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HOUSEHOLD CHOICES IN EQUILIBRIUM

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ABSTRACT

This paper investigates the role of aggregate shocks on household consumption and labor supply. It posits, estimates and tests a model where the equilibrium behavior of agents sometimes leads them to locate on the boundary of their respective choices sets. The framework is rich enough to nest much previous empirical work on life cycle labor supply and consumption based asset pricing. It also yields a structural interpretation of wage regressions on unemployment. An important feature of our model is that markets are complete. Consequently, aggregate shocks only enter through two price sequences, namely real wages, and a sequence comprising weighted prices for future contingent consumption claims which are ultimately realized. We examine the properties of this latter sequence, whose elements may be represented as mappings from real wages and aggregate dividends.

Our empirical findings may be grouped into three. First, aggregate shocks play a significant role in determining the choices people make. Second, we reject for males some of the restrictions implicit in structural interpretations of wage unemployment regressions. Moreover when these restrictions are imposed, we find wages are countercyclical, but cannot reject the null hypothesis of no effect. Third, the null hypothesis that markets are complete is not invariably rejected. However, the orthogonality conditions associated with the asset pricing equation are rejected, even though our specification of preferences incorporates types of heterogeneity which violate the necessary conditions for aggregating to a representative agent formulation. Finally, we reject the cross equation restrictions between the labor supply of spouses implied by equilibrium behavior.

1. INTRODUCTION

Several recent studies of labor supply using household data have detected the impact of aggregate shocks at the individual level. In econometric frameworks explicitly derived from optimization problems individuals face, Altonji (1986), Browning, Deaton and Irish (1985), Hotz, Kydland and Sedlacek (1987), Heckman and Sedlacek (1985) and Sedlacek and Shaw (1984) rejected a zero restriction on certain time dummy coefficients. The respective authors interpreted their findings as evidence against the null hypothesis that aggregate fluctuations do not affect labor supply choices. Bils (1985) and Keane, Moffitt and Runkle (1986) found that directly including the national unemployment rate in less structured models significantly contributes to the explanatory power of their models.

While the models mentioned above have a straightforward interpretation under the null hypothesis of no effect, a consensus has yet to emerge on precisely how aggregate shocks should be accounted for in analyses of household data. Chamberlain placed this issue on the research agenda, remarking (p. 1311, 1984): "A time average of forecast errors over T periods should converge to zero at $T \to \infty$. But an average of forecast errors across N individuals surely need not converge to zero at $N \to \infty$; there may be common components in those errors, due to economy-wide innovations." Hayashi (1985) tackled this problem using data on consumer expectations; Hotz, Kydland and Sedlacek (1985) assumed forecast errors are additively separable into common versus an idiosyncratic components; Browning, Deaton and Irish (1985) approximated the asset pricing equation; the model of Heckman and Sedlacek (1985) is static.

The issue is further complicated when individuals do not invariably locate in the interior of their choice sets but at boundary points instead.

In such cases the Euler equation methods developed by Hansen and Singleton (1982) are inapplicable. One approach, taken by Eckstein and Wolpin (1987) is to extend the dynamic programming solutions proposed by Miller (1984) and Wolpin (1984) for discrete choice problems to market settings. This involves specifying the production technology (along with preferences) to compute equilibrium prices. However, many panel data sets contain little information about the production process; therefore, finding ways to investigate the effect of aggregate shocks on individual behavior which are robust to alternative assumptions about the production technology would be fruitful.

The solution we seek to this problem appeals to restrictions which hold in the competitive equilibrium of an economy with a complete set of markets. Our analysis builds on the life cycle female labor supply model of Heckman and MaCurdy (1980). As we demonstrate below, their parameter estimates apply to a perfect foresight economy with complete markets in which prices change geometrically over time. Bearing in mind the evidence from panel data for aggregate shocks, our analysis relaxes the assumptions of perfect foresight and geometric pricing, but retains the assumption that (consumption and labor) markets are complete. The interest rate and the wage function are stochastic in our model, and we estimate their equilibrium realizations using two sets of time dummies, along with the parameters characterizing preferences. The coefficients on one sequence of time dummies we estimate are interpreted as discounted prices of contingent claims which are realized along the equilibrium path; the coefficients on the other sequence represent real wage rates. Section 2 lays out our approach.

Admittedly, the assumption of complete markets seems strong. Nevertheless, it is observationally equivalent to a procedure adopted by Browning, Deaton and Irish (1985) and Altonji (1986) in an incomplete markets setting; they approximate the asset pricing equation in order to estimate an interior first order condition for male labor supply. MaCurdy (1983) also uses a similar approximation when estimating monotonic transformations of the current utility function. The advantages of explicitly acknowledging the nature of their approximation are twofold: it reveals other situations which become amenable to analysis under the approximation, namely corner solutions, and suggests methods of checking the accuracy of the approximation.

Section 2 concludes by listing several ways of testing the null hypothesis that markets are complete. One of these tests, which we subsequently undertake in our empirical work, stems from the alternative hypothesis that asset markets are incomplete, but individuals may choose, sequentially, the number of hours they wish to work each period, subject to a given wage rate. Then the marginal rate of substitution between current consumption and leisure equals the real wage rate for those people participating in the labor force. Under the null hypothesis of complete markets, an estimation strategy based on this condition, exploited by MaCurdy (1983) in his study of male labor supply, is consistent but inefficient. Hence, a specification test can be constructed by comparing it with the estimator we propose (which is more efficient under the null hypothesis but inconsistent under the alternative).

Because of their central role in our analysis (and indeed more generally), the theoretical properties of the discounted prices for contingent claims are investigated in Section 3. We show these prices are Lagrange multipliers for a social planner's problem associated with the competitive equilibrium, and may be expressed as mappings from aggregate dividends and real wages. Under certain conditions, the prices (or multipliers) covary negatively with aggregate dividends and with real wages.

The latter relationship (between prices and wages) bears directly on the question of whether real wages are procyclical or not. Many previous studies have regressed average wage rates on unemployment to answer this question. (For example see Bodkin [1969], Neftci [1978], Sargent [1978], and Geary and Kennan [1982].) Recently Bils (1985) and Keane, Moffitt and Runkle (1987) addressed this issue with panel data. Our framework nests their wage and participation equations. Several auxiliary assumptions are required, however, to yield a structural interpretation of the unemployment coefficient in a wage equation (as a price transformation). When these assumptions are imposed, our prediction above (that discounted prices for contingent claims should covary negatively with real wages), only partially corresponds to the classicist's view that wages should be countercyclical.

Section 4 lays out the parametric forms for the preferences and labor productivities subsequently estimated. We consider specifications in which both exogenous and endogenous time varying components enter nonadditively with (food) consumption. These features may be justified in terms of a home production function, but they also have ramifications for the intertemporal capital asset pricing model. Using time series data on aggregate consumption and financial returns, Hansen and Singleton (1982) estimated the preferences of a representative consumer using orthogonality conditions derived from the (expected) marginal rate of substitution between goods consumed at different dates. They found asset prices were too volatile relative to consumption and rejected the overidentifying restrictions. (Similar findings were later reported by Mankiw, Rotemberg and Summers [1985], Dunn and Singleton [1986] and Eichenbaum, Hansen and Singleton [1987].) A potential source of this rejection is that the data might not satisfy conditions necessary for aggregating over a heterogenous population. By testing a model which does not rely on the representative consumer paradigm at all, we can investigate whether imposing such conditions explains why the intertemporal capital asset pricing model fails.

Our empirical methods and results are discussed in detail in Section 5, while the final section concludes the paper with several remarks that stem from these results. Estimation was conducted in three phases. First, we estimated the female labor supply and wage equations by themselves using maximum likelihood (ML) to see how well aggregate shocks can be detected in our data. A similar exercise was then undertaken for males in the larger sample, partly to investigate aggregate shocks, but mainly to assess the importance of sample selection bias that arises from excluding males who do not participate in the labor force every period. Second, generalized methods of moments (GMM) estimators were formed with the smaller sample to test the complete markets hypothesis and address the separability issue. From orthogonality conditions associated with the marginal rate of substitution between the husband's leisure and food consumption, we obtained estimates of the marginal rate of substitution function. These orthogonality conditions were then augmented with other ones derived from the first order conditions for household consumption, the husband's leisure and financial assets. The third phase, combined the equations characterizing how husbands and wives allocate their time to test whether the contingent commodity prices that wives are facing differ significantly from those of their spouses. In this phase GMM estimators were derived from orthogonality conditions associated with the scores for the wife's labor supply and wage equations, and added to those used in the second phase.

2. A FRAMEWORK

The Role of Complete Markets in Identification and Estimation.

This section describes a method for estimating models in which agents sometimes choose corner solutions in equilibrium, and indicates ways of testing its main premise, that a complete set of markets exist. Although the method applies to many competitive environments where markets are complete, our empirical study is based on information about consumption and labor supply choices by households. For this reason we let c_{nt} stand for choices which, in equilibrium, invariably satisfy a first order condition with equality, and l_{nt} stand for those choices which might not.

More specifically, let c_{nt} denote the consumption of the n^{th} household in period $t \in \{0,1,\ldots, \tau\}$, where τ is the last period in a finite horizon economy; let l_{nt} denote a vector of leisure for the individuals belonging to it. Suppose l_{nt} has only two elements, corresponding to the leisure time of spouses within each household. Then $l_{nt} = (l_{1nt}, l_{2nt})$ where $l_{int} \in [0,1]$ measures the proportion of time in period t the i^{th} member of household n spends in nonmarket activities. Households are identical up to a vector of time varying characteristics z_{nt}. We assume an individual's labor supply can be measured in efficiency units which depend on these time varying characteristics. Let h_{int} denote the labor supply of the i^{th} member belonging to the n^{th} household in period t weighted by an efficiency index $\gamma_i(z_{nt})$.

$$h_{int} = \gamma_i(z_{nt})(1 - l_{int}) \tag{2.1}$$

Suppose $a_t \in A$ describes the state of the economy in period t, and $a^t = (a_1,\ldots,a_t)$ represents the history up until then. The n^{th} household is active between dates $\underline{n}$ and $\bar{n}$ (where $0 \le \underline{n} < \bar{n} \le \tau$), having preferences which are defined over sequences $\{l_n(a^t), c_n(a^t), z_n(a^t)\}_{t=\underline{n}}^{\bar{n}}$, where we now acknowledge the (potential) dependence of (l_{nt}, c_{nt}, z_{nt}) on a^t. (There is no private information in this economy.) We assume households obey the expected utility hypothesis and have rational expectations, preferences taking the time additive form

$$E_0 \left[\sum_{t=\underline{n}}^{\bar{n}} \beta^t u(l_{nt}, c_{nt}, z_{nt})\right] \tag{2.2}$$

where $E_0(\cdot)$ denotes expectations taken over sequences $a^{\bar{n}} \in A^{\bar{n}}$, the scalar $\beta \in (0,1)$ is a common subjective discount factor, and $u(l_{nt}, c_{nt}, z_{nt})$ is concave increasing in (l_{nt}, c_{nt}) for each z_{nt}.

Given the efficiency units assumption embodied in (2.1), one condition which holds in all the competitive equilibria we investigate is that spot labor markets exist, so if $l_{int} < 1$ then

$$w_{int} = w(a^t)\ \gamma_i(z_{nt}) \tag{2.3}$$

where $w(a^t)$ represents the real wage of a standard unit of labor in period t conditional on history a^t.

In a competitive equilibrium with complete markets, household n maximizes (2.2) by choosing $l_n(a^t)$ and $c_n(a^t)$ for each $a^t \in A^t$ and $t \in \{\underline{n},\ldots,\bar{n}\}$ subject to a lifetime budget constraint. Accordingly, denote by η_n the Lagrange multiplier for the lifetime budget constraint of household n and $p(a^t)$ the price of a consumption unit contingent on history a^t and delivered on date t. Also let $\theta(a^t)$ denote the probability (density function) of a^t occurring and define $\lambda(a^t)$ to satisfy the equation

$$p(a^t) = \beta^t \theta(a^t)\lambda(a^t) \tag{2.4}$$

Thus $\lambda(a^t)$ is a weighted price of a contingent consumption claim; the claim is for a unit to be delivered at date t only if a^t occurs; the price is weighted by the (common) subjective rate and the probability (density) of a^t. Summing (integrating) over $a^t \in A^t$, it follows that $\beta^t E_0[\lambda(a^t)]$ is the price of a date t consumption unit. Subsuming the a^t notation, it follows that the budget constraint for the n^{th} household may now be written

$$E_0\{\sum_{t=\underline{n}}^{\overline{n}} \beta^t \lambda_t [c_{nt} - \sum_{i=1}^{2}(1-l_{int})w_{int}]\} \leq c_n \tag{2.5}$$

where c_n, an exogenously determined quantity, is bequests net of inheritances.

The first order conditions for the n^{th} household are

$$u_i(l_{nt}, c_{nt}, z_{nt}) \geq \eta_n \lambda_t w_{int} \tag{2.6}$$

$$u_3(l_{nt}, c_{nt}, z_{nt}) = \eta_n \lambda_t \tag{2.7}$$

where $u_i(l_{nt}, c_{nt}, z_{nt})$ is the partial derivative of $u(l_{nt}, c_{nt}, z_{nt})$ with respect to the i^{th} argument and (2.6) holds with equality wherever $l_{int} < 1$. Let $l_n^o(a^t)$ and $c_n^o(a^t)$ denote the optimal leisure and consumption plans for household n in equilibrium (as mappings from a^t). Clearly, conditions (2.6) and (2.7) hold for all $a^t \in A^t$, but as econometricians we only observe (a subsequence of) those allocations along the realized path $\tilde{a}^t$. Therefore our strategy is to estimate β, u and γ_i from observations on $l_n^o(\tilde{a}^t)$ and $c_n^o(\tilde{a}^t)$ for different n and t, treating η_n, $\lambda(\tilde{a}^t)$ and $w(\tilde{a}^t)$ as parameters too.

