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Measuring the Cyclical Behavior of Home Production: A Macroeconomic Analysis*

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ABSTRACT

Much economic activity takes place within the home. Unfortunately, it is difficult to assess the cyclical properties of home production because the available data are too sporadic. Under the assumption that each observation of historical U.S. data on consumption, investment, and hours worked is consistent with optimal behavior on the part of a representative agent, we construct quarterly data on three variables that would otherwise be unobservable at a quarterly frequency: hours worked in the home sector, hours spent in leisure, and the consumption of goods produced in the home sector. Three results emerge: leisure is highly countercyclical while nonmarket hours are acyclical; there has been a large decrease in hours spent in home production since the 1970s; fluctuations in market output are a good measure of fluctuations in individual utility as long as home consumption and market consumption are either extreme complements or extreme substitutes in the production of utility. The sensitivity of results to the parametric assumptions is examined.

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Anyone who has sat through undergraduate macroeconomics has seen a list of the defects of Gross Domestic product as a measure of aggregate production or economic welfare. One of the first items on such a list is sure to be, "GDP fails to account for the production of goods and services within the household." As Becker (1988) emphasizes, individuals spend a nontrivial portion of their time working in the home. It is hard to imagine that anyone can claim an understanding of the business cycle without some knowledge of the periodic fluctuations in this important part of the aggregate economy.

Obtaining this knowledge requires data. The National Income and Product Accounts provide quarterly data on Gross Domestic Product, but it is not possible, currently, to obtain data at a similar frequency for home sector activities. The available data are generated through the use of surveys and time-use diaries (Juster and Stafford, 1985). These data are sporadic; at best, the data are collected yearly. This is unfortunate: since we lack more frequent observations, the business cycle behavior of the home sector must remain largely a mystery.

In this paper, measurement is approached from a different perspective: we show how to use macroeconomic theory in conjunction with aggregate macroeconomic data to infer the behavior of unobserved home sector variables. We assume that each observation on market consumption, investment and market hours available in the National Income and Product Accounts is well-measured and is consistent with the optimal behavior of a representative agent who has stable preferences, but stochastic production technologies in the home and market sectors. The assumption of optimal behavior at every point in time means that the behavior of the representative individual in the market sector has strong implications about his behavior in the home sector. In fact, we can use the first order conditions of the representative individual to translate the quarterly numbers on market activity in the economy into quarterly numbers on home activity.

We then use this data to address three significant questions about home-sector activity over the business cycle. First, it is well known that market labor hours tend to expand during booms and contract during recessions. We determine the extent to which these changes in market hours reflect an adjustment in leisure hours, home labor hours, or both. Our results indicate that the procyclical behavior of market hours is associated with a strong countercyclical movement in leisure and with acyclical behavior in nonmarket hours. Thus, leisure increases dramatically during recessions but nonmarket hours tend not to change.

Second, per capita GDP is often said to be an inferior measure of economic welfare since it excludes the significant amount of production which occurs in the home sector. We look at the relationship between the traditional market output-based measure of the cycle and a welfare-based measure that takes into account the behavior of the home sector. We show that if goods produced by home production are either close substitutes for or are highly complementary to market consumption, then market output is a good measure of the cyclical behavior of welfare. In contrast, if the two types of goods are neither close substitutes nor highly complementary, then the traditional market output measure of the cycle is not well correlated with the behavior of the utility of the representative agent.

Finally, we address an issue which has been raised in many of the papers in this literature (Greenwood, Rogerson and Wright, 1995): when market consumption and home consumption are separable in the utility function of the representative agent, models with home production are essentially observationally equivalent to models without home production. While this is certainly theoretically true, we show that it is empirically irrelevant -- the assumption of separability of the two types of goods is dramatically at odds with the data.

For clarity, it is important to emphasize the difference in both approach and design between this paper and previous papers on home production. Many of the theoretical papers in this literature regard home production as a way to improve the empirical performance of standard macroeconomic models with regard to aggregate market data: Rios-Rull (1993) looks at the behavior of wages, Baxter and Jermann (1994) examine the correlation between market consumption and measured income, Benhabib, Rogerson and Wright (1991) concentrate on the correlation between aggregate hours worked in the market sector and market output. Empirical papers such as McGrattan, Rogerson and Wright (1993) estimate the parameters of a home production model based on macroeconomic data while other empirical papers (Rupert, Rogerson and Wright (1994)) use microeconomic data. The drawback of these exercises is that they rely on restrictive assumptions governing the shocks which drive the model economies.

In contrast, we investigate the behavior of nonmarket quantities given the observed – and optimal – behavior of individuals as they choose market quantities, while avoiding the imposition of strong prior restrictions on the stochastic shocks which drive the economy. To conduct our analysis, we calibrate the parameters of the model in the usual fashion, then employ the first order conditions implied by optimal behavior to estimate the realizations of the unobserved home sector variables, conditional on the parameter specification. Thus, we are interested in the implications that market data carry for nonmarket behavior. We explore the robustness of our conclusions by considering alternative parameterizations of the model.

Our approach is not uncommon in economics. Solow residuals have been estimated based on the assumption of a specific aggregate production technology and a calibrated share parameter at the sectoral level by Hall (1988) and at the aggregate level by Prescott (1986) and Hansen and Prescott (1993). Burnside, Eichenbaum and Rebelo (1993) estimate the realization of an unobserved variable – work effort – as a function of a vector of parameters and observed data in the context of a general equilibrium framework, making use of the optimizing behavior of a representative agent. Ambler and Paquet (1994) estimate a series for capital and for the (stochastic) rate of depreciation in a real business cycle framework. Beauchemin (1995) constructs a measure of the public capital stock based on private investment and consumption data and the optimal capital accumulation plan of an agent. We believe that this strategy can be fruitfully applied in the home production context.

