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Household Labor Supply and Dynamic Macroeconomic Analysis

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The theory of individual labor supply has been an integral part of *micro*economics, as an application of the neoclassical theory of consumer behavior, since the pioneering work of Robbins (1930). The analysis of labor-supply decisions made by individuals in the context of membership in a household can be traced to the early, influential studies of Becker (1960) on fertility and Mincer (1962) on female labor-force participation. Subsequently, Becker (1965) introduced the concept of *home work,* or *home production,* which he defined to be the productive use of time not spent working for pay in the private or public sector. Lawn care, cooking, shopping, and time spent in the care of other adults are all typical examples of home work. Thus, home work can be thought of as the portion of productive time undertaken that occurs outside of the formal labor market.

The implications for *macroeconomic* analysis of modeling labor supply in a household setting, was initially explored by Benhabib, et al. (1991) and Greenwood and Hercowitz (1991). Changes in market wages affect not only the decisions of existing workers concerning how many hours to work, but also the decisions of potential workers about whether or not to allocate time away from leisure and household production towards work in the formal labor market. Traditionally, econometric studies using individual-level data have reported estimates of the wage elasticity of labor supply derived from what is termed the "intensive margin." The intensive margin refers to changes in the hours worked by *employed* individuals in response to a change in their wage rates. These intensive-margin estimates of labor-supply elasticites are typically very small in magnitude [Pencavel (1998); (2002)]. This conclusion is in sharp contrast to the much larger values of the wage elasticity of labor supply commonly used in the macroeconomics literature.

Estimates of the wage elasticity of labor supply at the labor-force-participation or "extensive" margin are typically much higher than the corresponding intensive-margin estimates [Kimmel and Kniesner (1998)]. Labor-supply decisions at the extensive margin are often made by individuals in the context of their membership in a household, where the time allocations of one member may be complements with or substitutes for the allocations of other members of the same household. Labor-force participation within a household framework has most often been studied as the outcomes of decisions made by husbands and wives about specialization and division of labor between market and non-market production. The existence of an additional "extensive margin" between market work and home work provides, in principle, a means for reconciling the consistently small estimates of the wage elasticity of labor supply found in micro-econometric research with the much larger estimates required by simulations of widely-used macroeconomic models to reproduce the observed cyclical correlations among, and volatility of, various aggregate variables.

A burgeoning literature has attempted, with varying degrees of success, to bridge the gap between empirically estimated labor-supply elasticities and the calibrated values for aggregate labor supply typically found in real-business-cycle (RBC) models of the macroeconomy. We begin by reviewing some of the stylized facts that motivated much of this recent research. Figure 2.8.1 below depicts the unemployment rate and labor force participation rate (LFPR) for the ten–year period from January 2003 through May 2013. The unemployment rate reached a peak of 6.3% in June 2003 and declined to 4.4% several times before climbing back to 5% in December 2007, when the Great Recession officially began. The unemployment rate increased sharply thereafter, reaching a high of 10% in October 2009. The unemployment rate remained near 10% for the next six months, after which it began to fall slowly but steadily to 7.6% in May 2013.

From January 2003 to July 2009, the LFPR remained relatively stable, fluctuating between 65.5% and 66.5%. From August 2009 to May 2013, however, the LFPR steadily declined, from 65.4% to a low of 63.3% in March and April of 2013, and was at 63.4% in May 2013. In all, the LFPR declined by 2.6 percentage points from the beginning of the recession in December 2007 to May 2013.

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Figure 2.8.1 Unemployment Rate and Labor Force Participation Rate, 2003–2013

When viewed in the context of household decision making, the cyclical patterns of unemployment and labor-force participation raise several interesting and important questions: Do households pool resources in a risk-sharing manner to cope with rising unemployment? Does home production increase during a recession and, if so, by whom? Is access to credit markets effective in dampening the effects of cyclical shocks on household well-being? The answers to these questions depend, in part, on how and to what extent households change their allocation of time over the business cycle. This, in turn, will affect estimates of the elasticity of aggregate labor supply and bring greater clarity to the evaluation of alternative models of the macroeconomy.

Section 2 reviews the static and dynamic theories of labor supply, giving particular emphasis to the conceptual distinction among various measures of the responsiveness of hours of work to changes in wages and to alternative assumptions about the structure of household decision making. In section 3, we set out the neoclassical model of economic growth, which serves as the foundation for the modern theory of business cycles, and discuss the extent to which the observed cyclical fluctuations of key macroeconomic variables match the simulated values of these variables based on a prototypical model of the macroeconomy. Section 4 describes how the introduction of household production has played a critical role in the attempts to develop a more accurate model of the cyclical fluctuations in employment and hours of work. Section 5 reviews the recent scholarly literature that has addressed the disparity between individual-level and economy-wide estimates of the wage elasticities of labor supply. In section 6, we provide a summary of our review and evaluation, and suggest several possible avenues for future research.

The Theory of Labor Supply

In the textbook model of labor supply, the unit of analysis is interpreted to be either an individual or, equivalently, a multi-person, "unitary" household. In the latter interpretation, choices are assumed to be made by either a benevolent dictator, as in Becker (1976), or through an unspecified consensual process, as in Samuelson (1956) and Chiappori (1988), and the collective preferences are represented by a social welfare function. It is straightforward to show in this model that labor-supply choices made at the extensive (participation) margin imply a larger wage elasticity than decisions made at the intensive (hours) margin.