Incomplete Markets

Now suppose that markets are not necessarily complete but there still exist assets $r \varepsilon R$ which households may trade each period for current consumption and leisure. Let $s_{nt}(r)$ denote the mapping which represents, for such r, the quantity of asset r held by the n^{th} household in period t, $q_t(r)$ its price and $d_t(r)$ the associated dividend. In this case, household opportunities cannot be modeled with a single lifetime budget constraint. Instead, there are a sequence of constraints of the form

$$\int_{r \varepsilon R} \{q_t(r)[s_{nt}(r) - s_{n,t+1}(r)] + d_t(r)s_{nt}(r)\} = c_{nt} - \sum_{i=1}^{2}(1 - l_{int})w_{int} \tag{2.8}$$

for each a^t, where $t \varepsilon \{\underline{n},\ldots,\overline{n}-1\}$. Now the household maximizes (2.3) subject to (2.8), as well as some initial and terminal conditions which are respectively dictated by inheritances and bequests. Accordingly, define $\lambda_n(a^t)$ such that $\theta(a^t)\beta^t\lambda_n(a^t)$ is the multiplier associated with the budget constraint for history a^t. The first order conditions for this problem are

$$u_i(l_{nt},c_{nt},z_{nt}) \geq \lambda_{nt}w_{int} \tag{2.9}$$

$$u_3(l_{nt},c_{nt},z_{nt}) = \lambda_{nt} \tag{2.10}$$

$$\lambda_{nt} = \beta E_t[\lambda_{n,t+1} \pi_t(r)] \tag{2.11}$$

where $\lambda_n(a^t)$ has been rewritten as λ_{nt} and $\pi_t(r)$, the real return on the r^{th} asset in time t, is just

$$\pi_t(r) = [(q_{t+1}(r) + d_{t+1}(r))]/[q_t(r)] \tag{2.12}$$

Previous studies have used conditions analogous to (2.9), (2.10) and (2.11) to estimate and test life cycle models of consumption and labor supply which assume interior solutions. Notable among these studies are those by MaCurdy (1983), Browning, Deaton and Irish (1985) and Altonji (1986). In order to identify and estimate their respective models, however, the two latter studies approximate a version of (2.11). (MaCurdy's approach is similar.) This is done to substitute out the household-specific Lagrange multipliers λ_{nt}. Now (2.11) can be expressed as

$$\lambda_{nt} = \beta\lambda_{n,t+1}\pi_t(r) - \varepsilon_{t+1} \tag{2.13}$$

where ε_{t+1} is a forecast error orthogonal to a^t. Taking logarithms in (2.13) and expanding the right hand side in a Taylor series to the first order yields

$$\ell n(\lambda_{nt}) \approx \ell n(\lambda_{n,t+1}) + \ell n[\beta\pi_t(r)] - \varepsilon^*_{t+1} \tag{2.14}$$

where ε^*_{t+1} is another disturbance. Their approximation to the first order condition is now obtained by taking the logarithm of (2.10), differencing and using (2.14) to substitute out the right-hand side of this expression. Let Δ denote the first difference operator. Thus

$$\Delta \ln[u_3(l_{nt}, c_{nt}, z_{nt})] = \Delta \ln(\lambda_{nt})$$

$$\approx \varepsilon_t^* - \ln[\beta \pi_{t-1}(r))] \qquad (2.15)$$

Because ε_t^* and $\pi_{t-1}(r)$ do not depend on the characteristics z_{nt} of household n (unless there is private information in the economy or the asset market is subject to price discrimination), the second line in (2.15) can be treated as a time dummy, the procedure adopted in the studies cited above. Their approach is equivalent to assuming markets are complete. First differencing the logarithm of (2.7) we directly obtain

$$\Delta \ln[u_3(l_{nt}, c_{nt}, z_{nt})] = \Delta \ln(\lambda_t) \qquad (2.16)$$

In other words, if these authors appeal to the assumption of complete markets, their approximation in (2.15) is exact, with

$$\Delta \ln(\lambda_t) = \varepsilon_{t+1}^* - \ln[\beta \pi_t(r)] \qquad (2.17)$$

Let the data set contain T observations on N households. By comparing (2.7) with (2.10), notice the assumption of complete markets imposes NT - (N+T) restrictions of the form

$$\lambda_{nt} = \eta_n \lambda_t \qquad (2.18)$$

The restrictions in (2.18) cannot be tested directly, because under the alternative hypothesis that markets are incomplete, the parameters λ_{nt} are unidentified. Nevertheless, parameterizations of our framework which impose the restrictions in (2.18) are capable of being rejected by data using standard econometric techniques. In other words, there are ways of testing how robust approximation (2.15) is. Four such kinds of tests are undertaken here. First, the method of moments approach to estimation yields overidentifying restrictions which form the basis for omnibus specification testing. Second, previously estimated models can be nested within our more general framework, in terms of the restrictions they imply for the sequence of time effects $\{\lambda_t, w_t\}_{t=1}^{\tau}$, so the extra restrictions they impose can be tested. Third, when more than one choice per household is observed in period t, an estimate of λ_t is obtained for each choice; if these differ significantly, then households appear schizophrenic, optimizing against different sets of prices for different choices. (Similarly, households can be partitioned to investigate whether they all apparently belong to the same economy.)

The fourth kind of test explicitly focuses upon the complete markets hypothesis. For certain parameters are identified under much weaker assumptions about market structure, a fact which is exploited by MaCurdy (1983). We now show this provides a basis for testing whether markets are complete or not. Suppose that under the alternative hypothesis spot markets exist for two or more choice elements which invariably have interior solutions in equilibrium. Then their marginal rate of substitution function can be estimated using instrumental variables. Under the null hypothesis of complete markets, the orthogonality conditions associated with that marginal rate of substitution may be augmented with additional orthogonality conditions which come from the marginal utility equation that one of the goods must satisfy in equilibrium. For example, upon substituting (2.10) into (2.11), the resulting asset pricing equation may be estimated. In other words, provided the n^{th} household can trade in the r^{th} asset,

$$E_t[\beta\pi_t(r)\ u_3(l_{n,t+1},c_{n,t+1},z_{n,t+1})/(u_3(l_{nt},c_{nt},z_{nt})] = 1. \tag{2.19}$$

Similarly, if the second family member (say) invariably works each period in the labor force, the marginal rate of substitution between consumption and (his) leisure is the quotient of (2.9) and (2.10),

$$u_2(l_{nt},c_{nt},z_{nt})/u_3(l_{nt},c_{nt},z_{nt}) = w_{2nt} \tag{2.20}$$

Thus the idea is to estimate (2.19) or (2.20), and then see whether the data rejects the additional restrictions imposed by (2.7) or (2.6).

3. AGGREGATE SHOCKS

Wages, prices and dividends

This framework can also be used to investigate aggregate shocks, which enter our analysis through their effect on the sequence $\{\lambda_t, w_t\}_{t=1}^{\tau}$. Without specifying the aggregate production function, it is impossible to deduce precisely how λ_t and w_t depend on a^t. Nevertheless, for any given history a^t, we can partially characterize how $\lambda(a^t)$, $w(a^t)$ and dividends $d(a^t)$ are related to each other. In addition, under some weak assumptions about the stochastic process for dividends and wages, some properties can be deduced about the covariation between realizations of $\lambda(\tilde{a}^t)$, and $w(\tilde{a}^t)$ as well as $\lambda(\tilde{a}^t)$ and $d(\tilde{a}^t)$. The former set of results is now derived by exploiting the interpretation of λ_t as a Lagrange multiplier in the social planning problem for this competitive equilibrium. Given a^t, total dividends d_t and the marginal product of labor w_t are determined by aggregate employment and investment. For the sake of the exposition, suppose these have already been optimally determined; then the social planning problem reduces to solving the consumption and leisure choices of active households in the t^{th} period (given a^t). That is

$$v(w_t, d_t) = \max_{\{h_{1nt}, h_{2nt}, l_{nt}, c_{nt}\}} \{\textstyle\sum_{n\varepsilon N_t} \eta_n^{-1} u(l_{nt}, c_{nt}, z_{nt})$$

$$+ \lambda_t[d_t + \textstyle\sum_{n\varepsilon N_t} (h_{1nt} w_t + h_{2nt} w_t - c_{nt})]\} \qquad (3.1)$$

where η_n^{-1} is the social weight attached to the n^{th} household, h_{1nt} and h_{2nt} are defined by (2.1), while $v(w_t, d_t)$ is interpreted as an indirect utility function for the social planner. The first order conditions for (3.1) are, of course, (2.6) and (2.7).

Differentiating (3.1) with respect to d_t, the envelope theorem implies

$$\lambda_t = v_2(w_t, d_t) \tag{3.2}$$

Thus λ_t is the shadow price of aggregate consumption to the social planner. Noting $v(w_t, d_t)$ is concave in d_t, it follows that λ_t is decreasing in d_t. Higher current dividends are associated with poorer investment opportunities or favorable shocks to the current production technology. Either way, the price of goods is lower, inducing households to consume more.

The relationship between λ_t and w_t is ambiguous at the most general level (for $v(w_t, d_t)$ is not necessarily concave in w_t). However when current utility $u(l_{nt}, c_{nt}, z_{nt})$ is additively separable across l_{1nt}, l_{2nt} and c_{nt} (one possibility our empirical study investigates), we can show λ_t decreases in w_t by differentiating the budget constraint for the social planner's problem. In this case, from (2.6) and (2.7), the Frisch demands for household consumption and individual leisure may be respectively written as $c(\eta_n\lambda_t, z_{nt})$ and $l_i(\eta_n\lambda_t w_t, z_{nt})$ for $i \in \{1,2\}$. Using prime superscripts to denote their derivatives with respect to the first argument, it follows from (2.1) and the Lagrangian constraint in (3.1) that

$$\frac{d\lambda_t}{dw_t} = \frac{\sum_{n\in N_t}\sum_{i=1}^{2}[h_{int} - \eta_n\lambda_t\gamma_i(z_{nt})l_i'(\eta_n\lambda_t w_t, z_{nt})]}{\sum_{n\in N_t}[\eta_n c'(\eta_n\lambda_t, z_{nt}) + \sum_{i=1}^{2}\eta_n w_t^2\gamma_i(z_{nt})l_i'(\eta_n\lambda_t w_t, z_{nt})]} \tag{3.3}$$

If $u(l_{nt},c_{nt},z_{nt})$ is concave and additive in (l_{nt},c_{nt}), then (2.6) and (2.7) imply for $i \in \{1,2\}$ that $l_i'(\eta_n\lambda_t w_t,z_{nt})$ and $c'(\eta_n\lambda_t,Z_{nt})$ are negative; consequently (3.3) is too.

To derive results for the covariation of λ_t and w_t (as well as λ_t and d_t), some assumptions are made about the joint distribution of $w(\tilde{a}^t)$ and $d(\tilde{a}^t)$, conditional on $\tilde{a}^{t-1}$. In an economy which allows for physical investment, and where production depends on multiple inputs such as labor and capital, these assumptions amount to restricting equilibrium processes, because w_t and d_t are both endogenous. It is possible, however, to construct a simple economy, where d_t represents service flow from assets of the type Lucas (1978) analyzed, where w_t output units are produced per efficiency unit of labor unit, and where there is scope for neither investment nor storage. In this asset labor economy the exogenous $\{w_t,d_t\}_{t=1}^{T}$ process characterizes the production technology, equation (3.1) representing the associated planning problem. Thus, while our analysis applies to much richer environments, this interpretation of our framework should be kept in mind as we investigate the implications of different assumptions for the $\{w_t,d_t\}_{t=1}^{T}$ process. Since our empirical results are derived without using data on capital stocks and investment opportunities, it serves as a convenient benchmark for thinking about the effects of aggregate shocks.

Assume a joint probability density function exists for w_t and d_t, conditional on $\tilde{a}^{t-1}$. Denote by $f(d_t|w_t)$ the probability density function for d_t conditional on w_t (and $\tilde{a}^{t-1}$) and $f(w_t)$ the marginal density function for w_t (again given $\tilde{a}^{t-1}$). If $f(d_t|w_t)$ has a monotone likelihood ratio property (in w_t), and $\lambda(w_t,d_t)$ is decreasing in w_t, then the mapping (3.2) generates a negative covariance between λ_t and w_t as well as between λ_t and w_t. Under these assumptions, $E(\lambda_t|w_t)$ is decreasing in w_t also. To prove this claim, observe for all $w_1 < w_2$,

$$E(\lambda_t|w_2) = \int\{[\lambda(w_2,d_t) - \lambda(w_1,d_t)]f(d_t|w_2) + \lambda(w_1,d_t)f(d_t|w_2)\}dd_t$$

$$< \int\lambda(w_1,d_t)f(d_t|w_2)dd_t$$

$$\leq \int\lambda(w_1,d_t)f(d_t|w_1)dd_t$$

$$= E(\lambda_t|w_1) \tag{3.4}$$

The second line in (3.4) is true because $\lambda(w,d_t)$ decreases in w_t; the third follows from the assumption that $f(d_t|w_2)/f(d_t|w_1)$ is nondecreasing in w_t. (See Ferguson [1967]). Given $E(\lambda_t|w_t)$ is decreasing in w_t, there exists a unique w^* such that $E(\lambda|w^*) = E(\lambda)$. Hence $E(\lambda|w) > E(\lambda|w^*)$ if $w < w^*$ and vice versa. Therefore

$$\text{cov}(\lambda_t,w_t) = \int w_t[E(\lambda_t|w_t) - E(\lambda_t)]f(w_t)dw_t$$

$$= \int(w_t-w^*)[E(\lambda_t|w_t) - E(\lambda_t)]f(w_t)dw_t \tag{3.5}$$

Because (w_t-w^*) and $[E(\lambda_t|w_t) - E(\lambda_t)]$ are of opposite sign, $\text{cov}(\lambda_t, w_t) < 0$ as claimed. An analogous argument shows $\text{cov}(\lambda_t,d_t) < 0$ if the conditional density of w_t given d_t has a monotone likelihood ratio (in d_t).

