Consumption Inequality and Family Labor Supply[†]

By Richard Blundell, Luigi Pistaferri, and Itay Saporta-Eksten*

We examine the link between wage and consumption inequality using a life-cycle model incorporating consumption and family labor supply decisions. We derive analytical expressions for the dynamics of consumption, hours, and earnings of two earners in the presence of correlated wage shocks, nonseparability, progressive taxation, and asset accumulation. The model is estimated using panel data for hours, earnings, assets, and consumption. We focus on family labor supply as an insurance mechanism and find strong evidence of smoothing of permanent wage shocks. Once family labor supply, assets, and taxes are properly accounted for there is little evidence of additional insurance. (*JEL* D12, D14, D91, J22, J31)

The link between household consumption inequality and idiosyncratic income changes has been the focus of a large literature of recent economic research (Blundell, Pistaferri, and Preston 2008; Heathcote, Storesletten, and Violante 2014).[1] This literature usually relates movements in consumption to predictable and unpredictable income changes as well as persistent and nonpersistent shocks to economic resources. One remarkable and consistent empirical finding in most of this recent work is that household consumption appears significantly smoothed, even with respect to highly persistent shocks.[2] But what are the mechanisms behind such smoothing? This is the question we attempt to answer in this paper.

To do so, we set up a flexible life-cycle model that allows for several potential sources of smoothing. The first, a traditional one in the literature, is self-insurance

through credit markets. The second source is family labor supply, i.e., the fact that hours of work can be adjusted along with, or alternatively to, spending on goods in response to shocks to economic resources. While this is not a new channel (see Heckman 1974 and Low 2005), the focus on *family* labor supply has not received much attention. As we shall see, our empirical analysis suggests that this is a key insurance channel available to families. Estimating a single earner model when two earners are present potentially yields biased estimates for the level of self-insurance and for the elasticity of intertemporal substitution of consumption, a key parameter for understanding business cycle fluctuations. The third insurance channel is progressive taxation operating on joint family earnings, implying that any shock to after-tax income is attenuated relative to shocks to before-tax income. Moreover, we include insurance through government transfers by allowing households to become eligible for welfare programs that, in the United States, are designed to insure against low wage realizations, the Earned Income Tax Credit (EITC) program, and the Food Stamps program. Finally, households may have access to external sources of insurance, ranging from help received by networks of relatives and friends to formal market insurance. It is hard to model in a credible way the myriad of external insurance channels potentially available to households. We hence choose to subsume these external mechanisms into a single parameter, measuring all consumption insurance that remains after accounting for the other sources of insurance discussed above. We use our estimates to measure how much of the consumption smoothing we find in the data can be explained by these various forces in different stages of the life cycle.

From a modeling point of view, our paper has three distinctive features. First, the labor supply of each earner within a household is endogenous (hours are chosen to reflect preferences for work and the dynamics of market wages), heterogeneous (spouses respond differently to wage changes), and potentially nonseparable with respect to consumption and also with respect to the labor supply of the spouse (e.g., partners may enjoy spending time together). The focus on endogenous labor supply makes market wages the primitive source of uncertainty faced by households; the focus on heterogeneity and nonseparability agrees with most influential work on labor supply (for a survey, see Blundell and MaCurdy 1999). Second, we model the stochastic component of the wage process as being the sum of transitory and permanent components—these components are allowed to be freely correlated across spouses, reflecting, for example, assortative mating or risk-sharing arrangements. Finally, since our goal is to understand the transmission mechanisms from wage shocks to consumption and labor supply, we obtain analytical expressions for consumption and labor supply as a function of wage shocks using approximations of the first-order conditions of the problem and of the lifetime budget constraint (as illustrated in Blundell and Preston 1998 and Blundell, Pistaferri, and Preston 2008). A similar goal is pursued in Heathcote, Storesletten, and Violante (2014), but it differs from ours because the authors focus on one-earner labor supply models, assume that preferences are separable, and decompose permanent shocks into two components (measuring the fraction of permanent shocks which is insurable). The usefulness of our approach is that it gives an intuitive and transparent view of how the various structural parameters can be identified using panel data on individual wages and earnings (or hours), and household consumption and assets.

But where do we find such rich data? In the United States there are two sources of data that have been extensively used, the Consumer Expenditure Survey (CEX) and the Panel Study of Income Dynamics (PSID). The CEX has complete consumption data, but lacks a long panel component and the quality of its income, assets, and consumption data has recently raised some concerns. The PSID has been traditionally used to address the type of questions we are concerned with in this paper, but until recently had incomplete consumption data, which has meant that authors have either used just food data (Hall and Mishkin 1982), or resorted to data imputation strategies (Blundell, Pistaferri, and Preston 2008). In this paper we make use of new consumption data that, as far as we know, are untapped for the type of questions asked here. Starting in 1999, the PSID was drastically redesigned. In particular, it enriched the consumption information available to researchers, which now covers over 70 percent of all consumption items available in the CEX. On the other hand, as part of its redesign, data are now available only every other year. However, this can be easily accounted for in our framework.

We document several important findings. First, female labor supply is an important consumption insurance device against wage shocks faced by the husband (typically, the primary earner in couples), both on the intensive margin (i.e., through shifts from part-time to full-time, and vice-versa) and on the extensive margin (i.e., shifts from not working to working, and vice-versa). Second, in our flexible life-cycle model with self-insurance through savings, endogenous family labor supply, nonseparable preferences (between hours and consumption and between leisure times of the two spouses), government transfers, and progressive taxation, there is little evidence of "missing" insurance explaining consumption movements in response to wage shocks. This stark result partly depends on our sample selection, which focuses on stable married couples with continuously employed males, but partly also derives from the richness of our framework, which effectively exhausts the most economically relevant smoothing devices available to households in the United States. Third, we estimate sizable Frisch labor supply elasticities for both husband and wife, but show that the implied Marshallian elasticities are much smaller (and close to zero for the husband) due to strong wealth effects. We further show that ignoring progressive taxation in estimation leads to an attenuation of Frisch elasticities estimates. Finally, we find significant evidence of Frisch complementarity between the leisure times of the spouses and evidence of Frisch substitutability between consumption and hours at the intensive margin. The latter finding is confirmed in conditional Euler equation estimates and when explaining the demand for goods that are less likely to be work-related (such as home utilities). The finding of substitutability between consumption and hours is reversed on the extensive margin or when explaining the demand for goods that are work-related (such as transportation and food away from home). Moreover, there is evidence of consumption-hours complementarity when considering uncompensated wage changes (Marshallian responses). These are important qualifications because a recurrent finding in the literature is that consumption and hours comove positively. Our results show that the direction of the comovement may depend on the type of wage changes considered (temporary versus persistent), on the type of consumption good considered, and on the labor supply margin that is studied (intensive versus extensive margin).

Our paper is related to several literatures in macroeconomics and labor economics. A large literature in macroeconomics is devoted to understanding the response of consumption to income changes, both anticipated changes and economic shocks. Recent contributions which assume exogenous labor supply include Krueger and Perri (2006) and Blundell, Pistaferri, and Preston (2008). In contrast, Attanasio, Low, and Sanchez-Marcos (2008); Blundell and Preston (2004); and Heathcote, Storesletten, and Violante (2014) relax the exogeneity of labor supply but either focus on a single earner, aggregate hours across spouses, or impose restrictions on the nature and type of insurance available to consumers. Most of these papers find a significant degree of consumption smoothing against income shocks, including very persistent ones. We study how much of this smoothing comes from labor supply choices, and how much from more traditional sources (savings and transfers).

A related literature in labor economics asks to what extent a secondary earner's labor supply (typically, the wife's) increases in response to negative wage shocks faced by the primary earner (Lundberg 1985). This literature, also known as the "added worker effect" literature, investigates the role of marriage as a risk-sharing device focusing mostly on the wives' propensity to become employed when their husbands exit employment. We distinguish between three alternative channels through which spousal earnings can act as insurance. The first channel allows wage shocks to be negatively (or positively) correlated between spouses, the second channel accounts for behavioral responses in labor supply itself, and finally we allow for interactions through taxation of joint earnings. Typically these channels are not distinguished. Moreover, decisions over saving choices are also typically not modeled.[3] Studies of the "added worker effect" which disregard self-insurance through savings may find little evidence for an added worker effect if couples have plenty of accumulated assets to run down in case of negative shocks to resources.

A somewhat distinct but equally large and influential literature estimates the responsiveness of individual labor supply to wage changes using microdata (see Keane 2011, for a recent review of this literature). Most of the papers in this literature do not consider the joint consumption-labor supply choice (with some exceptions, Altonji 1986) and focus on the single earner case. We show how the labor elasticities of intertemporal substitution can be identified allowing for nonseparability with respect to consumption and the labor supply of the partner. As we shall see, separability is strongly rejected, as previously found in microdata (Browning and Meghir 1991).

With fixed consumption costs of work, differences will naturally appear between elasticities at the extensive and the intensive margin. We might naturally expect consumption and labor supply to be complements at the extensive margin as

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[3] The most relevant paper for our purposes is Hyslop (2001), which uses a life-cycle model to look directly at the response of hours worked by one earner to the other earners' wage shocks, decomposing it as the response to transitory and permanent components. Hyslop finds that the permanent shocks to wages are correlated for first and second earner, and that the relatively large labor supply elasticity for wives can explain about 20 percent of the rise in household earnings inequality in the early 1980s. A recent paper by Juhn and Potter (2007) finds that the value of marriage as a risk-sharing device has diminished due to an increase in correlation of employment among couples. Stephens (2002) advances the literature by studying short- and long-run female labor supply responses to the husband's job displacement shock. Haan and Prowse (2015) study the implications of insurance through family labor supply for the design of social insurance.

costs of work increase and home production falls upon entry in the labor market. This would capture the main effects at retirement and over the business cycle which occur mainly at the extensive margin. Indeed, our results at the extensive margin of labor supply confirm this pattern. At the intensive margin, however, behavior can be very different. As both partners work longer hours, they may reduce consumption of home-related goods, such as utilities, and decide to shift consumption to periods of lower hours of work. Indeed, for marginal utility constant elasticities (Frisch elasticities), we find such substitutability at the intensive margin to be empirically relevant. Perhaps less surprising, we also find the labor supply of spouses to be Frisch complements at the intensive margin.

The rest of the paper is organized as follows. Section I describes the flexible life-cycle model we use and considers as special cases those mostly used in the literature, i.e., additive separability and proportional taxes. In Section II we describe the data, discuss the empirical strategy, the identification, and the estimation problems we face. Section III discusses the main results (including estimation under alternative specifications and various robustness checks). Section IV includes a discussion of intensive versus extensive margin, a quantification of the degree and importance of the various insurance channels, and an evaluation of the goodness of fit of the model both for moments we fit explicitly and for moments we do not. Section V concludes.

I. Two Earners Life-Cycle Model

In this section we develop the link between wage shocks, labor supply, and consumption in a life-cycle model of a two earners' household drawing utility from consumption and disutility from work. The household chooses consumption and the two members' hours of work to optimize expected lifetime utility. We assume throughout that the hourly wage process is exogenous but nonstationary over the life cycle; we also allow wage shocks to be potentially correlated across spouses. Our baseline is a flexible model exhibiting nonseparability between household consumption and the leisure time of the two spouses and a progressive tax system allowing for means-tested transfers. We maintain the assumption of separability over time throughout the paper. We also assume that the two earners' decisions are made within a unitary framework. The difficulty with relaxing this is that identification becomes particularly cumbersome in the dynamic case (for a recent survey, see Chiappori and Mazzocco 2014).

A. *Wage Process*

For each earner within the household, we adopt a permanent-transitory type wage process, assuming that the permanent component evolves as a unit root process. The distinction between transitory shocks and permanent shocks is important from an identification point of view, as we will interpret transitory shocks as having negligible or no wealth effects. Hence, the response of hours to transitory wage shocks will be key in identifying Frisch (or λ-constant) elasticities, while the response to permanent wage shocks will identify Marshallian (or uncompensated) elasticities.

We assume that the log of real wage of earner $j = \{1, 2\}$ in household i at age t can be written as

$$(1) \qquad\qquad \log W_{i,j,t} = \mathbf{x}'_{i,j,t} \boldsymbol{\beta}^j_W + F_{i,j,t} + u_{i,j,t}$$

$$(2) \qquad\qquad F_{i,j,t} = F_{i,j,t-1} + v_{i,j,t} = F_{i,j,0} + \sum_{s=1}^{t} v_{i,j,s},$$

where $\mathbf{x}_{i,j,t}$ are observed characteristics affecting wages and known to the household. $u_{i,j,t}$ and $v_{i,j,t}$ are transitory shocks (such as short illnesses that may affect productivity on the job) and permanent shocks (such as technological shocks that make one's marketable skills less or more valuable), respectively, and $F_{i,j,0}$ is the individual initial condition in wages. Since we estimate the model in first differences, these initial conditions play no role in estimation and hence we can be silent about their distribution.

We assume that earner j's permanent and transitory wage shocks are serially uncorrelated with variance $\sigma^2_{v_j(t)}$ and $\sigma^2_{u_j(t)}$, respectively. We also assume that permanent (transitory) shocks can be contemporaneously correlated, with covariance $\sigma_{v_1 v_2(t)}$ $\left(\sigma_{u_1 u_2(t)} \right)$.[4] This correlation is theoretically ambiguous. If spouses were to adopt sophisticated risk-sharing mechanisms, they would select jobs where shocks are negatively correlated. Alternatively, assortative mating or other forms of sorting imply that spouses work in similar jobs, similar industries, and sometimes in the same firm—hence their shocks may be potentially highly positively correlated. Finally, we assume that transitory and permanent shocks are uncorrelated within and between persons.[5]

We let the variances and covariances of wage shocks vary by age. This is done to capture the possibility that there is more dispersion in shocks for, say, older workers than younger workers, due for example to worsening of health conditions. Since age-specific cells are quite small given the size of our dataset, however, we restrict the age-variation to stages of the life cycle (30–37, 38–42, 43–47, 48–52, 53–57). We assume that the wage variances do not vary over time. Our data do not span a long time period (6 waves, covering 11 years) and hence the year-stationarity assumption is not strong (the variance of annual wages were rather flat over the 1999–2009 period covered by our data).

While the stochastic wage structure embedded in (1)–(2) is widely used in models of the type we are considering here, it is not uncontroversial. Some authors have stressed the role of superior information issues (Primiceri and van Rens 2009); other researchers have emphasized the importance of allowing for growth heterogeneity (Guvenen and Smith 2014).[6] Nevertheless, we will show that (1)–(2) fit wage data rather well in our sample. We also assume that the household has no advance

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[4] This is potentially important given the empirical findings for the correlation of labor market outcomes of married couples. See, for example, Juhn and Potter (2007) and Hyslop (2001).

[5] Hryshko (2011) considers the consequences of relaxing this assumption for partial insurance models.

[6] If our model contained a random growth component, the estimates will be most likely only minimally affected, provided the random growth component had a small variance (of the magnitude estimated by Guvenen 2009, for example) and learning about it was either absent or fast (as found in Guvenen 2007).

information about the shocks and that the shocks are observed (separately) at age t.[7] We provide a test of no superior information in Section IIIB.

Given the specification of the wage process (1)–(2), the growth in (residual) log wages can be written as

$$(3) \qquad \Delta w_{i,j,t} = \Delta u_{i,j,t} + v_{i,j,t},$$

where Δ is a first difference operator and $\Delta w_{i,j,t} = \Delta \ln W_{i,j,t} - \Delta \mathbf{x}'_{i,j,t} \boldsymbol{\beta}^j_W$ (the log change in hourly wages net of observables). We discuss measurement error issues in Section IID.

B. *Household Maximization Problem*

Given the exogenous wage processes described above, we assume that the household's maximization problem is given by

$$(4) \qquad \max E_t \sum_{s=0}^{T-t} u_{t+s}\big(C_{i,t+s}, H_{i,1,t+s}, H_{i,2,t+s}; \mathbf{z}_{i,t+s}, \mathbf{z}_{i,1,t+s}, \mathbf{z}_{i,2,t+s}\big),$$

subject to the intertemporal budget constraint

$$(5) \qquad A_{i,t+1} = (1+r)\big(A_{i,t} + T(H_{i,1,t}W_{i,1,t} + H_{i,2,t}W_{i,2,t}) - C_{i,t}\big).$$

The age subscript on the utility function $u_{t+s}(\cdot)$ captures intertemporal discounting. The primary arguments of the utility function are household consumption $C_{i,t}$ and the hours chosen by the two earners, $H_{i,1,t}$ and $H_{i,2,t}$. The utility function also includes preference shifters specific to the household, such as number of children ($\mathbf{z}_{i,t}$), or specific to the earner, such as his or her age ($\mathbf{z}_{i,1,t}$ and $\mathbf{z}_{i,2,t}$). These preference shifters can potentially include stochastic components as well. We account for these empirically by using residual measures of consumption, wages, and earnings (see Section IIE for details).[8] We assume that $u_{t+s}(\cdot)$ is twice differentiable in all its primary arguments, with $u_C > 0$, $u_{CC} < 0$, $u_{H_j} < 0$, $u_{H_jH_j} < 0$ for $j \in \{1,2\}$ and $u(0, H_1, H_2) \to -\infty$. $A_{i,t}$ denotes the assets at the beginning of period t and r is the fixed interest rate (i.e., this is a Bewley-type model in which consumers have access to a single risk-free bond). Finally, we assume that joint earnings are subject to progressive joint taxation and, when they fall below certain thresholds, may entitle households to certain government transfers (EITC and Food Stamps). In particular, the function $T(\cdot)$ maps before-tax household earnings into disposable household income (earnings plus transfers minus taxes). We approximate the US tax system using the functional form suggested by Heathcote, Storesletten, and Violante (2014):

$$(6) \quad T\big(H_{i,1,t}W_{i,1,t} + H_{i,2,t}W_{i,2,t}\big) \approx (1 - \chi_{i,t})\big(H_{i,1,t}W_{i,1,t} + H_{i,2,t}W_{i,2,t}\big)^{1-\mu_{i,t}},$$

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[7] This is a key assumption in the context of empirical analysis on consumption insurance. See Meghir and Pistaferri (2011) for a discussion about the interpretation of insurance coefficients when this assumption is violated.