In the standard model, an individual (or other decision-making unit) simultaneously chooses the amount of goods and services to consume and the number of hours to work in order to maximize utility, subject to a resource or budget constraint. Utility is given by the function $U(c, h)$, where c is the quantity of a composite consumption commodity, h is the number of hours worked. The budget constraint can be written $Pc = Wh + Y$, where P is the price of the composite commodity c (P is interpreted as a price index), W is the wage rate, and Y is non-wage income. P, W, and Y are assumed to be exogenous; that is, they are not affected by the individual's behavior. The solution functions for the individual's problem are the uncompensated (Marshallian) demand function for goods and services $c^*(P,W,Y)$ and the supply function for labor $h^*(P,W,Y)$.

The uncompensated own-wage effect on labor supply can be written using the Slutsky decomposition

$$\partial h^*/\partial W = \partial h^*/\partial W|_{dU = 0} + h^*(\partial h^*/\partial Y).$$

The first term is the substitution effect, which is unambiguously positive. The second term is the income effect, and it is negative assuming leisure is a normal good. Thus, $\partial h^*/\partial W$ is generally ambiguous in sign because of the opposing substitution and income effects. However, at the extensive margin, where the individual's marginal market wage equals the reservation wage (or the minimum supply price of labor), $h^* = 0$ so that there is only a substitution effect and, therefore,

$$\partial h^*/\partial W|_{h^* = 0} = \partial h^*/\partial W|_{dU = 0} > 0.$$

The individual model of labor supply has been extended to encompass the behavior of multi-person households. The household utility function can be written as

$U(c_m, c_f, h_m, h_f, z)$, where the subscripts *m* and *f* denote male and female household members, respectively, c_m and c_f are the quantities of a (private) composite commodity consumed by each member, with $c = c_m + c_f$, and *z* is a household public good produced with the technology $z = f(x, h_m, h_f)$, where *x* is a market-purchased composite private good with price normalized to one. Quantities of the composite commodity and amounts of labor-market time for each individual are chosen to maximize household utility subject to the budget constraint $Pc + x = W_m h_m + W_f h_f + Y$. Although there is only one (household) utility function in this model, Grossbard (2011) has argued that the model can be interpreted as one in which each individual in the household independently maximizes his or her own utility with respect to consumption and labor-supply choices, but nevertheless takes into account the choices of the other individual(s) in the household. Individual-specific *conditional* labor-supply functions and demand functions for the private consumption good can be then derived in the usual manner, and they inherit some (but not all) of the properties of unconditional demand and supply functions in the individual case [Pollak (1969)].

As a framework for understanding the labor-supply decisions made by individuals who are members of households, however, the unitary approach is unsatisfactory on both theoretical and empirical grounds. From a theoretical perspective, the unitary approach ignores all of the problems, emphasized by Samuelson (1954) and Arrow (1963), associated with the aggregation of individual preferences and the social-choice process that characterize decision making in a collective setting. Moreover, among the most notable (and counterfactual) implications of this model are that each household member treats the labor-market income of the other member as non-labor income and household non-labor income is pooled between members. These implications are typically rejected in empirical studies, for example by Lundberg (1988), Phipps and Burton (1992), and Browning et al. (1994).

In the nonunitary approach, explicit recognition is given to the existence of separate (but possibly interrelated) preferences of individual household members. An alternative for modeling household labor-supply decisions in a nonunitary framework is the cooperative bargaining approach, pioneered by Manser and Brown (1980) and McElroy and Horney (1981). One possibility for representing household preferences in this context is with a weighted-average utility function of the general form, $sU_m(c_m, c_f, h_m, h_f, z) + (1 - s)U_f(c_m, c_f, h_m, h_f, z)$,

where $0 < s < 1$ is the weight attached to the male's utility and can be interpreted as reflecting the distribution of power in the household. Decisions are made in a two-stage process, with bargaining over the value of s taking place in the first stage and individual choices of h and c, as well as the joint choice of z, being made in the second stage, conditional on the first-stage value of s. These models, and their implications for household consumption and labor-supply decisions are admirably surveyed and critiqued by Lundberg and Pollak (1996) and, more recently, Donni and Chiappori (2011).

However, it is not clear how the introduction of interdependent labor-supply decisions affects the size of the Marshallian and Hicksian wage elasticities at the household level. Income effects arising from increases in others' incomes will reduce the Marshallian labor-supply elasticities, assuming leisure is a normal good, but will not affect the Hicksian elasticities. On the other hand, cross-substitution elasticities will raise or lower the Hicksian elasticities, depending on whether members' time spend in household production and leisure consumption are complements or substitutes. Finally, specifying that the husband's hours adjustments are made on the extensive margin while the wife's adjustments occur on the intensive margin, as in Donni and Moreau (2007), would seem to *increase* the Marshallian wage elasticity of household labor supply since there would then be only a substitution effect on the husband's labor supply of an increase in his wage rate. However, if the husband's labor supply is actually fixed exogenously (by either custom or demand-side conditions), *household* labor supply will be *less* wage-elastic.

