represent statistical significance at the 1%, 5%, and 10% level. P-values are included in parentheses. The instruments include the second, third, and fourth lag of consumption growth, the corresponding leisure growth, nominal interest rate, inflation, and labor income growth, and the second and third lags of the number of adults, children, and elderly (those older than 64), number of earners, single status, whether the spouse works full-time, spouse's nonmarket time, average age, age squared, and three seasonal dummies. In addition to the variables presented in the table, three seasonal dummies are also included.

Figure 1 Time-series Plots of Leisure Time

Note: Leisure time is plotted over time from 1996 to 2014. Nonmarket time is calculated from the CEX as total time minus annual work hours. Work hours are obtained as weeks worked per year times hours worked per week. Broad leisure and core leisure are predicted using data from the ATUS and the CEX. All measures are for employed persons.

Figure 2 Life-cycle Profile of Leisure, Consumption, and Wage Rate

Note: This figure plots the average cohort leisure, consumption, and wage rate by age. Each line segment represents one cohort and the sample period of 1996-2014 in CEX. All leisure measures except for nonmarket time are predicted using data from the ATUS and the CEX, whereas work hours, consumption, and wage rate are obtained from the CEX. Consumption is nondurable nominal consumption deflated by the Consumer Price Index (CPI) and log transformed. The wage rate is the nominal wage rate deflated by the CPI and log transformed. Consumption is measured at the household level and wage rate is measured at the individual level. All measures are for employed persons.

Figure 3 Comparison of Leisure Measures in CEX vs. ATUS: by Age and Cohort

Note: The left three panels plot the average log leisure time (nonmarket, broad, and core leisure) by age, conditional on cohort, year, and family characteristics. Each point represents the coefficient on the five-year age dummies in equation (17). The omitted age group is 41-45 years old. The right three panels plot the average log leisure time by cohort, conditional on age, year, and family characteristics. Each point represents the coefficients on the 5-year cohort dummies in equation (17). The omitted cohort is the 1951-1955 birth-year cohort. The CEX data are shown in squares and the ATUS data are shown in dots. Markers with solid fills represent statistical significance at the 5% level.

Appendix Tables

Table A.1 Summary Statistics of CEX/ATUS

	CEX, employed	CEX, not employed	ATUS, employed	ATUS, not employed
Age	42.21	45.21	41.22	44.10
Less than high school	0.11	0.23	0.08	0.18
High school diploma	0.26	0.32	0.28	0.35
College degree	0.62	0.46	0.64	0.47
Gender (male = 1)	0.52	0.35	0.53	0.36
White, non-hispanic	0.71	0.65	0.70	0.61
Black, non-hispanic	0.10	0.13	0.10	0.16
Hispanic	0.12	0.15	0.14	0.17
Other race	0.06	0.07	0.06	0.06
Marital status (single = 1)	0.34	0.37	0.40	0.44
# of children, aged 0-2	0.08	0.09	0.13	0.16
# of children, aged 3-6	0.19	0.21	0.18	0.21
# of children, aged 7-18	0.60	0.57	0.54	0.50
Observation	210,861	64,367	84,996	27,243

Note: Samples are restricted to those between 21-64 years old. Separate summary statistics are obtained for the employed and the unemployed. All statistics are adjusted using sample weights.

Table A.2: Leisure Measures and the Corresponding ATUS Codes

(a) Included in all leisure measures: socializing, passive leisure, active leisure, volunteering, pet care/gardening, sleeping, eating, personal activities

