Working Habit

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Preliminary and incomplete. Do not quote.

Abstract

This paper looks at a potentially important question for the dynamic propagation of shocks in dynamic general equilibrium models. In contrast to a recent literature that emphasizes the potential significance of habit formation in preferences for consumption [see Fuhrer (2000) and Christiano, Eichenbaum and Evans (2005), among others], the paper provides new evidence, based on postwar US aggregate time-series data, of substantial persistence characterizing the labor-leisure tradeoff, both at the intensive and at the extensive margins.

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1 Introduction

A large class of modern macroeconomic models assumes that the representative consumer's preferences are either time separable with respect to consumption and leisure or time nonseparable along the consumption dimension and time separable with respect to leisure. Such preferences imply that hours currently supplied are independent of hours supplied in previous periods, hence excluding potential elements of persistence that could possibly arise from the labor-leisure tradeoff as an endogenous channel of business cycle propagation.[1]

Unlike a recent strand in the macroeoconomic literature which has emphasized the importance of habit formation in preferences for consumption [see Fuhrer (2000) and Christiano, Eichenbaum and Evans (2005), among others], our paper provides new evidence, based on U.S. postwar aggregate time-series data, of strong persistence characterizing the labor-leisure tradeoff. We do so by formulating and estimating the parameters of preferences of a model of the representative consumer that highlights two main features.

First, this framework realistically accounts for fluctuations both in weekly hours per worker (the intensive margin) and weeks worked (the extensive margin). Second, for the first time in the context of a two-dimensional labor supply model, the representative consumer's preferences are modeled as being time nonseparable along the leisure dimension at the two margins. In my framework, the nonseparability of preferences can accommodate either intertemporal substitution or complementarity of leisure across horizons at the two margins.

I let the data determine the length, sign and magnitude of the temporal dependence between leisure in the current period and leisure in previous periods. I find evidence of strong habit formation in preferences both at the intensive and extensive margins of leisure. Also, according to the model's estimates, the representative household's habit-forming behavior appears to be empirically consistent at both margins.

[1] There are, however models, where combining time-separable preferences with labor market frictions can generate some business cycle propagation. These frictions include labor hoarding (Burnside, Eichenbaum and Rebelo, 1993), labor market search (Andolfatto, 1996) and sticky nominal wages and costly labor adjustment (Ambler, Guay and Phaneuf, 2003), among others.

Over the years, the relevance of time-separable preferences has been called into question by a few researchers, both at a theoretical and an empirical level. On the theoretical front, Barro and King (1984) have argued that if preferences are time separable and consumption and leisure are normal goods, consumption and hours worked can counterfactually move in opposite directions. They suggest that temporal non separabilities in preferences can more generally account for the positive comovement between consumption and hours and for the observed pro-cyclicality of aggregate hours worked. Following Kydland and Prescott (1982), they interpret temporal nonseparability in the leisure dimension as reflecting mostly the effect of fatigue accumulated from working hard in previous periods, implying that periods of leisure are intertemporal substitutes across all horizons.

From an empirical standpoint, Hotz, Kydland and Sedlacek (1988) report evidence against the time-separability of preferences using a sample of men from the Michigan Panel of Income Dynamics. Using a similar sample, Bover (1991) finds that past hours determine current hours decisions in a habit-forming fashion, with current and past periods of leisure being tied as temporal complements, rather than temporal substitutes. Employing aggregate time-series data, Eichenbaum, Hansen and Singleton (1988) also test the form of temporal dependence between current and past hours of leisure and conclude that the evidence supports habit formation in hours worked.[2]

In work which is more closely related to this one, Wen (1998) reports evidence of a three-lag dependence of hours supplied in the current period with respect to hours supplied in previous periods using aggregate time-series data. While he obtains a sum of coefficients on lagged leisure which is positive, indicating overall temporal complementarity in periods of leisure, the estimated impact of leisure three periods in the past is found to be strongly negative, a finding that indicates that the significance of the habit-forming effect declines over time and that the intertemporal substitution effect eventually seems to take over.

Unlike these studies in which the representative household's labor supply decision has only

[2]The over-identifying restrictions implied by their model are, however, rejected. They interpret the evidence of habit formation in leisure as contradicting the sources of endogenous dynamics in the Kydland-Prescott (1982) model.

one dimension, my framework rests on the assumption that leisure in the workweeks and non working weeks in the year are imperfect substitutes to the representative household, making the household's decision two-dimensional with respect to labor. Bils and Cho (1994) examine cross-sectional data on the relative size of individual changes in weeks and hours with the help of micro data from the Michigan Panel Study of Income Dynamics and find empirical in support of this specification of preferences.[3] Furthermore, using aggregate postwar time-series, they report evidence showing that a 1 percent deviation from trend in employment has resulted, on average, from a 0.2 percent change in the fraction of individuals who worked during the year and from a 0.8 percent change in the weeks at work during the year for a given sized workforce. Therefore, movements in employment rates for a given labor force are likely to be cyclically more important than movements in labor force participation.[4]

I capture the nonseparability of preferences with respect to leisure as an intertemporal household technology that converts leisure in the workweeks and leisure in the weeks off into leisure services at the two margins. Eichenbaum *et al.* (1988) assume a similar household technology in the context of a representative consumer framework with only one type of leisure. The parameters of preferences are recovered from the jointly estimated intertemporal Euler equations derived from the model.