In any case, for business-cycle analysis the relevant wage elasticity of labor supply is not the static (Marshallian or Hicksian) wage elasticity but rather a dynamic or intertemporal one. This intertemporal (or Frisch) wage elasticity of labor supply gives the response of labor supply in the current time period to a temporary change in the current-period wage rate. In other words, the intertemporal wage elasticity reveals by how much households are willing to reallocate their multi-period labor supply towards times in which the reward to working is (temporarily) relatively high and away from periods when the reward is relatively low. To investigate this issue, we need to recast the choice problem in an explicitly dynamic setting in which the entire time paths of labor supply and consumption are chosen to maximize the discounted present value of (lifetime) utility subject to a multi-period budget constraint.

In the basic dynamic labor-supply model, it is assumed that there is no uncertainty about the future values of the wage rate, the decision maker can borrow and lend at the same, certain interest rate r, human capital is accumulated on the job through work experience, the length of the relevant time horizon is known with certainty, and utility is inter-temporally separable (so that, for example, the marginal utility of consumption or leisure in one period is unaffected by the amount consumed and worked in any other period). Non-wage income Y in any given time period is not exogenous, as in the static labor-supply model, but depends in part on how much was saved (and how much interest was earned on this saving) in previous periods.

The household chooses c_t and h_t in each time period to maximize the present value of discounted utility, $\sum_{t=0}^{N} (1/(1+r))^t\, U(c_t, h_t)$

where N + 1 is the number of periods in the time horizon and r is the market rate of interest at which the household can borrow or lend, subject to the intertemporal budget constraint

$$K_0 + \sum_{t=0}^{N} (1/(1 + r))^t\, W_t\, h_t = \sum_{t=0}^{N} (1/(1 + r))^t\, P_t\, c_t$$

where K_0 is the initial level of assets. The intratemporal budget constraint, $Pc = Wh + Y$, does not bind in every time period in this model because of the ability to borrow or lend.

The Frisch labor-supply and commodity-demand functions are $h_t(\lambda, W_t\lambda, P_t\lambda)$ and, $c_t(\lambda, W_t\lambda, P_t\lambda)$, respectively, where λ is the marginal utility of intertemporal wealth. In contrast to the Marshallian and Hicksian labor-supply functions, which hold constant lifetime money income and utility, respectively, the Frisch labor-supply function holds constant the marginal utility of wealth. If the wage rate W increases in time period t, holding λ constant, the household will unambiguously work more in period t. That is, $\partial h_t/\partial W_t|_{d\lambda = 0} = (\partial h_t/\partial W_t\lambda)(\partial W_t\lambda/\partial W_t) > 0$.

This intertemporal substitution effect differs both conceptually and in magnitude from the (intratemporal) Hicksian substitution effect in the Slutsky equation. With regard to the relative size of the two substitution effects, we can infer unambiguously that the Frisch substitution effect is larger than the Hicksian substitution effect:

$$\partial h^*/\partial W|_{dU = 0} < \partial h_t/\partial W_t|_{d\square = 0}.$$

This result follows from the fact that the marginal utility of income □ is affected by the parameters W, P, and K_0 as follows: $\partial\lambda/\partial W_t < 0$; $\partial\lambda/\partial P > 0$, and $\partial\lambda/\partial K_0 < 0$.

The implications of modeling household labor supply in a nonunitary choice framework for the size of Frisch elasticities are not entirely clear. The extent of efficient risk sharing within the household in the face of cyclical shocks to the incomes of one or more family members would be critical to such an investigation. The relationship between the structure of household decision making and the elasticity of household and aggregate labor supply is a promising area for future theoretical and empirical research.

Business-Cycle Dynamics

The primary challenge for any model of business-cycle dynamics is to generate predictions about the cyclical behavior of key macroeconomic variables that match their observed movements, and co-movements, over the business cycle. There is widespread agreement among macroeconomists about these “stylized facts”: (1) consumption, investment, total hours worked, employment, and labor productivity are pro-cyclical in the sense that their de-trended, cyclical component appears to be positively correlated with the cyclical component of output; (2) consumption is much less volatile than output, while investment is much more volatile than consumption or output: (3) total hours worked and total employment are both about as volatile as output, while average hours worked per worker is much less volatile than output; (4) labor productivity is pro-cyclical, but is less volatile than output; (5) all of these series are strongly persistent in the sense that a positive (negative) realization tends to be followed by subsequent realizations of the same sign. Table 2.8.1, below, gives empirical justification for these stylized facts by providing for each of the listed, de-trended variables, its (A) volatility (standard deviation); (B) volatility relative to output (the ratio of standard deviations); (C) autocorrelation; and (D) contemporaneous correlation with output.

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Table 2.8.1 Actual Empirical Moments of the Aggregate U.S. Economy

The finding that total hours worked and employment are almost as volatile as output, while average hours worked are not nearly as volatile as employment, suggests that it is the *extensive* margin of adjustment (increases or decreases in the number of workers) that is more important in explaining changes in labor utilization over the business cycle than the *intensive* margin (increases or decreases in the hours of work of employed workers). This turns out to be an important shortcoming of the standard real business cycle model, as that model has only an intensive (hours) adjustment margin.

