CONSUMPTION INEQUALITY
AND FAMILY LABOR SUPPLY*

Richard Blundell
(University College London and Institute for Fiscal Studies)
Luigi Pistaferri
(Stanford University, NBER and CEPR)
Itay Saporta-Eksten
(Tel Aviv University and University College London)
November 2014

Abstract

In this paper we examine the link between wage inequality and consumption inequality using a life cycle model that incorporates household consumption and family labor supply decisions. We derive analytical expressions based on approximations for the dynamics of consumption, hours, and earnings of two earners in the presence of correlated wage shocks, non-separability, progressive taxation and government transfers, and asset accumulation decisions. We show how the model can be identified and estimated using panel data for hours, earnings, assets and consumption. We focus on the importance of family labour supply as an insurance mechanism to wage shocks and find strong evidence of smoothing of male’s and female’s permanent shocks to wages. Once family labor supply, assets, taxes and transfers are properly accounted for there is little evidence of additional insurance.

*Blundell: Department of Economics, University College London, and Institute for Fiscal Studies, Gower Street, London WC1E 6BT, UK (email: r.blundell@ucl.ac.uk); Pistaferri: Department of Economics, Stanford University, Stanford, CA 94305 (email: pista@stanford.edu); Saporta-Eksten: The Eitan Berglas School of Economics, Tel Aviv, Israel, and Department of Economics, University College London (email: itaysap@post.tau.ac.il). We thank Mark Aguiar, Nick Bloom, Olympia Bover, Martin Browning, Chris Carroll, Jon Levin, Tom MaCurdy, Alessandra Voena, Gianluca Violante and participants at various conferences and workshops in the US and Europe for comments. Thanks to Kerwin Charles for initial help with the new consumption data from the PSID. The authors gratefully acknowledge financial support from the UK Economic and Social Research Council (Blundell), and the ERC starting grant 284024 (Pistaferri). All errors are ours.
1 Introduction

The link between household consumption inequality and idiosyncratic income changes has been the focus of a large body of recent economic research (Blundell et al., 2008; Heathcote et al., 2014). This literature usually relates movements in consumption to predicted and unpredictable income changes as well as persistent and non-persistent 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. 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; 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, and hence its omission is particularly glaring if the goal is to have an accurate view of how households respond to changes in their economic fortunes. The third 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 US, 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 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

---

1 Meghir and Pistaferri (2011) and Jappelli and Pistaferri (2010) review the relevant theoretical and empirical literature.
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 non-separable 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 non-separability agrees with most influential work on labor supply (see Blundell and MaCurdy, 1999, for a survey). 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; Blundell et al., 2008). A similar goal is pursued in Heathcote et al. (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 a very 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 US there are two sources of data that have been extensively used, the CEX and the PSID. The CEX has complete consumption data, but lacks a long panel component and the quality of its income, asset 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 et al., 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% 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, non-separable 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 that may explain consumption movements conditional on 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 US. 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 co-move positively. Our results show that the direction of the co-movement may depend on the type of wage changes considered (temporary vs. persistent) and on the labor supply margin that is studied (intensive vs. 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 antici-
pated changes and economic shocks. A good understanding of how consumers respond to income changes is of course crucial when evaluating policy changes that impact households' resources (such as tax and labor market reforms), as well as for the design of stabilization, social insurance, and income maintenance policies. Recent contributions that assume exogenous labor supply include Krueger and Perri (2006), and Blundell et al. (2008). In contrast, Attanasio et al. (2008), Blundell and Preston (2004), and Heathcote et al. (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.

A somewhat distinct, but equally large and influential literature estimates the responsiveness of individual

---

3 More in detail, Attanasio et al. (2008) introduce a model with a two earners' household. They do not explicitly model the labor supply decision of the household, but rather use Markov process for the evolution of the participation of the second earner. Blundell and Preston (2004) develop a life cycle framework with two earners modeling the simultaneous decision on consumption and hours worked for each earner. As in Blundell and Preston (1998) they assume that permanent shocks to earnings are fully transmitted to consumption. Finally, Heathcote et al. (2014) develop an analytical framework for the estimation of the response of consumption to insurable and uninsurable shocks to wages in a single earner setup.

4 The most relevant paper for our purposes is Hyslop (2001). He 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. He 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% of the rise in household earnings inequality in the early 1980's. 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. See also Stephens (2002).
labor supply to wage changes using micro data (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 non-separability with respect to consumption and the labor supply of the partner. As we shall see, separability is strongly rejected, as previously found in micro data (Browning and Meghir, 1991). In a recent macro literature, the degree of complementarity between consumption and hours plays an important role for explaining multiplier effects (see for example Christiano et al., 2011). Adding consumption information besides labor supply information increases the efficiency of estimation and imposes on the model the tougher requirement of fitting not just labor supply moments, but also consumption moments.

One of our contributions is to enrich and extend the theoretical framework used in previous literature. In particular, we consider a life cycle setup in which two individuals within the family (husband and wife) make unitary decisions about household consumption and their individual labor supply, subject to uncertainty about offered market wages. We allow for partial insurance of wage shocks through asset accumulation; heterogeneous Frisch elasticities for husband and wife; non-separability; and differences between the extensive and intensive margins of labor supply. These extensions are not merely formal, but substantial. 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. Studies of the “added worker effect” that 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. Ignoring nonseparability could yield biased estimates for the response of consumption to permanent wage shocks (and also distorts the measurement of the welfare effect of risk). The direction of the bias is ambiguous and depends on the substitutability or complementarity of consumption and hours. If consumption and hours are complements, the response of consumption to permanent shocks is over estimated. If consumption and hours are substitutes the result is reversed. A similar bias emerges in estimating the elasticity of intertemporal substitution in labor supply.

With fixed consumption costs of work, differences will naturally appear between elasticities at the exten-
sive and the intensive margin. We might naturally expect consumption and labor supply to be substitutes at the extensive margin as costs of work increase and home production falls on entry into 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 complementarities 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.

From the empirical side, we highlight the separate identification of Marshallian and Frisch elasticities, obtained by looking at the response of labor supply to permanent and transitory wage shocks, respectively. Given the life cycle focus, we allow for age-varying impact of shocks onto consumption and we also consider the possibility that wage shocks are drawn from age-varying distributions. In this framework, the distinction between permanent and transitory shocks is important, although in a finite horizon model the effect of a permanent shock is attenuated by the horizon of the consumer.

Our work has important policy implications. First, most families (i.e., poor or young families) do not have the assets that would allow them to smooth consumption effectively. Without the labor supply channel one could conclude that, apart from government transfers, they have little in the way of maintaining living standards when permanent shocks hit. For a correct design of public and social insurance policies, it is important to know whether households can use labor supply as an alternative insurance mechanism and to what extent they do so. Much depends on whether labor supply is frictionlessly changeable, which can be modelled at the cost of some simplifications, and how strong preferences for leisure are. Moreover, studying how well families smooth income shocks, how this changes over the life and over the business cycle in response to changes in the economic environment confronted, and how different household types differ in their smoothing opportunities, is an important complement to understanding the effect of redistributive policies and anti-poverty strategies.

The rest of the paper is organized as follows. Section 2 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 3 we describe the data, discuss the empirical strategy, the identification, and the estimation problems we face. Section 4 discusses the main results (including estimation under alternative specifications and various robustness checks). Section 5 includes a discussion of intensive vs. 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 don’t. Section 6 concludes.