Wages and Unemployment

The introduction cited several studies which investigated how wages fluctuate over the business cycle by regressing them on the unemployment rate. These regressions have a structural interpretation within our framework, if three further assumptions are made. Given these assumptions, including unemployment as a regressor fully captures the price effects of aggregate shocks. This result rebuts Neftci's criticism of Bodkin (1969) for "ignoring the dynamics of the underlying problem" (p.283,1982) by not including lagged unemployment in the wage equation. Moreover, as explained below, the assumptions are not directly related to the time series properties of aggregate shocks, but concern the functional form preferences $u(l_{nt},c_{nt},z_{nt})$ and the efficiency index $\gamma(z_{nt})$ take, the population distribution of household characteristics z_{nt}, and the link between current dividends and real wages.

One reason for regressing wages on unemployment is that the classicists predicted wages are countercyclical, because they believed the marginal product of labor declines with employment and the capital stock is fixed in the short run. Amongst others, Neftci (1978) and Geary and Kennan (1982) have criticized this viewpoint, arguing that the demand curve for labor might shift even if the capital stock is fixed because of changes in expected future returns. Consequently observed wage employment pairs would not lie on the same labor demand schedule. Our general equilibrium framework accommodates shifts in both the supply and demand curves for labor; interpreted as an asset labor economy it predicts $cov(\lambda_t,w_t) < 0$. It turns out that, under the three assumptions mentioned above, this prediction is not equivalent to saying wages are countercyclical.

These issues are now explored in more detail. The first assumption is that $u_2(l_{1nt},1,c_{nt},z_{nt})$ and $\gamma_2(z_{nt})$ are log linear in z_{nt} alone. Defining the row vector of characteristics $\tilde{z}_{nt} = (\eta,z'_{nt})$, it immediately follows that

$$\tilde{z}_{nt}B = \ln[u_2(l_{nt},1,c_{nt},z_{nt})/\eta\gamma_2(z_{nt})] \tag{3.6}$$

where B is a constant vector. Second, the random variable $\tilde{z}_{nt}B$ is assumed to follow a uniform distribution across the population of active households, with support [0,k], where k is some positive constant (not depending on a^t). Thus for each $n \in N_t$

$$\Pr[\tilde{z}_{nt}B < \Lambda] = \Lambda/k \tag{3.7}$$

The third assumption restricts equilibrium prices via the equation

$$\lambda_t = k_0 w_t^{k_1} \tag{3.8}$$

Our empirical analysis adopts a parameterization which treats the first assumption as a maintained hypothesis, does not impose the second, and tests the third as a specialization. Notice the second assumption has ramifications for the distribution of unobservables. In particular, (3.7) is inconsistent with an assumption, typically made in workforce participation models, that the unobserved characteristics are normally distributed (thereby having unbounded support). Also, under (3.8), d_t is completely determined by w_t if the population distribution is stable. For substituting λ_t out of the constraint associated with (3.1) using (3.8) yields

$$d_t = \sum_{n \in N_t}[c(\eta_n k_0 w_t^{k_1}, w_t, z_{nt}) - \sum_{i=1}^{2} w_t h_i(\eta_n k_0 w_t^{k_1}, w_t, z_{nt})] \tag{3.9}$$

To derive the wage and participation equations, we begin by observing that in a large economy with a competitive equilibrium, the unemployment rate of males at date t, denoted υ_{2t}, is just the probability of a male not working, calculated with respect to the distribution of socioeconomic characteristics across the active population. Hence

$$\upsilon_{2t} = \Pr\{\ln[u_2(l_{1nt},1,c_{nt},z_{nt}))/\eta_n\gamma_2(z_{nt})] < \ln(w_t\lambda_t)\}$$

$$= \Pr\{\tilde{z}_{nt}B < \ln(w_t\lambda_t)\}$$

$$= k^{-1}\ln(w_t\lambda_t) \tag{3.10}$$

The three lines in (3.10) follow from (2.3) (2.6), (3.6) and (3.7) respectively. Define the participation index d_{2nt} to equal 1 if a male participates and 0 otherwise. Appealing to (2.3) (2.6), (3.6) and (3.10) we obtain

$$d_{2nt} = \begin{cases} 1 \text{ if } \tilde{z}_{nt}B \geq k\upsilon_{2t} \\ 0 \text{ if } \tilde{z}_{nt}B < k\upsilon_{2t} \end{cases} \tag{3.11}$$

Also (3.10) and the logarithm of (3.8) imply

$$\ln(w_t) = (1+k_1)^{-1}k\upsilon_{2t} + (1+k_1)^{-1}\ln(k_0) \tag{3.12}$$

Substituting for $\ln(w_t)$ using (3.12), the logarithm of (2.3) becomes

$$\ln(w_{2nt}) = \ln[\gamma_2(z_{nt})] + k(1+k_1)^{-1}\upsilon_{2t} + (1+k_1)^{-1}\ln(k_0) \tag{3.13}$$

for i = 2. (Recall the first assumption linearizes the first expression in (3.13).)

As $k > 0$, wages are said to be countercyclical if $k_1 > -1$ and procyclical if $k_1 < -1$. Moreover estimates of k_1 obtained directly from equation (3.8) may be compared with those estimated from wage and participation and equations. For dividing the coefficient on unemployment in (3.11) by the corresponding coefficient in (3.12), and then subtracting 1 yields k_1. However, while the derivation of models which regress unemployment on wages depends on all three assumptions made above, in our empirical analysis we can directly estimate k_1 and test the restrictions implied by (3.8) without invoking the second one.

With some minor modifications to the analysis presented in the first part of this section, our framework predicts that $k_1 \leq 0$ providing (3.8) holds. This prediction intersects with classical beliefs if and only if $-1 \leq k_1 \leq 0$. As before, suppose preferences are additive between current consumption and leisure; then (3.3) implies $\ell n(\lambda_t)$ decreases in $\ell n(w_t)$. Likewise, from the discussion surrounding (3.4) and (3.5), it then follows that $\ell n(\lambda_t)$ and $\ell n(w_t)$ have a negative covariance if the probability density of $\ell n(d_t)$ conditional on $\ell n(w_t)$ has a monotone likelihood ratio. But under (3.8), $\ell n(\lambda_t)$ and $\ell n(w_t)$ are perfectly correlated, and the sign of k_1 determines whether this correlation is negative or positive.

4. AN EMPIRICAL SPECIFICATION

Parameterizing Preferences and Labor Productivity

Our data consist of observations on married couples plus their dependents. Accordingly, denote by l_{1nt} the wife's leisure in the n^{th} family during the t^{th} period, l_{2nt} the husband's, c_{nt} the household's current consumption and assume $u(l_{nt},c_{nt},z_{nt})$ takes the form

$$u(l_{nt},c_{nt},z_{nt}) = \delta_0(z_{nt})c_{nt}^{\rho}l_{1nt}^{(1-\nu)\rho_0} + \nu\delta_1(z_{nt})l_{1nt}^{\rho_1} + \delta_2(z_{nt})l_{2nt}^{\rho_2} \qquad (4.1)$$

where $\nu \varepsilon \{0,1\}$.

The measure of current consumption we adopt is food expenditures. Presumably the household's marginal utility for food depends on the family's size, age and possibly sex composition. Furthermore, given the variety of choices available to shoppers over the degree to which ingredients for snacks and meals are processed, we should think household members, especially the mother, spend different amounts of homemaking time in food preparation. So, following Becker (1965), it is plausible to postulate utility from current consumption is generated by a home production function which depends nonadditively on female time spent homemaking and market inputs. For computational reasons, however, the analysis is restricted to the cases $\nu \varepsilon \{0,1\}$; thus ν is an indicator variable which determines whether current utility is separable in female nonmarket time and consumption or not.

The utility indices $\delta_i(z_{nt})$ and the efficiency indices $\gamma_i(z_{nt})$ are log linear in z_{nt}. (Thus the representation given by (3.6) holds.) More specifically, let x_{nt} be a k x 1 column vector of exogenously given socio-economic time varying attributes of the household such as its size, age and sex composition, observed by the econometrician. Suppose certain other characteristics denoted by u'_{in}, v_{in}, u_{int} and v_{int} are not observed. Letting B_{1i} and B_{2i} denote k x 1 column vectors of parameters to be estimated, then

$$\ln[\delta_i(z_{nt})] = x'_{nt}B_{1i} + u'_{in} + u_{int} \qquad i \in \{0,1,2\} \tag{4.2}$$

$$\ln[\gamma_i(z_{nt})] = x'_{nt}B_{2i} + v_{in} + v_{int} \qquad i \in \{1,2\} \tag{4.3}$$

The disturbance vector (u_{int}, v_{int}) is distributed bivariate normal for $i \in N$ and period $t \in T$, with covariance matrix comprising elements σ^2_{iu}, σ_{iuv} and σ^2_{iv}. (This assumption, which violates (3.7), is only used when estimating the participation equations.) Also, because of the nature of the data, we allow for measurement error in consumption. Measured consumption, denoted $\tilde{c}_{nt}$, is distributed about actual consumption such that

$$\ln(\tilde{c}_{nt}) = \ln(c_{nt}) + u_n + u_{nt} \tag{4.4}$$

where u_{nt} is identically and independently distributed over $(n,t) \in N \times T$ with variance σ^2.

The Data

The data on households used in our study come from the Panel Study of Income Dynamics (PSID). Out of a total of 6,852 households included in the survey as of 1983, we selected households composed of couples who had remained married throughout the period 1968 to 1981. In addition, we eliminated households that came from the nonrandom U.S. Census sample, who did not have a usable variable for the age of the household head, the sex of the household head, the age of the wife, the education of the head, and had heads older than 46 years in 1968. Taken together, these criteria reduced our sample to 546 households. We selected two subsamples from this sample. The first was chosen such that both the head of the household and the wife had worked at least once during the sample period. The number of households for which this was true was 497. The second subsample was chosen to have heads who had worked every year of the sample period and wives who had worked at least once. These criteria reduced the number of households to 455. Tables A1 and A2 in the appendix provide some summary statistics about the characteristics of the households in the two subsamples.

Let date t denote the calendar year (t + 1967). For each household $n \in \{1,\ldots,N\}$, we have data on

(a) leisure by the wife l_{1nt} and the husband l_{2nt} for $t \in \{1,\ldots,14\}$

(b) wage rates of wives w_{1nt} and husbands w_{2nt} who worked for $t \in \{1,\ldots,14\}$

(c) household food consumption c_{nt} for $t \in \{2,3,4,5,7,\ldots,14\}$

(d) births b_{nt} for $t \in \{1,\ldots,14\}$

(e) number of household members f_{nt} for $t \in \{1,\ldots,14\}$

(f) labor market experience by the wife t_{1nt} and the husband t_{2nt} for $t \in \{1,\ldots,14\}$

(g) household income I_{nt} for $t \in \{1,\ldots,14\}$

(h) house value H_{nt} for $t \in \{1,\ldots,14\}$

(i) rent value and imputed rental value of free housing, R_{nt} for $t \in \{1,\ldots,14\}$

We also used observations on stock and bond returns, denoted $\pi_t(r)$, for $r \in \{1,2\}$ and the aggregate unemployment rate υ_t. The appendix describes how all the variables were constructed.

5. ESTIMATION AND TESTING

Labor Supply and Participation

The first set of results, reported in Table 1, are derived from the labor supply decisions of each spouse within the household. Equations (2.6) and (2.7), the first order conditions for household leisures and consumption, together with equation (2.3), which characterizes the wage function, form the basis for the maximum likelihood estimators used in this phase.