The benchmark model for the modern, dynamic analysis of business cycles is based on the neoclassical growth model originally developed by Ramsey (1928) and extended by Cass (1965) and Koopmans (1965). A focal objective of any growth model is to determine the allocation of current output (or non-wage – i.e., “capital” – income) between current consumption, on the one hand, and saving and investment on the other The Ramsey-Cass-Koopmans (RCK) model posits an omniscient, benevolent central planner who chooses consumption at each point in time to maximize the present value of discounted social utility over an infinite horizon, subject to a technologically determined "law of motion" for investment per capita and the initial capital stock. The behavior of the central planner in the RCK model can be "decentralized" by replacing her with a fixed number of identical, immortal individuals or unitary households, each endowed with perfect foresight over an infinite future, and adding identical firms which have access to a perfectly competitive rental market for capital goods. The "households" maximize the present value of discounted utility, subject to an intertemporal wealth constraint, and firms with constant-returns-to-scale technologies maximize instantaneous profits period-by-period. The steady states can be characterized by the following two results: (1) the rate of growth of the capital stock and output equals the (exogenous) rate of growth of the labor force (or size of the household); (2) the ratio of saving (and investment) to output is a constant.

The canonical RCK growth model has been generalized to allow for human capital accumulation [Mankiw, et al. (1992)], exhaustible natural resources [Solow (1974)], imperfect competition, and increasing returns to scale. The uncomfortable assumption of an immortal household with an infinite planning horizon can be circumvented by populating the model economy with finite-lived, overlapping generations, each of which maximizes its own utility and leaves no bequest to succeeding generations. Although this overlapping-generations (OG) model has its origin in an analysis of interest-rate determination by Samuelson (1958), its implications for neoclassical growth theory were first examined by Diamond (1965). The central result of the OG and RCK models is the same: the rate of growth of output equals the (exogenous) growth rate in the labor force. Moreover, if the generational utility function in the OG model takes the logarithmic form, each generation saves a constant fraction of its earnings, as in the RCK model.

In the neoclassical growth model, whether of the Solow-Swan or RCK variety, the economy always converges to a steady-state growth path from any point off that path, and then grows smoothly thereafter. The model is especially well-suited, therefore, to the analysis of the long-run issues that arise in the study of economic development. To adapt the model for use in the analysis of short-run, cyclical fluctuations around the steady state, some type of disturbance or shock must be introduced. Brock and Mirman (1972) introduced a stochastic component into the neoclassical growth model by assuming that the production function is subject to random shocks to total factor productivity, resulting in an early, prototype Real Business Cycle (RBC) model. In their seminal contribution to business-cycle analysis, Kydland and Prescott (1982) followed Brock and Mirman (1972) by adding random shocks to technology in the neoclassical growth model that serve as the driving force or "propagation mechanism" behind the short-run fluctuations. Most importantly, Kydland and Prescott (1982) allowed labor supply (and, thus, employment), as well as consumption, to respond to the resulting changes in equilibrium output and input prices.

To see how well the RBC model performs in terms of matching the empirical features of the macroeconomic variables displayed in Table 2.8.1, one must specify in sufficient detail the dynamic structure of the model economy, and then choose values for certain key parameters (for example, the capital depreciation rate, the steady-state rate of technological progress, and labor's share of the value of income received or output produced) such that, when the model is perturbed with a random, exogenous shock, the resulting predictions match as closely as possible the empirical moments. The selection of these parameter values is called "calibration," and is the most innovative and controversial aspect of the methodological approach initiated by Kydland and Prescott (1982) and elaborated upon by Prescott (1986). Sims (2012) calibrated a conventionally specified RBC model of the U.S. economy, introduced a technological shock, and compared the resulting predictions. The results are as follows:

Please insert Table 2.8.2 here

In Table 2.8.2, there are no calibrated values for the separate moments of average work hours and employment because the model does not contain an extensive margin with which movements in total hours can be decomposed into changes in hours per worker and in the number of workers. But the calibrated model does well at matching the observed volatilities of output, consumption, investment, and labor productivity, as indicated by a comparison of the first three rows and the last row of column A in Tables 2.8.1 and 2.8.2. The model also does a good job of matching the autocorrelations of each of the series; all of the series exhibit substantial levels of persistence, with autocorrelations typically around 0.75. Finally, the calibrations capture the property that consumption, investment, total hours, and labor productivity are highly pro-cyclical, as evidenced by the large contemporaneous correlations with output, although these correlations are much too large relative to the empirical moments. However, the calibrated values for the volatility of total hours of work and the volatility of total hours relative to output substantially understate the (absolute and relative) volatility of work hours in the data. Specifically, the calibrated volatility for total hours of work is only about one-third of both its absolute and relative observed volatility. The inability of the standard RBC model to replicate these central features of real-world business cycles is an important and widely acknowledged shortcoming of that framework for understanding the cyclical dynamics of the labor market.

Labor Supply in the Real Business Cycle Model

The formulation of the labor-leisure choice in the RBC model presented in Prescott (1986) reveals both the theoretical strength and the empirical fragility of the Kydland-Prescott framework. Prescott (1986) observed that time devoted to non-market ("leisure") activities in the U.S. exhibited essentially no secular trend over the forty-year period from 1946 to 1985, whereas the average real wage increased steadily over that same time. From this stylized fact, Prescott inferred that the *intra*temporal elasticity of substitution between consumption and leisure is approximately one. Prescott then cited several empirical papers reporting estimates of the *inter*temporal elasticity of substitution of the composite consumption-leisure "commodity" near one. Together, the assumptions of unit intra- and intertemporal substitution elasticities imply that the limiting form of the instantaneous aggregate utility function in Prescott's model can be written, $U(c, l) = (1 - \phi) \log c + \phi \log l$,

where l is time spent in leisure, ϕ is the share of leisure in "full" income or expenditure, $Pc + Wl$.