My main findings can be summarized as follows. First, the overidentifying restrictions implied by the model with temporal nonseparabilities in preferences with respect to leisure are far from being rejected empirically. In contrast, the two-dimensional labor supply model is clearly rejected if preferences are assumed to be time separable with respect to consumption and both types of leisure.

Second, the model's estimates reveal that the distinction between leisure services in the workweeks and leisure services in weeks off is empirically supported by the aggregate time-series data, with both types of leisure services contributing quite substantially to the representative household's utility as shown by their estimated shares in preferences. Estimates reveal that the preferences share of leisure services in the workweeks can vary between

[3] They assume, however, that preferences are time separable.

[4] See also Hall and Lilien (198x).

0.19 and 0.36, whereas the share of leisure services in the weeks off ranges between 0.32 and 0.38.

Third, the paper finds evidence of a three-lag temporal dependence of leisure in the current period and leisure in previous periods both at the intensive and extensive margins. The summary effect from lagged leisure is strongly positive at both margins, with a sum of lagged coefficients that is close to unity for each type of leisure. Interestingly enough, the estimated pattern of temporal dependence is very similar for each type of leisure, suggesting that the representative household adopts similar habit-forming behavior at the intensive and extensive margins. Also, unlike the results reported by others, we find that the coefficients on lagged leisure are all strictly positive for each type of leisure, implying that the habit-forming effect always dominates the intertemporal substitution effect.

The paper is organized as follows. Section 2 lays out the two-dimensional model with time-nonseparable leisure along the intensive and extensive margins and derives the set of intertemporal Euler equations that will serve to estimate the preference parameters of the model. Section 3 describes the econometric procedure and data used in estimating the model. Section 4 presents the estimation results and performs the robustness check with regard to the sampling period, measures of real wages (adjusted or unadjusted for taxes), and functional form of the utility function. Section 5 contains concluding remarks.

2 A Two-dimensional Labor Supply Model with Temporal Leisure Dependence

Let the representative household have preferences over expected streams of consumption, c_t, leisure services in the workweeks, l^*_{wt}, and leisure services in non-working weeks per period, l^*_{nwt}. The representative household seeks to maximize the following lifetime expected utility:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, l^*_{wt}, l^*_{nwt}\right), \tag{1}$$

where $0 < \beta < 1$ is the discount factor, E_0 denotes the mathematical expectation, and $u(.)$ is a concave utility function. Leisure services at each margin are expressed as linear functions of current and lagged values of leisure:

$$l_{wt}^{*} = A(L)\, l_{wt}, \tag{2}$$

$$l_{nwt}^{*} = B(L)\, l_{nwt}, \tag{3}$$

where the polynomials in the lag operator L, $A(L)$ and $B(L)$, are given by:

$$A(L) = 1 - \sum_{i=1}^{m} \mu_i L^i, \quad |\mu_i| < 1, \quad \left| \sum_{i=1}^{m} \mu_i \right| < 1, \quad m \leq \infty, \tag{4}$$

$$B(L) = 1 - \sum_{j=1}^{n} \eta_j L^j, \quad |\eta_j| < 1, \quad \left| \sum_{j=1}^{n} \eta_j \right| < 1, \quad n \leq \infty. \tag{5}$$

This formulation imposes no *a priori* restrictions on either the sign or magnitude of the $\mu_i' s$ and $\eta_j' s$. According to (4) and (5), leisure today provides leisure services today and leisure services or disservices in future periods depending on whether the $\mu_i' s$ (intensive margin) and the $\eta_j' s$ (extensive margin) are positive or negative. If the lag coefficients in $A(L)$ (for $i \geq 1$) and $B(L)$ (for $j \geq 1$) are all strictly negative, periods of leisure are intertemporal substitutes at the two margins across all horizons. This is the type of restriction imposed by Kydland and Prescott (1982) in their model which accounts only for one type of leisure.[5] Instead, if the lag coefficients in $A(L)$ (for $i \geq 1$) and $B(L)$ (for $j \geq 1$) are all strictly positive, periods of leisure at both margins are temporal complements across all horizons, indicating an habit-forming effect.

[5] Specifically, Kydland and Prescott (1982) define leisure services as:

$$l_t^* = C(L) l_t,$$

where l_t denotes hours of leisure at date t. In turn, they express $C(L)$ as:

$$C(L) = 1 + \delta L/(1 - \eta L).$$

They impose $\delta \geq 0$ and $0 < \eta < 1$. Under these constraints, periods of leisure are intermporal substitutes across all horizons.