[8] An example for a formal derivation of residual measures from a utility function with taste shifters can be found in the online Appendix to Blundell, Pistaferri, and Preston (2008).

where the parameters χ and μ vary over time and by households characteristics (family size and number of children), to reflect differences in the degree of progressivity of the tax system. In a proportional tax system, μ will be zero and χ will be the proportional tax rate. Researchers have proposed a number of alternative mappings (see Carroll and Young 2011, and the references therein). We prefer this mapping because it provides a simple log-linear relationship between after- and before-tax income and we show it adequately approximates the effective negative marginal tax rates implicit in the government transfer system.

There are only a few special cases for which the general problem (4)–(5) can be solved analytically. One is the case of quadratic utility and additive separability (Hall 1978) which predicts that consumption evolves as a random walk. Unfortunately, a quadratic utility model does not generate precautionary savings and is therefore unrealistic. The exponential utility specification is another case for which analytical solutions exist (Caballero 1990). The caveats of exponential utility is that it implies constant absolute risk aversion and it may allow negative optimal consumption.

While analytical solutions are based on strong counterfactual assumptions regarding preferences, approximations for the evolution of consumption and hours can be found in the literature for more realistic assumptions about preferences. In Section IC we apply a two-step approximation procedure similar to the one used in Blundell and Preston (2004); Blundell, Pistaferri, and Preston (2008); and Attanasio et al. (2002). The overall accuracy of this approximation under a variety of preference and income specifications is assessed in detail in Blundell, Low, and Preston (2013), although their analysis does not cover the two-earner case considered here. We assume interior solutions for hours and discuss in the empirical section how we tackle the sample selection issues.

C. *The Dynamics of Consumption, Hours, and Earnings*

Our goal is to link the growth rates of consumption, hours, and earnings to the wage shocks experienced by the household. We achieve this in two steps. First, we use a Taylor approximation to the first-order conditions of the problem. This yields expressions for the growth rate of consumption and the growth rate of hours in terms of changes in wages and an additional expectation error term (the innovation in the marginal utility of wealth). This is a standard log-linearization approach of the first-order conditions. Second, we take a log-linearization of the intertemporal budget constraint. This allows us to map the (unobservable) expectation errors into wage shocks (the only sources of uncertainty of the model).

In online Appendix 1 we show that log-linear approximation of the Euler equations yields

$$(7) \quad \Delta c_{i,t} \simeq \left(-\eta_{c,p} + \eta_{c,w_1} + \eta_{c,w_2}\right) \Delta \ln \lambda_{i,t} + \eta_{c,w_1} \Delta w_{i,1,t} + \eta_{c,w_2} \Delta w_{i,2,t}$$
$$- \mu_{t+1}\left(\eta_{c,w_1} + \eta_{c,w_2}\right) \Delta y_{i,t}$$

$$(8) \quad \Delta h_{i,j,t} \simeq \left(\eta_{h_j,p} + \eta_{h_j,w_j} + \eta_{h_j,w_{-j}}\right) \Delta \ln \lambda_{i,t} + \eta_{h_j,w_j} \Delta w_{i,j,t} + \eta_{h_j,w_{-j}} \Delta w_{i,-j,t}$$
$$- \mu_{t+1}\left(\eta_{h_j,w_j} + \eta_{h_j,w_{-j}}\right) \Delta y_{i,t},$$

where from now on lowercase letters indicate logged variables net of predictable taste shifters.[9] Hence, $c_{i,t}$, $y_{i,t}$, $h_{i,j,t}$, and $w_{i,j,t}$ are log consumption, log of before-tax household earnings, log hours of earner j, and log of before-tax hourly wage of earner j all net of predictable taste shifters, respectively. Finally, $\lambda_{i,t}$ is the marginal utility of wealth (the Lagrange multiplier on the sequential budget constraint). The parameters $\eta_{l,m}$ represent the Frisch (or λ-constant) elasticities of variable l with respect to changes in the price m (p is the "price" of a unit of current consumption relative to future consumption). Note that the signs of the Frisch cross-elasticities η_{c,w_j} and $\eta_{h_j,p}$ determine whether consumption and hours of earner j are Frisch complements $(\eta_{c,w_j} > 0, \eta_{h_j,p} < 0)$ or Frisch substitutes $(\eta_{c,w_j} < 0, \eta_{h_j,p} > 0)$. Similarly, $\eta_{h_j,w_{-j}} > 0$ $(\eta_{h_j,w_{-j}} < 0)$ implies that the leisure times of the spouses are Frisch complements (substitutes).

Equations (7) and (8) show very clearly the effect of changes in prices and the feedback effect of taxes on consumption and leisure in an environment with nonseparable preferences. Consider, for example, a λ-constant (before-tax) wage shock to earner j. This change has several effects on intertemporal equilibrium consumption and hours. First, it leads to intertemporal substitution in own hours $\left(\text{as measured by } \eta_{h_j,w_j}\right)$. If preferences are nonseparable between the leisure of the two spouses, it also leads to an adjustment in the hours of the spouse $\left(\text{as measured by } \eta_{h_{-j},w_j}\right)$. Under tax progressivity, a wage change may cause individuals to shift tax brackets, which would change work incentives for both members' labor supply given joint taxation of earnings, creating feedback effects (the last term in (8)). Finally, a λ-constant change in the wage shifts household consumption due to nonseparability between consumption and leisure $\left(\text{as measured by } \eta_{c,w_j}\right)$ and the feedback effect of taxes on household earnings (the last term in equation (7)).[10]

While the characterization (7) and (8) is theoretically appealing, it is empirically not very useful because it does not allow us to distinguish between responses to λ-constant and λ-varying exogenous wage shocks. To achieve these goals, we follow Blundell, Pistaferri, and Preston (2008). First, we decompose the growth of the marginal utility of wealth $\Delta \ln \lambda_{i,t}$ into two components. The first captures the effect of aggregate variables on the consumption slope and is assumed to be fixed in the cross section. The second component captures innovations in the growth of the marginal utility of wealth. Second, to map innovations in the marginal utility of wealth into innovations in the wage process faced by the two earners, we log-linearize the intertemporal budget constraint,

$$E_t \sum_{s=0}^{T-t} \frac{C_{i,t+s}}{(1+r)^s} = A_t + E_t \sum_{s=0}^{T-t} \frac{T\left(W_{i,1,t+s}H_{i,1,t+s} + W_{i,2,t+s}H_{i,2,t+s}\right)}{(1+r)^s},$$

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[9] We use the notation "$-j$" to indicate variables that refer to the other earner. For example, $\eta_{h_j,w_{-j}}$ measures the elasticity of earner j's labor supply to the other earner's wage changes.

[10] We assume that transitory shocks are fully smoothed, and hence they affect consumption only through nonseparability.

and take the difference in expectations between period t and $t - 1$ to obtain equations that link consumption and hours growth of the two earners to the wage shocks they face (see online Appendix 1 for the exact derivation):

$$
(9) \qquad \begin{pmatrix} \Delta c_{i,t} \\ \Delta h_{i,1,t} \\ \Delta h_{i,2,t} \end{pmatrix} \simeq \begin{pmatrix} \kappa_{c,u_1} & \kappa_{c,u_2} & \kappa_{c,v_1} & \kappa_{c,v_2} \\ \kappa_{h_1,u_1} & \kappa_{h_1,u_2} & \kappa_{h_1,v_1} & \kappa_{h_1,v_2} \\ \kappa_{h_2,u_1} & \kappa_{h_2,u_2} & \kappa_{h_2,v_1} & \kappa_{h_2,v_2} \end{pmatrix} \begin{pmatrix} \Delta u_{i,1,t} \\ \Delta u_{i,2,t} \\ v_{i,1,t} \\ v_{i,2,t} \end{pmatrix},
$$

where $\kappa_{l,m}$ is a loading factor measuring the response of variable l to wage shock m. Note that in general, the loading factors κ vary by age and across households (i.e., we should write $\kappa_{c,v_1}^{i,t}$, etc.). To avoid cluttering we leave this individual and age-dependence implicit. The response of consumption to a permanent wage shock faced by earner j is a general function:

$$
\kappa_{c,v_j} = \kappa^{c,v_j} \big(\pi_{i,t}, s_{i,t}, \boldsymbol{\eta}, \mu_{i,t}, \chi_{i,t} \big),
$$

where $\pi_{i,t} \approx \dfrac{Assets_{i,t}}{Assets_{i,t} + Human\ Wealth_{i,t}}$ is a "partial insurance" coefficient (the higher $\pi_{i,t}$ the lower the sensitivity of consumption to shocks), $s_{i,t} \approx \dfrac{Human\ Wealth_{i,1,t}}{Human\ Wealth_{i,t}}$ is the share of earner 1's human wealth over family human wealth, $\boldsymbol{\eta}$ is the vector of all Frisch elasticities, and $\mu_{i,t}$ and $\chi_{i,t}$ are the tax parameters defined above.[11]

D. *What Drives the Transmission of Shocks onto Consumption and Hours?*

In this section we explain in intuitive terms how consumption and hours respond to wage shocks (transitory and permanent), faced by the two household members. We refer the reader to online Appendix 1 for an in-depth analysis of a number of special cases, some of which deliver closed-form expressions for the transmission coefficients. We start by considering labor supply responses.

Labor Supply Responses.—Each earner's labor supply responds to his/her own (before-tax) transitory wage shock to an extent that depends on his/her labor supply's Frisch elasticity. The intuition is simple: the Frisch elasticity measures the labor supply response to a wealth-constant wage change, which here is represented by a pure transitory shock.[12]

The distinction between before-tax and after-tax wage changes is important. Most researchers ignore progressive taxation when estimating Frisch elasticities, and hence assume that there is no difference between before-tax and after-tax wage changes. There are two problems with this assumption. First, neglecting progressive

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[11] *Human Wealth$_{i,t}$* (*Human Wealth$_{i,j,t}$*) is the expected discounted flow of lifetime earnings of the household (earner j) at the beginning of period t. The exact expression for Human Wealth is given in online Appendix 1, where we also discuss the role of the first earner's share of earnings in determining the feedback from joint taxation (omitted here for brevity).

[12] This is, of course, an approximation. Transitory shock will, in general, have a small wealth effect which here we assume is negligible.

taxation may provide evidence of nonseparable preferences even when there is none. This happens because married couples file taxes jointly in the United States. Hence, variation in one earner's labor supply may change the marginal tax rate (and hence the return to work) faced by the other earner even in the presence of separable preferences between spouses' leisure times. Second, with nonlinear progressive taxation, the (after-tax) price of leisure changes with the amount of hours worked, inducing feedback effects and dampening the overall hours response to an exogenous shock to (before-tax) wages. This is simply because any labor supply increase induced by an exogenous increase in before-tax wages is attenuated by a decrease in the return to work as people cross tax brackets (which they do "continuously" in our case). It follows that the Frisch elasticity estimated in the model that neglects progressive taxation is downward biased, as researchers attribute a low response of hours to wage changes to high tastes for leisure, while in fact it may reflect the disincentive to work induced by taxes. In online Appendix 1, we discuss the bias analytically and in the empirical section we report responses to both before-tax and after-tax wage changes.

The response of earner j's to a permanent shock to his/her own wage is informative about whether labor supply is used as a *consumption-smoothing device*, i.e., as a shock absorber. This depends crucially on the traditional tension between the wealth and the substitution effect of a wage change. The sign of this response is hence unrestricted by theory, and indeed the response of earner j's to a permanent shock to his/her own wage is the closest approximation to a *Marshallian* or uncompensated labor supply effect (as opposed to the *Frisch* effect discussed above). For labor supply to be used as a consumption-smoothing device, we require $\kappa_{h_j, v_j} < 0$ (implying that hours move in the *opposite* direction as the permanent shock—i.e., they rise, or people work longer, when wages decline permanently). This occurs when the wealth effect dominates the substitution effect of a permanent wage change. In online Appendix 1 we show that this is more likely to occur when insurance from other sources is limited or costly: (i) consumers have little or no accumulated assets ($\pi_{i,t} \to 0$); (ii) consumers are highly reluctant to intertemporal fluctuations in their consumption ($\eta_{c,p} \to 0$), so that adjustment is delegated to declines in the consumption of leisure rather than declines in the consumption of goods; or (iii) the other earner's share of lifetime earnings or Frisch elasticity is small, implying that the "added worker effects" discussed next do not contribute much to the smoothing of family earnings.

The response of earner j's to a permanent shock faced by the other earner is informative about *added worker effects*. This effect is (typically) negative, i.e., earner j increases her labor supply when earner i is hit by a permanent negative shock. The effect is unambiguously negative if preferences are separable. The reason is that in this case, a permanent negative shock faced by earner i has only a wealth effect as far as earner j is concerned, and no substitution effect (the household is permanently poorer when earner i has a permanently lower wage and hence a reduction in all consumptions, including consumption of leisure of earner j, is warranted).[13]

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[13]Ceteris paribus, the introduction of nonseparability reverts the sign of the added worker effect only in the presence of extremely high (and implausible) degrees of complementarity between husband's and wife's leisure.

Finally, the effect of one earner's j transitory shock on the other earner's hours of work depends crucially on whether preferences for the leisure times of the two household members are separable. If that is the case, and if taxes are linear, $\kappa_{h_j, u_{-j}} = 0$. However, when preferences are nonseparable, the marginal utility of one earner's hours depends on the hours worked by the other earner. In particular, one can show that, quite intuitively, $\kappa_{h_j, u_{-j}} = \eta_{h_j, w_{-j}}$ in the case without taxes (see online Appendix 1). In essence, a test of nonseparability between the leisure times of the two spouses is a test of whether labor supply of earner j respond to the (wealth-constant) transitory shock faced by the other earner. When preferences are separable, these transitory shocks have no wealth effect in the contexts considered, so no response is expected. But in the nonseparable case, these shocks shift preferences (for example, because spouses enjoy leisure together), so they generate a response that depends on the degree of complementarity/substitutability between the arguments of the period utility function.

Consumption Responses.—Consider now consumption responses, starting with the response to permanent shocks. We know that in traditional analyses with, e.g., quadratic utility, consumption responds one-to-one to permanent shocks. When we account for family labor supply and precautionary behavior, this can be quite misleading. In particular, in our framework the response of consumption to permanent wage shocks depends on the tax system, on the partial insurance parameter $\pi_{i,t}$, on the human wealth shares $s_{i,t}$, the consumption Frisch elasticity $\eta_{c,p}$, the labor supply Frisch elasticities of the two earners, η_{h_1, w_1} and η_{h_2, w_2}, and on the extent of nonseparability between consumption and leisure.

Interpreting the role of $s_{i,t}$ is straightforward: consumption is more sensitive to shocks faced by the earner who commands more resources, i.e., earner with larger human capital weight. Ceteris paribus, the sensitivity of consumption to the first earner's permanent wage shock is decreasing in the Frisch labor supply elasticity of the other earner (because in that case the added worker effect is stronger, and hence adjustment is partly done through increasing labor supply of the other earner); and it is decreasing in the own Frisch labor supply elasticity if the response of hours of this earner to a shock is negative (i.e., if there is smoothing done through own labor supply, as discussed above). The sensitivity of consumption to a permanent shock also increases with $\eta_{c,p}$ because consumers with high values of the consumption elasticity of intertemporal substitution are by definition less reluctant to intertemporal fluctuations in their consumption. Furthermore, the sensitivity of consumption to a permanent shock is higher whenever insurance through savings is small ($\pi_{i,t}$ is low). The intuition is that the smaller is $\pi_{i,t}$, the less assets the household has to smooth consumption when hit by a permanent shock of either spouse. It is indeed accumulation of these precautionary reserves that make consumption smoother than household earnings.

Finally, is the consumer response to permanent shocks in the nonseparable case smaller or larger than in the additive separable case? As originally remarked by Heckman (1974), the dynamic response of consumption to wage changes will depend on whether consumption and hours are complements or substitutes in utility. In particular, when C and H are substitutes ($\eta_{c,w_j} < 0$), we may have *excess*

smoothing of consumption with respect to wage shocks; while complementarity $(\eta_{c,w_j} > 0)$ may induce *excess sensitivity* (excess response to shocks relative to the additive separable case). To illustrate, consider the case in which the woman faces a permanent wage fall. Empirically, for women the substitution effect dominates the wealth effect, hence her hours decline, and earnings decline more than proportionally relative to the wage change. In the separable case (i.e., when $\eta_{c,w_2} = 0$), consumption decreases due to a pure *budget constraint* effect. With substitutability between hours and consumption, consumers want optimally to have more consumption in the state in which hours are lower, and this would be reflected in a smaller consumption response to permanent shock relative to the separable case (and vice-versa under complementarity). In other words, there is greater demand for consumption insurance and the downward adjustment in consumption is attenuated relative to the nonseparable case.