2 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 non-stationary over the life cycle; we also allow wage shocks to be potentially correlated across spouses. Our baseline is a flexible model exhibiting non-separability between household consumption and the leisure time of the two spouses and a progressive tax system allowing for means-tested transfers. To build intuition regarding the various forces at play in the model, we discuss in detail two simpler cases: the first has nonseparability and proportional taxes, the second maintains separability but allows for nonlinear joint taxation. 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 dynamics case (see Chiappori and Mazzocco, 2014, for a recent survey).

2.1 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 identify Frisch (or \( \lambda \)-constant) elasticities, while the response to permanent wage shocks will identify Marshallian (or
uncompensated) elasticities.

Suppose that the log of real wage of earner \( j = \{1, 2\} \) in household \( i \) at age \( t \) can be written as:

\[
\log W_{i,j,t} = x_{i,j,t}' \beta_{W} + F_{i,j,t} + u_{i,j,t}
\]

(1)

\[
F_{i,j,t} = F_{i,j,t-1} + v_{i,j,t}
\]

(2)

where \( x_{i,j,t} \) 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. We make the following assumptions regarding correlation of shocks over the life cycle and within the household:

\[
E(u_{i,j,t}u_{i,k,t-s}) = \begin{cases} 
\sigma_{u_j(t)}^2 & \text{if } j = k \text{ and } s = 0 \\
\sigma_{u_j,u_k(t)} & \text{if } j \neq k \text{ and } s = 0 \\
0 & \text{otherwise}
\end{cases}
\]

(3)

\[
E(v_{i,j,t}v_{i,k,t-s}) = \begin{cases} 
\sigma_{v_j(t)}^2 & \text{if } j = k \text{ and } s = 0 \\
\sigma_{v_j,v_k(t)} & \text{if } j \neq k \text{ and } s = 0 \\
0 & \text{otherwise}
\end{cases}
\]

(4)

\[
E(u_{i,j,t}v_{i,k,t-s}) = 0 \quad \text{for all } j, k = \{1, 2\} \text{ and all } s
\]

(5)

The shocks are not formally insurable. We let the variances and covariances of the 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 data set, however, we restrict the age-variation to stages of the life cycle (30-37, 38-42, 43-47, 48-52, 53-57).

Assumptions (3)-(5) imply that the process varies by age but not over time and it is serially uncorrelated. Our data do not span a long time period (six waves, covering eleven years) and hence the year-stationarity assumption is less strong than it appears at first (the variance of annual wages were rather flat over the 1999-2009 period covered by our data). We also assume that contemporary shocks (transitory or permanent) can be correlated across spouses.\(^5\) This correlation is theoretically ambiguous. If spouses were to adopt sophisticated

\(^5\)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).
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.\footnote{Hryshko (2011) considers the consequences of relaxing this assumption for partial insurance models.}

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 \cite{PrimiceriванRens2009}; other researchers have emphasized the importance of allowing for growth heterogeneity \cite{GuvenenSmith2014}. Nevertheless, we will show that (1)-(2) fit wage data rather well. We also assume that the household has no advance information about the shocks and that the shocks are observed (separately) at time $t$.\footnote{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.}

We provide a test of no superior information in Section 4.2.5.

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

$$\Delta w_{i,j,t} = \Delta u_{i,j,t} + v_{i,j,t}$$

where $\Delta$ is a first difference operator and $\Delta w_{i,j,t} = \Delta \ln W_{i,j,t} - \Delta x'_{i,j,t} \beta_W$ (the log change in hourly wages net of observables). We discuss measurement error issues in Section 3.3.2.

### 2.2 Household Maximization Problem

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

$$\max E_t \sum_{s=0}^{T-t} u_{t+s}(C_{i,t+s}, H_{i,1,t+s}, H_{i,2,t+s}; z_{i,t+s}, z_{i,1,t+s}, z_{i,2,t+s})$$

subject to the intertemporal budget constraint

$$A_{i,t+1} = (1 + r) (A_{i,t} + T (H_{i,1,t} W_{i,1,t} + H_{i,2,t} W_{i,2,t}) - C_{i,t})$$

The time subscript on the utility function $u_{t+s}(.)$ captures intertemporal discounting. The primary arguments of the utility function are household consumption $C_{i,t}$ and the hours chosen by the two earners, respectively $H_{i,1,t}$ and $H_{i,2,t}$. The utility function also includes preference shifters specific to the household,
such as number of children ($z_{i,t}$), or specific to the earner, such as his or her age ($z_{i,1,t}$ and $z_{i,2,t}$). 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 3.4 for detail).

We assume that $u_{t+s}(.)$ 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 $T(.)$ 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 et al. (2014):

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

(9)

where the parameters $\chi$ and $\mu$ 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 $\mu$ will be zero and $\chi$ 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 (7)-(8) 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.

---

8 An example for a formal derivation of residual measures from a utility function with taste shifters see the online appendix to Blundell, Pistaferri and Preston (2008).
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 the following subsection we apply a two-step approximation procedure similar to the one used in Blundell and Preston (2004), Blundell et al. (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 et al. (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.

2.3 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. 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 Appendix 1 we show that log-linear approximation of the Euler equations yields:

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

(10)

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

(11)

where from now on lower-case 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

\(^9\)We use the notation "\(-j\)" to indicate variables that refer to the other earner. For example, \(\kappa_{h_{j-w}}\) measures the response of earner \(j\)'s labor supply \((j = \{1, 2\})\) to the other earner’s permanent shock.
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 \( \lambda \)-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).

Equations (10) and (11) show very clearly the effect of changes in prices and the feedback effect of taxes on consumption and leisure in an environment with non-separable preferences. Consider for example a \( \lambda \)-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 (as measured by \( \eta_{h,j,w_j} \)). If preferences are non-separable between the leisure of the two spouses, it also leads to an adjustment in the hours of the spouse (as measured by \( \eta_{h_{-j},w_j} \)). 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 (11)). Finally, a \( \lambda \)-constant change in the wage shifts household consumption due to non-separability between consumption and leisure (as measured by \( \eta_{c,w_j} \)) and the feedback effect of taxes on household earnings (the last term in equation (10)).

While the characterization (10) and (11) is theoretically appealing, it is empirically not very useful because it does not allow us to distinguish between responses to \( \lambda \)-constant and \( \lambda \)-varying exogenous wage shocks. To achieve these goals, we follow Blundell et al. (2008). First, we decompose the growth of the marginal utility of wealth \( \Delta \ln \lambda_{i,t+1} \) into two components. The first component, \( \omega_t \), is a function of the interest rate \( r \), the discount factor \( \delta \), and the variance of the change of marginal utility. This component captures the effect of aggregate variables on the consumption slope. Assuming that the only source of uncertainty in this setup is the idiosyncratic wage shocks, \( \omega_t \) is fixed in the cross-section. The second component, \( \varepsilon_{i,t} \), captures the revisions 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:

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

\(^{10} \)We assume that transitory shocks are fully smoothed, and hence they affect consumption only through non-separability.
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 Appendix 1 for the exact derivation):

\[
\begin{pmatrix}
\Delta c_{i,t} \\
\Delta h_{i,1,t} \\
\Delta h_{i,2,t}
\end{pmatrix} \approx
\begin{pmatrix}
\kappa_{c,u_1} & \kappa_{c,u_2} & \kappa_{c,v_1} & \kappa_{c,v_2} \\
\kappa_{h_1,u_1} & \kappa_{h_1,u_2} & \kappa_{h_1,v_1} & \kappa_{h_1,v_2} \\
\kappa_{h_2,u_1} & \kappa_{h_2,u_2} & \kappa_{h_2,v_1} & \kappa_{h_2,v_2}
\end{pmatrix}
\begin{pmatrix}
\Delta u_{i,1,t} \\
\Delta u_{i,2,t} \\
v_{i,1,t} \\
v_{i,2,t}
\end{pmatrix}
\] (12)