The representative household's time endowment in a quarter is given by the product of the number of weeks, Q, and the hours available in the week, $\bar{T}$. The household allocates its time during the workweeks, e_t, to work, h_t, a fixed working-time cost, τ, and leisure, l_{wt}. During non-working weeks or weeks off, time is entirely devoted to leisure, l_{nwt}. Hence, the representative household's optimal decisions must satisfy the following time constraint:

$$Q \times \bar{T} = (h_t + \tau)e_t + l_{wt} + l_{nwt}. \tag{6}$$

Leisure at the intensive, (respectively, extensive) margin can be expressed as follows:

$$\begin{aligned} l_{wt} &= (\bar{T} - h_t - \tau)e_t, & (7) \\ l_{nwt} &= (Q - e_t)\,\bar{T}. & (8) \end{aligned}$$

The representative household seeks to maximize expected utility under the lifetime budget constraint given below:

$$\sum_{t=0}^{\infty} R_t P_t c_t \leq \sum_{t=0}^{\infty} R_t W_t e_t h_t + A_0, \tag{9}$$

where A_0 is the household's initial stock of assets, P_t is the aggregate price level in period t, W_t is the aggregate hourly nominal wage rate in t which can be either adjusted or unadjusted for taxes, and R_t is the discount factor:

$$R_t = \prod_{t=0}^{t-1} \left(\frac{1}{1 + r_t} \right), \tag{10}$$

where r_t stands for the rate of return - which can also be adjusted or unadjusted for taxes.

2.1 The Representative household's optimal decisions

The representative household ranks alternative streams of consumption and leisure services at the intensive and extensive margins using the following instantaneous time and state separable utility function:

$$u\left(c_t, l_{wt}^*, l_{nwt}^*\right) = \frac{1}{(1-\sigma)} \left\{ \left[(c_t)^{\alpha_c} \left(l_{wt}^*\right)^{\alpha_w} \left(l_{nwt}^*\right)^{\alpha_{nw}} \right]^{(1-\sigma)} - 1 \right\}, \tag{11}$$

where $\alpha_c + \alpha_w + \alpha_{nw} = 1$. Concavity of the utility function requires that α_c, α_w, and α_{nw} have positive signs, and that the product of each of these exponents with $(1 - \sigma)$ be less than unity. [6]

The representative consumer maximizes (11) subject to (9) in which (7) and (8) are used to express the product $e_t h_t$ as a function of l_{wt} and l_{nwt}. The first-order conditions for consumption, leisure in workweeks, l_{wt}, and leisure in weeks off, l_{nwt}, resulting from this optimization problem are, respectively:

$$\alpha_c \beta^t (c_t)^{\bar{\alpha}_c - 1} (l^*_{wt})^{\bar{\alpha}_w} (l^*_{nwt})^{\bar{\alpha}_{nw}} - \lambda_t R_t P_t = 0, \tag{12}$$

$$\alpha_w E_t \sum_{i=0}^{m} \mu_i \beta^{t+i} (c_{t+i})^{\bar{\alpha}_c} (l^*_{wt+i})^{\bar{\alpha}_w - 1} (l^*_{nwt+i})^{\bar{\alpha}_{nw}} + \lambda_t R_t W_t = 0, \tag{13}$$

$$\alpha_{nw} E_t \sum_{j=0}^{n} \eta_j \beta^{t+j} (c_{t+j})^{\bar{\alpha}_c} (l^*_{wt+j})^{\bar{\alpha}_w} (l^*_{nwt+j})^{\bar{\alpha}_{nw} - 1} + \widetilde{\tau} \lambda_t R_t W_t = 0, \tag{14}$$

where,

$$\begin{cases} \mu_0 = \eta_0 = -1, \\ \bar{\alpha}_c = \alpha_c (1 - \sigma), \\ \bar{\alpha}_w = \alpha_w (1 - \sigma), \\ \bar{\alpha}_{nw} = \alpha_{nw} (1 - \sigma), \\ \widetilde{\tau} = \left(1 - \frac{\tau}{T}\right). \end{cases} \tag{15}$$

and λ_t denotes the Lagrange multiplier attached to the lifetime budget constraint at time t.

2.2 The Intertemporal Euler Equations

The intertemporal Euler equations that will serve to recover the estimated parameters of preferences in this model are derived as follows. First, the Euler equation for consumption is obtained by forwarding (12) by one period, and then dividing the resulting expression by (12) for period t. Assuming that λ_t follows a martingale [e.g. MaCurdy, 1985; Mankiw,

[6]Eichenbaum *et al.* (1988) discuss into more details some of the desirable characteristics of the above form of the utility function.