Given the empirical specification for preferences and labor productivities, the logarithms of (2.7), (2.6) and (2.3) may be expressed as

$$(\rho-1)\ln(c_{nt}) + (1-\nu)\rho_0\ln(l_{1nt}) + x'_{nt}B_{10} - \ln(\lambda_t)$$

$$= \ln(\eta_n/\rho) - u'_{0n} - u_{0nt}$$

$$(\rho_\nu-1)\ln(l_{1nt}) - \ln(\lambda_t w_t) + (1-\nu)\rho\ln(c_{nt}) + x'_{nt}(B_{1\nu} - B_{21})$$

$$\leq \ln(\eta_n) - (1-\nu)\ln(\rho_\nu) - u'_{\nu n} + v_{1n} - u_{\nu nt} + v_{1nt}$$

$$(\rho_2-1)\ln(l_{2nt}) - \ln(\lambda_t w_t) + x'_{nt}(B_{12} - B_{22})$$

$$\leq \ln(\eta_n/\rho_2) - u'_{2n} + v_{2n} - u_{2nt} + v_{2nt}$$

$$\ln(w_{int}) = \ln(w_t) + x'_{nt}\beta_{2i} + v_{in} + v_{int} \qquad i \in \{1,2\} \tag{5.1}$$

Using the top equation to substitute $\ln(c_{nt})$ out of the second one and re-arranging implies

$$l'_{1nt} \geq u_{\nu nt} + (1-\nu)\rho u_{0nt}/(1-\rho) - v_{1nt}$$

$$l'_{2nt} \geq v_{2nt} - u_{2nt} \tag{5.2}$$

where

$$l'_{1nt} = [1-\rho_\nu - \rho\rho_0(1-\nu)/(1-\rho)]\ell n(l_{1nt}) + \ell n(w_t) + [1+\rho(1-\nu)/(1-\rho)]\ell n(\lambda_t)$$

$$+ [v_{1n} - u'_{\nu n} + \ell n(\eta_n) - \rho(1-\nu)(u'_{0n} - \ell n(\eta_n))/(1-\rho)]$$

$$- [\ell n(\rho_\nu) + (1-\nu)\rho(1-\rho)^{-1}\ell n(\rho)] - x'_{nt}[B_{1\nu} - B_{21} + (1-\nu)\rho B_{10}/(1-\rho)]$$

$$l'_{2nt} = (1-\rho_2)\ell n(l_{2nt}) + \ell n(w_t\lambda_t) + [v_{2n} - u'_{2n} - \ell n(\eta_n/\rho_2)] - x'_{nt}(B_{12} - B_{22}) \tag{5.3}$$

Now let the participation index d_{int} be 1 the i^{th} member of the n^{th} household works in the labor market and 0 otherwise. Then

$$d_{1nt} = \begin{cases} 1 \text{ if } l'_{1nt} = u_{1nt} + (1-\nu)\rho u_{0nt}/(1-\rho) - v_{1nt} \\ 0 \text{ if } l'_{1nt} < u_{1nt} + (1-\nu)\rho u_{0nt}/(1-\rho) - v_{1nt} \end{cases}$$

$$d_{2nt} = \begin{cases} 1 \text{ if } l'_{1nt} = u_{2nt} - v_{2nt} \\ 0 \text{ if } l'_{2nt} < u_{2nt} - v_{2nt} \end{cases} \tag{5.4}$$

For each spouse $i \in \{1,2\}$ let σ_{1i} denote the standard deviation of the composite disturbance in equation (5.3) and σ_{2i} the covariance between this disturbance and the idiosyncratic wage shock. Then,

$$\sigma_{1\nu}^2 = \sigma_{1v}^2 + \nu(\sigma_{1u}^2 - 2\sigma_{1uv}) + (1-\nu)[(1-\rho)^{-2}\sigma_{0u}^2 - 2(1-\rho)^{-1}\sigma_{0uv}]$$

$$\sigma_{12}^2 = \sigma_{2v}^2 + \sigma_{2u}^2 - 2\sigma_{2uv}$$

$$\sigma_{2\nu} = \nu\sigma_{1uv} + \rho(1-\nu)/(1-\rho)\ \sigma_{0uv} - \sigma_{2v}^2$$

$$\sigma_{22} = \sigma_{2uv} - \sigma_{2v}^2 \tag{5.5}$$

Let u_{in} for $i \in \{1,2\}$ denote the (composite) fixed effects in equation (5.3):

$$u_{\nu n} = [v_{1n} - u'_{\nu n} + \ell n(\eta_n) - \rho(1-\nu)(u'_{on} - \ell n(\eta_n)/(1-\rho)]$$

$$- [\ell n(\rho_\nu) + (1-\nu)\rho(1-\rho)^{-1}\ell n(\rho)]$$

$$u_{2n} = [v_{2n} - u'_{2n} - \ell n(\eta_n/\rho_2)] \tag{5.6}$$

Also, define $\tilde{\rho}$, $\tilde{\lambda}_t$ and $\tilde{\beta}_1$ as

$$\tilde{\rho} = 1-\rho_\nu - \rho\rho_0(1-\nu)/(1-\rho)$$

$$\ell n(\tilde{\lambda}_t) = [1+\rho(1-\nu)/(1-\rho)]\ell n(\lambda_t)$$

$$\tilde{\beta}_{1\nu} = \beta_{1\nu} + (1-\nu)\rho\beta_{10}/(1-\rho) \tag{5.7}$$

The log likelihood for the nonmarket time of the i^{th} spouse belonging to the n^{th} household is then

$$L_\omega(\alpha_\omega,n) = \sum_{t=1}^{T}\{(1-d_{int})\ln\Phi(\sigma_{1i}^{-1}l_{int}') + d_{int}\ln\phi(\sigma_{1i}^{-1}l_{int}') +$$

$$d_{int}\ln\phi[\frac{\ln(w_{int}) - x_{nt}B_{2i} - l_{int}'\sigma_{2i}\sigma_{1i}^{-1}}{(\sigma_{iv} - \sigma_{2i}\sigma_{1i}^{-1})^{-1/2}}]\} \qquad (5.8)$$

where ϕ and Φ are respectively the standard normal density and cumulative distribution functions, and α_i, the identified parameters, are defined for $i \in \{1,2\}$ as

$$\alpha_1 = (\tilde{\rho},\tilde{\beta}_{1\nu},\beta_{21},\tilde{\lambda}_t,w_t,\sigma_{1\nu}^2,\sigma_{2\nu},\sigma_{1v}^2)'$$

$$\alpha_2 = ((1-\rho_2),\beta_{12},\beta_{22},\lambda_t,w_t,\sigma_{12}^2,\sigma_{22},\sigma_{2v}^2)' \qquad (5.9)$$

Defining the vector of (observed) socio-economic characteristics for household n as

$$x_{nt} = (b_{nt}, \sum_{s=1}^{2}b_{n,t-s}, \sum_{s=3}^{5}b_{n,t-s}, \sum_{s=6}^{14}b_{n,t-s}, f_{nt}-\sum_{s=0}^{14}b_{n,t-s}, f_{nt}, t_{1nt}^2, t_{2nt}^2) \qquad (5.10)$$

the ML estimates reported in Table 1 can be found by summing over $n \in N$ and maximizing with respect to α_i and the fixed effects $\{u_{in},v_{in}\}_{n\epsilon N}$.

This procedure follows the approach Heckman and MaCurdy (1980) took. They considered a model of female workforce participation and labor supply in which individuals possess perfect foresight and credit markets are complete, with borrowing and lending occurring at the constant rate r. Ruling out intertemporal arbitrage in their economy means the $\{\lambda_t\}_{t=1}^{\tau}$ sequence must satisfy

$$\lambda_t = \lambda_0 e^{-rt} \tag{5.11}$$

They also assumed that (the logarithm of) individual wages grew with a quadratic in labor market experience. In our notation, this may be written as

$$\ell n(w_{int}) = B^1_{21} (t_{int}) + B^2_{2i}(t_{int})^2 + \tilde{v}_{in} + v_{int} \tag{5.12}$$

Notice that the effect on (log) wages of a linear experience term t_{int} plus some individual-specific component $\tilde{v}_{in}$ cannot be distinguished from the effect of a simple linear trend plus an appropriately redefined fixed effect. Therefore the behavior implied by (5.12) is identical to behavior implied by

$$\ell n(w_{int}) = \eta_2 t + B^2_{2i} (t_{int})^2 + v_{in} + v_{int} \tag{5.13}$$

Comparing equations (2.18) with (5.11) and (5.1) with (5.13) shows that Heckman and MaCurdy's model is an important specialization of our framework, with

$$(\lambda_t, w_t) = (e^{-rt}, e^{-\eta_2 t}) \tag{5.14}$$

Column (A) of Table 2 presents ML estimates of the wife's coefficients without any restrictions on the sequence of time effects; column (B) restricts them according to (5.14) while column (C) imposes restriction (3.8). Regardless of which specification is adopted, the elasticity of labor supply is roughly 1.5 when identified in the usual manner by dividing the experience squared coefficient in the leisure equation by the corresponding term in the wage equation. (This method assumes marginal productivity at home is a lower order polynomial than quadratic.) With one notable exception, household members of different ages have a negative effect on the wife's labor supply; most of the coefficients are significant and their magnitudes are similar across specifications. The exception occurs for specification (B) where the effect of offspring between 1 and 2 years old is estimated positive and significant.

The estimates of both sequences of coefficients for the time dummies rise monotonically over time. Nevertheless, the log linear trend implied by (B) is rejected by the likelihood ratio test against either of the two less restricted models. The criterion value and the parameter estimates obtained for specifications (A) and (C) are virtually identical; imposing the constraint (3.8) merely tightens the estimated standard errors on the time dummy coefficients. Finally we obtain an estimate of 0.4 for k_1 with a standard error of 0.1: based on information about female participation and labor supply, we find evidence that average real wages are countercyclical. Although this estimate meshes with classical beliefs, it is at odds with the predictions in Section 3 and, as such, might be interpreted as evidence against the model.

Column (D) of Table 1 presents our estimates of the husband's labor supply and wage equations. Because the coefficients on household members are all positive but insignificant, they were restricted to be the same in the latter stages of the estimation. Also, for this group of males, sample selection bias induced by excluding nonparticipants does not appear important (since our estimate of the correlation coefficient ρ_{22} is insignificant). It is therefore less likely our test results below (derived from estimates for the smaller sample of males who participate each period) are seriously biased.

Household Consumption and Male Leisure

Once males who do not participate in the labor force every period are excluded from the sample, we can construct estimators from the marginal rate of substitution function between male leisure time and (food) consumption, as do MaCurdy (1983) and Altonji (1986). In addition, however, we can test alternative versions of the complete markets hypothesis by augmenting the marginal rate of substitution function with conditions for the marginal utility for food consumption, the husband's marginal utility of leisure and the husband's wage equation.

These equation systems were estimated using GMM. (See Hansen [1982].) Denote by ω a particular system of equations, α_ω the identifiable parameters in that system, $f_\omega(\alpha_\omega,n)$ a vector of orthogonality conditions for the n^{th} observation, and A_ω a positive definite matrix conformable to $f_\omega(\alpha_\omega,n)$. Consistent estimates are then obtained by solving for

$$V_\omega = \min_{\alpha_\omega}\{[\tfrac{1}{N}\textstyle\sum_{n=1}^{N} f_\omega(\alpha_\omega,n)']A_\omega[\tfrac{1}{N}\textstyle\sum_{n=1}^{N} f_\omega(\alpha_\omega,n)]\} \tag{5.15}$$

For our application the smallest asymptotic covariance matrix within this class of estimators is found by making A_ω the inverse of $\hat{A}_\omega \equiv E[f_\omega(\alpha_\omega,n)f_\omega(\alpha_\omega,n)']$. In this case, the resulting estimator has an asymptotic covariance matrix of $(D_\omega'\hat{A}_\omega^{-1}D_\omega)^{-1}$ where $D_\omega \equiv E[\partial f_\omega(\alpha_\omega,n)/\partial\alpha_\omega]$.

The method of moments approach provides a convenient framework for conducting specification tests associated with the complete markets hypothesis. Suppose the null hypothesis imposes J extra orthogonality conditions in addition to those imposed under the alternative, and that there are K additional parameters to estimate. Then, by a result in Eichenbaum, Hansen and Singleton (1986), the test statistic $N(V_\omega - V_\xi)$ is distributed χ^2 with (J-K) degrees of freedom (df), where V_ω and V_ξ denote respective the values of the minimized criterion functions defined by (5.15).

Conditioning on the aggregate shocks has ramifications for how to construct the orthogonality conditions and the optimal weighting matrix. Our estimation strategy does not impose any assumptions on the time series properties of aggregate shocks; its main drawback stems from estimating time dummies for each period. (See Mundlak [1978].) More specifically, suppose theory delivers equations of the form

$$\varepsilon_{\omega nt} = g_\omega(\alpha_\omega, l_{nt}, c_{nt}, z_{nt}, \tilde{a}^t), \tag{5.16}$$

where $\varepsilon_{\omega nt}$ is an $r_\omega \times 1$ vector with $E_t(\varepsilon_{\omega nt}) = 0$. Orthogonality conditions can be formed for each $t \in \{1,\ldots,T\}$ with a q-dimensional instrument vector y_{nt} that satisfies the equation $E(\varepsilon_{\omega nt} \otimes y_{nt} | \tilde{a}^t) = 0$. It is unreasonable to assume aggregate shocks are serially uncorrelated; typically $E(\tilde{a}_t \tilde{a}'_{t+1}) \neq 0$. Consequently $E[(\varepsilon_{\omega nt} \otimes y_{nt})(\varepsilon_{\omega nt} \otimes y_{nt})' | \tilde{a}^t]$ depends on $\tilde{a}^t$, if only because y_{nt} (which includes elements representing past choices and outcomes of household n) is affected by previous aggregate shocks a^t. For this reason, we define the rqT dimensional vector $f_\omega(\alpha_\omega, n)$ as

$$f_\omega(\alpha_\omega, n)' = ((\varepsilon_{\omega n1} \otimes y_{n1})', \ldots, (\varepsilon_{\omega nT} \otimes y_{nT})') \tag{5.17}$$

Hence, $\hat{A}_\omega$ is a square rqT dimensional matrix.

