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**Abstract**

Studying the incentives and constraints in the non-market sector—that is, home production—enhances our understanding of economic behavior in the market. In particular, it helps us to understand (1) small variations of labor supply over the life cycle, (2) large variations of employment relative to wages over the business cycle, and (3) large income differences across countries.

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*JEL* Classifications: E3, J2, O4

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Studies such as the Michigan Time Use Survey (Hill, 1984; Juster and Stafford, 1991) indicate that a typical married couple allocates only about one-third of its discretionary time working for paid compensation in the market. The allocation of time for non-market activities, such as home production or leisure, may be as important for economic welfare as is the time spent working. Starting with Becker (1965) and Mincer (1962), the value of non-market activity has been explicitly incorporated into economic analysis in terms of forgone earnings. Since household decisions on the allocation of time to market and non-market activities are undertaken jointly, studying the incentives and constraints in the non-market sector—home production—enhances our understanding of economic behavior in the market sector. We discuss three examples where the inclusion of home production has improved our understanding of macroeconomic issues: (1) low estimates of the labor supply elasticity from panel data; (2) low correlation between return to working and hours worked over the business cycle; and (3) large differences in measured output across countries.

In a standard neoclassical growth model with home production, a household derives utility not only from the consumption of market goods, but also from the consumption of non-market goods. Non-market goods are produced in a home production sector using work effort and capital. The household's utility also depends on the consumption of leisure, which is the household's time endowment less work effort supplied to the market and the home production sector. One usually assumes that the economy's technology is such that investment goods that can be used to augment the capital stock in the market and non-market sectors are produced only in the market sector of the economy. Important factors in the determination of the dynamics of a neoclassical growth model with home production are the substitution elasticity between the consumption of market and non-market goods, the substitution elasticity between capital and labor in market and home production, the relative capital intensity of production in market and home production sector, and the correlation of total factor productivity in the two sectors. Examples of the neoclassical growth model augmented with home production are Benhabib, Rogerson and Wright (1991) and Greenwood and Hercowitz (1991).

## 1. Business cycle analysis

The allocation of hours worked—employment—is at the heart of business cycle analysis. Table 1 shows the standard deviations and correlation of the cyclical components of total hours worked and returns to work for the U.S. economy, 1964–2003.

Table 1. Business Cycle Statistics of the Labor Market:

| $\sigma_n/\sigma_w$ | $\sigma_n/\sigma_{y/n}$ | $cor(n,w)$ | $cor(n,y/n)$ |
|---|---|---|---|
| 1.51 | 1.72 | .38 | .01 |

Note: All variables are logged and de-trended with the Hodrick-Prescott filter. Hours worked ($n$) represents the total hours employed in the non-agricultural business sector. Wages ($w$) are the real hourly earnings of production and non-supervisory workers. Labor productivity ($y/n$) is output divided by hours worked. The period covered is from 1964:I–2003:II

Source: DRI-WEFA Basic Economics Database, Global Insight.

Two features are of great interest to macroeconomists. First, hours worked is substantially more volatile than the return to working. Second, hours worked is not highly correlated with the return to working. Employment in other countries also exhibits similar features (for example, Backus, Kehoe and Kydland, 1992). These facts present a serious challenge to modern business cycle theory that builds on the idea of inter-temporal substitution of work effort. This theory assumes that people work relatively more hours in some years than in others because the return from working in the market is unusually high in these years [for example, Lucas and Rapping (1969)]. According to Table 1, on the one hand it appears as if employment would have to be very elastic in its response to changes in the return to work, but on the other hand, the returns to work appear to be only weakly correlated with the supply of work time.

### 1.1. Estimates of the labor supply elasticity

Business cycle theory that builds on the stochastic growth model, for example, Kydland and Prescott (1982), indeed requires a large inter-temporal elasticity of substitution in order to account for the relatively large fluctuations of hours worked. Yet a substantial empirical literature based on micro data finds that households' willingness to substitute hours is quite low — less than 0.5 (for example, MaCurdy, 1981; Altonji 1986). Home production provides a potential resolution of this problem.

Most micro estimates of the inter-temporal substitution elasticity rely on the variation of hours worked and wages over the life cycle of households. Rupert, Rogerson and Wright (2000) show that these estimates may underestimate the true willingness to substitute hours across time if one does not take into account the fact that households simultaneously decide on the supply of hours for market and non-market activities. Essentially, conventional estimates of labor supply elasticities suffer from an omitted variable bias: home work is positively correlated with market work and should be included in the estimation. For simplicity assume that households' preferences are log-linear in a consumption aggregator of market, $c_{mt}$, and home-produced consumption, $c_{ht}$, and work time, be it in the market, $n_{mt}$, or at home, $n_{ht}$:

$$u(c_{mt}, c_{ht}, n_{mt}, n_{ht}) = \log c(c_{mt}, c_{ht}) - B\frac{(n_{mt} + n_{ht})^{1+1/\gamma}}{1 + 1/\gamma}.$$

Then the optimal labor supply of a household that is $t$ years old can be written as

$$\log w_t = (1/\gamma)\log(n_{mt} + n_{ht}) + A_t,$$

where $w_t$ denotes the market wage rate, and $A_t$ represents other terms that may depend on age. The parameter $\gamma$ denotes the willingness to substitute total hours over time—intertemporal substitution elasticity. For conventional estimates of the labor supply elasticity, which ignore home production, time spent for home production activities represents an unobserved supply shifter for market-labor.