Rotemberg and Summers, 1985], so that $E_t \lambda_{t+1} = \lambda_t$, and using 10, the Euler equation for consumption collapses to:

$$E_t \left\{ \beta \left(\frac{c_{t+1}}{c_t} \right)^{\bar{\alpha}_c - 1} \left(\frac{l^*_{wt+1}}{l^*_{wt}} \right)^{\bar{\alpha}_w} \left(\frac{l^*_{nwt+1}}{l^*_{nwt}} \right)^{\bar{\alpha}_{nw}} \frac{P_t \left(1 + r_t\right)}{P_{t+1}} - 1 \right\} = 0. \tag{16}$$

Next, the Euler equations for leisure in workweeks and leisure in non working weeks are obtained by first solving for $\lambda_t R_t$ from (12). The resulting expression is then substituted back into (13) and (14), before dividing each equation through by $\alpha_c \beta^t (c_t)^{\bar{\alpha}_c} (l^*_{wt})^{\bar{\alpha}_w} (l^*_{nwt})^{\bar{\alpha}_{nw}} \frac{w_t}{c_t}$. This yields the following two Euler equations for leisure in the workweeks and leisure in non working weeks, respectively:

$$E_t \left\{ \sum_{i=0}^{m} \frac{\alpha_w}{\alpha_c} \mu_i \beta^i \left(\frac{c_{t+i}}{c_t} \right)^{\bar{\alpha}_c} \left(\frac{l^*_{wt+i}}{l^*_{wt}} \right)^{\bar{\alpha}_w} \left(\frac{l^*_{nwt+i}}{l^*_{nwt}} \right)^{\bar{\alpha}_{nw}} \left(\frac{w_t l^*_{wt+i}}{c_t} \right)^{-1} + 1 \right\} = 0, \tag{17}$$

$$E_t \left\{ \sum_{j=0}^{n} \eta_j \beta^j \widehat{T} \left(\frac{c_{t+j}}{c_t} \right)^{\bar{\alpha}_c} \left(\frac{l^*_{wt+j}}{l^*_{wt}} \right)^{\bar{\alpha}_w} \left(\frac{l^*_{nwt+j}}{l^*_{nwt}} \right)^{\bar{\alpha}_{nw}} \left(\frac{w_t l^*_{nwt+j}}{c_t} \right)^{-1} + 1 \right\} = 0, \tag{18}$$

where $\widehat{T} \equiv \frac{\alpha_{nw}}{\alpha_c \widetilde{\tau}}$, and w_t is the real wage rate which can be either adjusted or unadjusted for taxes in the estimation.

For convenience, I shall denote the left hand side of equations (16), (17) and (18) as M_{ct+k}, M_{wt+k} and M_{nwt+k}, respectively. A more compact expression encompassing the same set of Euler equations is therefore given by:

$$E_t(M_{t+k}/\Omega_t) = 0, \tag{19}$$

where $M_{t+k} = (M_{ct+k},\ M_{wt+k},\ M_{nwt+k})'$, for $k = \max\{m, n\}$, and Ω_t is the information set available at time t.

3 Econometric Procedure and Data

As in Hansen (1982) and Eichenbaum *et al.* (1988), the econometric procedure used in estimating (19) in order to recover the parameters of preferences relies on the assumption that the variables entering the estimation are stationary. However, some of the time series used in this estimation may exhibit significant trends during throughout the sample period, hence the need for some stationary-inducing transformation of the data. As Eichenbaum *et al.* (1988) discuss in a context of a similar model, the choice of a detrending procedure is restricted by the fact that the transformed series must satisfy the stochastic Euler equations in (19).[7]

As a direct application of Eichenbaum *et al.* (1988) analysis to this framework, I shall assume that the following vector,

$$x_t \;=\; \left(l_{wt},\; l_{nwt},\; \frac{P_t\,(1+r_t)}{P_{t+1}},\; \{\frac{c_{t+k}}{c_t}\}_{k=1}^{\max\{m,n\}},\; \{\frac{w_t l_{wt+i}}{c_t}\}_{i=-m}^{m},\; \{\frac{w_t l_{nwt+j}}{c_t}\}_{j=-n}^{n},\; r_t \right),$$

is a strictly stationary stochastic process. As a result, l^*_{wt} and l^*_{nwt} are also stationary since they are linear combinations of stationary processes. Hence my estimation exercise only involves stationary variables. Note that, according to Eichenbaum *et al.* (1988), assuming that l_{wt} and $w_t l_{wt+i}/c_t$ both are stationary implies that $\ln l_{ct}$ and $\ln w_t$ have a common trend, a feature which is consistent with a growth model in which the technology shock is generated by a random walk with drift.

3.1 Estimation strategy: The GMM approach

The set of parameters of preferences that I seek to estimate is summarized by the following vector:

$$\theta = \{\beta, \alpha_c, \alpha_w, \alpha_{nw}, \sigma, \mu_1, ..., \mu_m, \eta_1, ..., \eta_n\}. \tag{20}$$

Estimates of the above structural parameters are recovered from the intertemporal Euler equations (19) which are jointly estimated using the Generalized Method of Moments (GMM) proposed by Hansen (1982), and Hansen and Singleton (1982).