ATUS categories	Descriptions	6-digit activity codes
<i>Socializing</i>		
Socializing and communicating	Socializing and communicating with others; Socializing and communicating, n.e.c.*	120101, 120199
Attending or hosting social events	Attending or hosting parties/receptions /ceremonies; Attending meetings for personal interest (not volunteering); Attending/hosting social events, n.e.c.*	120201, 120202, 120299
Waiting associated with socializing, relaxing, and leisure	Waiting assoc. w/socializing & communicating; Waiting assoc. w/ attending/hosting social events; Waiting associated with relaxing/leisure; Waiting associated with arts & entertainment; Waiting associated with socializing, n.e.c.*	120501, 120502, 120503, 120504, 120599
Socializing, relaxing, and leisure, n.e.c.*	Socializing, relaxing, and leisure, n.e.c.*	129999
Telephone calls (to or from)	Telephone calls to/from family members; Telephone calls to/from friends, neighbors, or acquaintances; Telephone calls to/from education services providers; Telephone calls to/from salespeople; Telephone calls to/from professional or personal care svcs providers; Telephone calls to/from household services providers; Telephone calls to/from paid child or adult care providers; Telephone calls to/from government officials; Telephone calls (to or from), n.e.c.*	160101, 160102, 160103, 160104, 160105, 160106, 160107, 160108, 160199
Waiting associated with telephone calls	Waiting associated with telephone calls Waiting associated with telephone calls, n.e.c.*	160201 160299
Telephone calls, n.e.c.*	Telephone calls, n.e.c.*	169999
Travel related to socializing, relaxing, and leisure	Travel related to socializing and communicating; Travel related to attending or hosting social events; Travel as a form of entertainment; Travel rel. to socializing, relaxing, & leisure, n.e.c.*	181201, 181202, 181205, 181299
Travel related to telephone calls	Travel related to phone calls Travel rel. to phone calls, n.e.c.*	181601 181699
<i>TV (“passive leisure”)</i>		
Relaxing and leisure	Television and movies (not religious) Television (religious)	120303 120304
<i>Entertainment, excl. TV (“passive leisure”)</i>		
Relaxing and leisure	Tobacco and drug use Listening to the radio Listening to/playing music (not radio) Playing games Computer use for leisure (excl. Games)	120302 120305 120306 120307 120308
<i>Sports/Exercise (“active leisure”)</i>		
Participating in sports, exercise, or recreation	Doing aerobics; Playing baseball; Playing basketball; Biking; Playing Billiards; Boating; Bowling;	130101, ...

	Climbing, spelunking, caving; Dancing; Participating in equestrian sports; Fencing; Fishing; Playing football; Golfing; Doing gymnastics; Hiking; Playing hockey; Hunting; Participating in martial arts; Playing racquet sports; Participating in rodeo competitions; Rollerblading; Playing rugby; Running; Skiing, ice skating, snowboarding; Playing soccer; Softball; Using cardiovascular equipment; Vehicle touring/racing; Playing volleyball; Walking; Participating in water sports; Weightlifting/strength training; Working out, unspecified; Wrestling; Doing yoga; Playing sports n.e.c.*	130136, 130199
Attending sporting /recreational events	Watching aerobics; Watching baseball; Watching basketball; Watching biking; Watching billiards; Watching boating; Watching bowling; Watching climbing, spelunking, caving; Watching dancing; Watching equestrian sports; Watching fencing; Watching fishing; Watching football; Watching golfing; Watching gymnastics; Watching hockey; Watching martial arts; Watching racquet sports; Watching rodeo competitions; Watching rollerblading; Watching rugby; Watching running; Watching skiing, ice skating, snowboarding; Watching soccer; Watching softball; Watching vehicle touring/racing; Watching volleyball; Watching walking; Watching water sports; Watching weightlifting/strength training; Watching people working out, unspecified; Watching wrestling; Attending sporting events, n.e.c.*	130201, ..., 130232, 130299,
Waiting associated with sports, exercise, & recreation	Waiting related to playing sports or exercising;	130301,
	Waiting related to attending sporting events; Waiting associated with sports, exercise, & recreation, n.e.c.*	130302, 130399
Security procedures related to sports, exercise, & recreation	Security related to playing sports or exercising;	130401,
	Security related to attending sporting events; Security related to sports, exercise, & recreation, n.e.c.*	130402, 130499
Sports, exercise, & recreation, n.e.c.*	Sports, exercise, & recreation, n.e.c.*	139999
Travel related to sports, exercise, and recreation	Travel related to participating in sports/exercise/recreation; Travel related to attending sporting/recreational events; Travel related to sports, exercise, & recreation, n.e.c.*	181301, 181302, 181399
<i>Reading (“passive leisure”)</i>		
Relaxing and leisure	Reading for personal interest; Writing for personal interest	120312, 120313
Household management	HH & personal mail & messages (except e-mail); HH & personal e-mail and messages	020903, 020904
<i>Hobbies (“active leisure”)</i>		
Relaxing and leisure	Relaxing, thinking; Arts and crafts as a hobby; Collecting as a hobby; Hobbies, except arts & crafts and collecting; Relaxing and leisure, n.e.c.*	120301, 120309, 120310, 120311, 120399
Arts and entertainment	Attending performing arts; Attending museums;	120401,