A typical worker faces a hump-shaped wage profile in his life: wage rates rise, reach a peak at age 45-55, and decline from then on. It is not unreasonable to assume that the consumption

of non-market goods, and therefore hours worked in home production, is correlated with the market wage profile over the life cycle. For example, high earning years tend to be around the years in which one buys a house or has children, both of which call for more time spent in home production. The fact that home work and market work are positively correlated over the life cycle, but home work is omitted from the estimation equation, implies that the estimated inverse labor supply elasticity $1/\hat{\gamma}$ will be biased upward.

### 1.2. Wage-employment correlations

One of the primary empirical patterns that has puzzled many business cycle theorists is the lack of a systematic relationship between employment and wages. On the one hand, Keynesian IS-LM models assume that real wages and hours worked lie on a stable, downward-sloped marginal product of labor schedule and predict a strong negative correlation between real wages and hours worked (for example, Dunlop, 1938). On the other hand, real-business-cycle models, such as that of Kydland and Prescott (1982), where productivity shocks shift the labor demand schedule along a relatively stable positively sloped market labor supply curve, tend to predict a strong positive correlation between wages and employment. Incorporating home production into the neoclassical growth model helps account for the low correlation between market work and wages as well as the large variation of employment.

Technical progress not only augments the marginal product of labor in the market sector, but it also affects the marginal product of labor in the home production sector. Consider, for example, technical progress that is embodied in consumer durables, such as vacuum cleaners, washers, etc. This kind of technological progress often reduces the required work effort in the home sector for household chores, and thereby shifts the supply curve of market work outward along a negatively sloped market demand for labor curve. Thus, while technical progress in the market sector causes a positive correlation between market hours and wages, technical progress in the non-market sector can cause a negative correlation between market hours and wages. If technical progress in the market is positively correlated with that in the non-market sector, then market hours may fluctuate substantially without any accompanying changes in real wages.

In general, the allocation of hours between the market and home depends on (i) the

covariance structure of productivity in the market and home, (ii) the substitution elasticity between market goods and home-produced goods, and (iii) the substitution elasticity between capital and labor in the home production function—in particular, if the purchase of home capital (for example, a home theater system) requires or saves hours in home production. Recently, rich structures between the market and home production have been introduced to study the various features of business cycles—for example, McGrattan, Rogerson and Wright (1997), Hornstein and Praschnik (1997), Fisher (1997), Einarsson and Marquis (1997), Ingram, Kocherlakota and Savin (1997), Perli (1998), Chang (2000), Gomme, Kydland, and Rupert (2001).

## 2. Cross-country income differences

There are enormous income differences across countries, and such disparity has persisted over time. According to Heston, Summers, and Aten (2002), the ratio of the average per capita GDP (based on Purchasing Power Parity Price) of the richest fifth of all countries to that of the poorest fifth of all countries was about 12 in 1960 and had doubled to almost 25 by 2000. In the standard neoclassical growth model, distortions to capital accumulation contribute to income differences. For a reasonably calibrated neoclassical growth model, the distortions that are required to account for the observed income differences are, however, unreasonably large. Parente, Rogerson and Wright (2000) show that the required distortions are substantially reduced once we distinguish between an economy's market sector whose output is measured in the National Income Accounts and a home-production sector whose output is not measured. With home production, distortions to capital accumulation not only reduce the capital stock but also can reallocate economic activity from the market sector to the non-market sector. Moreover, the measured income differences overstate the true differences in welfare, and the unmeasured consumption from home production may explain how individuals in some countries can survive on the very low levels of reported income.

Consider the neoclassical growth model with log preferences in consumption, $c_m$, and leisure, $l$. Output, $y_m$, is produced using capital, $k_m$, and labor, $n_h$, as inputs to a constant returns to scale Cobb-Douglas production function, $y_m = k_m^{\alpha_m} (z_m n_m)^{1-\alpha_m}$. Output can

be used for consumption and investment, $x_m$, to increase the capital stock: $k_{m,t+1} = (1 - \delta)k_{mt} + x_{mt}/\pi$, where $\delta$ is the depreciation rate. With capital accumulation distortions, investment increases the capital stock less than one for one: $\pi \geq 1$ (for example, Parente and Prescott, 1994). It is easily conceivable that there are substantial inefficiencies in capital accumulation in less-developed economies (for example, inefficient governments, ill-protected property rights). Given commonly assumed preferences and technology, the investment rate and work effort on the balanced growth path will be independent of the magnitude of capital distortions, but the capital stock and output will decline with the capital distortion. Two countries that look alike in terms of the investment rates may nevertheless have very different output levels. Conditional on a reasonable parameterization of the economy, we would, however, have to assume capital distortions, $\pi \geq 100$, in order to account for observed output differences of a factor of at least 10 (for example, Parente, Rogerson and Wright, 2000).

A straightforward extension of the neoclassical growth model that includes home production assumes that preferences are defined over a consumption aggregator that includes market consumption and non-market consumption, $c_h$, from the home-production sector. The home production sector also uses capital, $k_h$, and work effort, $n_h$, as inputs to a Cobb-Douglas production function. The household's time endowment can now be used in the market and the non-market sector, and market production can be used for investment in the market and the non-market sectors. If home production is less capital-intensive than market production and market and non-market goods are sufficiently close substitutes, a higher capital distortion not only reduces total capital accumulation, but also leads to a reallocation of the available capital and work effort from the market sector to the non-market sector. Parente, Rogerson and Wright (2000) argue that, for reasonable substitution elasticities between market and home-production consumption and capital shares in the home-production sector, capital distortions as low as $\pi = 15$ can account for income differences in the market sector of a factor of 10.

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