[7] They argue that the most desirable way to model nonstatioanrities in consumption and hours worked is to specify technologies for the production of new consumption goods and capital accumulation that account for temporal shifts in labor or capital productivity.

To briefly summarize this estimation strategy, let the following capture the moment conditions based on (19):

$$E\left[g(z_t,\theta)\right]=0, \tag{21}$$

where,

$$g(z_t,\theta)=\sum_{t=1}^{T} z_t\otimes M_{t+k}\left(\theta\right), \tag{22}$$

and vector z_t is composed of instrumental variables. The optimal two-step GMM estimator, $\hat{\theta}_2$, of the vector of parameters, θ, is obtained as the solution to the following problem:

$$\hat{\theta}_2=\arg\min_{\theta\in\Theta}\frac{1}{T}\sum_{t=1}^{T} g(z_t,\theta)'\left[\widehat{\Lambda}\left(\hat{\theta}_1\right)\right]^{-1}\frac{1}{T}\sum_{t=1}^{T} g(z_t,\theta), \tag{23}$$

where $\hat{\theta}_1$ is a set of first-step parameter estimates obtained using the identity matrix as an optimal weighting matrix, and $\widehat{\Lambda}^{\ -1}$ is a consistent inverse estimator of the variance-covariance matrix of the moment conditions. Note that (23) amounts to saying that the two-step GMM estimator $\hat{\theta}_2$ is characterized by the following first-order conditions or identifying restrictions:

$$\left[\frac{1}{T}\sum_{t=1}^{T}\frac{\partial g(z_t,\theta)'}{\partial\theta}\right]\widehat{\Lambda}\left(\hat{\theta}_1\right)\frac{1}{T}\sum_{t=1}^{T} g(z_t,\hat{\theta}_2)=0. \tag{24}$$

To retrieve the variance-covariance matrix of the moment conditions, I alternatively impose an 8 and 12-lag bandwidth without affecting the results. I also control for autocorrelation and heteroskedasticity using Newey and West (1993) weighting matrix.[8]

The list of instruments to be used in such an estimation exercise appears not to be uniform across studies. For example, Mankiw *et al.* (1985) use different combinations of variables including lagged consumption, lagged interest rate, lagged leisure, lagged prices and lagged wages.[9] Eichenbaum *et al.* (1988) employ the current rates of change of consumption, leisure and wages, and the current interest rate. Here, I shall use the following set of instrumental variables (or subsets of these instruments), which mainly derived from the estimation Euler equations:

$$z_t=(1,X_{t,}X_{t-1}), \tag{25}$$

[8]See Newey and West [1994] .

[9]They occasionally use up to five-period lagged values of the variables.

where

$$X_t = (R^s c_t, R^s l_{wt}, R^s l_{nwt}, Rc_t AP_t, Rl_{wt} Aw_t, Rl_{nwt} Aw_t, c_t/w_t, r_t), \tag{26}$$

and

$$R^s y_t = y_t/y_{t-s}, \; AY_t = Y_{t-1}(1 + r_{t-1})/Y_t, \; s = \{1, 2, 3\}. \tag{27}$$

Given the above instruments, the over-identifying restrictions implied by the theoretical model can be tested using the $J-$statistic if the dimension of the vector of moments is greater than the dimension of the vector of parameters underlying the estimation exercise. The $J-$statistic, defined as:

$$J = T\left\{g_T(\theta)'\left[\widehat{\Lambda}_T(\widetilde{\theta})\right]^{-1} g_T(\theta)\right\}, \tag{28}$$

asymptotically follows a χ^2 distribution with $nk - l$ degrees of freedom, where n is the number of intertemporal Euler equations in (19), l is the number of structural parameters in (20) and k denotes the number of instrumental variables included in the information set available at time t. Therefore, the model outlined earlier implies $(n \times k)$ unconditional moment restrictions.

3.2 Data

In estimating the model's parameters, I shall U.S., seasonally adjusted, quarterly data from Haver USECON for the sample period 1954:I to 2001:III. However, estimates for the sampling periods 1948:I - 2001:III and 1964:I - 2001:III, are also provided as a robustness check of my findings.

The aggregate price level, P_t, is measured as the nonfarm business sector deflator (LXNFI). The per capita real consumption, c_t, is the sum of real consumption expenditures on non-durables and services (CGSQ+CGND) divided by the civilian noninstitutional population aged 16 and over (LNN).[10]

[10] Data for the aggregate consumption of nondurables and services (CGSQ and CGND, chained) are from Citibase.