Next, we discuss the impact of transitory shocks. In traditional analyses of the permanent income hypothesis under separable preferences (and if credit markets are assumed to work well), consumption responds very little to transitory shocks $\left(\kappa_{c,u_j} \approx 0 \text{ for } j = \{1,2\}\right)$. This is because (for consumers with a long horizon) transitory shocks have no lifetime wealth effect (they have negligible impact on the revision of the marginal utility of wealth). But when preferences are nonseparable the marginal utility of consumption depends on hours (and vice-versa). As with hours, one can show that $\kappa_{c,u_j} = \eta_{c,w_j}$ for $j = \{1,2\}$ when taxes are ignored (see online Appendix 1). A test of nonseparability between consumption and the leisure of earner j is a test of whether consumption respond to transitory shock of that earner (shocks that do not have, or have only negligible, wealth effects). With nonseparability a transitory wage shock induces a change in hours and, through preference shifts, requires an adjustment also of consumption.[14]

Note that, similarly to the labor supply case, neglecting progressive taxation produces downward-biased estimates of the consumption elasticities (in particular, of the response of consumption to a change in the price of leisure).

II. Data, Estimation Issues, and Empirical Strategy

A. *Sample Selection*

We use the 1999–2009 Panel Study of Income Dynamics (PSID) to estimate the model. In 1968, the PSID started collecting information on a sample of roughly 5,000 households. Of these, about 3,000 were representative of the US population as a whole (the core sample), and about 2,000 were low-income families (the Census Bureau's Survey of Economic Opportunity (SEO) sample). Thereafter, both the original families and their split-offs (children of the original family forming a family of their own) have been followed. The PSID data were collected annually until 1996 and biennially starting in 1997. A great advantage of PSID after 1999 is that, in addition to income data and demographics, it collects data about detailed assets

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[14] Of course, the test can also reject if consumption responds to transitory shocks due to failure of self-insuring against it. In this case the coefficient κ_{c,u_j} should be positive. However, as we shall see in the empirical analysis we find that $\kappa_{c,u_j} < 0$.

holdings and consumption expenditures in each wave. To the best of our knowledge this makes the PSID the only representative large-scale US panel to include income, hours, consumption, and assets data. Since we need both consumption and assets data, we focus on the 1999–2009 sample period.

For our baseline specification we focus on non-SEO households[15] with participating and married male household heads 30–57 years old, and with nonmissing information on key demographics (age, education, and state of residence). Note that we do not select our sample based on the working status of the spouse. To reduce the influence of measurement error, we also drop observations with extremely high asset values ($20 million or more), as well as observations with total transfers (calculated as explained in Section IIB) more than twice the size of total household earnings.[16]

We choose the 30–57-year-old age range because we want to focus on a sample where household formation choices are completed and the intensive work margin is the dominating one. Whenever there is a change in family composition we drop the year of the change and treat the household unit as a new family starting with the observation following the change. The focus on married couples is due to our research objective (investigating the role of family labor supply as an insurance device).[17] Finally, the choice to focus on continuously working males is important but it is also less restrictive than it may seem at first, as the working requirement is relative to an annual measure of hours, and typically unemployment spells of prime-age males are short. Indeed, our work requirement sample selection ends up dropping only 10 percent of all male heads observations in this age range.

Descriptive Statistics: Baseline Sample.—To estimate our model we need to construct a series for household consumption. Since we do not model the household decision to purchase durables, we focus on nondurables and services. Before 1999, PSID collected data on very few consumption items, such as food (including food stamps), rent, and child care. However, starting in 1999, consumption expenditure data cover many other nondurable and services consumption categories, including health expenditures, utilities, gasoline, car maintenance, transportation, education, and child care. Other consumption categories have been added starting in 2005 (such as clothing). We do not use these categories to keep the consumption series consistent over time. The main items that are missing are clothing, recreation, alcohol, and tobacco.

While rent is reported whenever the household rents a house, it is not reported for homeowners. To construct a series of housing services for homeowners, we impute the rent expenditures for homeowners using the self reported house value.[18]

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[15] In the late 1990s, the PSID also added an immigrant sample. We exclude this sample as well.

[16] When calculating the relevant consumption, hourly wage, and earnings moments, we do not use data displaying extreme "jumps" from one year to the next (most likely due to measurement error). A "jump" is defined as an extremely positive (negative) change from $t-2$ to t, followed by an extreme negative (positive) change from t to $t+2$. Formally, for each variable (say x), we construct the biennial log difference $\Delta^2 \log(x_t)$, and drop the relevant variables for observation in the bottom 0.25 percent of the product $\Delta^2 \log(x_t) \, \Delta^2 \log(x_{t-2})$. Furthermore, we do not use earnings and wage data when the implied hourly wage is below one-half of the state minimum wage.

[17] While studying the consequences of family dissolution risk on behavior is an important task, we believe it is beyond the scope of the paper. Even from a theoretical point of view, the "unitary model" assumption we have made is less likely to hold in a context with voluntary divorce (unless one makes simplifying assumptions, such as random marriage dissolution).

[18] For our baseline measure we approximate the rent equivalent as 6 percent of the house price. See Poterba and Sinai (2008).

TABLE 1—DESCRIPTIVE STATISTICS

	Baseline sample		With nonworking males		All males ever married	
	Mean	Median	Mean	Median	Mean	Median
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Summary stats						
Consumption						
Total	39,257	32,920	38,733	32,392	37,389	31,300
Nondurable cons.	8,552	7,800	8,490	7,720	8,286	7,600
Food at home	6,165	5,200	6,104	5,200	5,932	5,200
Gasoline	2,339	1,800	2,318	1,800	2,281	1,800
Services	30,705	24,280	30,243	23,763	29,103	22,992
Food out	2,816	1,800	2,737	1,680	2,671	1,800
Health ins.	1,572	750	1,550	720	1,471	615
Health serv.	1,317	650	1,308	625	1,249	575
Utilities	3,856	3,300	3,823	3,264	3,715	3,180
Transportation	3,896	2,040	3,826	2,000	3,762	2,000
Education	2,589	0	2,523	0	2,304	0
Child care	714	0	677	0	683	0
Home ins.	581	480	574	470	548	435
Rent (or rent eq.)	13,364	9,900	13,225	9,600	12,700	9,240
Assets						
Total	389,105	221,000	389,578	215,000	359,104	196,175
Housing and RE	232,671	160,000	233,115	155,000	216,982	147,500
Financial assets	156,670	35,500	156,756	34,500	142,374	30,400
Total debt	108,984	78,000	106,019	73,000	103,219	70,000
Mortgage	99,083	70,000	95,997	65,800	92,882	62,000
Other debt	10,218	2,000	10,321	1,900	10,640	2,000
Total net worth	280,131	112,000	283,534	109,000	255,866	95,000
Total net financial worth	96,576	13,600	96,404	12,000	86,509	10,000
First earner (head)						
Participation rate	1.00		0.95		0.95	
Earnings | work	67,008	48,237	66,068	48,000	64,513	46,145
Hours worked | work	2,302	2,226	2,293	2,216	2,295	2,220
Share with some college	0.59		0.58		0.57	
Second earner						
Participation rate	0.80		0.79		0.75	
Earnings | work	32,988	26,600	33,485	26,500	33,618	26,742
Hours worked | work	1,688	1,864	1,699	1,872	1,709	1,880
Share with some college	0.60		0.58		0.58	
Observations	10,479		11,638		13,463	
Panel B. Volatility						
$\Delta \log(W_1)$	0.498		0.508		0.500	
$\Delta \log(W_2)$	0.457		0.462		N/A	
$\Delta \log(Y_1)$	0.513		0.534		0.536	
$\Delta \log(Y_2)$	0.616		0.628		N/A	
$\Delta \log(C)$	0.321		0.324		0.346	

Notes: Data from 1999–2009 PSID waves. See text for description of the three samples. Missing values in consumption and assets subcategories are treated as zeros. Measures of volatility are standard deviations of relevant variables.

We treat missing values in the consumption (and asset) subcategories as zeros and aggregate all nondurable and services consumption categories to get the household consumption series. Descriptive statistics on the various components of aggregate consumption (nominal values) are reported in Table 1. The first two columns refer

Table 2—Comparison of PSID Data with NIPA

	1998	2000	2002	2004	2006	2008
PSID total	3,289	3,782	4,300	5,082	5,953	5,773
NIPA total	5,139	5,915	6,447	7,224	8,190	9,021
Ratio	0.64	0.64	0.67	0.70	0.73	0.64
PSID nondurables	759	869	903	1,037	1,214	1,181
NIPA nondurables	1,330	1,543	1,618	1,831	2,089	2,296
Ratio	0.57	0.56	0.56	0.57	0.58	0.51
PSID services	2,530	2,914	3,398	4,045	4,740	4,592
NIPA services	3,809	4,371	4,829	5,393	6,101	6,725
Ratio	0.66	0.67	0.70	0.75	0.78	0.68

Notes: We use PSID weights (we have a total of 47,206 observations for the period 1999–2009). Total consumption is defined as nondurables + services (in $billion units). PSID consumption categories include food, gasoline, utilities, health, rent (or rent equivalent), transportation, child care, education, and other insurance. NIPA numbers are from NIPA Table 2.3.5. All figures are in nominal terms.

to our baseline sample, while the other columns refer to alternative samples (which we comment on in the next section).

A comparison of the main aggregates (total consumption, nondurables, and services) against the NIPA series is in Table 2. As shown in Table 2, taking into account that the PSID consumption categories that we use are meant to cover 70 percent of consumption expenditure on nondurables and services, the coverage rate is remarkably good.

Data on household's assets holdings are required for the construction of $\pi_{i,t}$, the share of assets out of total wealth. Starting in 1999, the PSID collects data on assets holdings in each wave (between 1984 and 1999, asset data were collected every five years). The data include detailed asset holdings as well as information on household debt including first and second mortgage and other debt. Since we are interested in the net assets holdings, our measure of assets is constructed as the sum of cash, bonds, stocks, the value of any business, pension funds, housing, and other real estate, and vehicles, net of any mortgage, and other debts.

In addition to consumption and assets, data on wages and earnings of the first and second earner are also required. The survey collects data on annual labor earnings and on annual hours of work. To construct the hourly wage we divide annual earnings by annual hours. Hence, we have a measure of the average hourly wage.

In the lower part of Table 1 we provide summary statistics on asset holdings and on labor supply and earnings for the two earners. It is worth noting that the female participation rate in this sample is fairly high (around 80 percent), and that on average they earn about one-half of what males earn, partly reflecting lower hours of work (conditional on working), and partly reflecting other factors, both explained and unexplained.

Descriptive Statistics: Sample Comparisons.—Our baseline sample selects households with participating and married male household heads 30–57 years old. The columns of Table 1 present summary statistics comparing our baseline sample with a sample of all married male heads (independently of work status) and with a sample of all households headed by a male recorded as married at least once in

the 1998–2008 period (again, independently of work status). The table shows very small differences in observables across samples. Male earnings (conditional on participation) are only slightly smaller in the more comprehensive samples, and permanent income (as measured by the fraction with two- to four-year college degrees) is similar. Finally, average total assets of the first two samples are similar, while they are substantially lower in the sample of all males. However, this is partly due to the fact that some of these males are now single or divorced, so there are fewer opportunities for sharing resources.

Notwithstanding the small differences between our baseline and alternative samples that do not condition on the work and marital status of the head, there may be some concerns that our sample selection drops households headed by males facing large permanent wage shocks resulting in long unemployment spells or labor force exits (for example, due to disability). This may understate the importance of added worker effects (if women enter the labor force when the men leave it) or overstate it (if wives have to care for their disabled husbands and lost earnings are replaced by government social insurance programs, such as disability insurance). In panel B of Table 1 we compare measures of risk (as given by the variance of wage growth, earnings growth, and consumption growth) for our baseline sample and the two alternative samples. There is indeed more volatility when the sample eschews selection on work or marriage. But the differences are, overall, modest.

B. *Accounting for Progressive Taxation and Government Transfers*

It is important to ensure that the tax function which we use in our model fits well the progressivity of the tax system in the United States, as well as the generosity of means-tested transfers programs. In the baseline model with progressive taxation and government transfers, the tax parameters $\chi_{i,t}$ and $\mu_{i,t}$ are estimated by regressing after-tax household income on a constant and before-tax household earnings (as reported in the survey), allowing for the regression coefficients to change by year and household characteristics. In particular, we first compute after-tax income as

$$Y_{i,t}^{AT} = \sum_{j=1}^{2} W_{i,j,t} H_{i,j,t} - \tau\left(\sum_{j=1}^{2} W_{i,j,t} H_{i,j,t}; \mathbf{z}_{i,t} \right) + EITC\left(\sum_{j=1}^{2} W_{i,j,t} H_{i,j,t}; \mathbf{z}_{i,t} \right)$$

$$+ FS\left(\sum_{j=1}^{2} W_{i,j,t} H_{i,j,t}; \mathbf{z}_{i,t} \right),$$

where $\tau(\cdot)$, $EITC(\cdot)$, and $FS(\cdot)$ are functions that compute taxes and eligible amounts of EITC and Food Stamps benefits using program information for the various years (allowing benefits to vary by demographic, such as number and age of children, etc.). Since using $Y_{i,t}^{AT}$ directly is infeasible in our log-linear approximation procedure, we approximate the relationship between after-tax income and before-tax household earnings using

$$Y_{i,t}^{AT} \approx \left(1 - \chi_{i,t}\right) \left(\sum_{j=1}^{2} W_{i,j,t} H_{i,j,t} \right)^{(1-\mu_{i,t})} .$$
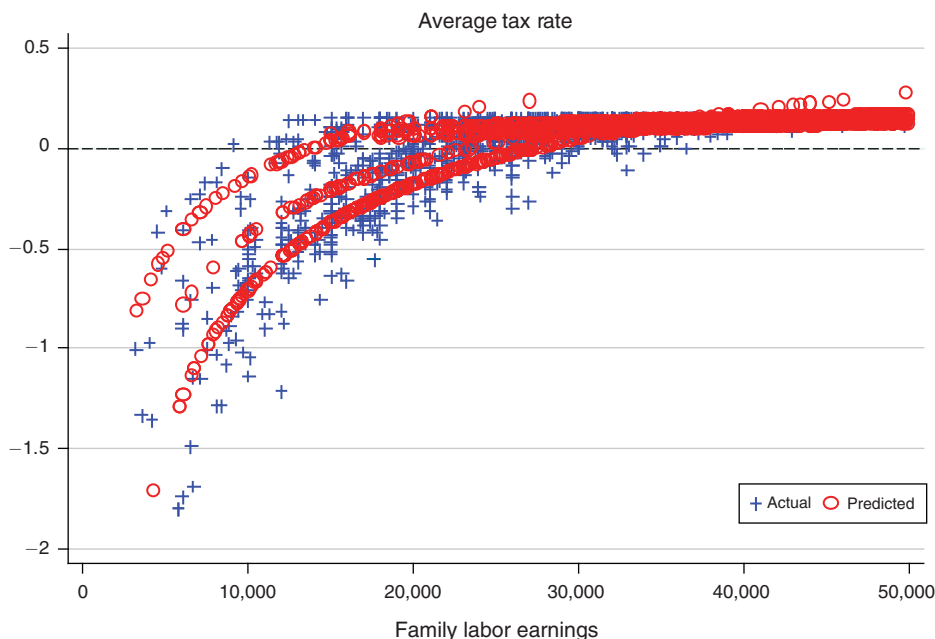
FIGURE 1. APPROXIMATION OF THE TAX AND TRANSFER CODES

To capture the very low and sometimes negative tax rates for low earnings households, we estimate the tax parameters separately for households who are eligible for Food Stamps and for those who are not. Furthermore, for the Food Stamps eligible group we allow the function to change by number of kids, and for the rest of the sample we allow the parameters to change by year in order to capture changes in the progressivity of taxes over time. Figure 1 focuses on households jointly earning less than $50,000 and compares average tax rates with those obtained using our approximation. In this group, average tax rates are often negative because of EITC and Food Stamps entitlements exceeding taxes paid, especially at low levels of joint earnings. The approximation procedure appears quite accurate. In fact, the R^2 for a regression of predicted on actual average tax rates is 0.93.

C. *Identification*

There are four sets of parameters that we are interested in estimating: wage parameters, smoothing parameters, preference parameters, and measurement error variances. In this section we discuss identification of these parameters from a more intuitive point of view (i.e., which variation in the data is helping identifying the parameters), and leave the more technical details to online Appendix 2.

Consider first the identification of wage variances and covariances (Meghir and Pistaferri 2004). As apparent from equation (3), the only reason why wage growth exhibits serial correlation is because of (mean-reverting) transitory shocks. This means that one can identify the variance of transitory shocks using the extent of serial correlation in wage growth. Identification of $\sigma_{u_1 u_2(t)}$ is an extension of this idea—between-period and between-earner wage growth correlation

reflects the correlation of their mean-reverting components. Identification of the variance of permanent shocks $\sigma^2_{v_j(t)}$ rests on the idea that the variance of wage growth $\left(E(\Delta w_{i,j,t} \Delta w_{i,j,t})\right)$, stripped of the contribution of the mean-reverting components $\left(E(\Delta w_{i,j,t} \Delta w_{i,j,t-1}) + E(\Delta w_{i,j,t} \Delta w_{i,j,t+1})\right)$, identifies the variance of innovations to the permanent component. Identification of $\sigma_{v_1 v_2(t)}$ follows a similar logic.

To discuss identification of structural preference and smoothing parameters in an intuitive way, consider the case with proportional taxes and nonseparable preferences.