The remainder of the paper is organized as follows. In section one, we outline the home production model described in Benhabib, Rogerson and Wright (BRW 1991). Section two contains a description of the observed data set and the mapping which we employ to estimate the nonmarket quantities from the observed market quantities. In section three, we analyze the relationship between the business cycle (changes in the growth rate of output) and movements in leisure, home labor hours and market labor hours. In addition, we gauge the efficacy of using the growth rate of per capita GDP as a measure of economic welfare. Section four concludes the paper.

1. The Home Production Model

In the prototypical real business cycle model (e.g., King, Plosser, and Rebelo, 1988), agents allocate time to two possible uses: leisure and market labor. Market labor and market capital combine to produce market output, which can then be consumed or invested. The behavior of these variables is stochastic because the production function is influenced by technological shocks that alter the productivity of factors of production.

Following the work of BRW, we add an additional sector to the model which we call the nonmarket or home sector. In this sector, nonmarket labor hours and nonmarket capital are used to produce a second type of consumption good. Like the market sector, home production is subject to technological shocks (which may or may not be correlated with market shocks) which change the productivity of factors of production.

More specifically, the agent chooses consumption of home-produced goods, c_{nt}, consumption of market-produced good, c_{mt}, and leisure, ℓ_t, to maximize the expected present value of utility (throughout, the subscript **m** refers to the market sector and the subscript **n** refers to the nonmarket or home sector):

$$(1) \qquad E_0 \sum_{t=1}^{\infty} \beta^t \left[(1-\phi_\ell) \ln[\phi_m c_{mt}^{\rho} + (1-\phi_m) c_{nt}^{\rho}]^{1/\rho} + \phi_\ell \ln(\ell_t) \right].$$

The parameters ϕ_m, ϕ_ℓ and β lie in the interval [0,1]; the parameter ρ must be less than or equal to one. Individuals have Cobb-Douglas utility functions over leisure (with share ϕ_ℓ) and a composite consumption good, which is a CES combination of non-market and market consumption (with share ϕ_m). The parameter ρ measures the individual's willingness to substitute between the two types of consumption goods. When $\rho = 0$, preferences are log-separable across the two consumption goods.

Each individual has access to two production technologies. Hours supplied to the market, h_{mt}, combine with the beginning-of-the-period market capital stock, k_{mt}, to produce market output, y_{mt}:

(2) $$A_{mt} k_{mt}^{\theta_m} h_{mt}^{1-\theta_m} = y_{mt} .$$

Likewise, hours supplied in the home sector, h_{nt}, and the beginning-of-the-period home capital stock, k_{nt}, are used to produce home output:

(3) $$A_{nt} k_{nt}^{\theta_n} h_{nt}^{1-\theta_n} = y_{nt} .$$

Here, A_{jt}, j=m,n, is an exogenous shock which affects the level of output in sector j. We assume that the individual knows the stochastic processes governing the two shocks; however, our analysis does not require that we write down a specific form for these processes.

Apart from possible differences in parameter values, the two sectors are, at this point, essentially equivalent. We follow BRW, however, in positing a key distinction between the sectors: while the output from the market sector can be used either for consumption or investment (as is typical in one sector growth models), the output from the home sector must be used for consumption. In other words, the production of capital goods – e.g., washing machines and computers – must take place in the market sector, even if they are ultimately used in the home sector.

Hence, the agent faces three other constraints on his behavior:

(4) $$\begin{aligned} c_{mt} + i_t &= y_{mt} \\ c_{nt} &= y_{nt} \\ h_{nt} + h_{mt} + \ell_t &= 1 \end{aligned}$$

Market output is split between market consumption, c_{mt}, and investment, i_t. Non-market output is devoted solely to non-market consumption, c_{nt}, and hours allocated to the home, to the market, and to leisure must sum to one, the number of hours available to the individual.

To complete the specification of the model, we would normally write down an expression for the capital accumulation technology (in the standard real business cycle model, an expression similar to $k_{t+1} = (1-\delta)k_t + i_t$). However, as will become apparent later, our analysis is based on the *intratemporal* choices made by the individual, and, hence, will be consistent with many forms of capital accumulation. We only require that capital evolve in such a way that the agent have an incentive to keep investment positive.

2. Solving for the Home Sector Variables

From an empirical viewpoint, the essential difference between the market and home sectors is that macroeconomic time series data is available for the former and not the latter. In this section, we derive a set of equations from the agent's optimization problem which allow us to use available macroeconomic data to infer a set of time series observations for the home sector variables. Optimal intratemporal behavior of the agent is described by the following two conditions, in addition to the constraints given by (2) - (4):

$$\text{(5)} \qquad \frac{\phi_\ell}{1-\phi_\ell}\left[1+\frac{1-\phi_m}{\phi_m}\left(\frac{c_{nt}}{c_{mt}}\right)^\rho\right]\frac{c_{mt}}{\ell_t} = (1-\theta_m)\frac{y_{mt}}{h_{mt}},$$

$$\text{(6)} \qquad \frac{1-\phi_m}{\phi_m}\left(\frac{c_{nt}}{c_{mt}}\right)^{\rho-1} = \frac{(1-\theta_m)y_{mt}/h_{mt}}{(1-\theta_n)y_{nt}/h_{nt}}.$$

The first equation stems from the agent equating the marginal rate of substitution between market consumption and leisure to the marginal product of labor in the market sector. According to the second equation, optimal behavior implies that the ratio of marginal utility in the market sector to that in the home sector is equal to the ratio of labor productivity in the market sector to labor productivity in the home sector. Substituting the identity $c_{nt} = y_{nt}$ into (6) produces the following relationship between home consumption, home hours, and the observable variables, market consumption, market hours and market output:

$$(7) \qquad \left(\frac{c_{nt}}{c_{mt}}\right)^{\rho} = \frac{\phi_m}{1-\phi_m}\frac{1-\theta_m}{1-\theta_n}\frac{y_{mt}}{c_{mt}}\frac{h_{nt}}{h_{mt}}.$$