	Attending movies/film; Attending gambling establishments; Security procedures rel. to arts & entertainment; Arts and entertainment, n.e.c.*	..., 120405, 120499
Travel related to socializing, relaxing, and leisure	Travel related to relaxing and leisure; Travel related to arts and entertainment;	181203, 181204
<i>Volunteering</i>		
Administrative & support	Computer use; Organizing and preparing; Reading; Telephone calls (except hotline counseling); Writing; Fundraising; Administrative & support activities, n.e.c.*	150101, ..., 150106, 150199
Social service & care (except medical)	Food preparation, presentation, clean-up; Collecting & delivering clothing & other goods; Providing care; Teaching, leading, counseling, mentoring Social service & care activities, n.e.c.*	150201, 150202, 150203, 150204, 150299
Indoor & outdoor maintainance, building & clean-up	Building houses, wildlife sites, & other structures; Indoor & outdoor maintenance, repair, & clean-up; Indoor & outdoor maintenance, building & clean-up activities, n.e.c.*	150301, 150302, 150399
Participating in performance & cultural	Performing; Serving at volunteer events & cultural activities; Participating in performance & cultural activities, n.e.c.*	150401, 150402, 150499
Attending meetings, conferences & training	Attending meetings, conferences & training	150501,
Public health & safety	Attending meetings, conferences & training, n.e.c.*	150599
	Public health activities, Public safety activities, Public health & safety activities, n.e.c.*	150601, 150602, 150699,
Waiting associated with volunteer	Waiting associated with volunteer activities;	150701,
	Waiting associated with volunteer activities, n.e.c.*	150799
Security procedures related to volunteer	Security procedures related to volunteer activities;	150801,
	Security procedures related to volunteer activities, n.e.c.*	150899
Volunteer activities, n.e.c.*	Volunteer activities, n.e.c.*	159999
Travel related to volunteer activities	Travel related to volunteering; Travel related to volunteer activities, n.e.c.*	181501, 181599
<i>Gardening/pet care</i>		
Lawn, garden, and houseplants	Lawn, garden, and houseplant care; Ponds, pools, and hot tubs; Lawn and garden, n.e.c.*	020501, 020502, 020599,
Animals and pets	Care for animals and pets (not veterinary care); Walking / exercising / playing with animals; Pet and animal care, n.e.c.*	020601, 020602, 020699
Travel related to household activities	Travel related to lawn, garden, and houseplant care; Travel related to care for animals and pets (not vet care)	180205, 180206
<i>Sleeping</i>		
Sleeping	Sleeping; Sleeplessness; Sleeping n.e.c.	010101, 010102, 010199
<i>Eating</i>		
Eating and drinking	Eating and drinking; Eating and drinking, n.e.c.	110101,

	Waiting associated w/eating & drinking;	110199
Waiting associated w/eating and drinking	Waiting associated w/eating & drinking, n.e.c.	110201, 110299
Eating and drinking, n.e.c.	Eating and drinking, n.e.c.	119999
Travel related to eating and drinking	Travel related to eating and drinking; Travel related to eating and drinking, n.e.c.*	181101, 181199
<i>Personal care (“personal activities”)</i>		
Grooming	Washing, dressing and grooming oneself; Grooming, n.e.c.	010201, 010299
Personal activities	Personal / Private activities; Personal activities, n.e.c.	010401, 010499
Personal care emergencies	Personal emergencies	010501
Travel related to personal care	Travel related to personal care; Travel related to personal care, n.e.c.*	180101, 180199
<i>Personal care services (“personal activities”)</i>		
Personal care services	Using personal care services; Waiting associated w/personal care services; Using personal care services, n.e.c.*	080501, 080502, 080599
Travel related to using professional and personal care services	Travel related to using personal care services	180805