Note that in general, the loading factors $\kappa$ vary over time and across households (i.e., we should write $\kappa_{c,v_1}$, etc.). To avoid cluttering we will leave this individual and time-dependence implicit. The response of consumption to a permanent wage shock faced by earner $j$ is a general function:

\[
\kappa_{c,v_j} = \kappa_{c,v_j}(\pi_{i,t}, s_{i,t}, \eta, \mu_{i,t}, \chi_{i,t})
\]

where $\pi_{i,t} \approx \frac{\text{Assets}_{i,t}}{\text{Assets}_{i,t} + \text{Human Wealth}_{i,t}}$ is a "partial insurance" coefficient (the higher $\pi_{i,t}$ the lower the sensitivity of consumption to shocks), $s_{i,t} \approx \frac{\text{Human Wealth}_{i,t}}{\text{Human Wealth}_{i,t}}$ is the share of earner 1’s human wealth over family human wealth, $\eta$ is the vector of all Frisch elasticities, and $\mu_{i,t}$ and $\chi_{i,t}$ are the tax parameters defined above.\(^{11}\) To provide an interpretation of the various forces present in the model, we start with simplified cases and then add the features that make up our more general framework.

### 2.3.1 The Additive Separability/Proportional Tax Case

The first case we consider is additive separable preferences ($\eta_{c,w_j} = \eta_{h_j,p} = 0$ for $j = \{1, 2\}$ and $\eta_{h_1,w_2} = \eta_{h_2,w_1} = 0$) and no taxes ($\mu_{i,t} = \chi_{i,t} = 0$).\(^{12}\) In this case, we get as a special case of (12) the following equations for consumption growth and for the growth of hours of the two earners:

\[
\begin{pmatrix}
\Delta c_{i,t} \\
\Delta h_{i,1,t} \\
\Delta h_{i,2,t}
\end{pmatrix} \approx
\begin{pmatrix}
0 & 0 & \kappa_{c,v_1}^S & \kappa_{c,v_2}^S \\
\kappa_{h_1,u_1}^S & 0 & \kappa_{h_1,v_1}^S & \kappa_{h_1,v_2}^S \\
0 & \kappa_{h_2,u_2}^S & \kappa_{h_2,v_1}^S & \kappa_{h_2,v_2}^S
\end{pmatrix}
\begin{pmatrix}
\Delta u_{i,1,t} \\
\Delta u_{i,2,t} \\
v_{i,1,t} \\
v_{i,2,t}
\end{pmatrix}
\] (13)

\(^{11}\)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 Appendix 1.

\(^{12}\)Note while our specification reported in Section 4.2.3 involves shutting down taxes, a proportional tax rate ($\chi_{i,t} \neq 0, \mu_{i,t} = 0$) will deliver similar expressions for the $\kappa$s, but would imply a different path for the accumulation of human wealth, therefore a different $\pi_{i,t}$.
where the transmission coefficients \( \kappa^S \) (the superscript \( S \) standing for "Separability") have now simpler analytical interpretations:

\[
\begin{align*}
\kappa^S_{c,e_j} &= \frac{\eta_{c,p} (1 - \pi_{i,t}) s_{i,t} \left( 1 + \eta_{h_j,w_j} \right)}{\eta_{c,p} + (1 - \pi_{i,t}) \eta_{h,w}} \quad (14) \\
\kappa^S_{h_j,w_j} &= \eta_{h_j,w_j} \quad (15) \\
\kappa^S_{h_j,v_j} &= \eta_{h_j,w_j} \left( 1 - \frac{(1 - \pi_{i,t}) s_{i,t} \left( 1 + \eta_{h_j,w_j} \right)}{\eta_{c,p} + (1 - \pi_{i,t}) \eta_{h,w}} \right) \quad (16) \\
\kappa^S_{h_j,v_{-j}} &= -\frac{\eta_{h_j,w_j} (1 - \pi_{i,t}) (1 - s_{i,t}) \left( 1 + \eta_{h_{-j},w_{-j}} \right)}{\eta_{c,p} + (1 - \pi_{i,t}) \eta_{h,w}} \quad (17)
\end{align*}
\]

with \( \eta_{h,w} = s_{i,t} \eta_{h_{1},w_{1}} + (1 - s_{i,t}) \eta_{h_{2},w_{2}} \).

Consider first labor supply responses. Because transitory shocks have negligible or no wealth effects, the labor supply of a given earner does not respond to the transitory wage shocks faced by the other earner (and vice versa) - hence the zero restrictions on \( \kappa^S_{h_j,u_{-j}} \). In contrast, each earner’s labor supply respond to his/her own transitory wage shock to an extent that depends on his/her labor supply’s elasticity of intertemporal substitution (EIS). This is almost definitional: the Frisch elasticity (which under separability coincides with the EIS) measures the labor supply response to a wealth-constant wage change, which here is represented by a pure transitory shock.\(^{13}\)

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

\[ \kappa^S_{h_j,v_j} < 0 \]

(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 particular, assume for simplicity that there is only one

\(^{13}\)This is, of course, an approximation. Transitory shock will, in general, have a small wealth effect which here we assume negligible.
earner \((s_{i,j,t} = 1)\). In this case, the condition that ensures that own labor supply is used as a consumption smoothing device is:

\[
(1 - \pi_{i,t}) - \eta_{c,p} > 0 \tag{18}
\]

This condition is more likely to be satisfied when consumers have little or no accumulated assets \((\pi_{i,t} \rightarrow 0)\), so that labor supply appears as the only source of consumption smoothing available to consumers, and when consumers are highly reluctant to intertemporal fluctuations in their consumption \((\eta_{c,p} \rightarrow 0)\), so that adjustment is delegated to declines in the consumption of leisure rather than declines in the consumption of goods.\(^{14}\)

The response of earner \(j\)'s to a permanent shock faced by the other earner is instead informative about the so-called added worker effect. Looking at \(\kappa_{h,j,v,j}^S\), it is easy to see that the latter effect is unambiguously negative, i.e., earner \(j\) always increases her labor supply when earner \(i\) is hit by a permanent negative shock. Why? The reason is that 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).

What about consumption responses to shocks? The first thing to notice is that in the additive separability case, and if credit markets are assumed to work well, consumption responds very little to transitory shocks \((\kappa_{c,u,j}^S \approx 0 \text{ for } j = \{1,2\})\). 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). As for the response to permanent shocks, we know that in traditional analyses with e.g. quadratic utility, consumption respond one-to-one to permanent shocks. Equation (14) shows how misleading this can be when we account for family labor supply and precautionary behavior. This is important because neglecting these two forces may give a misleading view of the response of consumption to, say, policies that affect wages permanently.\(^{14}\)

\(^{14}\)In the more general case with multiple earners, labor supply of the primary earner is more likely to be used to smooth consumption if the secondary earner counts little in the balance of life time earnings \(((1 - s_{i,t})\) is low, so the primary earner cannot count on the added worker effect contributing much to the smoothing of family earnings) or if her labor supply is relatively inelastic \((\eta_{h_{2,u_{2}}} \text{ is small - for similar reasons})\).
In our framework, the response of consumption to permanent wage shocks depends on the partial insurance parameter $\pi_{i,t}$, on the human wealth shares $s_{i,t}$, the consumption EIS $\eta_{c,p}$, and the labor supply EIS of the two earners, $\eta_{h1,w1}$ and $\eta_{h2,w2}$. Interpreting the role of $s_{i,t}$ is straightforward: consumption is more sensitive to shocks faced by the earner who brings more resources, i.e., earner with larger human capital weight. Ceteris paribus, the sensitivity of consumption to the first earner’s permanent wage shock ($\kappa_{c,v1}^S$) is decreasing in the 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 labor supply EIS 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 EIS are by definition less reluctant to intertemporal fluctuations in their consumption.