Substituting this expression and the constraint that $h_{mt}+h_{nt}+\ell_t = 1$ into equation (5), and rearranging terms yields the following expression:[1]

$$(8) \qquad \frac{h_{nt}}{h_{mt}} = \frac{(1-\theta_n)(1-\phi_\ell)}{1-(1-\phi_\ell)\theta_n}\frac{1-h_{mt}}{h_{mt}} - \frac{\phi_\ell}{1-(1-\phi_\ell)\theta_n}\frac{1-\theta_n}{1-\theta_m}\frac{c_{mt}}{y_{mt}}..$$

Equivalently, in terms of leisure:

$$(9) \qquad \frac{\ell_t}{h_{mt}} = \frac{\phi_\ell}{1-(1-\phi_\ell)\theta_n}\frac{1-h_{mt}}{h_{mt}} + \frac{\phi_\ell}{1-(1-\phi_\ell)\theta_n}\frac{1-\theta_n}{1-\theta_m}\frac{c_{mt}}{y_{mt}}.$$

Given data on the market variables, equations (8) and (9) can be used to derive realizations of leisure and nonmarket hours. Note that consumption and output enter the equation only through the ratio c_{mt}/y_{mt}, and that this ratio appears in both expressions with the same coefficient but opposite signs. This ratio can be thought of as a measure of the size of current output relative to the expectation of future output by the representative agent: the agent consumes a higher proportion of output *today* when the agent anticipates that beneficial shocks will boost output *tomorrow* relative to today. The quantity $(1-h_{mt})/h_{mt}$, which measures hours spent outside of market activity as a percentage of hours spent in market activity, enters both expressions with a positive coefficient. Hence, during periods in which market output and market hours are relatively low, leisure hours are high relative to market hours; during periods in which market output is low and market hours are high, nonmarket hours are low relative to market hours. In other

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[1] One crucial feature of the model that makes this analysis work is that preferences over consumption and leisure are stable over time. If there were a preference shock affecting the two variables, then inferring the behavior of the home sector would be much more difficult (and perhaps impossible).

words, during periods in which market output and market hours move in the same direction, the ratio of leisure to market hours varies in the opposite direction. When market output and market hours change in opposite directions, the ratio of nonmarket hours to market hours moves in the same direction as market output.

Interestingly, the expressions do not depend on the parameter ρ, the degree of substitutability between the two types of consumption goods. Thus, we need not make any assumptions about the complementarity/substitutability of the two consumption goods in order to draw conclusions about how the individual allocates time between home hours and leisure in response to exogenous shocks to productivity. This does not mean, however, that ρ has no influence on this choice: the effect of ρ on the leisure/home production decision is fully captured by its influence on the three observable variables.

To derive an expression for home consumption, we return to equation (7), which, under the assumption that $\rho \neq 0$, implies:

$$(10) \qquad \frac{c_{nt}}{c_{mt}} = \left(\frac{\phi_m}{1-\phi_m} \frac{1-\theta_m}{1-\theta_n} \frac{y_{mt}}{c_{mt}} \frac{h_{nt}}{h_{mt}} \right)^{1/\rho}.$$

If $\rho = 0$, then nonmarket consumption will not appear in either (5) or (7), making it impossible for us to draw any conclusions about the behavior of home consumption based on our knowledge of y_{mt}, c_{mt}, and h_{mt}. Essentially, the information we have about nonmarket consumption is derived from the effect that c_{nt} has on the individual's willingness to substitute between market consumption and leisure. If $\rho = 0$, preferences between home and market consumption are separable, and c_{nt} has no effect on this margin.

3. Data and Calibration of the Model

In order to use equations (8) - (10), we require observations on market variables and values for the parameters of the model. In this section, we describe the macroeconomic data and the parameter settings employed in our analysis.

3.1 Macroeconomic Data

Our data, taken from CITIBASE, is quarterly from 1951:I to 1993:IV. We measure market consumption in the model as aggregate real consumption of nondurables and services divided by the noninstitutional, 16+ population to convert to per capita terms. We measure market investment as the sum of real gross business fixed investment and purchases of consumer durables and residential structures, also divided by the population; market output is the sum of consumption and investment. We measure labor hours as average hours worked weekly multiplied by the percentage of the population which is employed and divided by 168, the number of hours in a week. We do NOT filter the data in any other way.

Figure 1 contains time series graphs of each of the series that we use, overlaid with shaded bars representing NBER-dated recessions. Market labor hours show a clear downward trend through the middle of the 1970's, reflecting a decline in the number of hours per worker. Driven by the influx of women into the labor force, hours climb dramatically over the course of the 1980's. Hours tend to rise during expansions and decline during recessions as workers enter and leave the labor force. Market consumption rises steadily over the period; as is well-known, market output, which is equivalent to consumption plus investment, exhibits much more volatility than consumption. Finally, the consumption/output ratio displays countercyclical behavior, reaching its highest level during business cycle troughs and its lowest level during business cycle peaks.

3.2 Model Parameterization

In conducting the analysis in the subsequent section, we choose a particular parameterization of the model, and then examine the robustness of our findings to perturbations in this parameterization. Throughout the analysis, the parameter θ_m is set to 0.28, which implies that labor's share of income in the market sector is 0.72. We assume that the labor input is more important in the home sector than in the market sector, and thus constrain the parameter θ_n to lie in the interval (0,0.28]. For our particular parameterization, we choose the midpoint of this interval, θ_n=0.14, which is consistent with the value used in BRW.