(b) Included in broad leisure and nonmarket time: time spent on childcare (primary, educational, recreational), education, own medical care, religious/civic activities, other non-work time

ATUS categories	Descriptions	6-digit activity codes
<i>Primary childcare</i>		
Caring for and helping hh children	Physical care for hh children; Organization & Planning for hh children; Looking after hh children (as a primary activity); Waiting for/with hh children; Picking up/dropping off hh children; Caring for & helping hh children, n.e.c.*	030101, 030108, 030109, 030111, 030112, 030199
Activities related to hh children’s health	Providing medical care to hh children; Obtaining medical care for hh children; Waiting associated with hh children's health; Activities related to hh child's health, n.e.c.*	030301, 030302, 030303, 030399
Travel related to caring for & helping hh children	Travel related to hh children's health	180303
<i>Educational childcare</i>		
Caring for and helping hh children	Reading to/with hh children	030102
Activities related to hh children’s education	Homework (hh children); Meetings and school conferences (hh children); Home schooling of hh children; Waiting associated with hh children's education; Activities related to hh child's education, n.e.c.*	030201, 030202, 030203, 030204, 030299

Travel related to caring for & helping hh children	Travel related to hh children's education	180302
<i>Recreational childcare</i>		
Caring for and helping hh children	Playing with hh children, not sports; Arts and crafts with hh children; Playing sports with hh children; Talking with/listening to hh children; Attending hh children's events	030103, 030104, 030105, 030106, 030110
Travel related to caring for & helping hh children	Travel related to caring for & helping hh children	180301
<i>Education</i>		
Education	Taking class	060101- 060199
	Extracurricular school activities (except sports) Research /homework	060201- 060299
	Registration/administrative activities	060301- 060399
	Education, n.e.c.	060401- 060499 069999
Travel related to education	Travel related to taking class; Travel related to extracurricular activities (ex. Sports); Travel related to research/homework; Travel related to registration/administrative activities; Travel related to education, n.e.c.*	180601, 180602, 180603, 180604, 180699
<i>Own medical care</i>		
Medical and care services	Using health and care services outside the home; Using in-home health and care services; Waiting associated with medical services; Using medical services, n.e.c.*	080401, 080402, 080403, 080499
Health-related self care	Health-related self care; Self care, n.e.c.*	010301, 010399
Travel related to using Professional and Personal care services	Travel related to using medical services	180804
<i>Religious/civic activities</i>		
Religious and spiritual activities	Religious/spiritual practices; Religious and spiritual activities, n.e.c.	140101- 149999
Civic obligations & participation	Civic obligations & participation; Civic obligations & participation, n.e.c.*; Waiting associated with civic obligations & participation	100201, 100299, 100305
Travel related to religious /spiritual activities	Travel related to religious/spiritual practices; Travel rel. to religious/spiritual activities, n.e.c.* Travel related to civic obligations & participation	181401, 181499
Travel related to using govt services & civic obligations		181002
<i>Other non-work time</i>		
Personal care, remaining	Personal care emergencies, n.e.c.*; Personal care, n.e.c.*	010599, 019999
Caring for & helping hh	Caring for household adults	030401-

members, remaining		030499
	Helping household adults	030501- 030599 039999
Caring for & helping nonhh members	Caring for & helping hh members, n.e.c.* Caring for & helping nonhh children	040101- 040199 040201- 040299 040301- 040399
	Activities related to nonhh children's education Activities related to nonhh children's health	040401- 040499
	Caring for nonhh adults	040501- 040599
	Helping nonhh adults	049999
Professional & personal care services, remaining	Caring for & helping nonhh members, n.e.c.* Security procedures rel. to professional /personal svcs.; Security procedures rel. to professional/personal svcs n.e.c.*; Professional and personal services, n.e.c.*	080801, 080899, 089999
Government services & civic obligations, remaining	Using police and fire services Obtaining licenses & paying fines, fees, taxes; Using government services, n.e.c.* Waiting associated with using government services; Waiting assoc. w/govt svcs or civic obligations, n.e.c.*; Security procedures rel. to govt svcs/civic obligations; Security procedures rel. to govt svcs/civic obligations, n.e.c.*; Government services, n.e.c.*	100101, 100103, 100199, 100304, 100399, 100401, 100499, 109999
Data codes	Unable to code	500101- 500107 509999
Travel time, remaining	Data codes, n.e.c. Travel related to household management; Travel related to caring for hh adults; Travel related to helping hh adults; Travel rel. to caring for & helping hh members, n.e.c.* Travel related to caring for & helping nonhh members Travel rel. to using prof. & personal care services, n.e.c.*; Travel related to using government services; Travel rel. to govt svcs & civic obligations, n.e.c.*; Security procedures related to traveling; Security procedures related to traveling, n.e.c.*; Traveling, n.e.c.*	180209, 180304, 180305, 180399, 180401- 180499, 180899, 181001, 181099, 181801, 181899