Finally, note that 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.

### 2.3.2 What happens under nonseparability?

Consider now removing the assumption of additive separability but maintain the no tax and transfers assumption. A direct implication of relaxing the separability assumption is that the marginal utility of consumption now depends on hours (and vice versa). This changes the decision-making process of the household in the sense that it has to choose hours considering the effect that this decision may have on the utility from consumption. This implies that while in the additive separable case the Frisch elasticity with respect to own price and the elasticity of intertemporal substitution coincide, in the non-separable case this is no longer the case (see the online Appendix 1 for definitions of the Frisch elasticities).\(^{15}\) The signs of the Frisch cross-elasticities $\eta_{c,w_j}$ and $\eta_{h_j,p}$ determine whether consumption and hours of earner $j$ are Frisch complements

---

15See for example Browning et al. (1999). They show that the EIS for consumption in the nonseparable case is the sum of the Frisch elasticities of consumption with respect to own price and with respect to wages. In the separable case the latter is zero, therefore the Frisch elasticity and the EIS coincide.
(η_{c,w_j} > 0, η_{h_j,p} < 0) or Frisch substitutes (η_{c,w_j} < 0, η_{h_j,p} > 0). Similarly, η_{h_j,w_j} > 0 (η_{h_j,w_{-j}} < 0) implies that the leisure times of the spouses are Frisch complements (substitutes).

Compared to the case of additive separability, in the non-separable case the parameters κ^{NS}_{c,u_j} and κ^{NS}_{h_j,u_{-j}} are no longer restricted to be zero as in (13) (and here we use the superscript NS to indicate the "Non-Separable" model). In particular, one can show that, quite intuitively, κ^{NS}_{c,u_j} = η_{c,w_j} and κ^{NS}_{h_j,u_{-j}} = η_{h_j,w_{-j}} for j = \{1, 2\} (see Appendix 1). In essence, a test of non-separability 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 non-separability a transitory wage shock induces a change in hours and, through preference shifts, requires an adjustment also of consumption.\(^{16}\) Similarly, a test of non-separability 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 non-separable case these shocks shift preferences (for example because spouses enjoy leisure together), so they generate a response that depends on the degree of complementarity/separability between the arguments of the period utility function.

The remaining transmission coefficients κ^{NS}_{m,n} are - as before - complicated functions of the Frisch elasticities (including those measuring the extent and sign of non-separability), partial insurance, as well as the human wealth shares. To save space, we report the relevant expressions in Appendix 1. Given its importance, we report here only the expression for κ^{NS}_{c,v_j}, the response of consumption to a permanent shocks to earner j’s wage:\(^{17}\)

\[ κ^{NS}_{c,v_j} = η_{c,w_j} + \left( η_{c,p} - \left( η_{c,w_j} + η_{c,w_{-j}} \right) \right) \left( 1 - π_{i,t} \right) \left( s_{i,j,t} + η_{h,w_j} \right) - η_{c,w_j} \]  

(19)

which of course collapses to κ^{S}_{c,v_j} of the additive separable case if η_{c,w_j} = η_{h_j,p} = 0 for j = \{1, 2\} and η_{h_1,w_2} = η_{h_2,w_1} = 0. The comparative statics discussion of the previous section applies to this case as well.

Is the consumer response to permanent shocks in the non-separable case smaller or larger than in the

---

\(^{16}\)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 κ_{c,u_j} < 0.

\(^{17}\)Where the notation \( \eta_{h,m} = s_{i,t} η_{h_1,m} + (1 - s_{i,t}) η_{h_2,m} \), and m = \{w_1, w_2, p\}
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). This is illustrated graphically in Figure 1, where we plot $\kappa_{NS}^{c,v}$ against $\eta_{c,w_j}$. We do it separately for males (left panel) and females (right panel). 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 the case in which consumption and hours are Frisch substitutes, in particular, the downward adjustment in consumption is attenuated relative to the non-separable case. How large is the extra insurance brought about by consumption/hours substitutability? One heuristic way to gauge it is to look at the value of $\kappa_{c,v_j}$ in the case in which preferences are separable ($\eta_{c,w_j} = 0$), while keeping everything else constant. From Figure 1 (which is obtained ignoring taxes) one can calculate that consumption-hours substitutability would attenuate the effect of permanent shocks on consumption by something between 11% (men) and 15% (women).

2.3.3 What happens with transfers and progressive tax system?

Consider now the case where we introduce a progressive tax system but restore the assumption of additive separability. This is an interesting intermediate case to consider, since neglecting taxes may provide evidence of non-separable preferences even when there is none. This happens because in the US married couples file taxes jointly. 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. In general, non-linear progressive taxation means that the optimal choice of consumption and hours of work is now done under a convex, non-linear budget set. Hence, 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. Indeed, consider the response of hours to a transitory (or $\lambda$-constant) shock to the \textit{before-tax} hourly wage. In the one-earner case one can use (11) to show that:

$$
\kappa_{h_j,u_j}^T = \frac{\eta_{h_j,w_j}(1 - \mu)}{1 + \mu \eta_{h_j,w_j}}
$$

where $\kappa_{h_j,u_j}^T$ is, as before, the elasticity of labor supply with respect to \textit{before-tax} wage changes, $0 \leq \mu \leq 1$, and we use the superscript $T$ to indicate the "Progressive Tax" model. Note that this parameter no longer coincides with the Frisch elasticity $\eta_{h_j,w_j}$ (the curvature of the utility function with respect to leisure). In particular, when $\mu$ increases (i.e., when the tax system becomes more redistributive), the labor supply response to a before-tax wage change is dampened relative to the no-tax or flat-tax case, 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).\footnote{When the tax system changes over time and we allow for multiple earners, $\kappa_{h_j,u_j}$ will vary to reflect time and individual characteristics (earnings shares within the household). In Table 5, we report a value of this elasticity averaged across all periods and individuals.} Note also that the Frisch elasticity that is 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.

Researchers interested in the effect of taxes on labor supply may want to distinguish between the elasticity of labor supply with respect to \textit{before-tax} changes in wages ($\kappa_{BT}$) and the elasticity of labor supply with respect to \textit{after-tax} changes in wages ($\kappa_{AT}$) (MaCurdy, 1983). The responses of hours and consumption to wage shocks captured by the $\kappa$'s in (12) are equivalent to the former. However, we can also back out the latter for both the Frisch and the Marshallian case. 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 $\eta$'s).

As for Marshallian elasticities, we use the preference parameters estimated in the progressive tax case to re-calculate the $\kappa$'s with respect to tax neutral permanent shocks to wages ($\kappa_{c,v_j}, \kappa_{h_j,v_j}$). For the simple
In the consumption case, one can calculate that the response of consumption to a before-tax transitory wage shock is no longer \( \eta_{c,w,j} \) (which was identifying the extent of non-separability between consumption and leisure). In the single earner case, for example, it equals \( \eta_{c,w,i} (1 - \mu) \), and hence it is also dampened (in absolute value). The reason is that this coefficient captures the extent of consumption co-movement with hours, but in the case with taxes hours move less and this lower sensitivity of hours to wage shocks spills over to a lower sensitivity of consumption to wage shocks induced by preference non-separability.