The assumption of a unit elasticity of intratemporal substitution between consumption and leisure implies that the Frisch (constant marginal-utility-of-income) wage elasticity of the demand for leisure is -1. Prescott interprets Ghez and Becker (1975) as finding that the typical household allocates approximately one-third of its productive time to market work and two-thirds to nonmarket activities, so that ϕ is assumed to be 2/3. Since $h = T - l$, the Frisch intertemporal wage elasticity of *labor supply* implied by Prescott's calibrations is simply $\phi/(\phi - 1)(-1) = 2$. However, the Frisch elasticity in the Kydland-Prescott RBC model is highly sensitive to assumptions about both the intratemporal elasticity of substitution and the leisure-share parameter, ϕ. For example, Summers (1986), in his critical comments on Prescott (1986), cites Eichenbaum et al. (1986) as providing evidence that $\phi = 5/6$, in which case the Frisch elasticity is 5, which is six times larger than the typical micro-based estimate. Summers' (1986) criticism of the large macro labor-supply elasticities embedded in most RBC models has remained one of the most persistent criticisms of the equilibrium approach to business-cycle analysis.

Reconciling Micro and Macro Estimates of the Elasticity of Labor Supply

Raj Chetty, along with various co-authors, has published several recent papers comparing labor-supply elasticity estimates from macro and micro data. In particular, Chetty's work tends to focus on how micro and macro estimates differ by both the nature of the elasticity estimated (i.e., Hicksian vs. Frisch elasticities), and the margin of adjustment that is considered (i.e., intensive vs. extensive). Hicksian and Frisch labor-supply elasticities can be estimated on either the intensive margin or the extensive margin. Recall that labor supply elasticity estimates of the intensive margin measure the response of hours worked to a change in the wage rate for *employed* individuals. Estimates of the extensive-margin elasticity, by contrast, measure the effect of a change in the wage rate on labor force participation. While microeconomists are concerned with understanding how individuals respond to shocks to their real wage rate, macroeconomists are interested in the aggregate response to real-wage shocks. More specifically, macroeconomists use assumptions about the size of aggregate labor-supply elasticities to calibrate representative-agent models of business-cycle dynamics. The aggregate labor-supply elasticities are the sum of the intensive- and extensive-margin elasticities, weighted by hours of work when there are individuals with heterogenous preferences.

Table 2.8.2 below summarizes various estimates of the steady-state (Hicksian) and intertemporal (Frisch) labor supply elasticities.

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Table 2.8.2 Micro vs. Macro Labor-Supply Elasticities

Table 2.8.2 reveals a considerable disparity between the findings of the macro and micro literatures on the cyclical elasticity of labor supply. From this table, Chetty et al. (2011a) conclude that both the macro and the micro estimates of the Hicksian aggregate labor supply elasticity are in rough agreement. The same can be said of the macro and micro Frisch intensive-margin estimates. However, the aggregate Frisch elasticity estimate is nearly three and a half times larger than the micro estimate, with the macro estimate appearing to be the outlier when compared to the Hicksian estimates. This evidence supports Summers' (1986) criticism of the labor-supply-elasticity assumptions in RBC models. The challenge for proponents of the RBC framework has been to find support for the relatively large aggregate Frisch elasticities required in RBC models to match the cyclical volatility of employment.

Much of the research on RBC models since Prescott (1986) has involved various attempts to determine the degree to which the addition of an extensive margin of adjustment to labor supply enables calibrations of a suitably modified RBC model to match more closely the observed volatility of total work hours, and this volatility relative to the volatility of output, that is documented in Table 2.8.1, above. Hansen (1985) considered the polar case in which there is *only* an extensive margin on which work hours can adjust; the labor-supply decision in that case is a binary one in which an individual determines whether or not to work but not how many hours to work once employed. This assumption has been justified by an appeal to the existence of fixed costs of employment, arising from either the demand side, as in Oi (1962), or the supply side, as in Cogan (1981). For example, initial hiring and training costs incurred by firms or the costs borne by workers of commuting to and from work or arranging child care place a lower bound on the optimal (profit- or utility-maximizing) hours of work demanded or supplied. At the intensive (hours) margin, the labor-supply response of (employed) married women to a wage increase is similar in magnitude to that for (married or unmarried) employed men. However, Hansen (1985) emphasized that it is the presence of an operative extensive (labor-force-participation) margin that drives the relatively large wage elasticity of labor supply for married women.

Cho and Rogerson (1988)

Cho and Rogerson (1988) extend the RBC model by introducing heterogeneity within the family with respect to the labor-supply responses of spouses to a change in their respective wage rates arising from a common technology shock. Husbands and wives are initially assumed to have identical (linear) preferences over consumption and market labor supply. However, Cho and Rogerson assume further that the family incurs a fixed utility cost when both the husband and the wife supply labor simultaneously. If the wife has a lower market productivity (relative to the value of time spent in household production) than the husband, this fixed cost is borne by the wife. As a result, there is always some fraction of all families in the economy where the husband is working and the wife is not. In such families, a positive technology shock that increases market productivities (and market wage rates) equally for the husband and wife results in a household labor-supply response only along the extensive margin; the intensive (hours) response of the husband is zero.