Except where indicated below, the same instruments where used for each component ω (which explains why y_{nt} is not subscripted by ω). Here the 10 x 1 instrument vector y_{nt} used was

$$y'_{nt} = (t^2_{2nt}, \ell n(w_{2n,t-2}), \sum_{s=1}^{2} b_{n,t-s}, \upsilon_t, l_{1n,t-2}, \sum_{s=6}^{14} b_{n,t-s}, \quad (1-d_{1nt})\ell n(w_{1n,t-2}), H_{nt}, R_{nt}, I_{n,t-2}) \tag{5.18}$$

where the variables are defined in our description of the data.

Tables 2 and 3 present estimates obtained by combining six different sets of orthogonality conditions associated with household (food) consumption and the husband's leisure decisions. To derive the first set, corresponding to the estimates in Column (A) of Table 2, consider condition (2.20) describing the marginal rate of substitution between food consumption and husband's leisure. Using (4.1) and (4.2) to evaluate this expression, take logarithms and difference to eliminate fixed effects to obtain

$$\Delta\ell n(\ell_{2nt}) + (\rho-1)(1-\rho_2)^{-1}\Delta\ell n(c_{nt}) + (1-\nu)\rho_0(1-\rho_2)^{-1}\Delta\ell n(\ell_{1nt})$$

$$+ (1-\rho_2)^{-1}\Delta\ell n(w_{2nt}) - \Delta x'_{nt}(B_{12}-B_{10})/(1-\rho_2) = (1-\rho_2)^{-1}\ (\Delta u_{0nt}+\Delta u_{2nt}) \tag{5.19}$$

Now replace the logarithm of true consumption by its measured counterpart, $\ell n(\tilde{c}_{nt})$, multiply the resulting scalar error term with y_{nt} and stack (the 9 years of available data) into the 90 x 1 dimensional vector $f_3(\alpha_3,n)$ where, with reference to (5.17) and (5.18),

$$\varepsilon_{3nt} = (1-\rho_2)^{-1}[\Delta u_{0nt} + \Delta u_{2nt} + (\rho-1)\Delta u_{nt}]$$

$$\alpha_3' = ((\rho-1)/(1-\rho_2),\ (1-\nu)\rho_0/(1-\rho_2),\ 1/(1-\rho_2),(B_{12}'-B_{10}')/(1-\rho_2))) \qquad (5.20)$$

Unfortunately little can be gleaned from the data at this level of generality. Although there is little evidence against the model, since the χ^2 critical value (for a .05 level test with 84 df is approximately 110 which exceeds the minimized criterion function value of 89), none of the coefficients are significant.

Our first test of the complete markets hypothesis is derived by adding the conditions associated with the household's marginal of consumption in equilibrium to the orthogonality conditions formed from (5.19). For this purpose, difference the top equation in (5.1) and substitute $\Delta\ell n(\tilde{c}_{nt})$ for $\Delta\ell n(c_{nt})$. Then

$$\Delta\ell n(\tilde{c}_{nt}) - (1-\nu)\rho_0(1-\rho)^{-1}\Delta\ell n(l_{nt}) - \Delta x'_{nt}B_{10}/(1-\rho)$$

$$+ (1-\rho)^{-1}\Delta\ell n(\lambda_t) = (1-\rho)^{-1}(\Delta u_{0nt} + \Delta u_{nt}) \qquad (5.21)$$

The orthogonality conditions $f_4(\alpha_4,n)$ are obtained by augmenting $f_3(\alpha_3 n)$ with those from (5.21); it is a 180 x 1 vector. Observe the coefficient on the wife's leisure $\Delta\ell n(l_{1nt})$ is restricted across (5.19) and (5.21). Hence the 2 x 1 disturbance ε_{4nt} and the parameter vector α_4 are defined as

$$\varepsilon'_{4nt} = (\varepsilon_{3nt},(1-\rho)^{-1}(\Delta u_{0nt} + \Delta u_{nt}))$$

$$\alpha_4' = (\alpha_3',\ \beta_{10}'/(1-\rho),\ \Delta\ell n(\lambda_t)/(1-\rho)) \qquad (5.22)$$

With 166 df and a test statistic of 151 the overidentifying restrictions are not rejected. (To calculate critical regions, we assumed a χ^2 random variable with df exceeding 100 is approximately normal with mean and variance respectively equal to df and 2 df. Under this approximation, the critical value for a test of size .05 is ± 1.645 while the value of the test statistic is -0.82.) Likewise, the additional orthogonality conditions from (5.21) are accepted at the .05 level. (The test statistic is the difference between the criterion functions, 62, whereas the critical value, 102, is found from a χ^2 table with 80 df.) Nevertheless none of the preference parameters are significant; nor are the time dummies individually significantly different from 1.

Another way of conducting this exercise uses the husband's marginal utility of leisure first order condition instead of the household's first order condition for consumption. Assuming the third line in (5.1) is met with equality when i = 2, first differencing yields

$$\Delta \ell n(l_{2nt}) - (1-\rho_2)^{-1}\Delta \ell n(w_{2nt}) - \Delta x'_{nt}B_{12}/(1-\rho_2)$$
$$- (1-\rho_2)^{-1}\Delta \ell n(\lambda_t) = (1-\rho_2)^{-1}\Delta u_{2nt} \qquad (5.23)$$

Now orthogonality conditions constructed from (5.22) are used to augment $f_3(\alpha_3,n)$. Denote the new set $f_5(\alpha_5,n)$; it is a 200 x 1 dimensional vector because (5.23) may be evaluated for $t \in \{4,\ldots,14\}$. Noting the single cross-equation restriction on the coefficient of $\Delta \ell n(l_{2nt})$, the disturbance ε_{5nt} and the parameter vector are respectively α_5 defined as

$$\varepsilon'_{5nt} = (\varepsilon_{3nt}, (1-\rho_2)^{-1}\Delta u_{2nt})$$

$$\alpha'_5 = (\alpha'_3, \beta'_{12}/(1-\rho_2), \Delta\ell n(\lambda_t)/(1-\rho_2)) \qquad (5.24)$$

Here evidence against the existence of complete markets is found. Under the normal approximation to the χ^2 distribution, the significance level associated with the minimized criterion function is less than .05. Moreover, the overidentifying restrictions associated with (5.22) are strongly rejected. (Our test statistic of 170 is the difference between the minimized criterion values in columns (A) and (C) of Table 2. With 100 df, it exceeds the critical value of 124 for a .05 size test.) Comparing across columns, coefficient estimates for the marginal rate of substitution function all lie within a standard deviation of each other, and appear to be more precisely estimated when this function is augmented by the first order condition associated with the husband's leisure choice. In particular, the coefficient on wage changes is significant; it implies the elasticity of labor supply is -19.

If orthogonality conditions for the wage equation are added to $f_5(\alpha_5,n)$, we can test restrictions on the $\{\lambda_t, w_t\}_{t=1}^{T}$ sequence. For this purpose, the wage equation in (5.1) is first differenced. Setting $i = 2$,

$$\Delta\ell n(w_{2nt}) - \Delta x'_{nt}B_{22} - \Delta\ell n(w_t) = \Delta v_{2nt} \qquad (5.25)$$

Now the number of orthogonality conditions increases by 110 and $f_6(\alpha_6,n)$ is constructed from

$$\varepsilon'_{6nt} = (\varepsilon'_{5nt}, \Delta v_{2nt})$$

$$\alpha_6' = (\alpha_5', B_{22}') \tag{5.26}$$

Column (A) of Table 3 reports the unrestricted estimates. The marginal significance level is 0.756 so this specification cannot be rejected. Because most of the time dummies have insignificant coefficient estimates, we imposed the constraints (5.24) below to assess the importance of aggregate shocks and life cycle effects

$$(\lambda_t, w_t) = (1,1) \tag{5.27}$$

Column (C) presents our findings. The minimized criterion value rose to 337; given 304 df, the normal approximation to the χ^2 the test statistic is 1.346 so the specialization cannot be rejected. However, when compared with the value obtained for the unrestricted version, the restrictions implied by (5.27) are rejected. (Compare the value of the test statistic 48 with the critical number of 34 for a .05 size test.) This second finding, which bears directly upon the applicability of (5.27), confirms previous studies on males which show these effects are significant.

The restrictions described by (3.8) were also examined, from two angles. First, comparing Columns (A) and (B), the difference between the minimized criterion function values is 38, which exceeds 18 the critical number for .05 size test with 10 df. This result suggests that using the unemployment rate to measure aggregate shocks in a wage regression is too restrictive. Second, the null hypothesis of no aggregate effects (5.27) is not rejected against the alternative hypothesis of (3.8). (The difference between the minimized criterion functions in columns (B) and (C) of Table 3 is

10 while the critical number for a .05 size test with 12 df is 21). By starting out with this specification, one might conclude aggregate shocks enter insignificantly in household choices.

When (3.8) is imposed, the resulting estimate of k_1, 0.4, is strikingly close to that obtained for females, but the standard error is much larger. Here, neither the predictions of the classicists nor those of our framework are refuted. Using the procedure outlined in Section 3, our estimates of k_1 can be compared with those obtained by Keane, Moffitt and Runkle (1987). Their results imply k_1 is negative varying in magnitude between -97 and -12, depending on how heterogeneity amongst individuals gets treated. These values tend to support our predictions more than our own estimates do (perhaps because their study measures changes in the unemployment rate directly rather than inferring it from estimated prices).

Regardless of the specification used, however, the preference parameters were not affected much. In particular, the coefficient on the wife's leisure time, $(1-\nu)\rho_0/(1-\rho_2)$ is never significantly different from zero for any set of estimates reported in Tables 2 and 3. According to our specification, whether utility is separable in consumption and the wife's leisure time cannot be identified from her labor supply and wage equations alone, as an inspection of (5.3) shows. And, while a test of separability can be based on the marginal utility of consumption condition (or, equivalently on the marginal rate of substitution condition for male leisure and consumption), our results indicate that the null hypothesis of separability cannot be rejected.

Financial Assets

Our interest in separability is partly motivated by its implications for estimating intertemporal asset pricing models. In our framework, an asset pricing equation can be derived from equation (2.11) and the restrictions in (2.18). That is

$$E_t[\beta(\lambda_{t+1}/\lambda_t)\ \pi_t(r)] = 1 \tag{5.28}$$

By estimating (5.28) in conjunction with other equations in the model (in order to identify λ_{t+1}/λ_t), we can test the over-identifying restrictions associated with this equation. Notice that if $\delta_0(z_{nt})$ is time-invariant, $\nu = 1$ and markets are complete, estimates of β and ρ can be obtained from aggregate time series data on consumption and asset returns. To see this, make c_{nt} the subject of (2.7), evaluate $u_3(l_{nt}, c_{nt}, z_{nt})$ using (4.1) and take expectations over the population; then take logarithms and first difference to obtain

$$(\rho-1)\Delta\ell n(E[c_{nt}]) = \Delta\ell n(\lambda_t) + (\rho-1)\Delta\ell nE[\eta_n^{1/(\rho-1)}\delta_0(z_{nt})^{1/(1-\rho)}l_{1nt}^{(1-\nu)\rho_0/(1-\rho)}] \tag{5.29}$$

Given the conditions above, the second term on the right hand side of (5.29) is zero, so $[E(c_{nt})/E(c_{n,t-1})]^{\rho-1}$ may be substituted for λ_t/λ_{t-1} in (5.28). Therefore, following Hansen and Singleton (1982), the parameters β and ρ may be estimated using instrumental variables techniques. In our framework, the method outlined above yields biased results if $\nu = 1$ and/or $\delta_0(z_{nt})$ is not constant over time.