3 Data, Estimation Issues, and Empirical Strategy

3.1 The PSID Data

We use the 1999-2009 Panel Study of Income Dynamics (PSID) to estimate the model. The PSID started in 1968 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 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

\[ \frac{\kappa_{BT}}{1 - \mu (1 + \kappa_{BT})} = \kappa_{AT}. \]

In the consumption case, one can see that the response of consumption to a before-tax transitory wage shock is no longer \( \eta_{c,w,j} \) (which was identifying the extent of non-separability between consumption and leisure). In the single earner case, for example, it equals \( \eta_{c,w,i} (1 - \mu) \), and hence it is also dampened (in absolute value). The reason is that this coefficient captures the extent of consumption co-movement with hours, but in the case with taxes hours move less and this lower sensitivity of hours to wage shocks spills over to a lower sensitivity of consumption to wage shocks induced by preference non-separability.

\[ \log \omega_{i,j,t} = \log (1 - \chi_t) + \log (1 - \mu_t) - \mu_t \log H_{i,j,t} + (1 - \mu_t) \log W_{i,j,t} \]

Taking total derivatives, we obtain:

\[ \frac{\kappa_{BT}}{1 - \mu (1 + \kappa_{BT})} = \kappa_{AT} \]

where \( \kappa_{BT} = d \log H_{i,j,t}/d \log W_{i,j,t} \) and \( \kappa_{AT} = d \log H_{i,j,t}/d \log \omega_{i,j,t} \). By evaluating these two elasticities in \( \lambda \)-constant or \( \lambda \)-varying scenarios, one gets Frisch and Marshallian elasticities with respect to before-tax and after-tax wage changes, respectively. For example, in the Frisch case: \( (d \log H_{i,j,t}/d \log W_{i,j,t})_{\lambda t=0} = \kappa_{h,j,w,j} = \frac{\eta_{h,j,w,j} (1 - \mu)}{1 + \mu \eta_{h,j,w,j}} \) and \( (d \log H_{i,j,t}/d \log \omega_{i,j,t})_{\lambda t=0} = \eta_{h,j,w,j} \). For the two earners case, this calculation has to include the effect of changing one earner’s hours on the other earner. Our approximation procedure takes this into account (see Appendix 1).
demographics, it collects data about detailed assets 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 with participating and married male household heads aged between 30 and 57. We choose this 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). The choice to focus on continuously working males is important but it is also less restrictive that 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 sample selection ends up dropping only 14% of all male heads observations in this age range, and summary statistics comparing our sample of male heads with all male heads in the same age range show very small differences in observables (see Table 1). Nonetheless, 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).

Besides the selections above, we also drop observations with missing values for state, education, race, labor earnings, hours, total consumption and total assets, and observations with wages that are lower than half the minimum wage in the state where the household resides. We drop observations with extreme negative values of assets, as well as observations with total transfers (calculated as explained in Section 3.2) more than twice the size of total household earnings. Finally, we drop observations for which consumption, wages or earnings of one of the earners show extreme "jumps" 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
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 \( \Delta^2 \log (x_t) \Delta^2 \log (x_{t-2}) \).

### 3.1.1 Descriptive Statistics

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, 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 home owners. To construct a series of housing services for home owners we impute the rent expenditures for home owners using the self reported house price. We then 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 the upper part of Table 1. 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% of consumption expenditure, the coverage rate is remarkably good.

Data on household’s assets holdings is 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 holding in each wave (between 1984 and 1999, asset data were collected every five years). The data include detailed holdings of cash, bonds, stocks, business, pensions, cars value, house and other real estate holdings. In addition, data is collected on household debt including first and second mortgage and other debt. Since we are interested in the net assets holdings, our

\(^{20}\)For detailed list of consumption categories covered in the PSID in different years refer to http://psidonline.isr.umich.edu/data/sl/ConsumptionSummaryVariablesPSID.xls
\(^{21}\)For our baseline measure we approximate the rent equivalent as 6% of the house price. See Flavin and Yamashita (2002).
\(^{22}\)We treat missing values in the consumption (and asset) subcategories as zeros.
measure of assets is constructed as the sum of cash, bonds, stocks, the value of any business, the value of pension funds, the value of any house, the value of other real estate, the value of any car, 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%) and that on average they earn about half of what males earn, partly reflecting lower hours of work (conditional on working), and partly reflecting other factors, both explained and unexplained.

### 3.2 Accounting for Progressive Taxation and Government Transfers

It is important to ensure that the tax function that we use in our model fits well the progressivity of the tax system in the U.S, 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:

$$Y_{i,t} = \sum_{j=1}^{2} W_{i,j,t} H_{i,j,t} - \tau \left( \sum_{j=1}^{2} W_{i,j,t} H_{i,j,t}, z_{i,t} \right) + EITC \left( \sum_{j=1}^{2} W_{i,j,t} H_{i,j,t}, z_{i,t} \right) + FS \left( \sum_{j=1}^{2} W_{i,j,t} H_{i,j,t}, z_{i,t} \right)$$

where $\tau(.)$, $EITC(.)$ and $FS(.)$ 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 $Y_{i,t}$ directly is infeasible in our log-linear approximation procedure, we approximate the relationship between after-tax income and before-tax household earnings using:
\[ Y_{i,t} \approx (1 - \chi_{i,t}) \left( \sum_{j=1}^{2} W_{i,j,t} H_{i,j,t} \right)^{(1-\mu_{i,t})} \]

To capture the very low and sometimes negative tax rates for low earnings households, we estimate the tax parameters separately for households that 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 2 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 0.90.

### 3.3 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 Appendix 2.

Consider first the identification of wage variances and covariances (Meghir and Pistaferri, 2004). As apparent from equation (6), the only reason why wage growth should exhibit 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 \( \sigma^2_{u_1 u_2(t)} \) 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 \( E(\Delta w_{i,j,t} \Delta w_{i,j,t}) \), stripped of the contribution of the mean reverting components \( E(\Delta w_{i,j,t} \Delta w_{i,j,t-1}) + E(\Delta w_{i,j,t} \Delta w_{i,j,t+1}) \), identifies the variance of innovations to the permanent component. Identification of \( \sigma_{v_{j,v_{-j}}(t)} \) follows a similar logic.

To discuss identification of structural preference and smoothing parameters in a clear way, we consider
the case with proportional taxes and non-separable preferences.

As argued above, Frisch labor supply elasticities $\eta_{h_j, w_j}$ are identified using the intuitive idea that $\lambda$-constant labor supply elasticities 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 $j$ (the Frisch cross-elasticity $\eta_{c, w_j}$) 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 leisure times of husband and wife (the Frisch cross-elasticities $\eta_{h_j, w_{-j}}$ and $\eta_{h_{-j}, w_j}$) 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.\footnote{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. The Appendix shows how we use the autocovariances of wage and hours growth of the two earners to pin down the parameters of interest.}

The identification of $\pi_{i,t}$ and $s_{i,j,t}$ 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 smaller $\kappa_{c,v_j}$. As $\eta_{c,p}$ rises, so does $\kappa_{c,v_j}$. As for $\kappa_{h_j,v_j}$, it is a Marshallian elasticity. At low values of $\eta_{c,p}$, the wealth effect dominates and $\kappa_{h_j,x_j} < 0$ (people increase hours to smooth the much more valued consumption in response to negative permanent shocks, as is clear from equation (18)); 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 $\kappa_{h_j,v_j} > 0$.}

---

23While 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. The Appendix shows how we use the autocovariances of wage and hours growth of the two earners to pin down the parameters of interest.
In practice, one way of thinking about what forces identify $\eta_{c,p}$ is to think about an overidentified case. Figure 3 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 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.