As argued above, Frisch (λ-constant) labor supply elasticities η_{h_j, w_j} can be identified looking at the hours response to wage changes that have no wealth effects (i.e., transitory wage shocks).

The extent of complementarity-substitutability between consumption and hours of earner j $\left(\text{the Frisch cross-elasticity } \eta_{c, w_j}\right)$ is identified by the response of consumption to a transitory wage shock faced by that earner (shocks that have no wealth effect). This is because a transitory shock faced by j shifts his labor supply due to intertemporal substitution reasons, and since the marginal utility of consumption now depends on hours, consumption will also adjust. Similarly, the extent of complementarity-substitutability between the hours of work of husband and wife $\left(\text{the Frisch cross-elasticities } \eta_{h_j, w_{-j}} \text{ and } \eta_{h_{-j}, w_j}\right)$ is identified by the response of one earner's hours to the transitory shock faced by the other earner (shocks that do not change the own price of leisure). This is because, exactly as before, a transitory shock faced by the husband, say, shifts his labor supply due to intertemporal substitution reasons, and since the marginal utility of leisure of the wife now depends on her husband's hours, her hours will also need to adjust despite the lack of a wealth effect.[19]

The identification of $\pi_{i,t}$ and $s_{i,t}$ uses data on assets, earnings, and projected earnings as explained in the next section.

Finally, we need to discuss the identification of $\eta_{c,p}$. In practice, the joint response of consumption and hours to permanent shocks both help pinning down $\eta_{c,p}$. Consider the one-earner case for simplicity. If this household has lower elasticity of intertemporal substitution in consumption, it is reluctant to accept wide fluctuations in consumption across periods, and hence we should see a smaller κ_{c, v_j}. As $\eta_{c,p}$ rises, so does κ_{c, v_j}. As for κ_{h_j, v_j}, it is a Marshallian elasticity. At low values of $\eta_{c,p}$, the wealth effect dominates and $\kappa_{h_j, v_j} < 0$ (people increase hours to smooth the much more valued consumption in response to negative permanent shocks); at high values of $\eta_{c,p}$, the substitution effect dominates and hours move in the same direction of the shock and we should find $\kappa_{h_j, v_j} > 0$.

In practice, one way of thinking about what forces identify $\eta_{c,p}$ is to think about an overidentified case. Figure 2 provides a graphical intuition. In both panels we plot $\kappa_{c, v}$ and $\kappa_{h, v}$ as a function of $\eta_{c,p}$. In the left panel, identification is tight: both

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[19] While these identification arguments are intuitive, from an implementation point of view, we note that we do not observe transitory shocks, but the convolution of transitory and permanent shocks. We also stress that we have an overidentified model, and hence in the general case it is difficult to provide intuitive one-to-one mappings from moments (or combination thereof) and structural parameters. We discuss these issues more in detail in online Appendix 2.
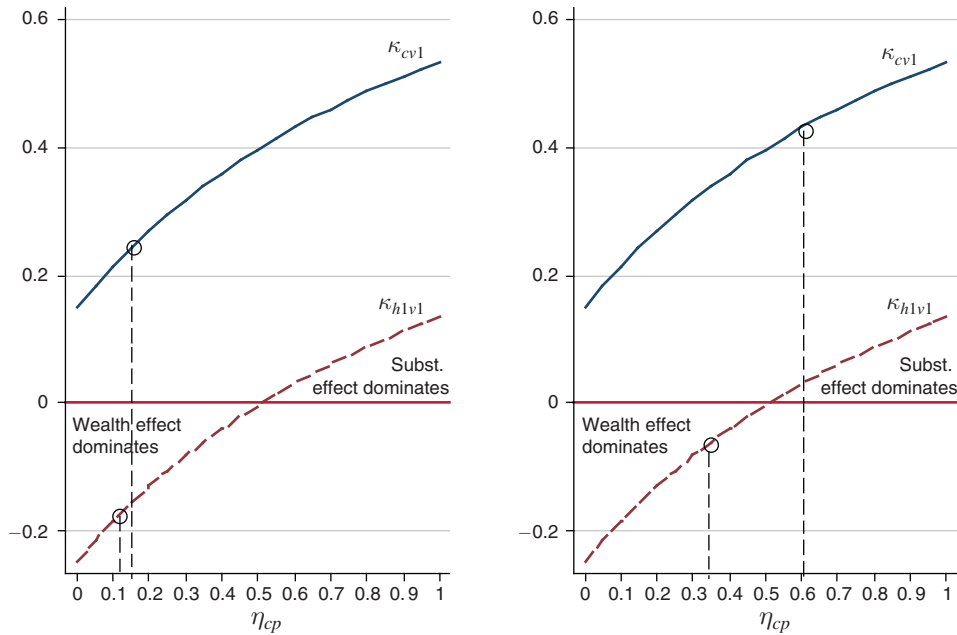
FIGURE 2. IDENTIFICATION OF CONSUMPTION FRISCH ELASTICITY

estimated $\kappa_{c,v}$ and $\kappa_{h,v}$ are consistent with a relatively small $\eta_{c,p}$. In the right panel, the estimated $\eta_{c,p}$ would be higher and (most likely) noisier.

D. *Estimation Issues*

From an estimation point of view, we need to take a stand on a number of difficult issues. These include: (i) adopting the correct inference for our estimation procedure; (ii) allowing for measurement error in consumption, wages, and earnings; and (iii) controlling for the selection into work of the secondary earner. We discuss these problems in the rest of this section.

Inference.—We use multiple moments, which we deal with using a generalized method of moments (GMM) strategy and an identity matrix as a weighting matrix. In particular, we use the restrictions that the model imposes on the joint distribution of consumption growth, the growth of the husband's earnings, and the growth of the wife's earnings.[20] Given the multistep approach (detailed below), and the fact that we use longitudinal data, we compute the standard errors of our estimated parameters using the block bootstrap (unless explicitly noted). In this way we account for serial correlation of arbitrary form, heteroskedasticity, as well as for the fact that we use preestimated variances when estimating the preference parameters.[21]

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[20] While the model has been described in terms of hours for intuitive purposes (as is easy to relate to hours elasticities), in estimation we use earnings and consumption moments. Earnings and hours moments are linked by a simple change of variables, as $\log Y_{i,j,t} = \log H_{i,j,t} + \log W_{i,j,t}$.

[21] To avoid the standard errors being affected by extreme draws, we apply a normal approximation to the interquartile range of the replications.

Measurement Error.—Consumption, wages, and earnings are most invariably measured with error. In our context, there are three problems one needs to confront when adding measurement errors. First, as discussed in Blundell, Pistaferri, and Preston (2008), among others, the distribution of the measurement error is indistinguishable from the distribution of the economically relevant transitory shock. Second, our wage measure (constructed as annual earnings divided by annual hours) suffers from the so-called "division bias." Third, measurement errors are hard to distinguish from stochastic changes in preferences or shocks to higher moments of the distribution of wages in terms of effects on consumption or labor supply choices. We make no attempt to resolve this distinction, and hence identify an aggregate of these various forces, some statistical and some economic.

Ignoring the variance of measurement error in wages or earnings is problematic since it has a direct effect on the estimates of the structural parameters. We thus follow Meghir and Pistaferri (2004) and use findings from validation studies to set a priori the amount of wage variability that can be attributed to error. We use the estimates of Bound et al. (1994), who estimate the share of variance associated with measurement error using a validation study for the PSID (which is the dataset we are using). Details are in online Appendix 3. In the separable utility case, measurement error in consumption can be identified using the consumption martingale assumption. Under nonseparability, there is some serial correlation in consumption not due to error; we keep the identification idea and interpret the first-order autocovariance as an upper bound on the measurement error in consumption.

Selection into Work by the Second Earner.—Above, we have derived the expressions for earnings and hourly wage growth assuming interior solutions for labor supply for both spouses. A major concern when modeling labor supply is endogenous selection into work and therefore the need to distinguish between the intensive and the extensive margin of employment. Male participation is very high (for example, in our sample, before conditioning on working, men 30–57 years old have average participation rates of 95 percent).[22] This justifies our decision to focus on a sample of always-employed males. As for wives, their participation is 80 percent on average, and hence it is potentially important to account for their selection into work (see Table 1).

One approach is to explicitly model the decision to participate of the secondary earner. While appealing from a theoretical point of view, it makes the solution of the life-cycle problem much more difficult; in fact, it would make our approximation procedure infeasible. We therefore adopt two empirical strategies. The first derives an empirical correction for the sample selection in the spirit of Low, Meghir, and Pistaferri (2010). We use "conditional covariance restrictions" rather than unconditional ones. Finding exclusion restrictions is the challenging part of this exercise. We use the presence of first and second mortgage interacted with year effects. There is some evidence showing that female participation rises when households move into home ownership (Del Boca and Lusardi 2003). We provide more details about this strategy in online Appendix 4. The second approach, detailed in

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[22] See column 3 of Table 1. Note that the reduction in the number of observations moving from column 3 to column 1 is larger than 5 percent, because column 1 conditions on being continuously employed.

Section IVA, considers a more reduced-form approach in which we model the change in the women's decision to work as a function of wage shocks and demographics.

E. *Empirical Strategy*

We adopt a multi-step empirical strategy. First, we regress consumption, wage, and earnings growth on observable characteristics and work with the residuals (the empirical equivalents of $\Delta c_{i,t}, \Delta y_{i,1,t}, \Delta w_{i,1,t}, \Delta y_{i,2,t}, \Delta w_{i,2,t}$ above).[23] Note that the wage and earnings regressions use only workers. Second, we use (6) to estimate the tax parameters $\chi_{i,t}$ and $\mu_{i,t}$ by regressing the log of after-tax joint earnings on a constant term and on the log of before-tax joint earnings, allowing for the regression coefficients to change by year and household characteristics. Third, we estimate the smoothing parameters $\pi_{i,t}$ and $s_{i,t}$ using asset and (current and projected) earnings data (as detailed in the next section). Fourth, we estimate the wage variances and covariances using the second-order moments of $\Delta w_{i,1,t}$ and $\Delta w_{i,2,t}$. Finally, we estimate the preference parameters using the restrictions that the model imposes on the second-order moments of $\Delta y_{i,1,t}$, $\Delta y_{i,2,t}$, and $\Delta c_{i,t}$ and conditioning on results (wage variances, covariances, and smoothing parameters) obtained in the previous steps.

Our baseline specification uses only workers and does not correct for selection into work. In the robustness section we show that the correction for selection makes little difference. When we apply the sample selection correction described in Section IID, we run the regressions that calculate residual measures for the wife's wages and hours equations (step 1) controlling for selection into work (which is done constructing conventional inverse Mills ratio terms).

III. Results

A. *Estimating $\pi_{i,t}$ and $s_{i,t}$*

The calculations of $\pi_{i,t} \approx \frac{Assets_{i,t}}{Assets_{i,t} + Human\ Wealth_{i,t}}$ and $s_{i,t} = \frac{Human\ Wealth_{i,1,t}}{Human\ Wealth_{i,t}}$ require the knowledge of assets, which we take directly from the data, the expected after-tax human wealth at age t, and the share of human wealth by each earner. We calculate after-tax human wealth as

$$Human\ Wealth_{i,t} = Y_{i,t}^{AT} + \frac{E_t\left(Y_{i,t+1}^{AT}\right)}{1+r} + \dots,$$

where $Y_{i,t}^{AT}$ is total household after-tax income (assuming no changes in tax policy).[24]

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[23] The observable characteristics in the wage equation include year, year of birth, education, race, state, and large city dummies as well as education-year, race-year, and large city-year interactions. For consumption and earnings we also add dummies for number of kids, number of family member, employment status (at the time of interview), income recipient other than head or wife in the household, and whether the couple has children not residing in the household. For observables which are not fixed over time, we use both the level and the change.

[24] The share of human wealth by earner j at time t is calculated similarly. The exact calculation (which is slightly more involved) is reported in online Appendix 1.

Note that the measure of assets we use is defined "beginning-of-period" (i.e., before any consumption decisions are taken), so no endogeneity issues arise.[25] The major difficulty is to form estimates of expected future earnings. We start by applying our tax approximation to pooled household earnings for all years and ages. We then regress after-tax earnings on characteristics that either do not change over time (race and education) or characteristics that change in a perfectly forecastable way (a polynomial in age, and interaction of race and education with an age polynomial). To obtain an estimate of expected earnings at age $t + s$ given information at age t $\left(\text{i.e., } E_t(Y_{i,t+s})\right)$, we simply use the predicted value of the regression above evaluated at age $t + s$. We assume that agents are working until age 65 and that the discount rate is the same as the interest rate, and set the annual interest rate to 2 percent.

The same idea is applied to calculate expected human wealth for the each earner. However, since we allow for nonparticipation of the second earner, we run the earnings regressions controlling for selection using the Heckman correction. Moreover, to control for participation in the prediction of earnings, we use a probit specification with education, race, polynomial in age, and interactions to predict the probability of participation for the secondary earner at each age. The expected earnings for the wife at age $t + j$ are then the product of the predicted offered wages in period $t + j$ and the probability of being employed in that period.

This procedure allows us to (pre-)estimate $\pi_{i,t}$ using asset and human capital data. The average value of these estimates is $E(\pi_{i,t}) = 0.15$; the age-specific averages are reported in the panel A of Figure 3 (on the left axis), together with the life-cycle evolution of the household's total assets (on the right axis). These trends remain very similar if we use medians rather than means. Panel B shows the distribution of $\pi_{i,t}$ (selected quantiles) over the life cycle. There is an enormous amount of heterogeneity across households. For example, around age 55, some households in the top quantiles have achieved almost full insurance against wage shocks given the large amount of accumulated assets, while some at the bottom have little or even negative assets—implying their only sources of insurance are family labor supply or social insurance.

The estimates of $\pi_{i,t}$ conform to expectations. The degree of self-insurance warranted by asset accumulation is negligible at the beginning of the life cycle, but the combination of asset accumulation due to precautionary and life-cycle motives (visible from the evolution of the right axis variable) and the decline of expected human capital due to the shortening of the time horizon imply an increase in $\pi_{i,t}$ as time goes by, and hence the household's ability to smooth permanent wage shocks also increases over time. As the household head nears retirement after age 55, the average value of $\pi_{i,t}$ exceeds 0.35. What needs to be noted, however, is that this estimate—reflecting "actual" saving decisions of households—embeds all forms of insurance (or constraints to them) that households have available. In other words, there is no obvious way to benchmark the pattern shown in Figure 3. The closest equivalent is the hypothetical pattern presented by Kaplan and Violante (2010). We also estimate the pattern of $\pi_{i,t}$ by terciles of the asset distribution and find that the

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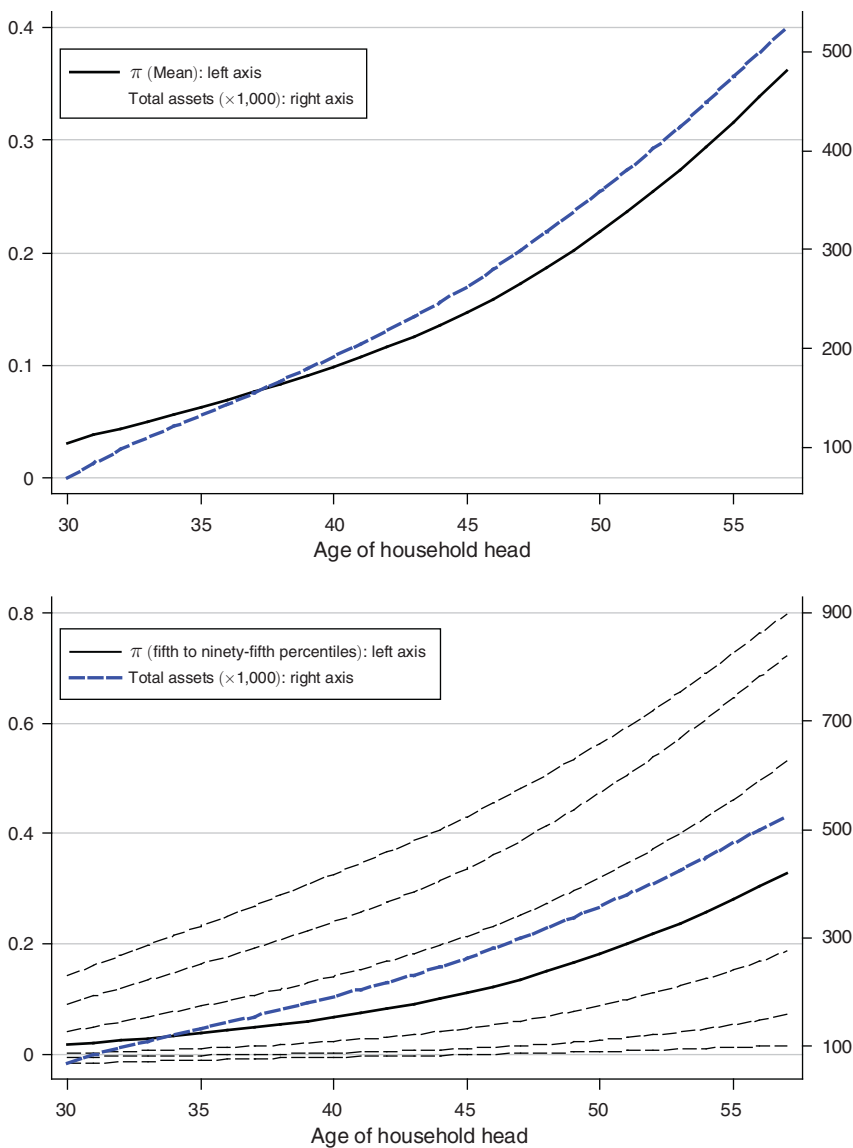[25] In practice we use assets reported in the previous $(t - 2)$ wave.