(c) Included in nonmarket time: nonmarket work (core nonmarket work, shopping/obtaining goods and services, other home production)

ATUS categories	Descriptions	6-digit activity codes
-----------------	--------------	------------------------

<i>Core nonmarket work</i>		
Household activities	Housework	020101- 020199
	Food & drink prep., presentation, & clean-up	020201- 020299
	Interior maintenance, repair, & decoration	020301- 020399
	Household management, excl. mail/email	020901, 020902, 020905, 020999
Traveling	Travel related to household activities	180201, 180202, 180203
<i>Shopping/obtaining goods and services</i>		
Consumer purchases	Shopping (store, telephone, internet)	070101- 070199
	Researching purchases	070201, 070299
	Security procedures rel. to consumer purchases	070301, 070399
Professional services, excl. med. care	Consumer purchases, n.e.c.	079999
	Childcare services	080101- 080199
	Financial services and banking	080201- 080299
	Legal services	080301- 080399
	Real estate	080601- 080699
	Veterinary services (excl. grooming);	080701- 080799
	Travel related to consumer purchases	180701- 180799,
Traveling	Travel related to using professional services (excl. med. care)	180801, 180802, 180803, 180806, 180807
<i>Other home production</i>		
Household activities	Exterior maintenance, repair, & decoration	020401- 020499
	Vehicles	020701- 020799
	Appliances, tools, & toys	020801- 020899
	Household activities, n.e.c.*	029999
Household services	Household services (not done by self)	090101- 090199
	Home maint /repair/décor/construction (not done by self)	090201- 090299
	Pet services (not done by self, not vet)	090301- 090399
	Lawn and garden services (not done by self)	090399

	Vehicle maint. & repair services (not done by self)	090401- 090499
	household services, n.e.c.	090501- 090599
		099999
Traveling	Travel related to household activities	180204, 180207- 180299
	Travel related to using household services	180901- 180999

(d) Included in the work time: market work (core market work, work-related activities)

ATUS categories	Descriptions	6-digit activity codes
<i>Core market work</i>		
Working	Work, main job; Work, other job(s); Security procedures related to work; Waiting associated with working; Working, n.e.c.*	050101, 050102, 050103, 050104, 050199
Other income-generating activities	Income-generating hobbies, crafts, and food; Income-generating performances; Income-generating services; Income-generating rental property activities; Waiting associated with other income-generating activities; Other income-generating activities, n.e.c.*	050301, 050302, 050303, 050304, 050305, 050399
Travel related to work	Travel related to working; Travel related to income-generating activities;	180501, 180503
<i>Work-related activities</i>		
Work-related activities	Socializing, relaxing, and leisure as part of job; Eating and drinking as part of job; Sports and exercise as part of job; Security procedures as part of job; Waiting associated with work-related activities; Work-related activities, n.e.c.*	050201, 050202, 050203, 050204, 050205, 050299
Job search and interviewing	Job search activities; Job interviewing; Waiting associated with job search or interview; Security procedures rel. to job search/interviewing; Job search and Interviewing, n.e.c.*	050401, 050403, 050404, 050405, 050499
Work and work-related activities, n.e.c.	Work and work-related activities, n.e.c.	059999
Using government services	Using social services	100102
Travel related to work	Travel related to work-related activities; Travel related to job search & interviewing; Travel related to work, n.e.c.*	180502 180504 180599