### 3.4 Estimation Issues

From an estimation point of view, we need to take a stand on a number of difficult issues. These include:

1. Adopting the correct inference for our estimation procedure,
2. Allowing for measurement error in consumption, wages, and earnings,
3. Controlling for the selection into work of the secondary earner.

We discuss these problems in the rest of this section.

#### 3.4.1 Inference

We use multiple moments, which we deal with using a 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.\(^{24}\) Given the multi-step approach (see below for details), 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 pre-estimated residuals.\(^{25}\)

#### 3.4.2 Measurement Error

Consumption, wages and earnings are most invariably measured with error. In our context, there are three problems one need to confront when adding measurement errors. First, as discussed among others in Blundell et al. (2008), adding measurement errors to models that include a permanent/transitory decomposition (as in our wage process) creates an identification problem, since the distribution of the measurement error is

\[ \log Y_{i,j,t} = \log H_{i,j,t} + \log W_{i,j,t}. \]

\(^{24}\)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. The two are linked by a simple change of variables, as $\log Y_{i,j,t} = \log H_{i,j,t} + \log W_{i,j,t}$.

\(^{25}\)To avoid the standard errors being affected by extreme draws, we apply a normal approximation to the inter-quartile range of the replications.
indistinguishable from the distribution of the economically relevant transitory shock. Second, our wage measure is constructed as annual earnings divided by annual hours, and therefore the measurement errors of earnings and wages are correlated (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 \( a \text{ priori} \) 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 data set we are using). Details are in the online Appendix 3. In the separable utility case measurement error in consumption can be identified using the consumption martingale assumption. Under non-separability 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.

### 3.4.3 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 between the age of 30 and 57 have average participation rates of 93%). This justifies our decision to focus on a sample of always-employed males. As for wives, their participation is 80% 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 decided to adopt two empirical
strategies. The first derives an empirical correction for the sample selection in the spirit of Low et al. (2010). We use “conditional covariance restrictions” rather than unconditional ones as done in most of the literature. 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 (see Del Boca and Lusardi, 2003). We provide more details about this strategy in Appendix 4. The second empirical strategy, detailed in Section 5.1.1, 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.

### 3.5 Empirical Strategy

The following steps summarize our empirical strategy:

1. Regress the log difference of $C_{i,t}, Y_{i,1,t}, W_{i,1,t}, Y_{i,2,t}$ and $W_{i,2,t}$ onto observable characteristics and construct the first-differenced residuals $\Delta C_{i,t}, \Delta Y_{i,1,t}, \Delta w_{i,1,t}, \Delta Y_{i,2,t}, \Delta w_{i,2,t}$. 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. Note that the wage and earnings regressions use only workers;

2. Estimate the wage variances and covariances using the second order moments of $\Delta w_{i,1,t}$ and $\Delta w_{i,2,t}$;

3. Use (9) to estimate the tax parameters $\chi_{i,t}$ and $\mu_{i,t}$ by regressions of log after-tax joint earnings on a constant term and log before-tax joint earnings allowing for the regression coefficients to change by year and household characteristics;

4. Estimate the smoothing parameters $\pi_{i,t}$ and $s_{i,1,t}$ using asset and (current and projected) earnings data;
5. Estimate the preference parameters using the second order moments for $\Delta y_{i,1,t}$, $\Delta y_{i,2,t}$ and $\Delta c_{i,t}$ conditioning on results (wage variances, covariances, and smoothing parameters) obtained in steps 2, 3 and 4.

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 3.4.3, 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 by preliminarily running female employment probits and then constructing conventional inverse Mills ratio terms).

4 Results

4.1 Estimating $\pi_{i,t}$ and $s_{i,1,t}$

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

$$\text{Human Wealth}_{i,t} = Y_{i,t} + \frac{E_t (Y_{i,t+1})}{1+r} + ...$$

where $Y_{i,t}$ is total household after-tax income (assuming no changes in tax policy).\(^{26}\)

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.\(^{27}\) 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 ($\pi^a$ below) that either do not change over time (such as race and education) or characteristics ($\pi^b$) that change in a perfectly forecastable way (such as a polynomial in age, and interaction of race and education with an age polynomial). That is, we regress:

26 The share of human wealth by earner $j$ at time $t$ is calculated similarly, but allowing also for some correlation between the share of earnings in a particular period and the share of each earner in this period. The exact calculation is reported in Appendix 1.

27 In practice we use assets reported in the previous $(t-2)$ wave.
\[ Y_{i,t} = \omega_t^a \gamma_1 + \omega_t^b \gamma_2 + \epsilon_{i,t} \]

To obtain an estimate of expected earnings at \( t + s \) given information at \( t \) (i.e., \( E_t(Y_{i,t+s}) \)) we simply use \( \hat{Y}_{i,t+s} = \omega_t^a \hat{\gamma}_1 + \omega_t^b \hat{\gamma}_2 \). We assume that agents are working until the age of 65 and that the discount rate is the same as the interest rate, and set the annual interest rate to 2%.

The same idea is applied to calculate expected human wealth for the each earner. However, since we allow for non-participation 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 4 (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 quintiles) over the life cycle. There is an enormous amount of heterogeneity across households. For example, around age 55 some households in the top quintiles 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 (all permanent shocks pass more or less through consumption), 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 \( \pi_{i,t} \) is exceeding 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 4. The closest equivalent is the hypothetical pattern presented by Kaplan and Violante (2011). We
also estimate the pattern of $\pi_{i,t}$ by terciles of the asset distribution and find that the 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 et al. (2008).

Our estimates of $s_{i,1,t}$ (the ratio of the husband’s human wealth to total household human wealth) are
plotted in Figure 5 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% of
total household human wealth. His weight rises initially due to fertility choices made by his wife, and
declines at the end of the life cycle due to early retirement choices coupled with age differences within the
household.

4.2 Main results

4.2.1 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, similar
to what is observed in Blundell and Mogstad (2013) 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 perhaps 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 non-stationarity 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.

4.2.2 Consumption and Labor Supply Parameters

Table 4, column 1 reports the estimates of our baseline specification (with non-separable preferences, progressive taxation and government transfers, and non-stationary 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 \( \eta_{c,p} = 0.49 \), implying a relative risk aversion coefficient of around 2, 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 \( \eta_{h1,w1} = 0.6 \) and \( \eta_{h2,w2} = 0.99 \). 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 0.17.28 For women, Heckman and MaCurdy (1980) report an elasticity of 1 (p. 65), 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 leisure (spouses enjoy spending time together),29 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 non-separability of preferences) reflect, in fact, liquidity constraints. However, with liquidity constraints the estimates of \( \kappa_{c,u_j} \) would be positive (a negative transitory shock that can’t be smoothed through borrowing would induce a fall in consumption), not negative as we find. If liquidity constraints explain the behavior of

28A 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).
29Evidence of complementarity of leisure time is also found in Browning, Deaton and Irish (1985), Hyslop (2001) and Voena (2014), among others.
consumption, then the implication is that we are even underestimating the degree of substitutability between consumption and hours.\textsuperscript{30}

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 baseline specification).\textsuperscript{31} 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 elasticities, and responses to permanent shocks pin down Marshallian elasticities with respect to before-tax wage changes.\textsuperscript{32}

We find that the average after-tax Marshallian elasticity for males is very close to zero (-0.04 with a standard error of 0.11). We find a larger average Marshallian elasticity of 0.4 for females (with a standard error of 0.1). As expected, these Marshallian elasticities are smaller than the corresponding after-tax Frisch elasticities (0.6 and 0.99 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 6 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 wealth, the role of the wealth effect is decreasing, driving the Marshallian elasticities up.\textsuperscript{33}

Of some interest are also the consumption cross-elasticities. In particular, while the compensated Frisch cross-elasticities $\frac{\partial \log C}{\partial \log W}$ \bigg|_{d\lambda=0} < 0, implying substitutability of consumption and hours of both spouses, uncompensated (Marshallian) consumption cross-elasticities are positive, implying complementarity, a result often 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

\textsuperscript{30}In Appendix 5 we also formally test the hypothesis that preferences are quasi-concave.
\textsuperscript{31}The theoretical relation between Marshallian and Frisch elasticities is well known. See for example Keane (2011), for a derivation in a constant elasticities set-up. The derivation in our setup is very similar, allowing for 2 earners and nonseparability.
\textsuperscript{32}These loading factors, or transmission coefficients, are obtained replacing the estimates of the structural parameters in the relevant theoretical expressions (see Appendix 1).
\textsuperscript{33}As $\pi \to 1$ the Marshallian elasticities are converging to their Frisch counterparts.
equivalent (from complementarity to substitutability). In all cases, it appears that lifetime wealth effects of changes in labor supply are non-negligible.