FIGURE 3. THE EVOLUTION OF PARTIAL INSURANCE COEFFICIENT BY AGE

average value of $\pi_{i,t}$ increases with the rank in the wealth distribution, suggesting greater ability to smooth consumption among the wealthier, a result also found by Blundell, Pistaferri, and Preston (2008).

Our estimates of $s_{i,t}$ (the ratio of the husband's human wealth to total household human wealth) are plotted in Figure 4 against the head's age. These estimates can be interpreted as the life-cycle evolution of the distribution of earnings power within the household. On average, the husband commands about 70 percent of total household human wealth. His weight rises initially due to the wife's fertility choices, and declines at the end of the life cycle due to early retirement choices coupled with age differences within the household.
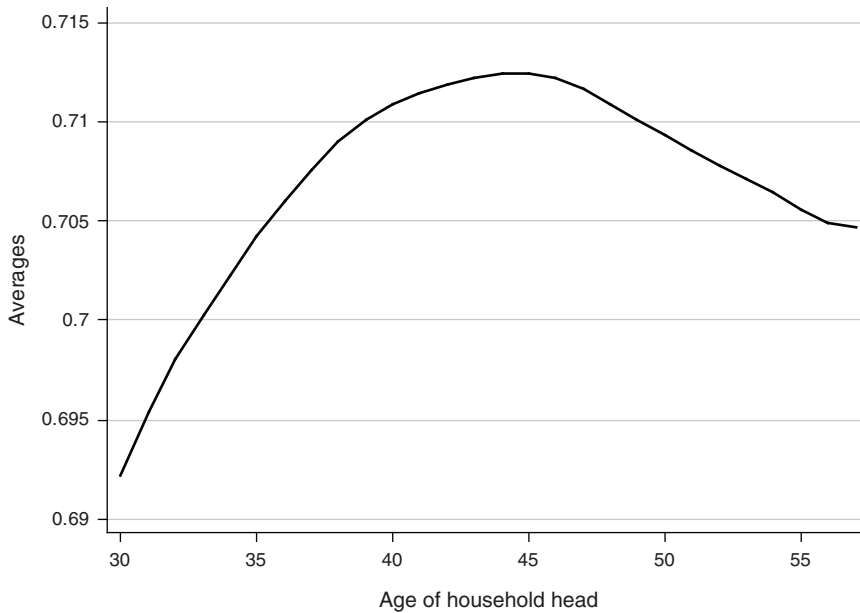
FIGURE 4. THE EVOLUTION OF S BY THE AGE OF THE HOUSEHOLD HEAD

TABLE 3—WAGE VARIANCE ESTIMATES

Sample			30–37	38–42	43–47	48–52	53–57	All ages
Males	Trans.	$\sigma^2_{u_1}$	0.0431***	0.0163	0.0364***	−0.0024	0.0408**	0.0275***
			(0.0127)	(0.0113)	(0.0141)	(0.0135)	(0.0182)	(0.0063)
	Perm.	$\sigma^2_{v_1}$	0.0273***	0.0264***	0.0146	0.0500***	0.0377***	0.0303***
			(0.0085)	(0.0075)	(0.0121)	(0.0142)	(0.0106)	(0.0049)
Females	Trans.	$\sigma^2_{u_2}$	0.0257*	0.0053	0.0157	0.0111	−0.0191	0.0125**
			(0.0142)	(0.0106)	(0.0107)	(0.0088)	(0.0116)	(0.0057)
	Perm.	$\sigma^2_{v_2}$	0.0442***	0.0447***	0.0245***	0.0324***	0.0506***	0.0382***
			(0.0120)	(0.0097)	(0.0070)	(0.0071)	(0.0128)	(0.0044)
Covariance of shocks	Trans.	σ_{u_1,u_2}	0.0124*	0.0060	0.0007	0.0020	0.0116**	0.0058**
			(0.0067)	(0.0058)	(0.0059)	(0.0048)	(0.0056)	(0.0027)
	Perm	σ_{v_1,v_2}	−0.0008	0.0018	0.0051	0.0072*	0.0002	0.0027
			(0.0067)	(0.0046)	(0.0037)	(0.0041)	(0.0053)	(0.0023)

Note: Wage process parameters estimated using GMM; GMM standard errors clustered by household in parentheses.
   ***Significant at the 1 percent level.
    **Significant at the 5 percent level.
     *Significant at the 10 percent level.

B. *Main Results*

Wage Variances.—The estimates of the wage variances and covariances are presented in Table 3. Three things are worth noting.

First, for both males and females, the variance of permanent shocks exhibits a U-shaped pattern over the life cycle, similar to what is observed in Blundell, Graber, and Mogstad (2015) and Meghir and Pistaferri (2004). These variances tend to be slightly higher for females, perhaps reflecting greater dispersion in the returns to

unobserved skills, etc. For transitory shocks, the pattern is less clear and less precise from a statistical point of view, although there is some evidence that "wage instability" (Gottschalk and Moffitt 2008) declines over the life cycle and tends to be larger for males, perhaps reflecting a larger influence of turnover, etc. Finally, the transitory components of the two spouses are positively correlated, and (to a less extent) the permanent shocks as well, most likely reflecting the fact that (due to assortative mating) spouses tend to work in sectors, occupations, or even firms that are subject to similar aggregate shocks. These estimates are fairly noisy, however. In particular, we find significant covariances of transitory shocks only at the beginning and end of the life cycle, and significant covariances of permanent shocks only in mid-life. In the last column we pool all ages and estimate a stationary model. Both correlations (of transitory shocks and permanent shocks) are positive, although only the one for transitory shocks significantly so. While allowing for nonstationarity in the wage process adds flexibility to the model, in one of our robustness we also estimate a stationary model. As we shall see, this makes little difference as far as estimation of the structural parameters is concerned.

Consumption and Labor Supply Parameters.—Column 1 of Table 4 reports the estimates of our baseline specification (with nonseparable preferences, progressive taxation and government transfers, and nonstationary wage variances). To increase the efficiency of our estimates, we impose symmetry of the Frisch substitution matrix (see the online Appendix 5 for details).

Some results are worth noting. First, we find an estimate of the consumption Frisch elasticity of $\eta_{c,p} = 0.42$, implying a relative risk aversion coefficient of around 2.4, which is in the plausible range of this parameter. Second, the Frisch labor supply elasticity of males is smaller than that for females, supporting previous evidence and intuition. In particular, we estimate $\eta_{h_1,w_1} = 0.68$ and $\eta_{h_2,w_2} = 0.96$. Our estimate of men's Frisch elasticity is slightly above the range of MaCurdy's (1981) estimates (0.1–0.45) and Altonji's (1986) estimates (0.08–0.54), which vary depending on the specification or set of instruments used. Keane (2011) surveys 12 influential studies and reports an average estimate of 0.83 and a median estimate of 0.17.[26] For women, Heckman and MaCurdy (1980, p. 65) report an elasticity of 1, which is much similar to our estimate. The literature surveyed in Keane (2011) confirms, with a few exceptions, the finding of high Frisch elasticities for women. Finally, moving to the Frisch cross-elasticities, we find evidence of Frisch complementarity of husband and wife hours (spouses enjoy spending time together),[27] and we also find that both husband's and wife's hours of work are Frisch substitutes with respect to household consumption. Note that there may be some worry that the response of consumption to transitory wage shocks (which here we interpret as reflecting nonseparability of preferences) reflects, in fact, liquidity constraints. However, with liquidity constraints the estimates of κ_{c,u_j} would be positive (a negative transitory shock that can't be smoothed through borrowing would induce

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[26] A number of other papers have challenged the notion of that the Frisch labor supply elasticity for males is close to zero. See, for example, Domeji and Floden (2006) and Wallenius (2011).

[27] Evidence of complementarity of leisure times is also found in Browning, Deaton, and Irish (1985); Hyslop (2001); and Voena (2015), among others.

TABLE 4—PARAMETER ESTIMATES

	Baseline estimates (1)	No taxes (2)	Separable preferences (3)	Stationary wage process (4)	Outside insurance (5)
π, s, and Frisch own elasticities					
$E(\pi)$	0.150*** (0.004)	0.139*** (0.004)	0.150*** (0.004)	0.150*** (0.004)	0.150*** (0.004)
$E(s)$	0.708*** (0.013)	0.709*** (0.012)	0.708*** (0.013)	0.708*** (0.013)	0.708*** (0.013)
$\eta_{c,p}$	0.417*** (0.122)	0.372*** (0.086)	0.578*** (0.175)	0.494*** (0.168)	0.433*** (0.121)
η_{h_1,w_1}	0.681*** (0.189)	0.594*** (0.155)	0.528*** (0.142)	0.653*** (0.178)	0.697*** (0.189)
η_{h_2,w_2}	0.958*** (0.267)	0.871*** (0.221)	0.850*** (0.165)	0.976*** (0.281)	0.961*** (0.271)
Frisch cross-elasticities					
η_{c,w_1}	−0.162** (0.074)	−0.148** (0.060)	—	−0.182*** (0.066)	−0.169*** (0.070)
$\eta_{h_1,p}$	0.126** (0.057)	0.085** (0.035)	—	0.141*** (0.052)	0.131** (0.055)
η_{c,w_2}	−0.050 (0.077)	−0.030 (0.059)	—	−0.072 (0.090)	−0.049 (0.074)
$\eta_{h_2,p}$	0.079 (0.121)	0.035 (0.069)	—	0.114 (0.140)	0.077 (0.116)
η_{h_1,w_2}	0.159** (0.071)	0.104** (0.053)	—	0.160** (0.068)	0.166** (0.068)
η_{h_2,w_1}	0.325** (0.140)	0.212* (0.108)	—	0.325** (0.138)	0.339** (0.136)
Outside insurance					
β	—	—	—	—	−0.137 (0.270)
Observations	7,295	7,295	7,295	7,295	7,295

Notes: Parameters estimated by GMM. Column 1 reports the estimates assuming nonseparable preferences, nonlinear taxes, and age-varying wage variances. Column 2 is as column 1, but shuts down taxes. Column 3 is as column 1, but assumes that preferences are separable. Column 4 restricts the variances over the life cycle to be constant. Column 5 allows for "outside insurance." Block bootstrap standard errors in parentheses.

   ***Significant at the 1 percent level.
   **Significant at the 5 percent level.
   *Significant at the 10 percent level.

a fall in consumption), not negative as we find. If liquidity constraints explain the behavior of consumption, then the implication is that we are even underestimating the degree of substitutability between consumption and hours.[28]

While Frisch elasticities give an important picture of consumption and labor supply responses to changes in wages, Marshallian elasticities that reflect the impact of a permanent change of wages are also of key importance from a policy point of view. The first column of Table 5 summarizes both (using the results of the

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[28] In online Appendix 5 we also formally test the hypothesis that preferences are quasiconcave.

TABLE 5—THE SENSITIVITY OF CONSUMPTION AND LABOR SUPPLY ELASTICITIES
TO THE TREATMENT OF TAXES

	Baseline model		No-tax model
	Response to a before-tax wage change	Response to an after-tax wage change	Response to a wage change
	(1)	(2)	(3)
Frisch own-elasticities			
Male labor supply	0.58*** (0.16)	0.68*** (0.19)	0.59*** (0.15)
Female labor supply	0.88*** (0.23)	0.96*** (0.27)	0.87*** (0.22)
Frisch cross-elasticities			
Male labor supply/female wage	0.11* (0.06)	0.16** (0.07)	0.10* (0.05)
Female labor supply/male wage	0.17 (0.11)	0.325** (0.14)	0.21* (0.11)
Consumption/male wage	−0.14** (0.07)	−0.162** (0.07)	−0.15** (0.06)
Consumption/female wage	−0.04 (0.07)	−0.05 (0.08)	−0.03 (0.06)
Marshallian own-elasticities			
Male labor supply	−0.08 (0.08)	−0.09 (0.09)	−0.10 (0.08)
Female labor supply	0.42*** (0.08)	0.41*** (0.09)	0.40*** (0.08)
Marshallian cross-elasticities			
Male labor supply/female wage	−0.22*** (0.04)	−0.23*** (0.04)	−0.23*** (0.03)
Female labor supply/male wage	−0.75*** (0.14)	−0.77*** (0.15)	−0.78*** (0.14)
Consumption/male wage	0.32*** (0.05)	0.34*** (0.06)	0.34*** (0.05)
Consumption/female wage	0.19*** (0.03)	0.20*** (0.04)	0.20*** (0.03)
Observations	7,295		7,295

Notes: Parameters estimated using GMM. Column 1 reports the elasticities with respect to before-tax wage changes. Note that these are the average κs from equation (9). Column 2 reports the elasticities with respect to after-tax wage changes. Both use the results from the baseline model of column 1 of Table 4. In Column 3 we reports the elasticities for the nonseparable case without taxes (as in column 2 of Table 4). Block bootstrap standard errors in parentheses.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

baseline specification).[29] In our framework, the Frisch and Marshallian elasticities are directly related to the transmission coefficients $\kappa_{m,n}$, where $m = \{c, h_1, h_2\}$ and $n = \{v_1, v_2, u_1, u_2\}$. In particular, responses to transitory shocks pin down Frisch

[29] The theoretical relation between Marshallian and Frisch elasticities is well known. See, for example, Keane (2011), for a derivation in a constant elasticities setup. The derivation in our setup, allowing for two earners and nonseparability, is very similar.
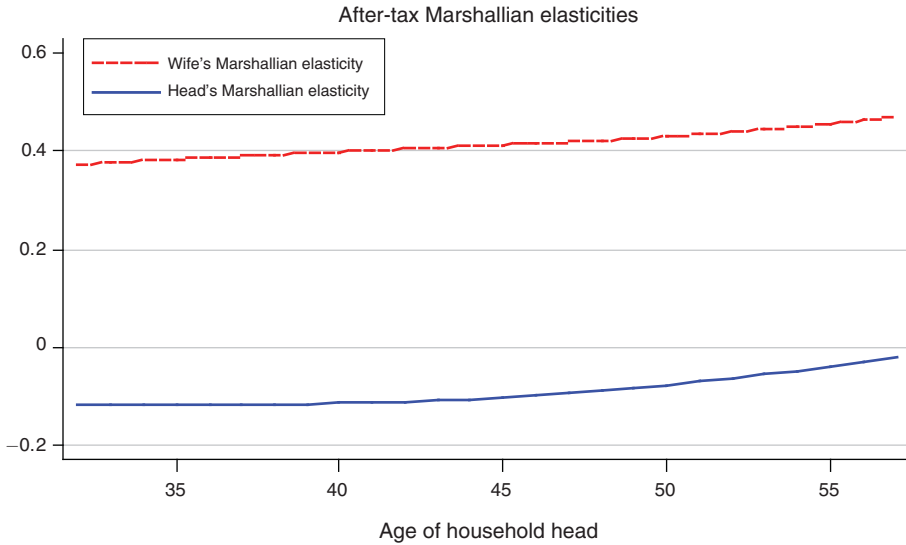
FIGURE 5. MARSHALLIAN ELASTICITIES BY AGE

elasticities, and responses to permanent shocks pin down Marshallian elasticities with respect to before-tax wage changes.[30]

We find that the average after-tax Marshallian elasticity for males is very close to zero (-0.09 with a standard error of 0.09). We find a larger average Marshallian elasticity of 0.41 for females (with a standard error of 0.09). As expected, these Marshallian elasticities are smaller than the corresponding after-tax Frisch elasticities (0.68 and 0.96, respectively). One advantage of recovering the Marshallian elasticities from the responses of hours to permanent shocks is that we can allow for heterogeneity in the elasticities as a function of household human and financial wealth (as reflected in $\pi_{i,t}$ and $s_{i,t}$). Figure 5 plots the Marshallian elasticities for both the husband and the wife against age. As is clear from the graph, late in the life cycle, as the household accumulate assets, the role of the wealth effect is decreasing, driving the Marshallian elasticities up.[31]

Of some interest are also the consumption cross-elasticities. In particular, while the compensated Frisch cross-elasticities $\left.\frac{\partial \log C}{\partial \log W_j}\right|_{d\lambda=0} < 0$, implying substitutability of consumption and hours of both spouses, uncompensated (Marshallian) consumption cross-elasticities are positive, implying complementarity, a result typically found in the empirical literature (although the distinction between Frisch and Marshallian responses is often blurred). Similarly, labor supply Marshallian cross-elasticities switch sign relative to their Frisch equivalent (from

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[30] Estimates of the κs are obtained replacing the estimates of the structural parameters in the relevant theoretical expressions and evaluating all expressions at the mean (see online Appendix 1).

[31] In the separable case, as $\pi \to 1$ the Marshallian elasticities are converging to their Frisch counterparts.

complementarity to substitutability). In all cases, it appears that lifetime wealth effects are nonnegligible.

Researchers interested in the effect of taxes on labor supply may want to distinguish between the elasticity of labor supply with respect to before-tax changes in wages and the elasticity of labor supply with respect to after-tax changes in wages (MaCurdy 1983). The responses of hours and consumption to wage shocks captured by the κs in equation (9) in the paper are equivalent to the former. However, we can also back out the latter for both the Frisch and the Marshallian case (the interested reader is referred to online Appendix 1 for the details). It is straightforward to recover Frisch elasticities with respect to after-tax wage changes as they are simply the preference parameters we estimate (i.e., the ηs). As for Marshallian elasticities, we use the preference parameters estimated in the progressive tax case to recalculate the κs with respect to tax neutral permanent shocks to wages $\left(\kappa_{c, v_j}, \kappa_{h_j, v_j} \right)$.