The real wages, w_t, are measured by the ratio of total compensation per hours worked in the nonfarm business sector (LXNFC) to the nonfarm business sector deflator. In adjusting real wages for taxes, I shall use the tax rate on labor income constructed by Jones (2002) and Burnside, Eichenbaum and Fisher (2004).[11]

The asset return is the value-weighted average of returns on the New York Stock Exchange and the American Exchange, which is also the measure used by Hansen and Singleton (1982), Cooley and Ogaki (1996), Eichenbaum *et al.* (1996) and Cho *et al.* (1998). The after-tax asset return is obtained using the effective marginal tax rate on capital income calculated by Jones (2002) and Burnside, Eichenbaum and Fisher (2004).

The representative consumer is endowed with $\bar{T} = 112$ hours per week, $Q = 13$ weeks in a quarter, and a fixed time-cost of going to work which is set at 6 hours in estimation - moving the time-cost from 2 to 12 hours does not alter the results. As in Alogoskoufis (1987) and Cho *et al.* (1998), the extensive margin, e_t, was approximated by the product of Q and the ratio of total employment (16 years and over) to the civilian noninstitutional population aged 16 and over (LNN). Finally, the weekly hours worked, h_t, was obtained by taking the ratio of hours of all persons in the nonfarm business sector (LXNFH) to the civilian noninstitutional population aged 16 and over (LNN) which was divided by the number of weeks in a quarter, Q.

4 Results

For estimation purposes, five lags were initially considered for each dimension of labor services, and then the lag length were sequentially reduced to statistically significant habit coefficients (at conventional levels). Results are reported only for the relevant lag lengths m and n with regard to the polynomials in equations (4) and (5).

[11] Jones construct labor and capital tax rates using US quarterly data from the national income and products accounts. For more details, see Jones (2002) and Burnside, Eichenbaum and Fisher (2004).

4.1 Estimation results

The first column in Table 1 provided in appendix depicts the estimates of our baseline model, where neither tax on labor nor tax on capital income are taken into account, an the sample period goes from 1954:01 to 2001:03. The next two columns give the new estimates once we control for both taxes (model 2), in addition to fixing β to 0.995 (model 3). Models 4 to 6 refer to tax-adjusted cases for various sampling periods, *i.e.* starting at 1948:01, 1960:01 and 1954:01 (in the last-mentioned case, I also use logarithmic preferences). The last column in Table 1 displays estimates of the model without habit forming effects.

First, and most importantly, the utility function is found to be concave in all cases according to the estimated value of $1 - \sigma$ which is always negative. In addition, and as expected, the weights of past leisure period declines geometrically and sum to a value always below unity (between 0.88 and 0.94).

Moreover, the baseline model accurately estimates the discount factor since β is equal to 0.9995. To our knowledge, this is one of the very first studies that estimate the discount factor with such precision. When taxes are controlled for, we lost that feature of the model as β is now slightly above unity (model 2). However, this finding is common to several macro studies. Further, we are able to provide evidence that our main results are robust to the value of β as can be seen in the third column (model 3), where beta is fixed to 0.995 and we almost reach the same conclusions regarding habit formation in leisure. The only noticeable point has to do with the relative weights of leisure services in the utility function. In the baseline model, the representative agent seems to value type 1 leisure more, whereas the opposite holds once we control for taxes. Increasing (reducing, respectively) the sample period, model 4 (model 5), or controlling for logarithmic preferences (model 6) does not alter our results. Except for the model without habit forming effects, the over-identifying restrictions implied by any of the just above-mentioned specifications are far from being rejected, according to the *p-value* attached to the J-statistics which ranges from 0.16 to 0.68.

4.2 Intertemporal substitution elasticities

In this subsection, we compute the intertemporal substitution elasticities implied by our model. Our calculations follow McLaughlin (1985) approach, and we uncover λ-constant elasticities of intertemporal substitution from parameter estimates based on the joint estimation of the Euler equations in (19).

We first write the λ-constant counterparts of equations (12) - (14) using (2) and (3). Minor algebraic manipulations then lead to the following system of equations:

$$\begin{cases} \alpha_c \xi \beta^t (c_t)^{\bar{\alpha}_c - 1} (l_{wt})^{\bar{\alpha}_w} (l_{nwt})^{\bar{\alpha}_{nw}} = \lambda_t R_t P_t, \\ \alpha_w \xi \beta^t (c_t)^{\bar{\alpha}_c} (l_{wt})^{\bar{\alpha}_w - 1} (l_{nwt})^{\bar{\alpha}_{nw}} = \lambda_t R_t W_t, \\ \alpha_{nw} \xi \beta^t (c_t)^{\bar{\alpha}_c} (l_{wt})^{\bar{\alpha}_w} (l_{nwt})^{\bar{\alpha}_{nw} - 1} = \widetilde{\tau} \lambda_t R_t W_t, \end{cases} \tag{29}$$

where ξ is a scale factor composed of habit coefficients and parameters of the utility function,

$$\xi = \left(1 -_{i=1}^{m} \mu_i\right)^{\alpha_w (1-\sigma)} \left(1 -_{j=1}^{n} \eta_j\right)^{\alpha_{nw}(1-\sigma)}. \tag{30}$$