With this feature of an otherwise standard RBC model in place, simulations reveal that the response of aggregate hours of work in the model economy to a technology shock is very similar to that observed for the U.S economy. Moreover, fluctuations in the total work hours of married females in response to the shock are approximately twenty times larger than the resulting fluctuations in the hours of married men, closely matching estimates of the relative intertemporal wage elasticities of labor supply for married men and women reported in the miroeconometric literature. Thus, the model is capable of replicating the large difference in the wage elasticities of labor supply between married men and women, while generating aggregate labor-supply elasticities that are large enough to explain fluctuations in total hours over the business cycle as an equilibrium response to exogenous shocks.

These results seem at first glance to be at odds with the model specified and estimated by Donni and Moreau (2007), who note that men are either employed, in which case their average hours per week are closely clustered around a forty-hour full-time workweek, or they are unemployed and their work hours are zero. In contrast, women who are employed in the formal labor market have greater flexibility in their work hours. However, a reconciliation of the findings of Cho and Rogerson (1988) and Donni and Moreau (2007) is possible once it is understood that there is no unemployment in the Cho-Rogerson model; all cyclical labor-supply adjustments by men and women in their model are equilibrium in nature so a reduction in male employment during a recession would be classified by Cho and Rogerson (1988) as a voluntary reduction in labor-force participation but an increase in unemployment in the Donni-Moreau framework.

Benhabib, Rogerson and Wright (1991)

Despite the widespread interest generated by the concept of home work, introduced by Becker (1965), its implications for business-cycle analysis were not immediately appreciated. The RBC model of Kydland and Prescott (1982) and Prescott (1986) assumed that households allocate their time solely between market work and leisure. Thus, the large changes to aggregate hours worked implied by productivity shocks in their model were explained entirely by the decisions of employed workers along the intensive margin,

Benhabib, Rogerson and Wright (1991) (henceforth, BRW) were the first to include home work as a third use of time in the standard RBC model. The addition of home work not only provided a more complete depiction of labor-supply changes over the business cycle but also, BRW claimed, substantially improved the quantitative performance of the standard RBC model. In particular, BRW sought to demonstrate how the inclusion of home work could address five notable criticisms of the standard RBC model: when compared with business-cycle data, the standard RBC model predicts that, "(1) output fluctuates too little; (2) relative to output, labor hours fluctuate too little; (3)

relative to output, consumption fluctuates too little; (4) relative to output, investment fluctuates too much; and (5) the correlation of productivity with output or hours is far too high."

BRW began their analysis by citing Eisner's (1988) survey of the home-production literature, which concluded that the value of home production in the United States is equivalent to between 20 to 50 percent of measured gross national product. Similarly, Benhabib, Rogerson, and Wright (1990) use the Michigan Time Use Survey to show that the average married couple in the sample devotes almost as much discretionary time to non-market production (28%) as they do to market production (33%). BRW noted that there is a positive relationship between the labor-supply elasticity and the elasticity of substitution in production between market and non-market consumption. In particular, if market and non-market goods are highly substitutable then, when faced with a temporary decline in wages, the household will reduce work hours in favor of home work. This finding implies that the wage elasticity of labor supply will be higher the greater is the substitutability in *production* between market-purchased and home-produced goods.

In calibrating their model, BRW attempted to match the proportion of time devoted to market work (33%) and non-market work (28%) cited in Benhabib, Rogerson, and Wright (1990). BRW defined total household production C as a composite good produced by combining market-purchased goods C_m and non-market goods C_n according to the household production function: $C = (a_m C_m^e + a_n C_n^e)^{\frac{1}{e}}$ $C = (a_m C_m^e + a_n C_n^e)^{\frac{1}{e}}$. They identified the intratemporal input substitution parameter $e = 1 - 1/□$ as crucial for matching the model's predictions with the observed volatility in the data, where □ is the elasticity of substitution between C_m and C_n in production and $a_m a_m$ and $a_n a_n$ are input-share parameters for market and non-market goods, respectively.

Using data from the Panel Study of Income Dynamics (PSID) previously analyzed by Rios-Rull (1993), BRW estimated a value of 0.6 for *e*. This estimate suggests that market and non-market inputs in household production are highly (albeit not perfectly) substitutable. However, BRW noted that their micro-based approach to estimating *e* is quite different from that of Eichenbaum and Hansen (1990), who used aggregate data and assumed there are no household time-allocation decisions. Based on their findings, as well as those of Eichenbaum and Hansen (1990) who made a case for $e = 1$, BRW decided to set $e = 0.8$.

Table 2.8.3, taken from BRW, shows the results of simulating their RBC model with home production and comparing them with simulated values from the standard RBC model and U.S. data.

Table 2.8.3 here:

Table 2.8.3

Domeij and Floden (2006)

Prior to Domeij and Floden (2006), models which reported estimates of the Frisch elasticity failed to consider the impact that borrowing constraints may have on household labor-supply decisions. From a theoretical standpoint, the ability to borrow enables households to smooth consumption over time. This implies that the response to a wage shock by households that face no credit-market constraints will be greater than the response by households that cannot fully access credit markets. Consider, for example, a representative household that lives in a world with no credit markets. Now imagine a negative shock that decreases the wages received by the household. The substitution effect implies that the household's hours of work will decrease since the opportunity cost of leisure has declined. However, this substitution effect will be offset to some degree by an income effect. The size of the income effect is determined by the household's preference for current consumption and its ability to smooth consumption over time, among other factors. In the absence of a credit market, the most efficient way for the household to smooth consumption over time is to leave its work hours relatively unaltered (implying the income effect is relatively large). This conclusion implies that the Frisch elasticity will be small since the response of hours of work by the household is small relative to the decline in the wage rate.