The second column of Table 5 reports elasticities to after-tax wage changes. Note that these calculations still use the estimates of the baseline model of column 1 of Table 4, but consider different types of wage changes. The difference is important. While responses to before-tax changes include both "preference" effects and the dampening implied by progressive taxation, after-tax wage changes isolate the pure "preference" effects. Since an increase in the price of leisure encourages work, but taxes discourage it, we expect the response to after-tax changes to be larger than that to before-tax changes. How large is an empirical issue that depends on the degree of progressivity of the tax system. In our case, the differences accord with intuition but are not large.

Alternative Specifications.—In columns 2–5 of Table 4 we report estimates of alternative specifications.

In column 2 we consider the case without taxes. The estimates of the Frisch elasticities are typically smaller (in absolute values) than in the progressive tax case, because failing to account for taxes induces a downward bias—the feedback effect of taxes is wrongly interpreted as a low elasticity of response instead of the labor supply disincentive effect of taxes. Nevertheless, it is worth noting that removing taxes does not affect our qualitative results. Column 3 of Table 5 demonstrates that the estimation that ignores taxes delivers estimates that are closer to the before-tax estimates of the baseline model with progressive taxation (column 1), rather than to the structural preference parameters that represent the after-tax responses (column 2).

In column 3 of Table 4 we consider the case with separable preferences. We find a larger consumption elasticity $(\eta_{c,p})$ and smaller labor supply elasticities $\left(\eta_{h_1, w_1}, \eta_{h_2, w_2} \right)$. However, this model is overwhelmingly rejected. As argued above, under separable preferences the Frisch cross-elasticities should all be zero, a hypothesis that is rejected with p-value of 1.2 percent. Hence, imposing separability (both between consumption and leisure, and between the leisure times of spouses) gives an incorrect view of behavior.

In column 4 of Table 4, we allow for a stationary wage process in which variances and covariances of shocks do not vary over the life cycle. Again, our estimates are similar to the baseline specification.

In principle, it is still possible that our model, despite its richness, misses sources of insurance that go above and beyond self-insurance (here captured by savings and

family labor supply) and government-related insurance. For example, implicit or informal arrangements within families or among unrelated individuals (networks of friends, etc.) may provide more insurance than warranted by our framework. To account for this possibility, we estimate a model that parameterizes in a parsimonious way such insurance.

The way we introduce "outside insurance" in our baseline framework is to scale insurance provided by assets $\left(\text{measured by the parameter } \left(1 - \pi_{i,t}\right)\right)$ by the multiplicative factor $\left(1 - \beta\right)$. Here, $\beta = 0$ means that there is no external insurance over and above self-insurance through assets, labor supply, and taxes and transfers, while $\beta > 0$ would imply some external insurance is present. Note that it is also possible that $\beta < 0$—which may capture the fact that consumption over-responds to shocks (relative to the frictionless self-insurance case), for example because assets are held in illiquid forms and transaction costs exceed the utility benefit of smoothing (for a similar argument, see Kaplan and Violante 2014).

The results are reported in column 5 of Table 4. The estimate of β is negative but very imprecise, implying that we cannot reject the null of no outside insurance. The inference that can be drawn from these results is that a model with nonseparable preferences that allows for asset accumulation, family labor supply, government transfers, and progressive taxation exhausts all sources of consumption smoothing available to married couples. It is possible, of course, that different types of families (such as lone parents, singles, etc.) establish endogenously networks of relatives and friends that replace, for example, low levels of assets or inability to borrow as sources of insurance. While an interesting issue, it goes beyond this paper's research objectives.

Robustness.—We conducted a number of additional empirical exercises with the goal of assessing how robust our results are to some changes in sample selection and specification. The results are reported in Table 6.

First, we focus on a sample that excludes older workers, focusing on heads aged 30–50 (column 2). We find that the degree of partial insurance accounted for by asset accumulation declines when we focus on a sample of younger workers who have had less time to accumulate assets (the estimate of $\pi_{i,t}$ on average decreases by almost 30 percent relative to the baseline case). The estimates of the other parameters remain very similar. Second, we restrict our analysis to the more educated group (column 3). The estimate of $\pi_{i,t}$ increases on average reflecting more asset accumulation among the highly educated. We also find slightly smaller labor supply elasticities, as well as a larger consumption elasticity (smaller risk aversion) in this group. The pattern of cross-elasticities is qualitatively similar. Third, we apply the selection correction to account for female nonparticipation, described in Section IID and online Appendix 4. The results (reported in column 4) are very similar to the baseline specification, perhaps because our sample of women have very high participation rates to start with (80 percent on average).

Our measure of consumption imputes rent to the homeowners using a fixed proportion of the self-reported value of the home of 6 percent.[32] Since there may

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[32] The idea is that imputed rental income over the house value is equal in equilibrium to the user cost of housing, estimated to be 6 percent on average in Poterba and Sinai (2008).

TABLE 6—ROBUSTNESS

	Baseline specific (1)	Age 30–50 (2)	No high school dropouts (3)	Selection correction (4)	No rents (5)	Using median assets (6)
π, s, and own elasticities						
$E(\pi)$	0.150***	0.107***	0.158***	0.150***	0.150***	0.120***
	(0.004)	(0.003)	(0.005)	(0.004)	(0.004)	(0.005)
$E(s)$	0.708***	0.708***	0.713***	0.668***	0.708***	0.708***
	(0.013)	(0.011)	(0.013)	(0.013)	(0.013)	(0.013)
$\eta_{c,p}$	0.417***	0.400**	0.501**	0.412**	0.616**	0.426***
	(0.122)	(0.190)	(0.172)	(0.148)	(0.238)	(0.120)
η_{h_1,w_1}	0.681***	0.586***	0.553***	0.681***	0.613***	0.690***
	(0.189)	(0.165)	(0.164)	(0.202)	(0.187)	(0.190)
η_{h_2,w_2}	0.958***	1.032***	0.940***	1.010***	0.929***	0.965***
	(0.267)	(0.347)	(0.258)	(0.303)	(0.255)	(0.266)
Cross-elasticities						
η_{c,w_1}	−0.162**	−0.140*	−0.176***	−0.156**	−0.244**	−0.168**
	(0.074)	(0.076)	(0.061)	(0.076)	(0.107)	(0.070)
$\eta_{h_1,p}$	0.126**	0.108*	0.133***	0.121**	0.124***	0.130**
	(0.057)	(0.056)	(0.048)	(0.060)	(0.053)	(0.056)
η_{c,w_2}	−0.05	−0.047	−0.068	−0.052	−0.095	−0.052
	(0.077)	(0.099)	(0.094)	(0.086)	(0.132)	(0.075)
$\eta_{h_2,p}$	0.079	0.074	0.107	0.082	0.098	0.082
	(0.121)	(0.154)	(0.149)	(0.136)	(0.136)	(0.119)
η_{h_1,w_2}	0.159**	0.185***	0.124**	0.179**	0.123	0.165**
	(0.071)	(0.070)	(0.061)	(0.076)	(0.080)	(0.071)
η_{h_2,w_1}	0.325**	0.376**	0.258**	0.365**	0.251	0.336**
	(0.140)	(0.150)	(0.121)	(0.150)	(0.165)	(0.137)
Observations	7,295	5,441	6,433	7,295	7,295	7,295

Notes: Parameters estimated using GMM. All columns allow for nonseparability of hours of the two earners and for nonseparability of hours and consumption. Column 1 reports our baseline specification (as in column 1 of Table 4). In column 2 the sample is restricted to households with heads aged 30–50 (and we impose stationary wage variances). In column 3 the sample is restricted to households with heads who have at least a high school degree. In column 4 we apply the participation sample selection correction. In column 5 we use a consumption measure that excludes housing rents from the consumption measure. Finally, in column 6 we replace household assets by median assets (by education and age cells). Block bootstrap standard errors in parentheses.

   ***Significant at the 1 percent level.
    **Significant at the 5 percent level.
     *Significant at the 10 percent level.

be worries that this imputation procedure may not be appropriate during a period in which housing prices were growing faster than rental rates, in column 5 we reestimate the model using a measure of consumption that omits housing (paid rent for tenants and imputed rent for homeowner). None of our results are qualitatively affected (although there is less precision for some parameters). This stability is probably due to the fact that rent is a "committed consumption good" (see Chetty and Szeidl 2007). In response to shocks, households are more likely to adjust on other consumption margins before adjusting the consumption of housing.

Finally, we calculate $\pi_{i,t}$ using median assets by age and education groups rather than individual assets (column 6). This is because assets can be subject to severe mismeasurement and are characterized by a heavy-tailed distribution. We estimate a lower $\pi_{i,t}$ (as the influence of values in the tail is reduced), but this

exercise (similarly to the ones commented above) does not affect our main conclusions: (i) the consumption Frisch elasticity is in a reasonable range; (ii) labor supply elasticities reflect a moderate degree of intertemporal substitution (larger for women); (iii) male and female hours are Frisch complements; and (iv) consumption and hours are Frisch substitutes.

Advance Information.—Our estimates of the response of consumption to permanent wage shocks, κ_{c, v_j}, are reported in Table 5. We interpret the magnitude of this response in the section that follows. However, it must be noted from the outset that some of the attenuation of consumption to wage shocks may be due to wage changes not being shocks at all. In other words, consumers may have some advance information about shocks, and may have therefore adapted their consumption in advance of the shocks themselves. To test whether this is an explanation of our findings, we present a test of "superior or advanced information." We follow the intuition of Cunha, Heckman, and Navarro (2005), that with advanced information we should find that *future* wage growth predicts *current* consumption growth. Hence, we compute the covariances $E(\Delta c_{i, t} \Delta w_{i, j, t+\tau})$ for $\tau = \{4, 6\}$ (as our panel is biennial) and test whether they are jointly insignificant (the null of no advanced information).[33] The test does not reject the null of zero correlation with a *p*-value of 29 percent. We conclude that superior or advance information do not appear to be responsible for our findings.[34]

IV. Discussion

In this section we discuss and extend our empirical findings. In particular, we focus on three issues: (i) extensive and intensive margin in labor supply; (ii) consumption smoothing accounting; and (iii) goodness of fit of the model.

A. *Nonseparability and the Extensive-Intensive Margin of Labor Supply*

Our approximation procedure cannot directly handle corner solutions, hence the focus on intensive margin responses. In this section we integrate this evidence with a discussion of extensive margin responses. We look at two issues in detail. First, do added worker effects exist both on the extensive and intensive margin? For example, we might expect the secondary earner's decision to move into work (from nonparticipation) to be as important as the decision to switch from part-time to full-time in response to a shock faced by the primary earner. Second, we examine whether the result of Frisch substitutability between consumption and hours is an artifact of ignoring the extensive labor supply margin. We look at this issue in two

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[33] Note that we cannot use $\tau = 2$ as this moment is nonzero in the nonseparable case.

[34] There are two potential problems with this test. First, suppose that the true income process is the sum of a transitory shock and a heterogeneous growth component, and that the individual growth rate is known at time 0. In this case the correlation between current consumption growth and future income growth is going to be zero. However, this model would predict that also the correlation between current consumption growth and current income growth is zero, something that is clearly violated in our data. Second, the test is weak due to the fact that changes in income may reflect measurement error. It is worth noting, however, that if there is advance information about the permanent shocks, then the test will still be valid. Moreover, we are preadjusting our measure of income growth to account for measurement error.

ways. First, we estimate conditional Euler equations (which condition on both labor supply margins). Second, we delve into the composition of household consumption and investigate whether nonseparability depends on the type of goods that households consume.

Added Worker Effects on the Extensive Margin.—While we cannot derive the relationship between wage shocks and extensive margin responses structurally, we can write "semi-structural" equations that are consistent with the spirit of our empirical strategy. In particular, we consider a regression aimed at explaining the woman's decision to work:

$$(10) \qquad \Delta P_{i,2,t} = \theta_0 u_{i,1,t} + \theta_1 v_{i,1,t} + e_{i,2,t},$$

where $P_{2,t} = 1$ if the wife works. Hence, one can interpret θ_0 and θ_1 as the "added worker" response on the extensive margin in response to transitory and permanent shocks faced by the husband, respectively. For the time being we ignore the effect of observable characteristics (age, number of children, etc.), but our regressions below fully control for them.

To see how the added worker parameters can be identified, assume that $E(e_{i,2,t}|u_{i,1,t}, v_{i,1,t}) = 0$. Then, the following IV regressions identify θ_0 and θ_1:

$$\hat{\theta}_0 = \frac{\text{cov}(\Delta P_{i,2,t}, \Delta w_{i,1,t+1})}{\text{cov}(\Delta w_{i,1,t}, \Delta w_{i,1,t+1})}$$

$$\hat{\theta}_1 = \frac{\text{cov}(\Delta P_{i,2,t}, \Delta w_{i,1,t-1} + \Delta w_{i,1,t} + \Delta w_{i,1,t+1})}{\text{cov}(\Delta w_{i,1,t}, \Delta w_{i,1,t-1} + \Delta w_{i,1,t} + \Delta w_{i,1,t+1})}.$$

To identify θ_0 (the response to the husband's transitory shocks) we run a regression of changes in wife's participation decision against the husband's wage growth using *future* wage growth as instrument (which *isolates* the effect of the mean-reversion component). To identify θ_1 (the response to the husband's persistent shocks), we run the same regression, but this time instrument the husband's wage growth with long-run wage growth (which removes the mean-reversion component).[35]

The results of these regressions are reported in Table 7 and show very clearly that the "added worker" effect that we find on the intensive margin is confirmed also at the extensive margin: women are more likely to switch from nonworking to working if the spouse faces a permanent decline in wages.[36] The effect is sizable: a permanent 10 percent decrease in the husband's wage is associated with an increase in the probability of wife participation of 1.7 percentage points.

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[35] The regressions below also control for year, husband's and wife's age, age squared and education, state of residence, metropolitan statistical area (MSA) size, change in number of kids, change in age of the youngest child, and change in the presence of children one-year old or younger.

[36] The estimates of θ_0 and θ_1 are potentially biased because extensive margin decisions depend also on *own* wage shocks, which in turn are correlated with the spouse's shock (albeit little). However, back-of-the-envelope calculation (performed using our estimates of the extent of correlation between shocks and external estimates of the extensive margin elasticity from Blundell, Bozio, and Laroque 2011) suggests that, if anything, the effect is underestimated because of the positive Marshallian elasticity estimated for women.

TABLE 7—ADDED WORKER EFFECT: THE EXTENSIVE MARGIN

Dependent variable: Change in wife's participation ($\Delta P_{i,2,t}$)	(1)	(2)
Permanent shock to husband's wages ($v_{i,1,t}$)	−0.168*	
	(0.087)	
Transitory shock to husband's wages ($u_{i,1,t}$)		0.002
		(0.030)
Δ Kids	−0.027*	−0.030***
	(0.016)	0.011
Δ Age of youngest kid	0.010***	0.003
	(0.004)	(0.002)
First-stage F-stat	21.95	156.52
Observations	3,143	4,941

Notes: Regressions of wife's participation on changes in husband's wages. In column 1, the change in husband's wages is instrumented using future wage growth. In column 2, it is instrumented using long-run wage growth. Both regressions also control for husband's and wife's age, age squared and education, state of residence, MSA size, change in number of kids, change in the age of the youngest child, change in the presence of a one-year old, and year effects. Standard errors clustered by household in parentheses.

   ***Significant at the 1 percent level.
   **Significant at the 5 percent level.
    *Significant at the 10 percent level.

Note that there is no evidence of a response to transitory shocks. If we interpret cross-responses to transitory shocks as evidence for nonseparable preferences, this suggests that the nonseparability channel is active at the intensive margin, but not at the extensive margin. We also find intuitively plausible effects of demographics: the arrival of kids reduces participation; when the youngest child grows up, it becomes easier for women to work. Finally, the instruments appear to pass conventional thresholds for power.

These results can be used to get a sense of how much income and consumption smoothing is achieved by the added worker effect on the extensive margin. We provide this calculation in Section IVB.

Nonseparability on the Intensive and Extensive Labor Supply Margin.—One of the most intriguing results of our empirical analysis is the finding that hours and consumption are Frisch substitutes on the intensive margin: keeping constant the marginal utility of wealth, consumption and hours tend to move in opposite directions.[37] In general, whether consumption and hours are Frisch complements or substitutes is an empirical question. In the literature, evidence for substitutability has been rare (for an early example, see Browning, Deaton, and Irish 1985). A more

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[37] If hours and consumption were instead complements, we would expect a negative covariance between consumption growth and lagged (or future) wage growth. However, as Figure 8 and online Appendix Table 1 show, this covariance is positive (albeit insignificant). Nevertheless, there may be two alternative explanations for the positive covariance (besides nonseparability). First, the timing of the consumption data (we assume that what people report in the spring of survey year $t+1$ refers to calendar year t). Second, the possibility of habits in consumption. While these explanations are interesting alternatives, they do not necessarily imply that the evidence for nonseparability is spurious. First, evidence for nonseparability between consumption and hours emerges also from the other two exercises we discuss in this section, which use completely different empirical strategies. Second, as we explain in online Appendix 2, in our overidentified setting, this covariance is not the only moment contributing to the estimation of the nonseparability patterns. Other moments that help pinning down the η_{c,w_j} parameters also appear consistent with consumption-hours substitutability.

frequent finding—for example, when studying how consumption changes when people become unemployed or disabled—is that of complementarity (see, e.g., Aguiar and Hurst 2005; Meyer and Mok 2013). However, two things are worth noting. First, since disability and unemployment may be fairly persistent shocks, it is possible that the consumption-hours complementarity result found in the literature actually refers to Marshallian responses, rather than the Frisch responses we have focused on. But the results reported in Table 5 show that our Marshallian estimates are consistent with complementarity between consumption and hours, hence revealing no disagreement between the typical literature findings and our results. Second, the finding of complementarity between consumption and hours comes primarily from studying the relationship between changes in consumption and *large* changes in hours, often associated to events like exits from the labor force, unemployment or retirement, i.e., extensive margin shifts. In this paper, in contrast, we have mainly focused on the relationship between changes in consumption and small changes in hours (i.e., intensive margin shifts).[38]

Can we reconcile our "intensive margin" consumption-hours Frisch substitutability finding with the evidence of "extensive margin" Frisch complementarity in the literature? Consider the following example. Suppose that there are fixed costs associated with employment (i.e., when the extensive margin becomes active). For example, a worker needs to buy a suit in order to show up at work. This cost exists independently of the number of hours worked. This is an example where consumption is *complementary* to hours (on the extensive margin). But the consumer's budget may include other goods that are Frisch *substitutes* with respect to hours (the intensive margin), such as utilities. The use of electricity or gas at home depends on the number of hours the worker actually spends at home or at work. Blundell, Bozio, and Laroque (2011) derive a model with both margins.