Next, taking both side log of each equation in Eq.(29), solving the resulting system and rearranging terms yields the following:

$$\begin{cases} \ln c_t = (\alpha_w + \alpha_{nw}) \left(1 - \frac{1}{\sigma}\right) \ln w_t - \frac{1}{\sigma} \ln \lambda_t R_t P_t + C_1, \\ \ln l_{wt} = \left[(\alpha_w + \alpha_{nw}) \left(1 - \frac{1}{\sigma}\right) - 1\right] \ln w_t - \frac{1}{\sigma} \ln \lambda_t R_t P_t + C_2, \\ \ln l_{nwt} = \left[(\alpha_w + \alpha_{nw}) \left(1 - \frac{1}{\sigma}\right) - 1\right] \ln w_t - \frac{1}{\sigma} \ln \lambda_t R_t P_t + C_2, \end{cases} \tag{31}$$

where w_t stands for the real wage and the C_i's are constants composed of parameters of the utility function

$$\begin{cases} C_1 = \frac{1}{\sigma} \left[\ln \alpha_c + \bar{\alpha}_w \ln (\alpha_2/\alpha_1) + \bar{\alpha}_{nw} \ln (\alpha_{nw}/\widetilde{\tau}\alpha_1)\right], \\ C_2 = C_1 + \ln (\alpha_w/\alpha_c), \\ C_3 = C_1 + \ln (\alpha_{nw}/\widetilde{\tau}\alpha_c). \end{cases} \tag{32}$$

Based on these results, the $\lambda-$constant elasticities of intertemporal substitution with respect to real wage and price can be easily computed using the estimated structural parameters. The $\lambda-$constant elasticity of consumption with respect to real wage is hence found to be 0.6113, whereas those of leisure are about -0.3886 in the baseline case. On the other hand, the price-elasticity of consumption is found to be -0.7156, as opposed to those of leisure (0.2844). As pointed out in Cho *et al.* (1998), both types of leisure share the same inter temporal elasticities of substitution because though their respective weights in preferences may be different, they are governed by the same intertemporal substitution parameter.

Further, using the first order conditions of the maximization problem, it can be shown that the ratio of both leisure services is constant over time, implying that they are valued differently by the representative household, even if they are still adjusted at the same rate following any price change.

Keeping the same sampling period of 1954:01 to 2001:03 while taking income taxes into account, the $\lambda-$constant elasticities with respect to real wage are now found to be as low as 0.4308 for consumption and -0.5691 for leisure. On the other hand, price-elasticities are higher, whether for consumption (-0.5330), or leisure (0.4668). These findings seem to align well with economic intuition. At first glance, an increase in wage rate fosters hours at work, whereas labor income tax dampens the incentive to supply more hours.

In the next step, the same $\lambda-$constant elasticities are computed while accounting for capital and labor income taxes and using the same sampling period, *i.e.* 1954:01 - 2001:03. Real wage-elasticities are now higher compared to the baseline model, with a value of 0.6511 for consumption and -0.3489 for leisure, whereas price-elasticities are now lower (-0.7229 for consumption and 0.2770 for leisure). This clearly illustrates the role of taxation in driving the trade off between the competing claims on the household's time endowment, i.e. work and leisure.

Using the sampling period starting as early as 1954:01, a logarithmic specification for preferences points to a trivial $\lambda-$constant elasticity for consumption with respect to real wage (*e.i.* 0), whereas that of leisure is unitary in absolute value (*e.i.* -1). The opposite holds for price-elasticities, *i.e.* unitary in absolute value for consumption and trivial for leisure. Once again, the intuition are straight forward.

The next step involves solving for hours and weeks of work elasticities of substitution with respect to the same just above-mentioned prices. To that goal, we totally differentiate l_{wt} and l_{nwt}, while making use of the definition of an elasticity, for which means of explanatory variables are put forward. Clearly, differentiating (7) and (8) with respect to w_t and P_t, rearranging terms yields:

$$\left\{ \begin{array}{c} \zeta_{e_t/j} = -\frac{l_{nwt}}{e_t T}\zeta_{l_{nwt}/j}, \\ \zeta_{h_t/j} = \left(\frac{T-\tau}{h_t} - 1\right)\zeta_{e_t/j} - \frac{l_{wt}}{e_t h_t}\zeta_{l_{1t}/j}, \end{array} \right. \tag{33}$$

where $\zeta_{i/j}$ stands for the elasticity of i with respect to j, $i \in \{e_t, h_t, l_{wt}, l_{nwt}\}$ and $j \in \{w_t, P_t\}$. Substituting the respective values of $\zeta_{l_{wt}/j}$ and $\zeta_{l_{nwt}/j}$ back into the above system yields columns five and six in Table 2 in appendix, whereas the last column gives the value of the intertemporal elasticity of substitution as implied by the model laid out earlier on.