Table A.3 Goodness-of-functional-form of the Fractional Regression to Predict Leisure time

	Leisure: broad	less education	less childcare	Leisure: core
<i>(a) Weekday</i>				
Conditional mean distribution	Cauchy	Cauchy	Probit	Loglog
RESET – LM	21.074*** (0.000)	28.377*** (0.000)	2.036 (0.154)	0.009 (0.924)
GOFF2 -Ramalho	6.035*** (0.000)	12.370*** (0.000)	0.323 (0.570)	1.135 (0.287)
<i>(b) Weekend</i>				
Conditional mean distribution	Logit	Logit	C-Loglog	C-Loglog
RESET – LM	0.036 (0.850)	0.000 (0.982)	6.577** (0.010)	0.028 (0.868)
GOFF2 -Ramalho	0.068 (0.794)	0.000 (0.999)	6.299** (0.012)	0.016 (0.898)

Note: The numbers in the parenthesis are p-values for each test. RESET is the heteroskedasticity robust version of the original RESET test by Ramsey (1969). See Papke and Wooldridge (1996) for the heteroskedasticity robust version. GOFF2 is an alternative to the RESET proposed by Ramalho *et al.* (2011). The sample size for weekday is 43,411 and the sample size for weekend is 45,450.

Table A.4 Occupation Categories

Occupation categories	ATUS code	CEX code
Manager and professional	1 - 10	1 - 3, 7
Administrative support	17	4
Sales	16	5, 6
Protective services	12	8
Private household services	15	9
Other services	11, 13, 14	10
Laborer (operator, assembler, inspector, repairer, precision production)	20 - 22	11 - 14
Construction, mining	19	15
Farming, fishing, forestry, armed forces	18	16 - 18

Note: The occupation variable in the ATUS is trdtocc1. The occupation variable in the CEX is occucode.

Table A.5 Comparison of Leisure Measures: Predicted Outcome vs. ATUS

	Predicted Outcome			ATUS		
	Nonmkt. time	Leisure: Broad	Leisure: Core	Nonmkt. time	Leisure: Broad	Leisure: Core
<i>single</i>	0.017*** (0.001)	0.021*** (0.001)	0.025*** (0.001)	0.006* (0.003)	0.012*** (0.003)	0.015*** (0.003)
<i>dfamsize2</i>	0.018*** (0.001)	0.011*** (0.001)	0.010*** (0.002)	0.013*** (0.004)	0.006 (0.004)	0.004 (0.004)
<i>dfamsize3</i>	0.024*** (0.002)	0.018*** (0.002)	0.022*** (0.002)	0.014*** (0.005)	0.009* (0.005)	-0.005 (0.005)
<i>dfamsize4</i>	0.028*** (0.002)	0.023*** (0.002)	0.031*** (0.002)	0.010 (0.006)	0.008 (0.006)	0.001 (0.006)
<i>dfamsize5</i>	0.031*** (0.002)	0.026*** (0.002)	0.038*** (0.002)	0.001 (0.008)	0.005 (0.008)	0.010 (0.009)
<i>nchild0-2</i>	0.000 (0.002)	-0.003** (0.001)	-0.069*** (0.002)	0.013*** (0.004)	0.007* (0.004)	-0.060*** (0.004)
<i>nchild3-6</i>	-0.003** (0.001)	-0.005*** (0.001)	-0.046*** (0.001)	0.012*** (0.003)	0.005 (0.003)	-0.036*** (0.003)
<i>nchild7-18</i>	0.000 (0.001)	-0.008*** (0.001)	-0.026*** (0.001)	0.009*** (0.003)	0.000 (0.002)	-0.019*** (0.003)
Observation	80,425	80,412	80,412	84,193	84,192	84,188

Note: The numbers reported are the coefficients appearing in equation (17). We only report the results of 2-5 family dummies for the family size variable. Standard errors clustered at the individual level are included in the parentheses. ***, ** and * represent statistical significance at the 1%, 5%, and 10% level, respectively.