To test in an informal way whether this story holds up in our data, we estimate "conditional" Euler equations, controlling for growth in hours (the intensive margin) and changes in participation (the extensive margin)—and instrumenting the two appropriately. The results are presented in Table 8. In the first column we use the PSID sample without conditioning on male participation, so we control for the growth in hours and the changes in participation of both spouses. To avoid the issues of zeros in hours for nonparticipant, we approximate the growth in hours with the expression $\Delta \ln h_t \approx \dfrac{h_t - h_{t-1}}{(1/2)(h_t + h_{t-1})}$. We use current and lagged average wages (by education, age, year) and average participation (again by education, age, year) as instruments. The results seem consistent with the story above. For both males and females there is evidence of Frisch substitutability with hours on the *intensive* margin (consumption falls when hours grow), confirming the results of the previous sections; however, consistent with most findings in the literature, we also find

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[38] Home production may also induce substitutability between consumption and leisure at the intensive margin. For example, individuals who are working a reduced number of hours may have more time to devote to home production and, if time and goods are substitutes, this may induce lower spending on goods needed to produce a given amount of consumption. Our finding that there is Frisch complementarity at the intensive margin suggests that this effect, while possibly present, is dominated by the alternative interpretation we offer here. Home production could also induce a substitution pattern between the husband's and wife's leisure times. Once more, this is an empirical issue. A number of papers in the literature (Browning, Deaton, and Irish 1985; Hyslop 2001; Voena 2015) find evidence of complementarity, as we do.

Table 8—Conditional Euler Equations

	Regression results		First-stage F-stats	
	(1)	(2)	(1)	(2)
$\Delta EMP_t(Male)$	0.134		29.31	
	(0.207)			
$\Delta h_t(Male)$	−0.108	−0.297	9.61	7.52
	(0.204)	(0.194)		
$\Delta EMP_t(Female)$	0.388**	0.444**	102.84	122.02
	(0.173)	(0.216)		
$\Delta h_t(Female)$	−0.241**	−0.282**	33.93	48.32
	(0.112)	(0.135)		
Sample	All	$EMP_t(Male) = 1$		
Observations	7,046	6,459		

Notes: The table reports conditional Euler equations estimates. Δh_t is defined as $(h_t - h_{t-1})/[0.5(h_t + h_{t-1})]$. Hours changes are instrumented using current and lagged average wages (by education, age, year) and average participation (by education, age, and year). All specifications also control for year effects, husband's and wife's age, age squared and education, race, state of residence, change in family size, and number of kids. Column 1 does not condition on the head's employment. Columns 2 conditions on the head's employment. Standard errors clustered by household are reported in parentheses.

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

evidence that consumption and hours are complements on the *extensive* margin (consumption rises when participation rises). The estimates are more precise for females and remain so even when we focus on our estimation sample (always-working husbands), as shown in column 2. Reassuringly, the signs of the estimate do not change. In conclusion, while some of these estimates are noisy (and the instruments for the male labor supply variables appear weak), the evidence reported here appears to be able to reconcile the internal evidence of the previous sections with the external evidence coming from most of the literature once allowance is made for the distinction between intensive and extensive margin, a crucial one as such.

Another analysis we perform is to look at how demand for specific goods changes in response to changes in labor supply. This analysis provides some additional credibility to the results above, since we should find evidence of complementarity with labor supply for goods that are more likely to be associated with work (transportation, food away from home) and substitutability for goods that are more likely to be associated with staying at home (utilities). We look precisely at these three broad aggregates and write demand equations that are of the AIDS (almost ideal demand system) variety (Deaton and Muellbauer 1980):

$$\omega_{i,t}^{j} = \mathbf{X}_{i,t}'\boldsymbol{\beta} + \eta \log C_{i,t} + \mathbf{p}_t\varphi + \zeta_{i,t}^{j},$$

where ω^j is the budget share of good j, $\mathbf{p}$ are price indices, and $\mathbf{X}$ are additional controls. To test for nonseparability between consumption and leisure (Browning and Meghir 1991), we add hours variables for both husband and wife. Since labor supply variables and total spending are endogenous, we instrument them using lagged wages, lagged income, and income from assets. Table 9 reports the results.

Table 9—Demand System Estimation

	Budget shares			
	Utilities (1)	Transportation (2)	Food out (3)	First-stage F-stat
$h_t(Male)$	0.0051 (0.0033)	0.0096 (0.0070)	0.0008 (0.0032)	102.29
$h_t(Female)$	−0.101** (0.0050)	0.0183* (0.0111)	0.0110** (0.0053)	27.68
c_t	−0.505*** (0.0045)	−0.0648*** (0.0093)	0.0146*** (0.0051)	131.28
Observations	5,887	5,887	5,887	

Notes: The table reports demand estimation for utilities, transportation, and food out. All regressions also include controls for education and age of the husband and wife, race, family size, number of kids, size of MSA, and state dummies. We control for CPIs by consumption category. Hours of the two earners and consumption are instrumented using second lag of wages of the two earners, second lag of income, and asset income. Standard errors clustered by household reported in parentheses.

    ***Significant at the 1 percent level.
    **Significant at the 5 percent level.
    *Significant at the 10 percent level.

For women, we find that utilities and hours are substitutes, while for transportation and food away from home we find a complementarity pattern. The estimates are much noisier for men. Hence, at least for women, there is robust evidence that different goods are differently nonseparable with respect to labor supply, consistent with the basic intuition provided above.

B. *How Much Insurance?*

Main Accounting.—We now use our estimates to understand the importance of the various sources of insurance available to households. In particular, we use the intertemporal budget constraint (with $r \to 0$ for simplicity) to decompose the response of consumption growth to a permanent wage shock faced by the primary earner as

$$(11) \qquad \frac{\partial \Delta c}{\partial v_1} \cong \underbrace{\frac{\partial \Delta y}{\partial v_1}}_{\text{Insurance via family labor supply}} \underbrace{- \frac{\partial \Delta(S/Y)}{\partial v_1}}_{\text{Insurance via savings}},$$

where S/Y is the average propensity to save out of family earnings, and it represents the extent of insurance achieved through asset accumulation. In turn, the response of household earnings to a permanent shock to the male's hourly wage can be decomposed as follows:

$$\underbrace{\frac{\partial \Delta y}{\partial v_1}}_{\text{Insurance via family labor supply}} \cong (1 - \mu)\left(s\frac{\partial \Delta y_1}{\partial v_1} + (1 - s)\frac{\partial \Delta y_2}{\partial v_1}\right)$$

$$= (1 - \mu)\left(s\left(1 + \frac{\partial \Delta h_1}{\partial v_1}\right) + (1 - s)\frac{\partial \Delta h_2}{\partial v_1}\right).$$

Empirically, a 10 percent permanent decrease in the husband's wage rate $(v_1 = -0.1)$ decreases consumption by 3.2 percent $\left(\frac{\partial \Delta c}{\partial v_1} = \hat{\kappa}_{c, v_1} = 0.32\right.$: see column 1 of Table 5$\left.\right)$. This insurance is for the most part coming from family labor supply (as we document below) and partly from self-insurance through savings and from government intervention.

The response of consumption can be decomposed into several steps. Consider a case in which there is one earner $(s = 1)$, labor supply is fixed $\frac{\partial \Delta h_1}{\partial v_1} = 0$, taxes are proportional, and there is no self-insurance through savings. Then $\frac{\partial \Delta c}{\partial v_1} = 1$ and consumption responds one-to-one to permanent shocks in hourly wages. In the family labor supply case (but still assuming fixed labor supply and no savings or transfers), household earnings fall by 7.1 percent (the male's share in household human wealth) and the fall in consumption is of the same magnitude given the absence of self-insurance through savings and labor supply behavioral responses. Hence, the mere presence of an additional earner, albeit supplying labor inelastically, acts as a significant source of consumption smoothing. The addition of a government transferring resources to low-income households through EITC and food stamps and providing implicit insurance through a progressive tax system induces some additional implicit insurance. In particular, we calculate that a 10 percent permanent decline in husband wages now induces a more modest 6.3 percent decline in consumption.

The introduction of behavioral responses changes the picture. Assume, for example, that males can vary their labor supply (while keeping female labor supply exogenous). Since the husband's Marshallian elasticity is almost zero, $\frac{\partial \Delta c}{\partial v_1} = 0.58$, not very different from the case above. In contrast, allowing for added worker effects reduces the impact of a 10 percent decline in male permanent shock on consumption to only 3.9 percent. Finally, with all insurance channels active, the fall in household earnings is still 3.9 percent, but the fall in consumption is attenuated, to 3.2 percent. In other words, we can use (11) to calculate that, of the 39 percentage points (p.p.) of consumption "insured" against the shock to the male's wage,[39] 8 p.p. come from government insurance (20 percent of the total insurance effect), 25 p.p. (63 percent) come from family labor supply (she increases her labor supply when his wages fall permanently), and the remaining 7 p.p. (17 percent of the total insurance effect) come from self-insurance through savings.

In contrast, we find that the husband's labor supply is a relatively poorer insurance channel against shocks to the wife's wages. We can go through the same decomposition exercise, but this time considering a 10 percent permanent decline in the wife's wage (and focusing on the intensive margin response). First, with fixed labor supply and no savings or transfers, household earnings would fall by 2.9 percent as the woman's wage falls permanently by 10 percent (since her "weight" on total household earnings is $(1 - s) = 0.29$). The fall in consumption would be of the same magnitude given the absence of self-insurance through savings, etc. Second, with the family labor supply insurance and the government insurance channels active,

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[39] The 39 p.p. figure is derived from the difference between the response of consumption with savings, family labor supply responses and taxes/transfers (a 3.2 percent decline) and without these (a 7.1 percent decline).

the fall in household earnings is smaller (2.3 percent) but unlike the male case, family labor supply plays a proportionally less important role as an insurance device when considering the response to female permanent wage shocks. This is for two reasons. First, the woman's labor supply declines a lot given her larger behavioral response (in fact, without the husband's response there will be *less* insurance than in the exogenous labor supply case). Second, although the husband's labor supply increases, this is not enough to keep household earnings stable due to his low behavioral responses (and despite his larger share in household earnings). Finally, with both insurance channels active, the fall in household earnings is 2.3 percent, but the fall in consumption is only 1.9 percent (see again column 1 of Table 5). In other words, of the 10 percentage points of consumption "insured" against the shock to her wage, almost one-half can be attributed to conventional insurance sources (savings and transfers) and the other to family labor supply/progressive taxation effects.

The fact that wage shocks faced by the husband are mainly insured through family labor supply while those faced by the wife are mainly smoothed through savings has a simple explanation: Marshallian own labor supply elasticities are basically zero for men and highly positive for women (implying that own shocks are poorly insured through own labor supply) and Marshallian cross-elasticities are much larger for women than men (implying that added worker effects are stronger when men are hit by shocks).

Additional Issues.—We now discuss four important aspects of the consumption insurance accounting exercise.

First, there is important heterogeneity in the role of insurance through labor supply. In Figure 6 we offer a graphical representation of the insurance decomposition exercise focusing on the life-cycle aspects. We focus on the experiment in which we let the permanent wage of the husband decline by 10 percent. Early on in the life cycle, essentially all consumption insurance can be explained by labor supply responses as households do not have enough assets to smooth consumption through savings. As assets start to cumulate, though (after age 50), some of the insurance is taken up by savings, and the role of labor supply as an insurance device declines in importance.

Second, we repeat the insurance decomposition exercise, focusing on the Food Stamps eligible group. Consider again a 10 percent permanent decline in the husband's wages. Given the share of the husband in household earnings for this group, consumption will decline on average by 7.2 percent. As expected, the introduction of taxes and transfers plays an important role for the Food Stamps eligible group, reducing the consumption response to 3.6 percent. As before, allowing for husbands' labor supply responses does not change the picture much, and introducing wife's labor supply reduces consumption response to 2.3 percent, with a total decline in consumption of 2.1 percent. This implies that of the 51 percentage points of consumption "insured," 36 come from government transfers (71 percent of the total insurance effect), and the rest from family labor supply, with negligible insurance from savings.

Third, we investigate the role of nonseparability in explaining consumption insurance. We illustrate this graphically in Figure 7. We plot κ_{c,v_j} against η_{c,w_j} (we fix $\eta_{c,p}, \eta_{h_j,w_j}, \eta_{h_1,w_2}, \eta_{h_2,w_1}, \eta_{c,w_{-j}}$, and $\eta_{h_{-j},p}$ to the baseline estimates, use the

Response of consumption to a 10 percent permanent decrease in the male's wage rate
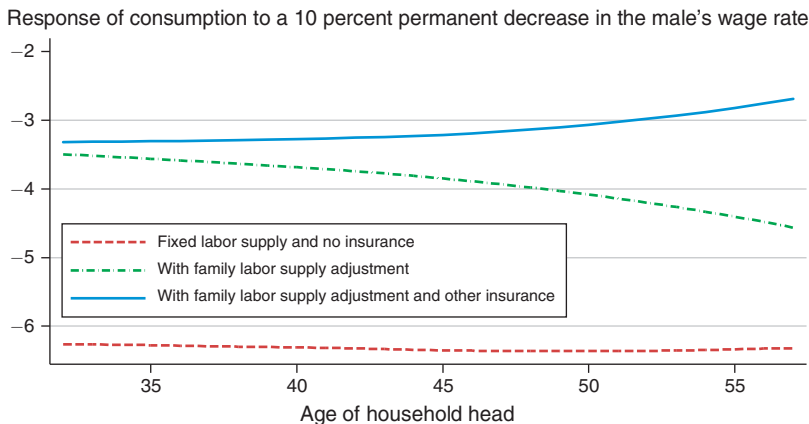
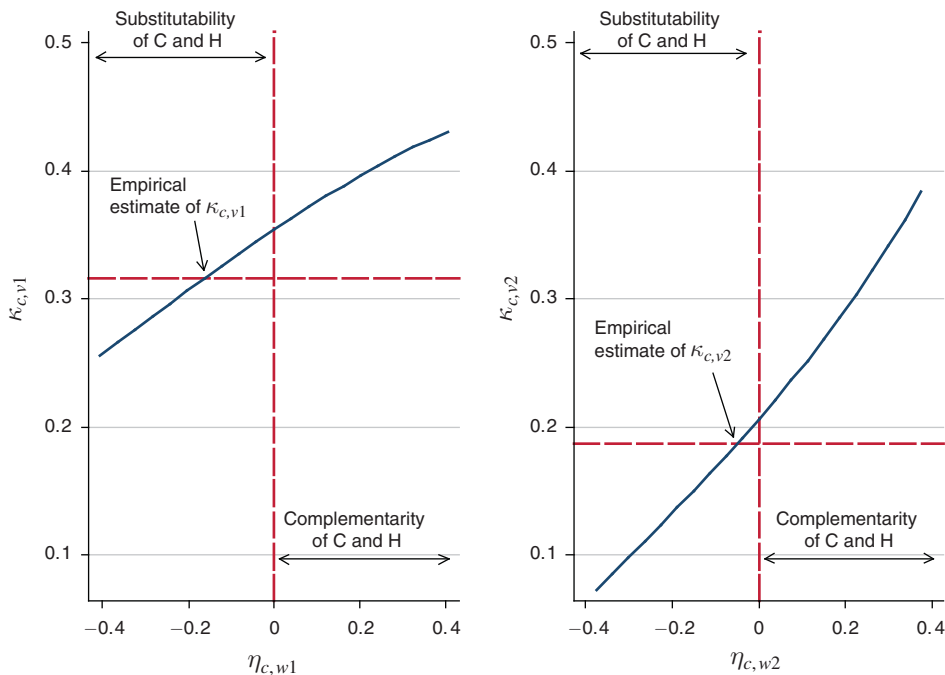FIGURE 6. DECOMPOSING THE SOURCES OF CONSUMPTION SMOOTHING

FIGURE 7. THE RELATIONSHIP BETWEEN CONSUMPTION RESPONSE TO PERMANENT SHOCKS AND NONSEPARABILITY

sample distribution for $\pi_{i,t}$ and $s_{i,t}$, and let η_{c,w_j} and $\eta_{h_j,p}$ vary). We do it separately for males (left panel) and females (right panel). How large is the extra insurance brought about by consumption/hours substitutability? One way to gauge it is to look at the value of κ_{c,v_j} in the case in which preferences are separable $(\eta_{c,w_j} = 0)$, while keeping everything else constant. From Figure 7, one can calculate that consumption-hours substitutability would attenuate the effect of permanent shocks on consumption by something between 9 percent (women) and 11 percent

(men). Hence, while allowing for nonseparability is important if one wants to provide a correct specification of preferences, its role in explaining consumption insurance against wage shocks is modest.