When credit markets are introduced, the household has an additional means for smoothing consumption. The household can now borrow in the credit market during periods where there has been a negative shock to its wage income, and pay off the loan later when its income has returned to the pre-shock level. In other words, the ability to borrow leaves the household's lifetime income relatively unaffected by the shock (i.e., the income effect is small). As a result, the intertemporal substitution effect dominates, and the household will devote more time to leisure. Thus, the Frisch labor-supply elasticity will be higher when households have access to credit markets.

Domeij and Floden (2006) assume that there are two types of households: unconstrained (which have a low default risk and can easily borrow), and constrained (which have a high default risk and cannot readily borrow). Using evidence from the credit-market literature, they assume that approximately 20 percent of U.S. households are credit-constrained. Domeij and Floden extend the standard RBC model to include an imperfect credit market, and introduce stochastic shocks to labor productivity. Using real-world data from the Panel Study of Income Dynamics (PSID), they show that estimates of the Frisch labor-supply elasticity rise as credit- constrained households are eliminated from the sample.

Aguiar, Hurst, and Karabarbounis (2012)

Aguiar et al. (2012) use the American Time Use Survey (ATUS) 2003-2010 to examine the extent to workers substitute away from market work toward other uses of time during a recession. Survey respondents in the ATUS are drawn from the out-rotation groups in the Current Population Survey (CPS). These respondents are asked to keep a 24-hour time diary. Every event recorded in the time diary is assigned to one of 400 time-use categories. Aguiar et al. aggregate these into seven broad categories: 1) market work, 2) other income-generating activities, 3) job search, 4) child care, 5) non-market work, 6) leisure, and 7) other.

When the Great Recession began, time devoted to market work fell by 2.11 hours per week in the ATUS. Aguiar et al. explored the relative importance of the substitution toward non-market work (including household production) during this recession by computing the share of the overall decrease in aggregate hours of market work that was reallocated to each of the other time-use categories. Additionally, they estimated the fraction of the decrease in aggregate market-work hours that occurred at the intensive and extensive margins.

For the entire sample, Aguiar et al. found that leisure accounted for nearly 80 percent of respondents' time when they were not engaged in market work, while non-market work and job search accounted for approximately 13 percent and 0.21 percent, respectively. However, during the Great Recession 30 percent of the decline in market work was reallocated to non-market work, 50 percent to leisure, and between 2 and 6 percent to job search. Similarly, Aguiar et al. estimated that about 74 percent of the decrease in aggregate market-hours worked was the result of extensive-margin adjustments, while only 26 percent represented adjustments to hours of market work by employed workers.

Aguiar et al. also compared the time reallocations of men and women, and married and single individuals. They fail to reject the hypothesis of no difference in the reallocations of men and women. However, they did find that women reallocated more of their reduced market-work hours to "core home production activities" (cooking, cleaning, and laundry) and sleep, while men devoted more of their time formerly spent in market work to leisure (especially, watching television) and "other" activities (in particular, investing in human capital).

Married individuals, on the other hand, responded quite differently than single individuals to the reduction in hours of market work. Married individuals allocated 34 percent of their additional non-market time to household production, while single individuals allocated only 15 percent to that category. Similarly, married individuals reported an 8 percent increase in time devoted to child care. Single individuals did not allocate any of the additional time to child care. Instead, they devoted more time to leisure (with almost all of the difference relative to married individuals accounted for by increased sleep time) and human-capital investment.

Aguiar et al. concluded that increased time spent in home production comprises a substantial portion of the decline in aggregate market-work hours caused by a business-cycle downturn. They find that the elasticity of non-market work with respect to market work is approximately 0.50. This is consistent with the relationship between non-market work and leisure hours reported in Benhabib, Rogerson and Wright (1991) under the assumption that the elasticity of substitution in production between market-produced and home-produced goods in their model is 2.5.

Imai and Keane (2004)

In the benchmark RBC model, wage changes over the life cycle are assumed to be exogenous. This assumption is somewhat problematic since it presupposes that a household's accumulation of human capital (defined here as education, work experience, and training) has no effect on observed wage changes. In other words, as Keane and Rogerson (2012) state, " … these models assume that the approximate doubling of wages that is observed for the average person as they go from their early twenties to their mid-forties would still be realized if members of these households were to stay home and watch television for twenty years and then suddenly decide to look for a job." Instead, it is most likely the case that, over those twenty years, the average person has acquired additional human capital through education, on-the-job training, or learning-by-doing. As human capital accumulates, workers becomes more productive, causing their wages to rise.

Imai and Keane (2004) incorporate human-capital accumulation into the standard life-cycle labor-supply model, and find that doing so has important implications for the analysis of aggregate labor-supply elasticities. Throughout their analysis, Imai and Keane refer to the return to an hour of work as the "opportunity cost of time" (OCT). The OCT is the after-tax wage rate plus the expected present value of the increased (after-tax) earnings in all future periods obtained by working an extra hour at time t. Imai and Keane denote the latter term the “human capital term” (HC).

Figure 2.8.2 below is taken from Imai and Keane (2004), and is a stylized representation of how wages, hours, OCT, and HC evolve over a representative male’s life cycle. In the early stages of the individual’s career (i.e., at a young age), hours worked rise slowly. As the individual ages, hours worked will eventually peak and then fall sharply as he moves toward retirement. The individual’s wages follow a similar pattern. However, as Figure 2.8.2 shows, wages rise far more sharply than hours when the individual is young and falls slightly less sharply as he nears retirement. When considered together, these two stylized facts imply that labor-supply elasticities will be low, as large wage increases that occur when the worker is young will lead to relatively small adjustments to hours worked.