As noted above, researchers interested in the effect of taxes on labor supply may want to distinguish between consumption and labor supply elasticities with respect to before-tax and with respect to after-tax wage changes. The second column of Table 5 reports elasticities to after-tax wage changes, obtained using the strategy outlined in Section 2.3.3. Note that these calculations still use the estimates of the baseline model of Table 4, column 1, 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.

4.2.3 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 induce 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 progressive taxation delivers estimates that are closer to the before-tax estimates, rather than to the structural preference parameters that represent the after-tax responses.

In column 3 of Table 4 we consider the case with separable preferences. We find larger consumption elasticity ($\eta_{c,p}$) and smaller labor supply elasticities ($\eta_{h_1,w_1}, \eta_{h_2,w_2}$). 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 1.5%.

In column 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 (measured by the parameter $(1 - \pi_{i,t})$) by the multiplicative factor $(1 - \beta)$. Here, $\beta = 0$ means that there is no external insurance over and above self-insurance through assets and 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-respond 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 (see for a similar argument Kaplan and Violante, 2014).

The results are reported in column 5 of Table 4. The estimate of $\beta$ 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 non-separable 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 type 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.

4.2.4 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. Second, we restrict our analysis to the more educated group. Third, we apply the selection correction to account for female non-participation,
described in section 3.4.3 and Appendix 4. Fourth, we consider a measure of consumption that excludes housing. Finally, we calculate $\pi_{i,t}$ using median assets rather than individual assets. For comparison, in column (1) we report the baseline specification.

In column (2), the estimates show 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% relative to the baseline case). The estimates of the other parameters remain very similar. In 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.

The estimates with selection correction, reported in column (4), are very similar to the results obtained in the baseline specification that omits the correction. It is possible that this is because our sample of women have very high participation rates to start with (80% 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%. Since there may 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 re-estimate 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.

Our pre-estimated value of $\pi_{i,t}$ is obtained using information on individual assets and human capital. Since assets can be subject to severe mis-measurement and are characterized by a heavy-tailed distribution, in column (6) we re-estimate our model constructing a measure of $\pi_{i,t}$ that uses median assets by age and education groups rather than individual assets. This results in a lower estimated $\pi_{i,t}$ (as the influence of

---

34The idea as in Flavin and Yamashita, 2002 is that rent would cover interest or forgone interest and depreciation, which we set together to 6%. They also include property tax which we neglect.
values in the tail is reduced), but this exercise (similarly to the ones commented above) does not affect our main conclusions: (1) the consumption Frisch elasticity is in a reasonable range, (2) labor supply elasticities reflect a moderate degree of intertemporal substitution (larger for women), (3) male and female leisure times are Frisch complements, and (4) consumption and hours are Frisch substitutes.

4.2.5 Advance Information

Our estimates of the response of consumption to permanent wage shocks, $\kappa_{c,v_j}$, 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 et al. (2005) that with advanced information we should find that future wage growth predicts current consumption growth. We hence 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). The test does not reject the null of zero correlation with a p-value of 32%. We conclude that superior or advance information do not appear to be responsible for our findings.

4.3 How Much Insurance?

We can now use our estimates to understand the importance of the various sources of insurance available to households. In particular, we can 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:

35 Note that we cannot use the $\tau = 2$ as this moment is non-zero in the non-separable case.

36 There are two problems with this test. First, suppose that the true income process is a heterogeneous growth model and that the individual growth rate is known at time 0. In this case the correlation between current consumption growth and future consumption 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 pre-adjusting our measure of income growth to account for measurement error.
Insurance via family labor supply

\[
\frac{\partial \Delta c}{\partial v_1} \approx \frac{\partial \Delta y}{\partial v_1} - \frac{\partial \Delta (S/Y)}{\partial v_1}
\]

where \( y \) is \( S/Y \) 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:

\[
\frac{\partial \Delta y}{\partial v_1} \approx (1 - \mu) \left( s \frac{\partial \Delta y_1}{\partial v_1} + (1 - s) \frac{\partial \Delta y_2}{\partial v_1} \right)
\]

Insurance via family labor supply

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

Empirically, a 10% permanent decrease in the husband’s wage rate \((v_1 = -0.1)\), decreases consumption by 3.5% \((\frac{\partial \Delta c}{\partial v_1} = \hat{\kappa}_{c,v_1} = 0.35\), see column 1 of Table 5). 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.

In fact, we can decompose the response of consumption 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% (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% permanent decline in husband wages now induces a more modest 6.3% decline in consumption.

Introduction of behavioral responses changes the picture considerably. 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, \( \frac{\partial c}{\partial w} = 0.61 \), not very different from the case above. In contrast, allowing for added worker effects reduces the impact of a 10% decline in male permanent shock on consumption to only 4.2%. Finally, with all insurance channels active, the fall in household earnings is still 4.2%, but the fall in consumption is attenuated, to 3.5%. In other words, we can use (21) to calculate that, of the 35 cents of consumption "insured" against the shock to the male’s wage,\(^{37}\) 7 cents come from government insurance (20% of the total insurance effect), 21 cents (60%) come from family labor supply (she increases her labor supply when his wage fall permanently), and the remaining 7 cents (20% 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% permanent decline in the wife’s wage (and focusing on the intensive margin response).

As before, the response of consumption can be decomposed working through several steps. First, with fixed labor supply and no savings or transfers, household earnings would fall by 3% as the woman’s wage falls permanently by 10% (since her “weight" on total household earnings is \((1 - s) = 0.3\)). 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, the fall in household earnings is smaller (2.5%) 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 2.5%, but the fall in consumption is only 2% (see again column 1 of Table 5). In other words, of the 10 cents of consumption "insured" against the shock to her wage, about half can be attributed to conventional insurance sources (savings and transfers) and the other

\( ^{37}\)The 35 cents figure is derived from the difference between the response of consumption with savings, family labor supply responses and taxes/transfers (a 3.5% decline) and without these (a 7% decline).
half 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).

Before moving on, we discuss two important dimensions of heterogeneity in the role of insurance through labor supply. First, in Figure 7 we offer a graphical representation of the 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%. 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% 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 6.9%. As expected, the introduction of taxes and transfers plays an important role for the Food Stamps eligible group, reducing the consumption response to 3.4%. As before, allowing for husbands’ labor supply responses does not change the picture much, and introducing wife’s labor supply reduces consumption response to 2.2%, which is also the total decline in consumption. This implies that of the 46 cents of consumption "insured", 34 cents come from government transfers (74% of the total insurance effect), and the rest from family labor supply, with no insurance from savings.