Our estimation procedure adapts, to a GMM setting, the analyses of Chetty (1968) and Zellner (1971) for linear models which pool time series data with cross sectional data. Here we must assume that aggregate shocks are stationary and ergodic. Two returns series were used, the annual real return for the value-weighted index of stocks on the NYSE, denoted π_{1t}, and the annual return from holding 3-month Treasury bills, denoted π_{2t}. A 4 x 1 vector of orthogonality conditions was then constructed, with the lagged returns as instruments, taking the form

$$f(\alpha_7,t)' = [\beta\pi_{1t}(\lambda_{t+1}/\lambda_t) - 1,\ \beta\pi_{2t}(\lambda_{t+1}/\lambda_t) - 1] \otimes (\pi_{1,t-1},\pi_{2,t-1}) \qquad (5.30)$$

where $\alpha_7' = (\alpha_6',\beta)$. The orthogonality conditions $f_6(\alpha_6,n)$ and $f(\alpha_7,t)$ were then combined by defining $f_7(\alpha_7,j)$ for $j \in \{1,\ldots, N+T\}$ as

$$f_7(\alpha_7,j)' = \begin{cases} (f_6(\alpha_6,j)',0) & \text{if } 1 \le j \le N \\ (0,f(\alpha_7,j-N)') & \text{if } N < j \le N+T \end{cases} \qquad (5.31)$$

Because ε_{6nt} is orthogonal to the forcaste error in the asset pricing equation, it follows that $E[f_7(\alpha_7,j) \otimes f_7(\alpha_7,k)'] = 0$ whenever $j \neq k$. Hence the optimal weighting matrix is $\hat{A}_7$, defined following (5.15) by setting $\omega = 7$. Upon substituting the sample moment for $E[f_7(\alpha_7,j) \otimes f_7(\alpha_7,k)']$ into the criterion function, some matrix algebra shows V_7 defined in (5.14) simplifies to

$$(N+T)V_7 = \min_{\alpha_7}\{[\sum_{n=1}^{N} f_6(\alpha_6,n)'][\sum_{n=1}^{N} f_6(\alpha_6,n)f_6(\alpha_6,n)']^{-1}[\sum_{n=1}^{N} f_6(\alpha_6,n)]$$

$$+ [\sum_{t=1}^{T} f(\alpha_7,t)'][\sum_{t=1}^{T} f(\alpha_7,t)f(\alpha_7,t)']^{-1}[\sum_{t=1}^{T} f(\alpha_7,t)]\} \qquad (5.32)$$

Table 4 reports our findings. They support those of Hansen and Singleton (1982), Mankiw, Rotemberg and Summers (1985), Dunn and Singleton (1986), and Eichenbaum, Hansen aad Singleton (1987) who analysed time series data on aggregate consumption and returns by exploiting the first order conditions from a representative consumer model. Under the null hypothesis the normal approximation to the χ^2 test statistic for the overidentifying restrictions of the unrestricted model is 2.35 which exceeds the .05 critical value (of 1.96) but not the .01 number (of 2.58). Comparing column (A) in Tables 3 and 4, we see the four orthogonality conditions associated with the asset pricing equation are strongly rejected. (Adding these conditions entails estimating an additional parameter. Consequently, the test statistic, 52, is distributed χ^2 with 3 df, which exceeds 11.3, the critical value for a .01 level test.) Imposing the restrictions (3.8) yields similar results; the test statistics for the constrained model are respectively 2.43 and 27. Finally, our estimate of the (annual) subjective discount factor β, .83, is not affected by whether the restrictions (3.8) are imposed or not.

Household Consumption and Labor Supply

Viewed collectively, Tables 1 through 4 show most of the evidence against the assumption of complete markets comes from data on asset prices. We now subject our model to one final test which utilizes only panel data. If markets are complete, both spouses have access to them; therefore estimates of the $\{w_t, \lambda_t\}_{t=1}^{\tau}$ sequence should not significantly differ by sex. Accordingly we augmented $f_6(\alpha_6, n)$, the orthogonality conditions used to estimate the marginal rate of substitution function, the first order condition characterizing the husband's leisure and his wage equation, with orthogonality conditions derived from the wife's marginal utility of leisure and wage equations. Based on the evidence contained in Tables 2 through 4, we restricted preferences to be additively separable with respect to consumption and wife's leisure time. Following Hotz and Miller (1987), the orthogonality conditions associated with the wife's equations were formed from the scores to the log likelihood, which have an unconditional expectation of zero. That is, since $E\{\partial \ell n[L_1(\alpha_1,n)/\partial\alpha_1]\} = 0$, we may construct orthogonality conditions $f_8(\alpha_8,n)$ of the form

$$f_8(\alpha_8,n)' = (f_6(\alpha_6,n)', \partial \ell n[L_1(\alpha_1,n)/\partial\alpha_1]') \tag{5.32}$$

where α_8 is the union of elements comprising α_1 and α_6.

To derive the estimates in Table 5 the cross equation restrictions between the time dummies which appear in the husband's marginal utility of leisure and wage equations and the scores from the log likelihood for the wife's leisure and wages were imposed. We also allowed for a linear time trend in the wife's marginal utility of leisure and her wage equation to capture aging differences between the sexes, Nevertheless the specification strongly rejected the constraints implied by the hypothesis that males and females face the same set of aggregate prices $\{\lambda_t, w_t\}_{t=1}^{\tau}$ and have access to the same set of markets. Taken at face value, this rejection is evidence for sexual discrimination, but there are alternative explanations. For example, this framework neglects human capital considerations which may affect males and females differently. Private information is not accounted for either, and with it the possibility that wages might reflect insurance by employers of their workers. (Both these factors may also explain why the orthogonality conditions in the asset pricing equation are rejected.)

6. CONCLUSION

Motivated by previous work that has found evidence for aggregate shocks in panel data which describe household decision making, this paper provides a simple equilibrium representation of them within economies where a complete set of markets exist. The framework developed here nests numerous earlier models on asset pricing, lifecycle labor supply, and wage cyclicality. It provides the means for reexamining these issues within a structural model of competitive equilibrium where the solution to a typical agent's optimization problem is not necessarily an interior point but may lie on the boundary of the choice set. A detailed presentation of our empirical results appears in the previous section, but we should like to conclude with three general remarks about them.

The evidence accumulated against the intertemporal capital asset pricing model based on time series data has led some to suggest that this is because the aggregation conditions necessary for justifying the representative individual paradigm are violated. However our results show this diagnosis is premature. Although the model presented here accommodates partially observed endogenous and exogenous factors which upset aggregation, the observed components are found insignificant at conventional levels, and more to the point, the orthogonality conditions associated with the asset pricing equation are rejected.

Although many analyses of panel data include time dummies to capture intertemporal aggregative effects, much less concern is paid to equilibrium issues than population heterogeneity. Our results indicate that with regards individual labor supply and wage equations, the parameter estimates are moderately insensitive to alternative assumptions about how the production technology and the distribution of heterogeneity across the population are transmitted through equilibrium prices to consumers. Also the model does not reject equilibrium restrictions which are simultaneously imposed across the equations characterizing household consumption, male labor supply and his wages. However, when this system is augmented with the female labor supply and wage equations, not only is the specification jointly rejected, but the estimates and especially their precision is greatly affected.

Recent investigations of panel data which treat unemployment as a regressor in male participation and wage equations have found real wages are procyclical. Our results suggest wages are countercyclical or acyclical. In addition, we find evidence against an assumption which is used to derive the wage-employment regressions as a specialization of our framework. More specifically, this assumption, which deterministically links the marginal rate of substitution between consumption in successive periods to changes in the marginal product of labor, is rejected for males, and when imposed as a maintained hypothesis, leads us to accept the null that aggregate shocks are insignificant.

REFERENCES

Altonji, J. (1986) "Intertemporal Substitution in Labor Supply: Evidence from Micro Data" Journal of Political Economy 94, S176-S215.

Becker, G. S. (1965) "A Theory of the Allocation of Time "Economic Journal 75, 493-517.

Bils, M. (1985) "Real Wages over the Business Cycle: Evidence from Panel Data" Journal of Political Economy 93, 666-689.

Bodkin, R. (1969) "Real Wages and Cyclical Variations in Employment: A Reexamination of the Evidence" Canadian Journal of Economics 2, 353-374.

Browning, M., A. Deaton, and M. Irish (1985) "A Profitable Approach to Labor Supply and Commodity Demands over the Life-Cycle" Econometrica 53, 503-543.

Chamberlain, G. (1984) "Panel Data," in Handbook of Economics, Zvi Griliches and Michael Intriligator, eds. North Holland, Amsterdam and New York.

Chetty, V. (1968) "Pooling of Time Series and Cross Section Data", Econometrica 36,279-290.

Dunn, K. and K. Singleton (1986) "Modeling the Term Structure of Interest Rates Under Nonseparable Utility and Durability of Goods" Journal of Financial Economics 17,27-56.

Eckstein, Z. and K. Wolpin (1987) "Estimating a Market Equilibrium Search Model from Panel Data on Individuals", unpublished manuscript.

Eichenbaum M., L. Hansen and K. Singleton (1987) "A Time Series Analysis of Representative Agent Models of Consumption and Leisure Choice under Uncertainty", Quarterly Journal of Eonomics (forthcoming0.

Ferguson, T. (1967) Mathematical Statistics, A Decision Theoretic Approach, Academic Press, New York.

Geary, P. and J. Kennan (1982) "The Employment-Real Wage Relationship: An International Study" Journal of Political Economy 90,854-871

Hansen, L. (1982) "Large Sample Properties of Generalized Method of Moments Estimators," Econometrica 50, 1029-1054.

__________ and K. Singleton (1982) "Generalized Instrumental Variables Estimation of Nonlinear Rational Expectations Models," Econometrica 50, 1269-1286.

Hayashi, F. (1985) "The Permanent Income Hypothesis and Consumption Durability: Analysis Based on Japanese Panel Data," Quarterly Journal of Economics 100, 1083-1113.

Heckman, J. and T. MaCurdy (1980) "A Life Cycle Model of Female Labor Supply," Review of Economic Studies 47, 47-74.

____________ and G. Sedlacek (1985) "Heterogeneity, Aggregation and Market Wage Functions: An Empirical Model of Self-Selection in The Labor Market," Journal of Political Economy 93, 1077-1125.

Hotz, V., F. Kydland and G. Sedlacek (1987) "Intertemporal Preferences and Labor Supply," Econometrica (forthcoming).

____________ and R. Miller (1987) " An Empirical Analysis of Life Cycle Fertility and Female Labor Supply" Econometrica (forthcoming).

Keane, M., R. Moffitt and D. Runkle (1987) " •Real Wages over the Business Cycle: Estimating the Impact of Heterogeneity with Micro Data" Working Paper No. 87-10 Brown University.

Lucas, R. (1978) "Asset Prices in an Exchange Economy" Econometrica 46, 1429-1445.

MaCurdy, T. (1981) "An Empirical Model of Labor Supply in a Life-Cycle Setting," Journal of Political Economy 89, 1059-1085.

____________ (1983) "A Simple Scheme for Estimating an Intertemporal Model of Labor Supply and Consumption in the Presence of Taxes and Uncertainty," International Economic Review 24, 265-289.

Mankiw, N., J. Rotemberg and L. Summers (1985) "Intertemporal Substitution in Macroeconomics" Quarterly Journal of Economics 100, 225-251.

Miller, R. (1984) "Job Matching and Occupational Choice" Journal of Political Economy 92, 1086-1120.

Mundlak, Y. (1978) "On the Pooling of Time Series and Cross Section Data" Econometrica 46, 69-85.

Neftci, S. (1978) "A Time-Series Analysis of the Real Wages-Employment Relationship" Journal of Political Economy. 86, 281-291.

Sargent, T. (1978) "Estimation of Dynamic Labor Demand Schedules under Rational Expectations," Journal of Political Economy 86, 1009-1044.

Sedlacek, G. and K. Shaw (1984) "An Empirical Model of Life-Cycle Labor Supply and Human Capital Accumulation," unpublished manuscript, Carnegie-Mellon University.

Wolpin, K. (1984) "An Estimable Dynamic Stochastic Model of Fertility and Child Mortality" Journal of Political Economy 92, 852-874.

Zellner, A. (1971) An Introduction to Bayesian Inference in Econometrics Wiley, New York.

TABLE 1

Variable	Coefficient	Estimate (A)	Estimate (B)	Estimate (C)	Coefficient	Estimate (D)
First Order Condition for l_{1nt} and Wage Equation (w_{1nt})						
b_{nt}	$\tilde{B}^1_{1\nu}/\tilde{\rho}$	-0.033 (.023)	-0.028 (0.0004)	-0.032 (0.023)	$B^1_{12}/(\rho_2-1)$	0.005 (0.441)
$\Sigma^2_{s=1} b_{n,t-s}$	$\tilde{B}^2_{1\nu}/\tilde{\rho}$	-0.119 (0.0005)	0.016 (0.0144)	-0.118 (0.001)	$B^2_{12}/(\rho_2-1)$	0.027 (0.989)
$\Sigma^2_{s=3} b_{n,t-s}$	$\tilde{B}^3_{1\nu}/\tilde{\rho}$	-0.128 (0.0003)	-0.131 (0.009)	-0.129 (0.006)	$B^3_{12}/(\rho_2-1)$	0.011 (0.264)
$\Sigma^{14}_{s=6} b_{n,t-s}$	$\tilde{B}^4_{1\nu}/\tilde{\rho}$	-0.024 (0.011)	-0.024 (0.007)	-0.025 (0.011)	$B^4_{12}/(\rho_2-1)$	0.004 (0.040)
$f_{nt} - \Sigma^{\infty}_{s=0} b_{n,t-s}$	$\tilde{B}^5_{1\nu}/\tilde{\rho}$	-0.0009 (0.0002)	-0.001 (0.0006)	-0.001 (0.003)	$B^5_{12}/(\rho_2-1)$	0.0003 (0.001)
$(t_{1nt})^2$ in leisure equation	$B_{21}/\tilde{\rho}$	-0.027 (0.002)	-0.026 (0.013)	-0.028 (0.115)	$B_{22}/(\rho_2-1)$	-0.008 (0.438)
$(t_{1nt})^2$ in wage equation	B_{21}	0.019 (0.900)	0.021 (316.54)	0.019 (86.26)	B_{22}	-0.006 (0.0002)
Variance of disturbance in leisure equation	$\sigma^2_{1\nu}/\tilde{\rho}^2$	0.015 (0.0002)	0.016 (0.0144)	0.015 (0.006)	$\sigma^2_{12}/\rho_2-1^2)$	0.044 (0.229)
Variance of disturbance in wage equation	σ^2_{1v}	0.209 (0.023)	0.199 (0.022)	0.208 (0.024)	σ^2_{2v}	0.019 (0.010)
Covariance of disturbance in leisure and wage equations	$\sigma_{2\nu}/\tilde{\rho}$	0.018 (0.002)	0.014 (0.002)	0.017 (0.002)	$\sigma_{22}/\rho_2-1)$	0.018 (0.010)
Correlation coefficient	$\rho_{1\nu}$	0.318 (0.070)	0.243 (0.067)	0.307 (0.069)	ρ_{22}	0.279 (0.672)
	k_1	—	--	0.412 (0.115)		--
t in leisure equation	$\eta_1/\tilde{\rho}$	--	0.004 (1.476)	--		--
t in wage equation	η_2	--	0.011 (20.964)	--		--