The parameter ϕ_ℓ must not exceed 0.8 to guarantee positive nonmarket hours in our sample; a lower limit of 0.5 implies that the number of hours spent in leisure activity is always greater than nonmarket hours, a requirement that seems reasonable under our assumption that leisure includes sleep. Hence, we examine values of ϕ_ℓ in the interval [0.5,0.8]. When ϕ_ℓ=0.73, the mean value for home hours is about 85% of the mean of market hours, which is consistent with panel data on time use. The parameter ϕ_m alters the level of c_n relative to c_m, but has little relevance for most of our results. We fix this parameter to be equal to 0.4.

In many studies of home production, the parameter ρ is restricted to be positive. (For example, Gronau (1986) assumes that the two goods are perfect substitutes.) This implies that the marginal utility derived from consuming home-produced goods is declining in the level of consumption of market goods. To further clarify the role played by ρ, we refer to Figure 2 which contains the level curves over leisure and nonmarket consumption of the period utility function for fixed amounts of market consumption. Panel a contains the case in which c_n and c_m are substitutes. Notice that the slope of the tangent to the level curve is inversely related to the level of c_m: the amount of leisure that the agent is willing to forgo for an extra unit of c_n is declining in the level of c_m. For example, over the course the relevant time period, if an individual has consumed one restaurant meal, he is less willing to spend the time necessary to create a subsequent home meal than if he had consumed no restaurant meals. In this sense, market consumption (restaurant meals) and home consumption (home meals) are substitutes in the production of utility.

When market and nonmarket consumption are complements, as illustrated in panel b of Figure 2, the agent is less willing to substitute leisure for nonmarket consumption as the level of market consumption increases: the slope of the tangent to the level curve is increasing with c_m. In this case, over a specific time period, the agent becomes more willing to give up leisure activities to prepare one home cooked meal as the number of restaurant meals she has consumed increases.

Given that our data is quarterly, the question is whether the agent is more or less willing to eschew leisure activities to consume one additional home-cooked meal as the number of restaurant meals consumed over a three month period increases . Since we believe that the answer to this question is not obvious,, we are agnostic about the sign of ρ.[2]

When ρ = 0, the period utility function is separable across the two types of consumption goods. In that case, equation (7) does not provide that information that we need to identify nonmarket consumption. Our claim, however, is that this particular value for ρ is empirically uninteresting; when ρ = 0, the model has a very strong testable implication which can be rejected by the data for *any* chosen level of significance. Under this restriction on preferences, equations (7) and (8) can be written:

$$\frac{\phi_\ell}{(1-\phi_\ell)\phi_m}\frac{c_{mt}}{\ell_t}=(1-\theta_m)\frac{y_{mt}}{h_{mt}},$$

$$\frac{1-\phi_m}{\phi_m}c_{mt}=\frac{1-\theta_m}{1-\theta_n}\frac{y_{mt}h_{nt}}{h_{mt}}.$$

Combining these two equations produces:

(11) $c_{mt}/y_{mt}=a_0(1-h_{mt})/h_{mt},.$

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[2] McGrattan, Rogerson and Wright (1994) estimate ρ to be around 0.4. They obtain this estimate by assuming that certain macroeconomic aggregates are measured with error (which seems plausible) and by assuming that the measurement error is uncorrelated with the true series (which does not seem plausible). Rupert, Rogerson and Wright (1994) also estimate ρ to be around 0.4. They obtain their estimate by assuming that certain instrumental variables are correlated (cross-sectionally) with market productivities but not with home sector productivities. These instrumental variables include age, wife's education, and various lagged variables. The first two seem to us like they should be correlated with home sector productivities, although this is arguable; lagged variables are only valid instruments if all productivity shocks are uncorrelated over time, which is demonstrably false. More generally, standard estimates of ρ are based on particular identification assumptions about the unobservable exogenous variables in a model. Since these identification assumptions are often debatable (because they are restrictions on unobservables), we choose to be relatively agnostic about the value of ρ.

where a_0 is a constant. Equation (11) imposes a strong restriction on the data: c_m/y_m and $(1-h_m)/h_m$ are perfectly correlated, ***independent of the specifications of the other parameters and the sample size.*** Essentially, when $\rho = 0$, a single shock -- the market sector productivity shock -- drives movements in the two variables c_{mt}/y_{mt} and $(1-h_{mt})/h_{mt}$. In the data, however, the correlation between these two quantities is only 0.3, and we thus conclude that the data rejects the hypothesis that $\rho = 0$.

3. Results

3.1 Time series behavior of nonmarket variables

Figure 3 contains time series graphs of nonmarket hours and leisure hours for the particular values of θ_m, θ_n and ϕ_ℓ discussed above, $(\theta_m, \theta_n, \phi_\ell) = (0.28, 0.14, 0.73)$. Each panel is overlaid with the market hours series, scaled to fit the panel appropriately. Nonmarket hours climb until the 1970s (as market hours fall) and decline thereafter (as market hours climb). The *trend* behavior of the market hours series is mirrored in the nonmarket hours series. In contrast, leisure hours seem to trend slightly downward over the entire period. The peaks in the leisure series correspond to business cycle troughs (e.g., note 1974, 1981 and 1991): leisure increases during recessions and decreases during expansions. For this parameterization of the model, the *cyclical* behavior of market hours is reflected in the leisure series.

Figure 4 contains a graph of the realizations of c_{nt} for two values of ρ, $\rho \in \{-0.5, 0.5\}$. As we would expect, nonmarket consumption behaves quite differently when the two goods are complements ($\rho=-0.5$) than when they are substitutes ($\rho = 0.5$). All three time series trend upward until about 1984. The 1980s are characterized by rising home consumption when ρ is negative, and flat or falling home consumption when ρ is positive. Hence, in the case of complements, we infer that labor productivity in the home sector rose during the 1980s.