We have stressed that added worker effects are important, but the focus has been on intensive margin responses. The final issue we investigate is insurance through extensive margin responses. To compute the extent of insurance, we use the results of Table 7, in which we estimate a 1.68-percentage-point increase in female participation in response to a 10 percent permanent decline in male wages. Since the families with nonworking wives are 20 percent of the sample (see Table 1), this means that in this particular group a 10 percent permanent decline in male wages induces a 8.4 percent increase in female participation. What is the corresponding change in household earnings? We consider households with nonworking females in period $t - 1$; in this particular group, average male earnings are $77,235. The average earnings earned by spouses who become employed in period t are $13,572. Assume that the permanent decline in male wages induces no labor supply response on the male side (which is consistent with our finding of a close to zero Marshallian elasticity for males). It follows that the average change in household earnings is given by

$$\log\!\left(0.9 \times \overline{Y}_{1,t-1} + 0.084 \times \overline{Y}_{2,t}\right) - \log\!\left(\overline{Y}_{1,t-1}\right) \, =$$

$$\log\!\left(0.9 \times 77{,}235 + 0.084 \times 13{,}572\right) - \log\!\left(77{,}235\right) \, = \, -0.089.$$

Hence, a 10 percent permanent decline in male wages induces a labor supply response on the extensive margin that attenuates the fall in household earnings from 10 percent to 8.9 percent.[40] While this exercise is simple, it illustrates that for families without participating wives, the added worker effect on the extensive margin is a powerful source of insurance.

What about consumption smoothing? We note that the transmission from earnings to consumption might not be the same on the intensive and extensive margins. In particular, as we show in Table 8, on the extensive margin there is evidence of *complementarity* between labor supply and consumption. This implies that the household requires higher levels of consumption to smooth marginal utility as the wife starts to work (and hence consumption will be more smoothed than earnings). In this sense, the effects calculated above (for family earnings) should be seen as a lower bound on the extent of consumption smoothing. However, putting aside the issue of nonseparability, we can evaluate the average consumption response taking into account the extensive margin effect assuming that for this group the extent of insurance from taxes and savings is similar as the one we estimate for the entire population. In particular, using the approximation to the tax schedule, a 8.9 percent decline in earnings translates into a 7.9 percent decline in after-tax household earnings. Finally, taking savings into account, the predicted decline in consumption is about 6.5 percent.

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[40] If we evaluate female earnings at the sample unconditional mean ($32,988), the decline is further attenuated to 6.6 percent.
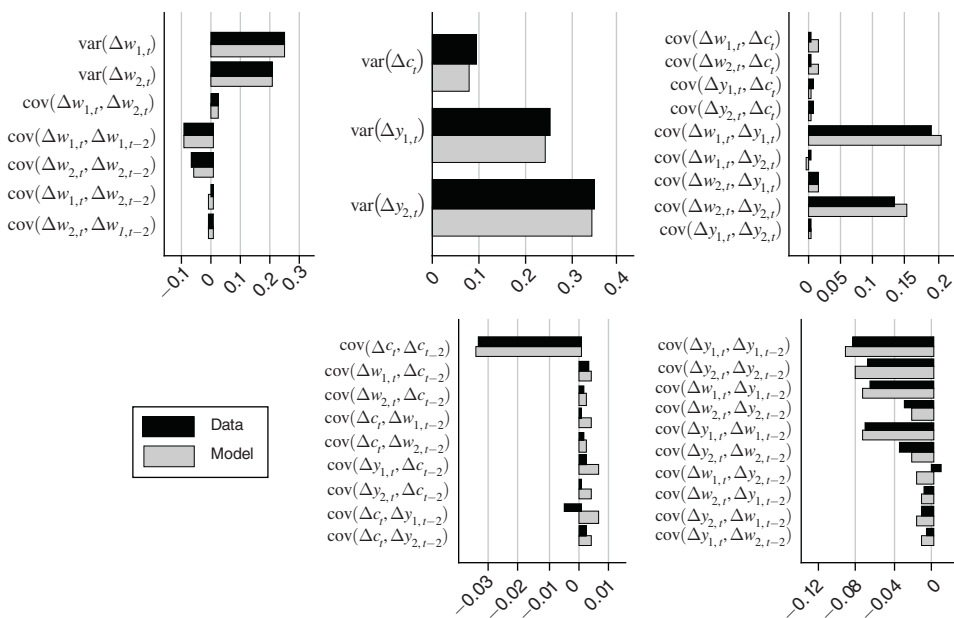
FIGURE 8. FIT OF THE MODEL

C. *Goodness of Fit of the Model*

In this concluding section we assess the goodness of fit of our model. We do this in two ways. First, since our model is overidentified, we can examine the discrepancy between the actual data moments and the predicted value of such moments generated by our estimates. Second, we examine the fit of our model for moments that were not targeted directly by our estimation procedure.

Internal Fit.—In Figure 8 we plot the estimates of the moments we target in estimation against the value of the same moments predicted by the model. Online Appendix Table 1 reports these numbers along with standard errors for the data moments (and, additionally, fit for hour moments). The model does an excellent job in predicting moments of the joint hourly wage growth distribution of husband and wife (top left panel). The model predicts quite well not only wage inequality, but also inequality in husband and wife's earnings and in household consumption (top middle panel).

In the top right panel we plot contemporaneous covariances. The largest ones, $\text{cov}(\Delta w_{j,t}, \Delta y_{j,t})$, reflecting labor supply intertemporal substitution effects, are similar in the data and in the model; the model does a good job also for the covariances that pin down cross-spouse responses $\left(\text{cov}(\Delta w_{j,t}, \Delta y_{-j,t})\right)$.

Finally, in the bottom two panels we plot lagged auto- and cross-covariances. It is hard to find cases of severe misfit in this dimension, the exceptions being $\text{cov}(\Delta c_t, \Delta y_{1,t-2})$ and $\text{cov}(\Delta w_{1,t}, \Delta y_{2,t-2})$, where the data and model have opposite signs.

Life-Cycle Variances.—A different way to assess goodness of fit of the model is to verify whether it is capable of replicating trends in consumption, wage, hours, and earnings inequality in the life-cycle domain—a domain we do not model explicitly. This is a popular exercise in the macro literature (see Heathcote, Storesletten, and Violante 2014, for a recent example; Kaplan 2012, for detailed discussion; and the classical Deaton and Paxson 1994). It is based on using the model to derive the implications of the model for moments in levels, as opposed to the moments in first differences that we have used in the estimation process. As we discuss below, this exercise requires making additional assumptions that are not required when estimating the model in first differences. The reason is simple: moments in first differences remove the contribution of initial conditions (fixed effects), which instead are still present when considering levels.

To understand how to use the model to derive the variance of the relevant variables at different points over the life cycle, consider what our baseline model, (1) and (2), predicts regarding the evolution of log wages over the life cycle:

$$w_{i,j,t} = F_{i,j,0} + \sum_{s=1}^{t} v_{i,j,s} + u_{i,j,t},$$

where $F_{i,j,0}$ is the "initial condition" (the level of wages at the point of entry in the labor market—age 0). Assuming that the components that appear in the wage process are correlated as assumed in our baseline specification, and that the initial condition is orthogonal to all current and future wage shocks, wage inequality at age t will be given by

$$(12) \qquad \text{var}(w_{i,j,t}) = \text{var}(F_{i,j,0}) + \sigma^2_{u_{j(t)}} + \sum_{s=1}^{t} \sigma^2_{v_{j(s)}}.$$

Our model provides estimates of the variances and covariances of wage shocks, but not of $\text{var}(F_{i,j,0})$. We obtain external estimates of $\text{var}(F_{i,j,0})$ as the variance of log wages at ages 28–32 for people entering the labor market in different calendar years (using PSID data for various calendar years), i.e., for different year of birth cohorts. We can then compare the model's predicted estimate of $\text{var}(w_{i,j,t})$ with the nonparametric estimate of $\text{var}(w_{i,j,t})$ from the data.

We repeat the procedure for inequality in log consumption, log hours, and log earnings. We abstract from female measures of life-cycle inequality because the formulae above work well for individuals with consistent attachment to the labor market (so that shocks can be "cumulated"), a condition that is unfortunately not satisfied by women.

Since deriving the evolution of inequality in endogenous variables (like hours or consumption) over the life cycle requires making additional assumptions, it is useful to show the derivation for log consumption. Using (9), it is easy to show that

$$c_{i,t} = c_{i,0} + \sum_{s=1}^{t} \left(\kappa^{i,s}_{c,v_1} v_{i,1,s} + \kappa^{i,s}_{c,v_2} v_{i,2,s} \right) + \kappa^{i,t}_{c,u_1} u_{i,1,t} + \kappa^{i,t}_{c,u_2} u_{i,2,t},$$

where $c_{i,0}$ is the "initial condition" (the level of consumption at the point of entry in the labor market) and we have made explicit the dependence of κ_{c,v_j} and κ_{c,u_j} on
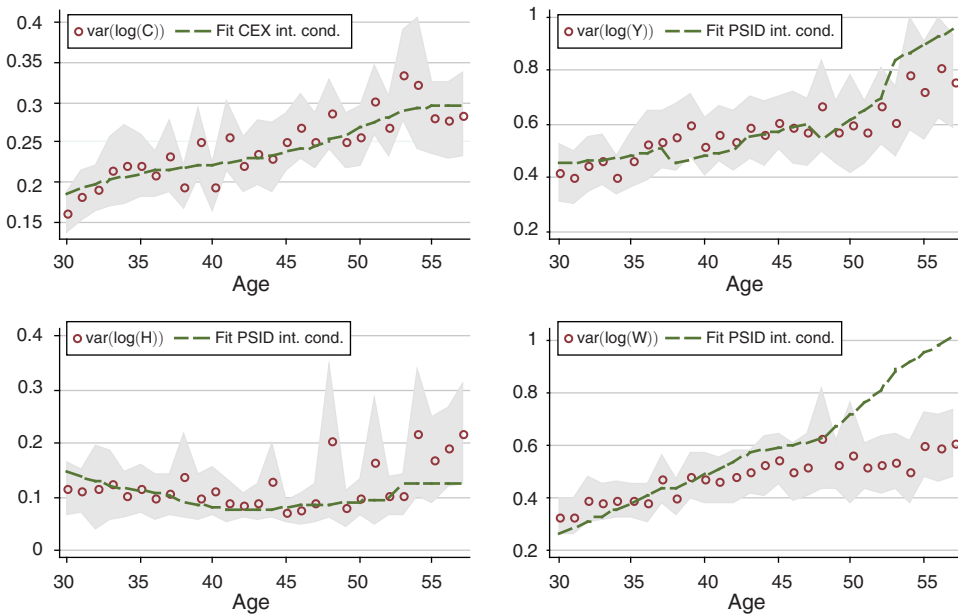
FIGURE 9. FIT OF KEY MOMENTS OVER THE LIFE CYCLE

individual and age. Assuming that the wage process is as described in Section IA, that the $\kappa_{c,v_j}^{i,s} = \overline{\kappa_{c,v_j}^{s}}$ and $\kappa_{c,u_j}^{i,t} = \overline{\kappa_{c,u_j}^{t}}$ are evaluated at the age-specific means, and that initial conditions are orthogonal to everything else, consumption inequality at age t will be given by

$$\text{var}(c_{i,t}) = \text{var}(c_{i,0}) + \overline{\kappa_{c,u_1}^{t}}^{2} \sigma_{u_1(t)}^{2} + \overline{\kappa_{c,u_2}^{t}}^{2} \sigma_{u_2(t)}^{2} + 2\overline{\kappa_{c,u_1}^{t} \kappa_{c,u_2}^{t}} \sigma_{u_1,u_2(t)}^{2}$$

$$+ \sum_{s=1}^{t} \left(\overline{\kappa_{c,v_1}^{s}}^{2} \sigma_{v_1(s)}^{2} + \overline{\kappa_{c,v_2}^{s}}^{2} \sigma_{v_2(s)}^{2} + 2\overline{\kappa_{c,v_1}^{s} \kappa_{c,v_2}^{s}} \sigma_{v_1,v_2(s)}^{2} \right).$$

Our model provides (implied) estimates of the κs, and of the variances and covariances of wage shocks. We obtain external estimates of $\text{var}(c_{i,0})$ as the variance of log consumption at ages 28–32 for people entering the labor market in different calendar years using CEX data for various calendar years (since PSID consumption data only start in 1999).

In Figure 9 we plot the variance of log consumption, log earnings, log hours, and log hourly wages as predicted by our model (the dashed lines) and the nonparametric estimates of the same variables (together with a 95 percent confidence interval—the gray bands) over the life cycle. In all graphs we add a normalizing constant which is meant to capture the variance of observable characteristics or covariance terms that we do not model explicitly. The graph shows that the model does quite a good job in predicting the life-cycle dispersion in consumption. For the other three variables there is more nuanced evidence. The model does a pretty good job early on in the life cycle (up until age 50). In fact, for all three variables, a test that the data and model

give statistically similar predictions never rejects the null if we focus on ages 30–50 (not shown). Nevertheless, in the last 6–7 years of the working life cycle we focus on, the model predicts only a slight increase in the dispersion of annual hours, while in the data the increase is extremely large and the series exhibits much volatility.

One concern with Figure 9 is that the model predicts a more rapid increase in wage inequality over the life cycle than observed in the data. However, note that the computation of the variances in levels using (12) makes strong assumptions about the joint distribution of the fixed effect and the wage shocks. No such assumptions are needed when estimating the model in first differences, since initial conditions are removed. If, for example, initial conditions were cross-sectionally negatively correlated with permanent wage shocks, as would happen if (to give an example) individuals who invest heavily in human capital early on in the life cycle are "compensated" by higher than average realization of their permanent wage component,[41] then the predicted wage variance profile would be much closer to what we observe in the data.

One additional reason for the gap opening up in the last part of the working life cycle between the model's predicted dispersion in hours and the dispersion we observe in the data is that the model (being focused on the intensive labor supply margin) is ill-equipped to capture the variation in hours induced by changes in work arrangements of older workers (partial retirement and disability).

V. Conclusions

This paper estimates a life-cycle model with two earners making consumption and labor supply decisions. We allow for flexible preferences (nonseparability among all the arguments of the utility function, namely consumption and leisure time of the two spouses), correlated wage shocks, progressive joint taxation, and government transfers for the low-income population, and use approximations of the first-order conditions and the lifetime budget constraint to derive expressions linking changes in consumption and hours to wage shocks. The sensitivity of consumption and hours to shocks depends on the structural parameters of the problem (Frisch elasticities and cross-elasticities), as well as terms that measure the relevance of self-insurance, earnings power within the family, the degree of progressivity of the tax system, and possibly external insurance. We reject separability. We find no evidence that advance information is an explanation for consumption smoothing relative to wage shocks. Once we allow for nonseparable preferences, assets, progressive taxation, and government transfers, we find little evidence of additional insurance channels.

Most of the consumption smoothing we observe can be explained by decisions that are within the boundaries of the household, i.e., an extended view of self-insurance. We find a particularly important role for family labor supply, and calculate that, on average, of the total amount of consumption "insured" against permanent shocks to the male's wage through behavioral responses, about 63 percent comes from family labor supply and only about 17 percent comes from self-insurance through savings, with the rest explained by taxes and transfers. We find a smaller insurance role for

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[41] This is an alternative way of capturing "random growth" effects similar to those emphasized by Guvenen (2009).

the husband's labor supply. Finally, there is a lot of heterogeneity in availability and use of the various insurance channels, both across people and across stages of the life cycle. Some households accumulate so few assets that the only way to maintain their living standards is through changes in family labor supply and government transfers. Needless to say, this is an imperfect insurance channel, not only because of its welfare costs (leisure is valued) but also because it may be particularly ineffective in circumstances in which wage shocks are of aggregate nature (and labor demand may be too weak to accommodate the willingness to work longer hours). Furthermore, family labor supply insurance is more important early on in the life cycle, while self-insurance through savings and borrowing is more important at later stages of the life cycle.

Our work could be fruitfully extended in a number of directions. In a new paper, Blundell, Pistaferri, and Saporta-Eksten (2015) highlight the insurance role of time allocation between work, leisure, and childcare. We suggest here a few additional avenues. First, it is important to understand the role played by liquidity constraints in affecting consumption and labor supply choices. In our framework, consumption responds to transitory shock, but while liquidity constraints predict a positive response to transitory shocks, we find that the response is negative and interpret this as evidence for substitutability between hours of work and household consumption. It is possible that substitutability is even higher and this masks a role for liquidity constraints (perhaps concentrated among low wealth households). Future work should aim at disentangling these two distinct forces. Second, we need to understand the role of nonseparability of consumption and hours separately from the effect of fixed cost of work. Third, intrafamily allocation issues have been neglected. This is not because we think they are unimportant, but because identification is extremely challenging given the paucity of appropriate data (i.e., spending on "exclusive" goods). Finally, we have assumed that hours can be freely adjusted in response to wage shocks, but with adjustment costs in hours this is less obvious. Our results, suggesting an important role for family labor supply in self-insuring household consumption against wage shocks, would be presumably even more prominent if adjustment costs in labor supply were important.

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