Time Effects

$(\tilde{\lambda}_2 w_2/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.009	1.009	$(\lambda_2 w_2/\lambda_1 w_1)^{(\rho_2-1)}$	1.045
	(0.035)	(0.018)		(0.184)
$(\tilde{\lambda}_3 w_3/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.013	1.013	$(\lambda_3 w_3/\lambda_1 w_1)^{(\rho_2-1)}$	1.050
	(0.034)	(0.025)		(0.209)
$(\tilde{\lambda}_4 w_4/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.019	1.019	$(\lambda_4 w_4/\lambda_1 w_1)^{(\rho_2-1)}$	1.050
	(0.038)	(0.025)		(0.235)
$(\tilde{\lambda}_5 w_5/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.023	1.023	$(\lambda_5 w_5/\lambda_1 w_1)^{(\rho_2-1)}$	1.068
	(0.033)	(0.029)		(0.196)
$(\tilde{\lambda}_6 w_6/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.028	1.028	$(\lambda_6 w_6/\lambda_1 w_1)^{(\rho_2-1)}$	1.069
	(0.041)	(0.027)		(0.234)
$(\tilde{\lambda}_7 w_7/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.033	1.033	$(\lambda_7 w_7/\lambda_1 w_1)^{(\rho_2-1)}$	1.073
	(0.040)	(0.026)		(0.276)
$(\tilde{\lambda}_8 w_8/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.037	1.037	$(\lambda_8 w_8/\lambda_1 w_1)^{(\rho_2-1)}$	1.086
	(0.047)	(0.025)		(0.249)
$(\tilde{\lambda}_9 w_9/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.041	1.041	$(\lambda_9 w_9/\lambda_1 w_1)^{(\rho_2-1)}$	1.075
	(0.041)	(0.020)		(0.218)
$(\tilde{\lambda}_{10} w_{10}/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.046	1.046	$(\lambda_{10} w_{10}/\lambda_1 w_1)^{(\rho_2-1)}$	1.082
	(0.057)	(0.024)		(0.489)
$(\tilde{\lambda}_{11} w_{11}/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.052	1.052	$(\lambda_{11} w_{11}/\lambda_1 w_1)^{(\rho_2-1)}$	1.091
	(0.161)	(0.069)		(0.913)
$(\tilde{\lambda}_{12} w_{12}/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.056	1.056	$(\lambda_{12} w_{12}/\lambda_1 w_1)^{(\rho_2-1)}$	1.099
	(0.081)	(0.028)		(0.607)
$(\tilde{\lambda}_{13} w_{13}/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.060	1.061	$(\lambda_{13} w_{13}/\lambda_1 w_1)^{(\rho_2-1)}$	1.120
	(0.092)	(0.035)		(0.573)
$(\tilde{\lambda}_{14} w_{14}/\lambda_1 w_1)^{1/\tilde{\rho}}$	1.066	1.066	$(\lambda_{14} w_{14}/\lambda_1 w_1)^{(\rho_2-1)}$	1.135
	(0.127)	(0.050)		(0.940)
w_2/w_1	1.023	1.023	w_2/w_1	0.824
	(0.185)	(0.044)		(0.156)
w_3/w_1	1.034	1.034	w_3/w_1	0.883
	(0.189)	(0.059)		(0.195)
w_4/w_1	1.046	1.046	w_4/w_1	0.960
	(0.211)	(0.057)		(0.146)
w_5/w_1	1.057	1.057	w_5/w_1	1.006
	(0.227)	(0.063)		(0.223)
w_6/w_1	1.070	1.070	w_6/w_1	1.016

		(0.254)		(0.060)		(0.314)
	w_7/w_1	1.082 (0.221)		1.082 (0.056)	w_7/w_1	1.046 (0.229)
	w_8/w_1	1.094 (0.246)		1.094 (0.059)	w_8/w_1	1.090 (0.202)
	w_9/w_1	1.104 (0.289)		1.104 (0.053)	w_9/w_1	1.088 (0.238)
	$w_{10}w_1$	1.117 (0.390)		1.117 (0.063)	w_{10}/w_1	1.102 (0.022)
	w_{11}/w_1	1.131 (0.077)		1.131 (0.169)	w_{11}/w_1	1.147 (0.055)
	w_{12}/w_1	1.142 (0.128)		1.142 (0.079)	w_{12}/w_1	1.221 (0.040)
	w_{13}/w_1	1.154 (0.168)		1.154 (0.105)	w_{13}/w_1	1.230 (0.050)
	w_{14}/w_1	1.168 (0.273)		1.68 (0.165)	w_{14}/w_1	1.207 (0.100)
			Fixed Effects			
Mean in leisure equation	$u_{\nu n}/\hat{\rho}$	-8.989 (0.019)	-8.992 (0.019)	-8.989 (0.019)	$u_{2n}/(\rho_2-1)$	(-8.809) (0.009)
Mean in wage equation	v_{1n}	(0.723) (0.289)	(0.612) (0.289)	(0.652) (0.331)	v_{2n}	1.704 (0.240)
Value of Log Likelihood		6,928	6,881	6,927		14,564

TABLE 2

Variable	Coefficient	Estimate (A)	(B)	(C)
	Marginal Rate of Substitution between c_{nt} and l_{2nt}			
$\Delta\ell(c_{nt})$	$(\rho-1)/(1-\rho_2)$	-0.009 (0.188)	-0.020 (0.100)	-0.007 (0.282)
$\Delta\ell n(l_{1nt})$	$(1-\nu)\rho_0/(1-\rho_2)$	0.214 (1.320)	0.008 (0.100)	0.214 (0.282)
$\Delta\ell n(w_{2nt})$	$1/(1-\rho_2)$	0.054 (0.420)	0.042 (0.340)	0.049 (0.016)
Δf_{nt}	$(B_{10}-B_{12})/(1-\rho_2)$	0.015 (0.102)	0.019 (0.082)	0.012 (0.063)
	First Order Condition for c_{nt}			
Δf_{nt}	$B_{10}/(1-\rho)$	--	0.155 (0.457)	--
	First Order Condition for l_{2nt}			
Δf_{nt}	$B_{10}/(1-\rho_2)$	--	--	0.010 (0.062)
	Time Effects			
	$(\lambda_4/\lambda_3)^{\hat{\rho}}$	--	1.004 (0.083)	0.997 (0.010)
	$(\lambda_5/\lambda_4)^{\hat{\rho}}$	--	0.959 (0.150)	1.001 (0.008)
	$(\lambda_6/\lambda_5)^{\hat{\rho}}$	--	--	1.003 (0.042)
	$(\lambda_7/\lambda_6)^{\hat{\rho}}$	--	--	0.998 (0.045)
	$(\lambda_8/\lambda_7)^{\hat{\rho}}$	--	0.744 (0.075)	1.003 (0.025)
	$(\lambda_9/\lambda_8)^{\hat{\rho}}$	--	0.983 (0.334)	1.002 (0.005)

$(\lambda_{10}/\lambda_9)^{\hat{\rho}}$	--	1.004 (0.459)	1.002 (0.009)
$(\lambda_{11}/\lambda_{10})^{\hat{\rho}}$	--	0.967 (0.170)	1.000 (0.009)
$(\lambda_{12}/\lambda_{11})^{\hat{\rho}}$	--	0.966 (0.172)	1.001 (0.010)
$(\lambda_{13}/\lambda_{12})^{\hat{\rho}}$	--	1.008 (0.178)	0.999 (0.009)
$(\lambda_{14}/\lambda_{13})^{\hat{\rho}}$	--	1.013 (0.171)	1.000 (0.011)
J_N	88.72	150.60	257.98
Degrees of freedom (df)	84	166	184

*Note: For the estimates of Column (1), $\hat{\rho} = (1-\rho)^{-1}$.

For Column (2), $\hat{\rho} = (1-\rho_2)^{-1}$.

TABLE 3

Variable	Coefficient	Estimate (A)	(B)	(C)
	Marginal Rate of Substitution between c_{nt} and l_{2nt}			
$\Delta \ell n(c_{nt})$	$(\rho-1)/(1-\rho_2)$	0.005 (0.058)	-0.005 (0.049)	-0.008 (0.019)
$\Delta \ell n(l_{1nt})$	$(1-\nu)\rho_0/(1-\rho_2)$	0.174 (0.221)	0.174 (0.189)	0.208 (0.172)
$\Delta \ell n(w_{2nt})$	$1/(1-\rho_2)$	0.035 (0.005)	0.054 (0.005)	0.060 (0.004)
Δf_{nt}	$(B_{12}-B_{10})/(1-\rho_2)$	0.016 (0.046)	0.006 (0.043)	0.008 (0.040)
	First Order Condition for l_{2nt}			
Δf_{nt}	$B_{12}/1-\rho_2)$	0.023 (0.048	0.003 (0.044)	-0.002 (0.039)
	Wage Equation (w_{2nt})			
$\Delta)t_{2nt})^2$	B_{22}	-0.013 (0.104)	0.022 (0.063)	0.029 (0.034)
	Time Effects			
	k_1	--	0.401 (10.427)	--
	$(\lambda_4/\lambda_3)^{(1-\rho_2)^{-1}}$	1.000 (0.007)	1.000 (0.049)	--
	$(\lambda_5/\lambda_4)^{(1-\rho_2)^{-1}}$	1.001 (0.007)	1.000 (0.049)	--
	$(\lambda_6/\lambda_5)^{(1-\rho_2)^{-1}}$	0.999 (0.032)	1.001 (0.189)	--
	$(\lambda_7/\lambda_6)^{(1-\rho_2)^{-1}}$	1.002 (0.034)	0.999 (0.005)	--
	$(\lambda_8/\lambda_7)^{(1-\rho_2)^{-1}}$	0.998 (0.018)	1.000 (0.044)	--
	$(\lambda_9/\lambda_8)^{(1-\rho_2)^{-1}}$	1.001	0.999	

	(0.008)	(0.006)	--
$(\lambda_{10}/\lambda_9)^{(1-\rho_2)^{-1}}$	0.999	1.000	
	(0.007)	(0.006)	--
$(\lambda_{11}/\lambda_{10})^{(1-\rho_2)^{-1}}$	0.999	1.000	
	(0.007)	(0.025)	--
$(\lambda_{12}/\lambda_{11})^{(1-\rho_2)^{-1}}$	1.002	1.000	
	(0.009)	(0.025)	--
$(\lambda_{13}/\lambda^3{}_{12})^{(1-\rho_2)^{-1}}$	1.002	1.000	
	(0.007)	(0.015)	--
$(\lambda_{14}/\lambda_{13})^{(1-\rho_2)^{-1}}$	1.001	1.000	
	(0.009)	(0.006)	--
w_4/w_3	1.027	1.001	
	(0.138)	(0.006)	--
w_5/w_4	1.026	1.001	
	(0.138)	0.006)	--
w_6/w_5	1.058	1.003	
	(0.134)	(0.007)	--
w_7/w_6	0.977	0.999	
	(0.124)	(0.006)	--
w_8/w_7	1.015	1.001	
	(0.137	(0.006)	--
w_9/w_8	1.024	0.999	
	(0.137)	(0.043)	--
w_{10}/w_9	1.037	1.001	
	(0.140)	(0.038)	--
w_{11}/w_{10}	1.009	1.001	
	(0.107)	(0 .086)	--
w_{12}/w_{11}	1.018	1.000	
	(0.1219)	(0.062)	--
w_{13}/w_{12}	1.000	1.000	
	(0.126)	(0.060)	--
w_{14}/w_{13}	1.013	1.000	
	(0.134)	(0.018)	--
J_N	289.38	327.14	337.15
Degrees of Freedom (df)	282	292	304

TABLE 4

Variable	Coefficient	Estimate (A)	Estimate (B)
	Marginal Rate of Substitution between c_{nt} and l_{2nt}		
$\Delta \ell n(c_{nt})$	$(\rho-1)/(1-\rho_2)$	-0.010(0.061)	-0.011(0.047)
$\Delta \ell n(l_{1nt})$	$(1-\nu)\rho_0/(1-\rho_2)$	0.174(0.217)	0.170(0.169)
$\Delta \ell n(w_{2nt})$	$1/(1-\rho_2)$	0.066(0.005)	0.068(0.004)
Δf_{nt}	$(B_{12}-B_{10})/(1-\rho_2)$	0.003(0.048)	0.002(0.042)
	First Order Condition for l_{2nt}		
Δf_{nt}	$B_{12}/(1-\rho_2)$	-0.003(0.047)	-0.002(0.042)
	Wage Equation (w_{2nt})		
$\Delta (t_{2nt}$	B_{22}	0.028(0.117)	0.025(0.045)
	k_1	—	0.040(0.763)
	Asset Pricing Equation		
	β	0.834(0.269)	0.833(0.263)
	Time Effects		
	$(\lambda_4/\lambda_3)^{(1-\rho_2)^{-1}}$	1.002(0.008)	1.003(0.042)
	$(\lambda_5/\lambda_4)^{(1-\rho_2)^{-1}}$	1.000(0.007)	1.000(0.047)
	$(\lambda_6/\lambda_5)^{(1-\rho_2)^{-1}}$	1.008(0.032)	1.011(0.169)
	$(\lambda_7/\lambda_6)^{(1-\rho_2)^{-1}}$	1.005(0.033)	1.006(0.004)
	$(\lambda_8/\lambda_7)^{(1-\rho_2)^{-1}}$	1.005(0.020)	1.005(0.042)
	$(\lambda_9/\lambda_8)^{(1-\rho_2)^{-1}}$	0.997(0.007)	0.995(0.006)
	$(\lambda_{10}/\lambda_9)^{(1-\rho_2)^{-1}}$	1.003(0.007)	1.003(0.005)
	$(\lambda_{11}/\lambda_{10})^{(1-\rho_2)^{-1}}$	0.998(0.008)	0.995(0.024)
	$(\lambda_{12}/\lambda_{11})^{(1-\rho_2)^{-1}}$	1.011(0.011)	1.013(0.025)