3.1. The Cyclical Behavior of Leisure and Nonmarket Hours

Our interest lies in an analysis of the business cycle behavior of leisure and nonmarket hours. Following Plosser (1989), we choose to measure the business cycle by movements in the growth rate of market output, $\ln(y_{mt}/y_{m,t-1})$. We then examine the correlation of the cycle with the first difference of logged market hours, leisure, and nonmarket hours for various parameterizations of the model. Although the results depend on the parameters θ_m, θ_n, ϕ_ℓ, they are independent of all other model parameters. Here, we fix $\theta_m = 0.28$, θ_n varies over the interval [0,0.28] and ϕ_ℓ varies over the interval [0.5,0.8].

We find that the growth rate of market hours are procyclical (correlation coefficient equal to 0.4). More interestingly, we find that the growth rate of leisure is highly countercyclical, while that of nonmarket hours is essentially acyclical. The correlation of the growth rate of leisure with the cycle, which does not depend on ϕ_ℓ, varies only between -0.83 (when θ_n is large) and -0.86 (when θ_n is small). The correlation of the growth rate of nonmarket hours with the cycle, which does not depend on θ_n, is always small in absolute value, increasing from -0.17 when ϕ_ℓ is small to 0.11 when ϕ_ℓ is large. Hence, when market hours fall during recessions, workers adjust by switching into leisure, not home production.

There is a simple intuition behind our results that leads us to believe that it would survive in models that allowed for a wider range of uses for time. We know from our analysis in Section 2 that leisure and the market consumption/output ratio tend to be positively correlated. Since the market consumption/output ratio is highly countercyclical in the data, leisure must also be countercyclical. To change this result, the model must include an activity which changes the leisure/consumption tradeoff. Modifications which merely change how the agent uses time to produce consumption goods will not, we believe, alter the basic result.

As noted earlier, there are two basic trends in the behavior of market hours: they fall between 1951 and 1973 and rise between 1973 and 1993. We next ask whether this trend behavior is mirrored in the trend behavior of leisure or of nonmarket hours. To answer this question, we define h_t to be the noncyclical movements of the first difference of logged market hours: that is, the residuals in a regression of $\ln(h_{mt}/h_{mt-1})$ on $\ln(y_{mt}/y_{mt-1})$. We then calculate the correlation of h_t with the first difference of logged leisure and nonmarket hours for the parameter settings. For large values of ϕ_ℓ, the correlation between h_t and the first difference in the log of nonmarket hours is -0.925 while it is -0.968 for ϕ_ℓ small. In contrast, the correlation between h_t and the first difference in the log of leisure varies between -0.09 (when θ_n is small) and -0.39 (when θ_n is large). This correlation analysis confirms our original examination of Figure 3: it appears that the rise in market hours during the 1980's occurs at the expense of home hours, not leisure.

3.3 The "True" Business Cycle

One of the arguments which has been made for performing more careful measurement of the home sector is that current market-based definitions of the business cycle neglect a significant amount of economic activity. It may well be that downturns in market activity coincide with upturns in home activity that compensate for declining output in the market sector. To address this concern, we use the information derived in the previous section to construct a measure of business cycle fluctuations that accounts for movements in both sectors. This task is nontrivial because the relative price of nonmarket consumption in terms of market consumption is not constant over time. Instead, it is slightly countercyclical if $\rho > 0$ and slightly procyclical if $\rho < 0$ (the absolute value of the correlation is independent of ρ). This means that any output-based measure of the cycle will depend on which consumption good is being used as the *numeraire*.

To avoid this problem, we construct a welfare-based measure of the cycle. In particular, suppose (c_{mt}, c_{nt}, ℓ_t) are the period-t values of market consumption, nonmarket consumption and leisure. We determine the growth rate of "welfare" from period t to period (t+1) as the value w_{t+1} such that:

$$u(c_{m\,t+1}, c_{n\,t+1}, \ell_{t+1}) = u\left((1+w_{t+1})c_{mt}, (1+w_{t+1})c_{nt}, (1+w_{t+1})\,\ell_t\right)$$

where u (.) is defined as the representative agent's intratemporal utility function. Essentially, the quantity w_t measures the equi-proportional change in the variables of the utility function required to equate utility between two consecutive periods. Note that w_{t+1} is invariant to monotonic transformations of the utility function. Given our particular parametric form for the utility function, one can easily show that $\ln(1+w_{t+1}) = u(c_{m\,t+1}, c_{n\,t+1}, \ell_{t+1}) - u(c_{m\,t}, c_{n\,t}, \ell_t)$.

Conditional on this definition of welfare, we can investigate the adequacy of more standard output-based measure of the cycle. In other words, are changes in market output a satisfactory indicator of movements in welfare in this model? As before, we assume that $\theta_m = 0.28$, $\theta_n = 0.14$, $\phi_\ell = 0.73$ and ϕ_m=0.4. Figure 5 illustrates the correlation of $\ln(1+w_t)$ with market output growth for a sequence of values of $\rho \in [-2.0,1.0]$. The results are relatively sensitive to changes in the degree of substitutability of the two consumption goods. The correlation of welfare growth with output growth is positive but somewhat small (less than 0.3) when ρ is positive and when ρ is significantly negative. On the other hand, if ρ is only slightly negative, the correlation of welfare with output growth falls below zero: welfare tends to be high when output growth is low in the market sector.

Thus, using output growth as a measure of welfare is quite problematic when ρ is negative and small in absolute value, and misses much of the movement in welfare for other values of ρ. Intuitively, if ρ is large and positive, then upward movements in market output and market consumption coincide with favorable market shocks and higher levels of period utility. If ρ is significantly negative, the complementary relationship between the two types of consumption goods implies that upward movements in market consumption – and market output – will be associated with positive nonmarket shocks and higher period utility. If, however, ρ approaches zero, the agent becomes less apt to move hours between the sectors in response to shocks which alter relative labor productivity in the two sectors. In this case, it is impossible for market output to reflect changes in period utility induced by movements in nonmarket variables.