The results point to a greater sensitivity of hours worked as compared to working weeks (almost fivefold in the less favorable, baseline case, *i.e.* 1.1062 for real wages and −0.8095 for price, as compared to 0.2266 and −0.1658 respectively). The fact that hours worked now react more to both wages and prices than in previous studies (1.1062 as compared to 0.978 for Cho *et al.* [1998] for instance), explains why we are able to uncover a slightly higher wage-elasticity of intertemporal substitution for total hours (1.3328 compared to 1.22). Except when β is fixed, as we move from the baseline model to the tax-adjusted model and further to the logarithmic specification, the above features become stronger, pushing elasticities of intertemporal substitution upward (1.9517 and 3.4297).

5 Concluding remarks

This paper develops and estimates a model of a representative consumer that highlights two main features with respect to previous work. First, this framework realistically permits workers to adjust labor supply along both the intensive and extensive margins. Second, for the first time in the context of a two-dimensional labor supply model, utility from leisure at the two margins is modeled as nontime-separable. As in the one-margin model of Eichenbaum, Hansen and Singleton (1988), the nonseparability of preferences can accommodate intertemporal substitution or complementarity of leisure, but this time at the two margins. The Euler equations of the two-dimensional labor supply model are estimated using GMM. The data determine the length, sign and magnitude of the temporal dependence between current leisure services and past quantities of leisure. The evidence shows the presence of habit formation in preferences with respect to both types of leisure. Also, the representative household's habit-forming behavior is empirically consistent at the two margins, since the estimated patterns of coefficients on lagged leisure terms are very similar at the two margins.

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Table 1: Model's estimates

	Baseline	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
β	.9995	1.0388	.995	1.0336	1.0391	1.0268	1.0523
	(.0067)	(.0044)	-	(.0051)	(.0037)	(.001)	(.0033)
α_w	.36	.2090	.3206	.2639	.2635	.1908	.0178
	(.0099)	(.0056)	(.0068)	(.0073)	(.0051)	(.0363)	(.00001)
α_{nw}	.3225	.2709	.3809	.2786	.3687	.3520	.0199
	(.0106)	(.0096)	(.0089)	(.0075)	(.0093)	(.0531)	(.00005)
$1-\sigma$	-8.5925	-8.778	-12.921	-9.6659	-9.0017	0	-8.7412
	(.3412)	(.3066)	(.4508)	(.3498)	(.2487)	-	(.5981)
μ_1	.6206	.6456	.7278	.6307	.6147	.6123	-
	(.0134)	(.0178)	(.0082)	(.0098)	(.0105)	(.023)	-
μ_2	.2228	.1651	.1499	.2009	.2074	.245	-
	(.0154)	(.0159)	(.0112)	(.0136)	(.0105)	(.0251)	-
μ_3	.10	.1303	.0573	.1069	.1056	.107	-
	(.0091)	(.0098)	(.0053)	(.0109)	(.0132)	(.0172)	-
η_1	.621	.6383	.6187	.6412	.6342	.6311	-
	(.012)	(.0118)	(.0091)	(.0119)	(.009)	(.0212)	-
η_2	.2219	.2056	.2191	.2034	.1959	.2278	-
	(.0164)	(.0136)	(.0125)	(.0145)	(.0113)	(.0227)	-
η_3	.0992	.0937	.0871	.0911	.0934	.0969	-
	(.0089)	(.0078)	(.0079)	(.0074)	(.0076)	(.0136)	-
$J-stat$	20.649	15.616	16.917	18.056	17.095	26.049	143.71
	(.3565)	(.6827)	(.6583)	(.5187)	(.5834)	(.1642)	(.0000)

Note: Standard errors are in parentheses and P-values in parentheses under J-statistics.

Table 2:

Real wage and price elasticities of choice variables.

	c_t	l_{wt}	l_{nwt}	h_t	e_t	$e_t \times h_t$
	A. Baseline model (1954:01 - 2001:03)					
w_t	.6113	-.3886	-.3886	1.1062	.2266	1.3328
P_t	-.7156	.2844	.2844	-.8095	-.1658	-
	B. Tax-ajusted model (1954:01 - 2001:03)					
w_t	.4308	-.5691	-.5691	1.6199	.3318	1.9517
P_t	-.5330	.4668	.4668	-1.3286	-.2721	-
	C. Tax-ajusted with fixed beta (1954:01 - 2001:03)					
w_t	.6511	-.3489	-.3489	.9931	.2034	1.1965
P_t	-.7229	.2770	.2770	-.7885	-.1615	-
	D. Model with log preferences (1954:01 - 2001:03)					
w_t	0	-1	-1	2.8466	.5831	3.4297
P_t	-1	0	0	0	0	-

Note: Respective elasticities are computed for variables in the first row with respect to those in the first column.