$(\lambda_{13}/\lambda_{12})^{(1-\rho_2)^{-1}}$	0.999 (0.007)	0.997 (0.016)
$(\lambda_{14}/\lambda_{13})^{(1-\rho_2)^{-1}}$	0.996 (0.008)	0.994 (0.006)
w_4/w_3	1.009 (0.103)	1.008 (0.005)
w_5/w_4	1.002 (0.128)	1.001 (0.006)
w_6/w_5	1.029 (0.134)	1.028 (0.009)
w_7/w_6	1.015 (0.129)	1.015 (0.006)
w_8/w_7	1.014 (0.144)	1.014 (0.006)
w_9/w_8	0.989 (0.143)	0.989 (0.021)
w_{10}/w_9	1.009 (0.131)	1.009 (0.013)
w_{11}/w_{10}	0.984 (0.111)	0.989 (0.081)
w_{12}/w_{11}	1.038 (0.132)	1.033 (0.068)
w_{13}/w_{12}	0.991 (0.131)	0.993 (0.046)
w_{14}/w_{13}	0.985 (0.141)	0.985 (0.024)
J_N	341	353
Degrees of Freedom (df)	285	295

Table 5

Variable	Coefficient	Estimates
First Order Condition for l_{1nt} and Wage Equation (w_{1nt})		
b_{nt}	$B^1_{11}/(1-\rho_1)$	-0.021(1.558)
$\Sigma^2_{s=1} b\ n,t-s$	$B^2_{11}/(1-\rho_1)$	0.125(1.784)
$\Sigma^5_{s=3} b\ n,t-3$	$B^3_{11}/(1-\rho_1)$	0.148(3.603)
$\Sigma^{14}_{s=6} b\ n,t-s$	$B^4_{11}/(1-\rho_1)$	0.016(1.131)
$f_{nt} - \Sigma^{14}_{s=0}\ b_{n,t-s}$	$B^1_{11}/(1-\rho_1)$	-0.031(0.658)
$(t_{1nt})^2$ in leisure equation	$B_{12}/(1-\rho_1)$	-0.021(1.558)
$(t_{1nt})^2$ in wage equation	B_{12}	0.099(0.679)
t in leisure equation	$\eta_1/(1-\rho_1)$	0.247(0.530)
t in wage equation	η_2	0.006(0.154)
Variance of disturbance in leisure equation	$\sigma^2_{11}/(1-\rho_1)^2$	0.492(0.274)
Variance of disturbance in wage equation	σ^2_{1v}	0.354(20.153)
Covariance of disturbance in leisure and wage equation	$\sigma_{1yv}/(1-\rho_1)$	0.321(11.274)

Marginal Rate of Substitution Between c_{nt} and l_{2nt}

$\Delta \ln(c_{nt})$	$(\rho-1)/(1-\rho_2)$	0.020(0.152)
Δf_{nt}	$(B_{10}-B_{12})/(1-\rho_2)$	0.072(0.164)

First Order Condition for l_{2nt} and Wage Equation (w_{2nt})

Δf_{nt}	$B_{12}/(1-\rho_2)$	-0.082(0.146)
$\Delta(t_{2nt})^2$	B_{22}	0.019(0.028)
	$1-\rho_1$	2.557(90.154)
	$1-\rho_2$	1.984(0.666)

Time Effects

	λ_2/λ_1	0.513(4.670)
	λ_3/λ_1	0.900(4.630)
	λ_4/λ_1	0.898(3.500)
	λ_5/λ_1	0.898(3.531)
	λ_6/λ_1	0.870(3.737)
	λ_7/λ_1	0.882(3.703)
	λ_8/λ_1	0.874(4.170)
	λ_9/λ_1	0.870(3.850)
	λ_{10}/λ_1	0.871(4.070)
	λ_{11}/λ_1	0.876(3.501)
	λ_{12}/λ_1	0.861(3.325)
	λ_{13}/λ_1	0.846(4.070)
	λ_{14}/λ_1	0.871(3.561)

J_N	2194
Degrees of Freedom	302

APPENDIX

Tables A.1 and A.2 provide some summary statistics about the characteristics of the households in the two subsamples, described in the text. Of the variables listed in these tables, average hourly earnings for both husbands and wives were defined from the ratio of total labor income to total annual hours. Two steps were followed to obtain the empirical measure for food consumption expenditures. First, a variable corresponding to food expenditures for a given year was obtained by summing the values of annual food expenditures for meals at home, annual food expenditures for eating out, and the value of food stamps received for that year. The empirical measure of consumption expenditures for year t was then obtained by taking 0.25 of the value of this variable for year t -1 and 0.75 of its value for year t. The second step was taken to account for the fact that the survey question used to elicit information about household food consumption is asked sometime in the first half of the year, while the response is dated in the previous year. We also constructed experience variables for both the head and wife of the household. For the household head, this variable was constructed as age minus education minus six. The education variable was in turn constructed from a polytomous variable defined to equal:

1 if number of grades attended was between 0 and 5.

2 if number of grades attended was between 6 and 8.

3 if number of grades attended was between 9 and 11.

4 if the husband had attended 12 grades.

5 if the husband had a high school degree plus nonacademic training.

6 if the husband had attended college but had not earned a degree.

7 if the husband had earned a B.A. but no advanced degree.

8 if the husband had earned both a B.A. and advanced or professional degrees.

0 if the husband cannot read or write or has trouble reading or writing.

The education variable was obtained as three times the value of this variable whenever its value was less than or equal to four. Otherwise, the education variable was defined to equal eight plus the value of the polytomous variable. We constructed the education variable in this way because the variable corresponding to the number of years of schooling is not consistently measured across the different years of the PSID. The experience variable for the wife was constructed as the age of the wife minus eighteen, precisely because a consistent measure of education for the wife was available only for the survey years 1969, 1970, and 1971. The variable H_{nt} was constructed by multiplying the value of a household's home by an indicator variable determining homeownership. A similar procedure was followed to generate the variable R_{nt} showing the value of rent paid and rental value of free housing for a household. Finally, household income I_{nt} was measured from the PSID variable total family money income.

In addition to the individual data recorded in the PSID, we used measures on the civilian unemployment rate, and two types of financial returns. The first variable is comprised of annual observations on monthly, seasonally adjusted data and is obtained from Table B-35 of the 1986 Economic Report of the President We used the implicit price deflator for personal consumption expenditures, including expenditures for durable and nondurable goods and services, from the National Income and Product Accounts to convert all nominal quantities to real. The base year of 1972. Of the two types of financial returns, one is an (annual) stock return. This was measured in two different ways. The first measure was calculated from the monthly returns on the value-weighted stock index for stocks on the New York Stock Exchange. The other measure was calculated for the equally-weighted stock index. The monthly rate of return series were taken from the CRISP tapes. Annual gross asset returns were calculated according to the geometric average

$$r_t = \prod_{j=1}^{12} \frac{\sqrt[12]{1 + r_{tj}}}{1 + \Pi_{tj}}, \qquad (A.1)$$

where r_{tj} is the yearly nominal rate of return for year t, month j and Π_{tj} is the monthly inflation rate for month j of year t. $1 + \Pi_{tj}$ was in turn calculated as th ratios of the monthly implicit consumption deflators. The second type of return is the annual return on 3-month Treasury bills. Formula (A.1) was again used to derive the appropriate measure.

TABLE A.1

Summary Statistics for Sample of 497 Households

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Average Age of Husband	34.8													
Average Age of Wife	32.2													
Average Annual Hours of Husband	2367.42	2372.91	2371.38	2337.90	2367.85	2384.55	2344.03	2322.27	2350.91	2321.50	2352.61	2342.96	2295.78	2283.67
Average Annual Hours of Wives Who Worked	1276.73	1111.63	1117.86	1180.45	1171.73	1232.14	1247.04	1244.68	1234.49	1266.25	1287.02	1307.07	1338.63	1441.07
Average Hourly Wages of Husband	4.25	4.46	4.84	5.03	5.05	5.11	5.30	5.22	5.40	5.48	5.66	5.61	5.62	5.68
Average Hourly Wages of Wives Who Worked	2.62	2.50	2.69	2.73	2.86	2.88	3.00	3.00	3.03	3.25	3.34	2.92	2.94	3.03
Average House Value of Homeowners	22042.	22280.4	23402.7	23330.2	24459.7	25891.8	27532.5	28815.5	28164.0	30565.4	33147.0	35317.2	38217.1	36161.0
Average Annual Rent of Renters	1156.4	1123.6	1109.2	1282.3	1224.6	1266.5	1201.8	1290.0	1382.5	1387.2	1407.2	1482.2	1587.5	1707.8
Average Annual Rent Value of Free Housing for Non-Homeowners and Non-Renters	997.3	886.7	947.0	1277.2	1089.4	1184.7	746.0	1156.2	1071.4	1409.1	737.7	1318.6	1004.5	949.7
Average Annual Value of Food Consumption at Home	2399.2	1919.7	2003.7	1965.2	1999.0	--	2271.2	2171.5	2166.6	2138.7	2164.6	2227.0	2130.2	2034.4
Average Annual Value of Amount Eating Out	--	351.0	355.2	352.4	372.2	--	450.0	363.1	400.3	425.2	466.6	478.2	457.5	441.0
Average Annual Value of Food Stamps Received	196.2	493.6	954.2	642.0	641.0	--	667.5	355.8	257.9	498.0	514.1	256.4	315.0	270.9
Average Annual Income	12141.0	13016.4	13780.7	14121.8	14726.4	15230.0	16143.1	15946.4	16499.0	17285.5	17805.7	18387.3	18506.4	19480.4
Number of Homeowners	346	363	387	398	415	430	432	438	442	447	457	455	460	461
Number of Renters	135	117	99	88	67	58	54	51	44	43	37	36	35	32
Number Receiving Food Stamps	44	5	3	13	13	--	8	11	12	8	5	7	6	8
Number Receiving Dividends	177	204	191	200	224	194	204	206	224	218	249	279	270	273

TABLE A.2

Summary Statistics for Sample of 455 Households

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Average Age of Husband	34.63													
Average Age of Wife	32.09													
Average Annual Hours of Husband	2381.64	2385.80	2391.37	2366.64	2399.72	2363.88	2368.36	2322.48	2353.76	2313.88	2346.54	2331.12	2287.24	2271.35
Average Annual Hours of Wives Who Worked	1285.74	1103.08	1098.95	1181.85	1176.76	1208.35	1241.95	1235.19	1221.91	1251.81	1263.42	1289.47	1328.70	1427.86
Average Hourly Wages of Husband	4.31	4.53	4.84	5.03	5.05	5.18	5.20	5.27	5.45	5.53	5.69	5.69	5.62	5.65
Average Hourly Wages of Wives Who Worked	2.82	2.51	2.72	2.72	2.88	2.90	2.94	3.04	3.08	3.27	3.33	2.97	2.97	3.08
Average House Value of Homeowners	22226.89	22646.57	23698.85	23584.18	24781.45	25886.32	26767.96	27262.34	28578.30	30792.90	33281.00	35783.57	38780.74	38532.78
Average Annual Rent of Renters	1167.38	1127.16	1120.26	1243.39	1218.88	1282.43	1164.45	1314.94	1414.00	1335.74	1432.84	1543.95	1640.95	1715.40
Average Annual Rent Value of Free Housing for Non-Homeowners and Non-Renters	1020.19	913.82	1007.48	1038.55	930.00	1464.84	715.82	1399.36	1102.77	1668.82	0	1288.48	889.64	1028.45
Average Annual Value of Food Consumption at Home	2411.41	1925.33	2017.89	1971.00	2013.71	0	2188.48	2169.26	2168.04	2137.34	2173.98	2243.04	2132.16	2055.17
Average Annual Value of Amount Eating Out	0	359.38	363.07	354.69	380.74	0	429.84	366.99	407.93	436.01	482.41	491.06	465.12	455.68
Average Annual Value of Food Stamps Received	199.53	339.37	0	615.36	659.40	0	612.04	390.10	276.60	571.33	453.55	191.47	297.54	269.92
Average Annual Income	12296.35	13206.24	13947.52	14311.81	14920.24	15357.19	15694.60	16150.70	16828.94	17649.20	18110.08	18656 10	18884.90	19908.33
Number of Homeowners	320	334	358	370	384	398	399	405	408	413	422	420	425	428
Number of Renters	122	106	88	75	59	51	48	45	39	37	33	30	29	28
Number Receiving Food Stamps	41	2	0	11	10	0	5	10	10	3	4	4	5	7
Number Receiving Dividends	168	190	179	188	205	182	190	193	209	204	233	255	253	253