4. Conclusions

In this paper, we assume that each observation in the available macroeconomic data on consumption, investment, and hours worked is consistent with optimal behavior on the part of a representative individual who can work in a market sector or a home sector. We use this assumption to construct explicit quarterly data on three variables that would otherwise be unobservable at such a high frequency: hours worked in the home sector, hours spent in leisure, and the consumption of goods produced in the home sector.

We have four major findings. First, leisure is highly countercyclical, while nonmarket hours are basically acyclical. Second, the upward trend in market hours since the mid-1970's is associated with a large decrease in hours spent in home production, not a decrease in leisure. Third, fluctuations in output are a good measure of fluctuations in individual utility as long as home consumption and market consumption are either extreme complements or extreme substitutes. Finally, the "observational equivalence" between home production models and standard models stressed by BRW, while theoretically interesting, is of no empirical relevance.

Throughout the paper, we are careful to examine the sensitivity of our results to our parametric assumptions. Some readers might wonder why we don't estimate these unknown parameters. The answer is quite simple: we can't. For every possible parameter specification (except $\rho = 0$ or $\phi_m = 1$), it is possible to find realizations of the unobservable variables so that the representative individual's first order conditions are consistent with every observation in the United States data. In other words, the data on consumption, investment and hours cannot help us discriminate among the possible parametric specifications; technically, the parameters are not identified.

For similar reasons, the data on the three observable variables cannot be used to invalidate the particular model of home production that we use to construct our measures of economic activity in the home sector. This lack of testability may trouble some readers who believe that our results depend on our particular model specification. We have two responses to this criticism. First, the construction of data is always dependent on the model being used. For example, suppose one were to use the accumulation technology ($k_{t+1} = B(k_t)^{1-\delta}(i_t)^{\delta}$) in Greenwood, Hercowitz, and Huffman (1988) to construct capital series for the aggregate economy instead of the more traditional Solow accumulation technology ($k_{t+1} = i_t + k_t(1-\delta)$). There is no way to use the available data to decide which technology is more appropriate but the resulting capital series look quite different.

Our second response is that we believe that the properties of the constructed data that we stress do not depend on the specific details of the BRW model that we employ. For example, the reason leisure is so countercyclical is that it covaries greatly with the consumption-output ratio which is itself countercyclical. We believe that this relatively large covariance between leisure and consumption/output will exist in virtually any model of home production.

Measurement is always conducted in the context of some kind of economic model. Generally, data construction exploits firm optimality or budget constraints. This paper shows that individual optimality can be a useful source of information in data construction.