However, this model fails to account for the effect of human-capital accumulation on hours worked. Consider what happens when HC is added to the model. The value of HC is initially high when the individual is young, and then falls at a decreasing rate as diminishing returns to HC causes the returns to HC fall over time. Moreover, as the individual nears retirement, the potential returns to additional HC will also fall. When the worker makes his labor-supply decision, he considers the full OCT inclusive of wages and HC. As Figure 2.8.2 demonstrates, the life-cycle profile for OCT is much smoother than the wage profile, and is almost parallel to the hours-worked profile. As OCT rises, there will be a similar response of hours worked. In other words, the inclusion of HC in the model implies that the wage elasticity of labor supply may be much higher than estimates from the micro literature that do not include human capital accumulation.

Please put Figure 2.8.2 here:

Figure 2.8.2 The Opportunity Cost of Time

Rogerson and Wallenius (2009)

Rogerson and Wallenius (2009) extend the benchmark model to consider two very important aspects of lifetime labor supply: the fraction of the individual's life spent in employment and the time devoted to work when employed. The individuals in this model have a fixed length of life that is normalized to one, derive utility from consumption, and receive disutility from the hours they devote to work. Productivity varies over the life cycle and will ultimately diminish towards the end of the individual's life. Rogerson and Wallenius assume that producers require that individuals work some minimum number of hours in order to remain employed. Thus, labor supply g(h) is equal to

$$g(h) = \max\{h - \bar{h}, 0\}$$

where h denotes the individual's instantaneous, optimal number of hours worked, and $\bar{h}$ is the minimum-hours requirement. When $h < \bar{h}$, the agent chooses to retire; i.e., his labor supply equals zero. Thus, the model includes both intensive-margin adjustments (changes to h) and extensive-margin adjustments (retirement).

Rogerson and Wallenius use the model to analyze the potential effect of a reform to a basic tax-and-transfer scheme. In particular, they are concerned with studying how the response of aggregate labor supply differs with different values of γ. Rogerson and Wallenius calibrate the model for different values of γ (0.1, 0.5, 1.0, 2.0), and then use the conventional labor-supply model to estimate [illegible]. They first consider the impact of changes in the wage rate on the number of hours worked, and find that the estimated Frisch elasticities are consistently around one-half of their true value. Rogerson and Wallenius then investigate the response of aggregate hours to a rise in the marginal tax rate on labor income from 30% to 50%. They find that the change in aggregate hours worked is relatively large (an increase of more than 20 percent) for all four stipulated values of [illegible] This increase occurs despite the fact that the estimated micro labor-supply elasticities vary considerably (from 0.05 to 1.29). In other words, the aggregate response to the increased tax rate remains approximately constant, at around 20 percent, even though the individual micro Frisch elasticities differ substantially. Therefore, Rogerson and Wallenius show that the small Frisch elasticities found in the micro literature can exist alongside large estimated aggregate Frisch elasticities that fall in a range between 1 and 2.

Concluding Remarks

The neoclassical model of economic growth provides an insightful framework for the analysis of the determinants of the long-run trends in savings, investment, employment, and output. A major attraction of this model is the ability to interpret it in terms of the outcomes of the optimizing behavior of individuals and firms, giving it "microeconomic foundations". It is not well-suited, however, for the study of short-run, cyclical fluctuations of employment and output around these long-run trends. Extensions of the model to accommodate random shocks and, subsequently, the labor-leisure choice gave macroeconomists a toolkit with which to analyze business-cycle dynamics within an equilibrium environment.

An important shortcoming of the equilibrium or "real" approach to the study of business cycles is its inability to provide an understanding of the cyclical volatility of employment as an optimum response of work hours to temporary changes in productivity. The incorporation of labor-supply decisions, especially on the extensive margin of labor-force participation, has been a key advance in the quest for concordance between the predictions of this theory and the observed reality. Placing labor-supply decisions in a setting where choices about the allocation of time are made among leisure, market work, and home work (or household production), has put researchers on a fruitful path towards reconciling the large body of empirical findings of a small elasticity of labor supply at the micro level with the much larger elasticity required of macro models to make sense of the magnitude of the cyclical fluctuations in employment.

While some progress has been made toward achieving this reconciliation, much theoretical and empirical work remains to be done and several challenges remain. For example, it may be possible to use results from the literature on public finance on the elasticity of taxable income, emphasized by Feldstein (1995) and recently surveyed by Saez, et al. (2012), to examine decision margins, such as effort level and occupational choice, that have been unexplored in the business-cycle literature. These additional dimensions are, in principle, relevant for the estimation of aggregate labor-supply elasticities and may contribute to a further narrowing of the gap between the micro and macro results. It is also imperative to confront the fact, inconvenient for RBC adherents, that demographic groups such as prime-age males, for which labor supply is the most wage-inelastic, counterfactually experience the largest cyclical fluctuations in employment. The model introduced by Donni and Moreau (2007) may point a way for proponents of the RBC framework to respond to that concern. Finally, more realistic assumptions about the structure of family decision making will undoubtedly have an effect on empirical estimates of the responsiveness of household labor supply to macroeconomic shocks.

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