Table A.6 Relationship between Consumption and Leisure, Overall Sample

	Leisure: Broad	Leisure: Core	House- work	Child- care	Edu- cation	Exercise
$\Delta \ln (C)$	-0.007 (0.008)	0.067*** (0.009)	-0.005 (0.005)	-0.050*** (0.010)	-0.010*** (0.002)	0.035*** (0.003)
$\Delta \ln (w)$	0.047*** (0.008)	0.015** (0.009)	-0.021*** (0.005)	0.004 (0.008)	-0.001 (0.002)	0.009*** (0.003)
$\Delta \ln (nonmkt)$	-0.224*** (0.054)	-0.160** (0.062)	0.111*** (0.036)	0.097* (0.056)	-0.001 (0.014)	-0.069*** (0.021)
$\Delta single$	1.208*** (0.105)	1.406*** (0.121)	-0.999*** (0.080)	-1.127*** (0.119)	0.164*** (0.021)	-0.004 (0.024)
$\Delta spouse$ <i>fulltime</i>	-0.026 (0.018)	-0.018 (0.021)	0.016 (0.012)	0.034 (0.022)	-0.002 (0.003)	-0.006 (0.007)
$\Delta spouse$ <i>nonmkt</i>	1×10^{-5} (1×10^{-5})	8×10^{-6} (1×10^{-5})	-8×10^{-6} (9×10^{-6})	1×10^{-5} (1×10^{-5})	-1×10^{-6} (2×10^{-6})	4×10^{-7} (3×10^{-6})
$\Delta dfamsize2$	0.076** (0.037)	0.116** (0.047)	-0.036 (0.026)	-0.375*** (0.037)	0.001 (0.014)	0.033** (0.016)
$\Delta dfamsize3$	0.113*** (0.041)	0.319*** (0.053)	-0.054* (0.028)	-0.972*** (0.050)	-0.006 (0.014)	0.009 (0.018)
$\Delta dfamsize4$	0.099** (0.048)	0.426*** (0.060)	-0.045 (0.033)	-1.388*** (0.068)	-0.015 (0.015)	0.014 (0.020)
$\Delta dfamsize5$	0.052 (0.059)	0.367*** (0.072)	-0.012 (0.040)	-1.569*** (0.088)	0.003 (0.016)	0.000 (0.022)
$\Delta nchild0-2$	-0.546*** (0.023)	-5.732*** (0.034)	0.485*** (0.015)	5.195*** (0.076)	-0.115*** (0.006)	-0.313*** (0.008)
$\Delta nchild3-6$	-0.463*** (0.019)	-3.477*** (0.025)	0.472*** (0.012)	3.160*** (0.053)	-0.064*** (0.005)	-0.070*** (0.006)
$\Delta nchild7-18$	-0.702*** (0.019)	-1.924*** (0.021)	0.608*** (0.013)	1.399*** (0.029)	0.009* (0.005)	-0.029*** (0.005)
Observation						

Note: The numbers reported are the coefficients appearing in equation (18). We only report the results of 2-5 family members for the family size dummies. Standard errors clustered at the individual level are included in the parentheses. ***, ** and * represent statistical significance at the 1%, 5%, and 10% level, respectively.

Table A.7 Alternative Specification with Income Used as an Additional Control Variable

Parameter estimates	Nonmarket Time	Leisure: core
(a) use before-tax labor income of the other CU member		
θ^{cl}	0.122 ^{***} (0.000)	0.278 ^{**} (0.000)
ν	-0.163 ^{***} (0.000)	-0.623 ^{**} (0.038)
$\Delta \ln (Income)$	-0.046 ^{***} (0.001)	-0.040 ^{**} (0.011)
(b) use after-tax CU income as income measure		
θ^{cl}	0.121 ^{***} (0.000)	0.265 ^{***} (0.000)
ν	-0.164 ^{***} (0.000)	-0.547 ^{**} (0.000)
$\Delta \ln (Income)$	-0.001 (0.853)	-0.016 [*] (0.096)

Note: This table checks the sensitivity of our results by including additional income variables. The specification is the same as in Table 2. Specification (a) uses before-tax labor income of the other CU members; specification (b) uses after-tax CU income simulated using TAXSIM 9.0.