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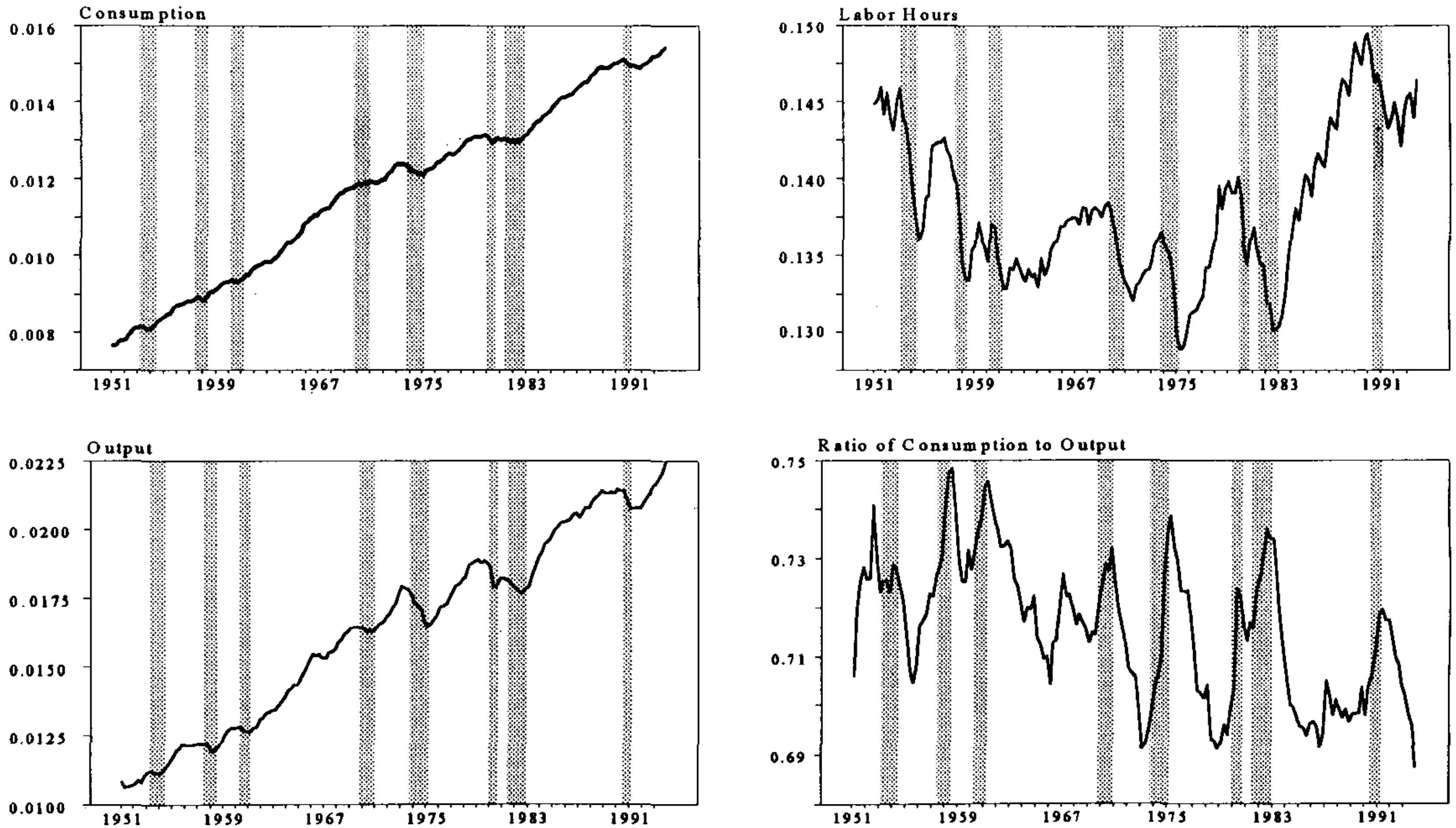
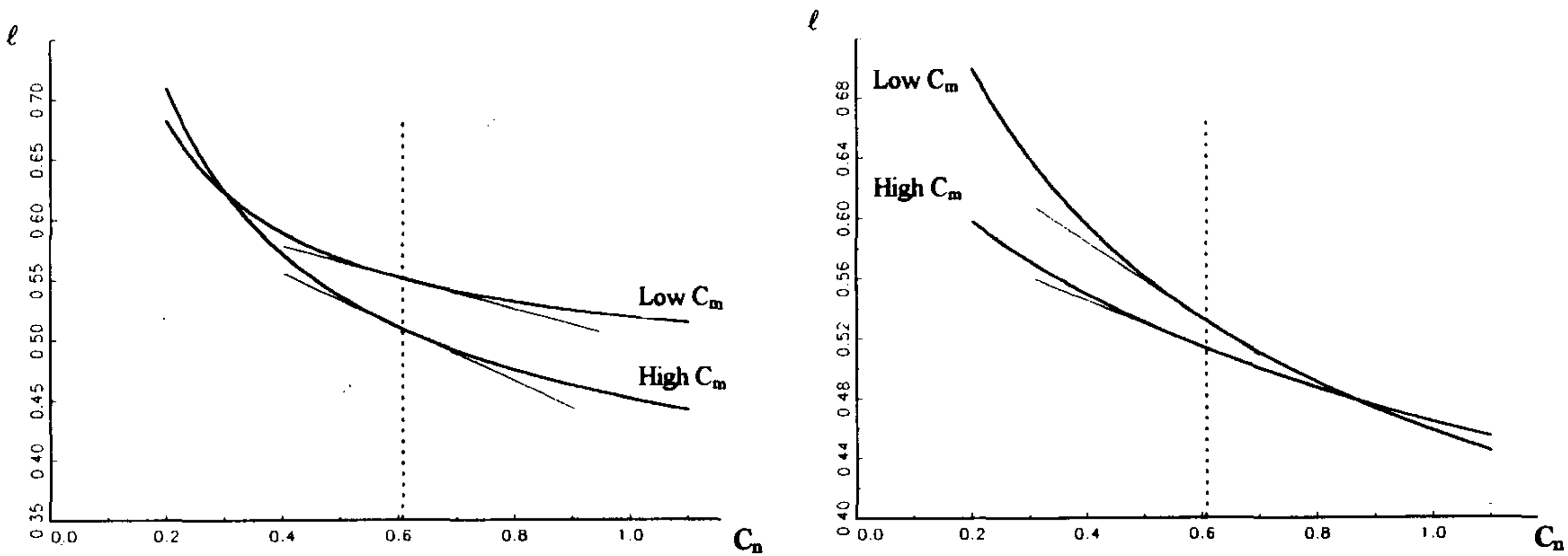


Figure 1. Real U.S. data, 1951:I - 1993:IV. Consumption is real per capita consumption of nondurables and services; output is real per capita GDP; labor hours is average hours worked weekly in the market divided by available time (168 hours); Ratio of consumption to output is market consumption divided by market output.



Panel a. Complements, $\rho = -1.0$.

Panel b. Substitutes, $\rho = 0.95$.

Figure 2. Level curves of the period utility function for two values of market consumption. Straight line represents the tangent to the level curve at $C_n = 0.6$. Panel a correponds to a value of $\rho = -1.0$ (market and non-market consumption are complements) and panel b coresponds to ρ=0.95 (market and nonmarket consumption are substitutes).

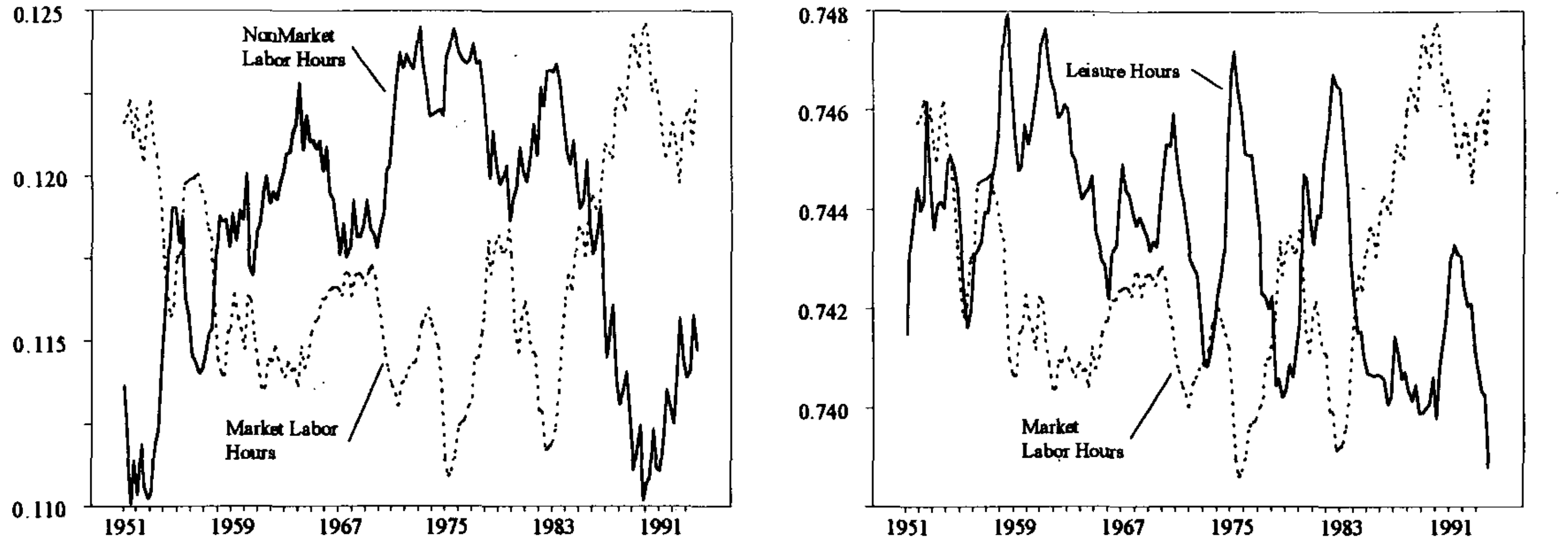


Figure 3. Time series graphs of nonmarket labor hours and leisure hours. Parameterization is $\theta_m = 0.28$, $\theta_n = 0.14$, ϕ_ℓ=0.73. Each panel is overlaid with the observed market labor hours series, scaled to fit the appropriate graph.

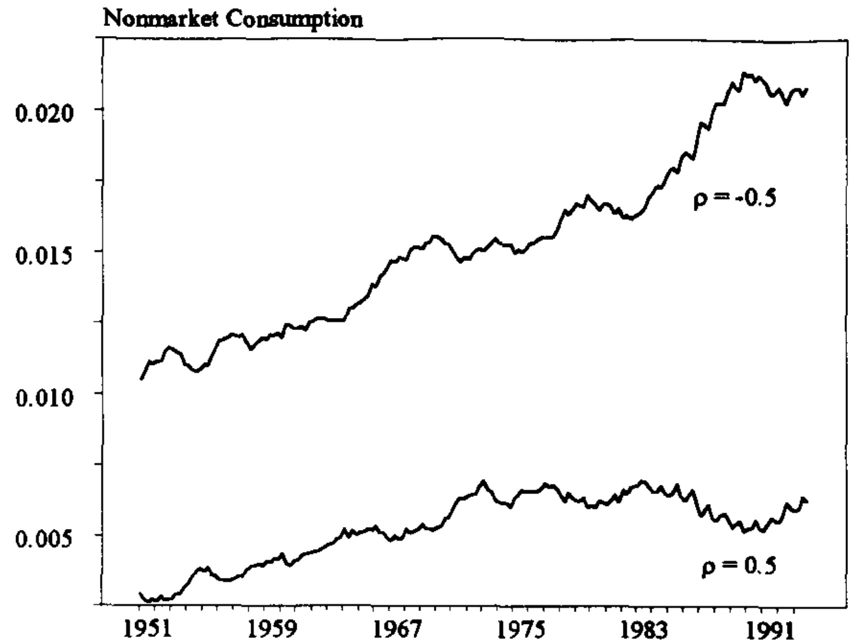


Figure 4. Time series graph of non-market consumption. Parameterization is θ_m=0.28, θ_n=0.14, and ϕ_ℓ=0.73.

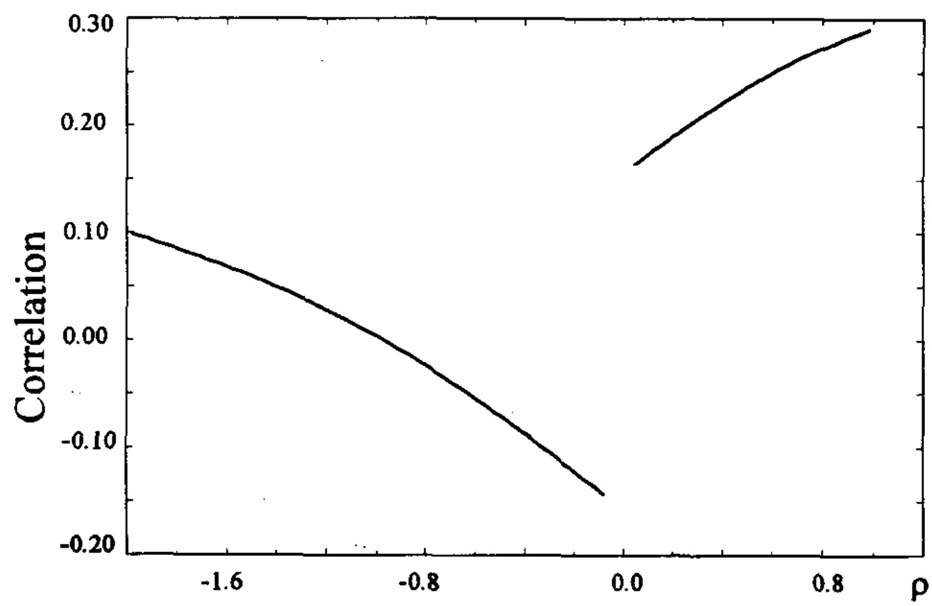


Figure 5. Correlation of welfare growth as defined in text with measures of the business cycle (logged growth rate of GDP) for various values of ρ. Parameterization is θ_m=0.28, θ_n=0.14, and ϕ_ℓ=0.73.