5 Discussion

In this section we discuss and extend our empirical findings. In particular, we focus on three issues: (a) extensive and intensive margin in labor supply; (b) the importance of outside forms of insurance not accounted for by the model; (c) goodness of fit of the model.
5.1 Non-separability and the Extensive-Intensive Margin of labor Supply

Our approximation procedure cannot 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 non-participation) 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 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 non-separability depends on the type of goods that households consume.

5.1.1 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, for example we can consider a regression aimed at explaining the woman’s decision to work:

\[ \Delta P_{i,2,t} = \theta_0 u_{i,1,t} + \theta_1 v_{i,1,t} + e_{i,2,t} \]  

(22)

where \( P_{2,t} = 1 \) if the wife works. Hence one can interpret \( \theta_0 \) and \( \theta_1 \) 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 \( \theta_0 \) and \( \theta_1 \):
\[ \hat{\theta}_0 = \frac{\text{cov}(\Delta P_{i,2,t}, \Delta w_{i,1,t+1})}{\text{cov}(\Delta w_{i,1,t}, \Delta w_{i,1,t+1})} \]
\[ \hat{\theta}_0 = \frac{\text{cov}(\Delta P_{i,2,t}, \Delta w_{i,1,t-1} + \Delta w_{i,1,t} + \Delta w_{i,1,t+1})}{\text{cov}(\Delta w_{i,1,t}, \Delta w_{i,1,t-1} + \Delta w_{i,1,t} + \Delta w_{i,1,t+1})} \]

To identify \( \theta_0 \) (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 \( \theta_1 \) (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).\(^ {38}\)

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 non-working to working if the spouse faces a negative permanent decline in productivity.\(^ {39}\)

The effect is sizable: A permanent 10% decrease in the husband’s wage is associated with an increase in the probability of wife participation of 2 percentage points. Note that there is no evidence of a response to transitory shocks. If we interpret cross-responses to transitory shocks as evidence for non-separable preferences, this suggests that the non-separability 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 (although the effect is insignificant); when the youngest child grows up, it becomes easier for women to work. Finally, the instruments appear to pass conventional thresholds for weakness, and the overidentification test does not reveal evidence of misspecification.

\(^ {38}\)We also control in the regressions for year, husband’s and wife’s age, age squared and education, state of residence, MSA size, change in number of kids and change in age of the youngest child.

\(^ {39}\)The estimates of \( \theta_0 \) and \( \theta_1 \) 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, 2013) suggests that, if anything, the effect is underestimated because of the positive Marshallian elasticity estimated for women.
5.1.2 Non-separability 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.\textsuperscript{40} In general, whether consumption and hours are Frisch complements or substitutes is an empirical question. In the literature, evidence for substitutability has been rare (see Browning et al., 1985, for an early example). A more 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, 2014). 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).\textsuperscript{41}

Can we reconcile our "intensive margin" consumption-hours Frisch substitutability finding with the ev-

\textsuperscript{40}The extent of non-separability between consumption and hours depends crucially on the cross-covariance $E(\Delta c_t \Delta w_{t+1})$, which is positive in the data. While Frisch substitutability between consumption and hours is one way to justify a positive cross-covariance, two alternative explanations are possible. 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. Both could potentially generate the positive covariance above. While these explanations are interesting alternatives, they do not necessarily imply that the evidence for non-separability is spurious. Indeed, evidence for non-separability between consumption and leisure emerges also from the other two exercise we discuss in this section, which use complete different empirical strategies and do not rely on the lagged covariance structure of consumption and wages.

\textsuperscript{41}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 et al., 1985; Hyslop, 2001; Voena, 2014) find evidence of complementarity, as we do.
idence 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, 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 et al. (2011a) 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 non-participant, we approximate the growth in hours with the expression $\Delta \ln h_t \approx \frac{h_t - h_{t-1}}{(1/2)(h_t + h_{t-1})}$. 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 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 variety (Almost Ideal Demand System, Deaton and Muellbauer, 1980):

$$\omega^j_{i,t} = X'_{i,t}\beta + \eta \log C_{i,t} + p_t\varphi + \xi^j_{i,t},$$

where $\omega^j$ is the budget share of good $j$, $p$ are price indices and $X$ are additional controls. To test for non-separability 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 and lagged income. Table 9 reports the results. We find that utilities and hours are substitutes for women, while for men there is some (noisy) evidence of complementarity. For transportation and food away from home we find instead a complementarity pattern (and very noisy estimates for men). Hence, at least for women, there is robust evidence that different goods are differently non-separable with respect to labor supply, consistent with the basic intuition provided above.

### 5.2 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.

#### 5.2.1 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. 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 (left medium panel).

In the medium right panel we plot contemporaneous covariances. The largest ones, $cov(\Delta w_{j,t}, \Delta y_{j,t})$,
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 ($cov(\Delta w_{jt}, \Delta y_{jt})$).

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

5.2.2 External Fit

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 et al., 2014, for a recent example, and the classical Deaton and Paxson, 1994).

To understand what we do, consider what our baseline model predicts regarding the evolution of consumption over the life cycle, as in (12):

$$c_{i,t} = c_{i,0} + \sum_{s=1}^{t} \left( \kappa_{c,v_{1,s}} v_{1,s} + \kappa_{c,v_{2,s}} v_{2,s} \right) + \kappa_{c,u_{1,s}} u_{1,t} + \kappa_{c,u_{2,s}} u_{2,t}$$

where $c_{i,0}$ is the "initial condition" (the level of consumption at the point of entry in the labor market - reflecting heterogeneity in the permanent component of wages, preference heterogeneity, etc.) and we have made explicit the dependence of $\kappa_{c,v_{j}}$ on time. Assuming that the components that appear in the wage process are correlated as assumed in (4)-(5), consumption inequality at age $t$ will be given by:

$$var(c_{i,t}) = var(c_{i,0}) + \kappa_{c,u_{1,s}}^{2} \sigma_{u_{1,s}}^{2} + \kappa_{c,u_{2,s}}^{2} \sigma_{u_{2,s}}^{2} + 2\kappa_{c,v_{1,s}} \kappa_{c,v_{2,s}} \sigma_{v_{1,s}}^{2} \sigma_{v_{2,s}}^{2}$$

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

Our model provides (implied) estimates of the $\kappa$’s, and of the variances and covariances of wage shocks. We obtain external estimates of $var(c_{i,0})$ as the variance of log consumption at age 28-32 for people entering the labor market in different calendar years (using CEX data for various calendar years). We can then compare the model’s predicted estimate of $var(c_{i,t})$ with the non-parametric estimate of $var(c_{i,t})$ from the
We repeat the procedure for inequality in the husband’s log earnings, log hours, and log hourly wages. We abstract from female-measures of life cycle inequality because the formulae above work well for individuals with consistent attachment to the labor market, a condition that is unfortunately not satisfied by women.

In Figure 9 we plot the variance of (residual) log consumption, log earnings, log hours, and log hourly wages as predicted by our model (the dashed lines) and the non-parametric estimates of the same variables (together with a 95% confidence interval - the grey 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, a test that the data and model give statistically similar predictions never rejects the null if we focus on ages 30 to 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. Since the variance of earnings is approximately well matched, this results in overprediction of the variance of log wages in the last part of the working life cycle.

One possible explanation 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 (shifts from full- to part-time work, or intermittent participation over a calendar year).

6 Conclusions

This paper estimates a life cycle model with two earners making consumption and labor supply decisions. We allow for flexible preferences (non-separability 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 data.
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 depend 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 also reject advance information as an explanation for consumption smoothing relative to wage shocks. Once we allow for nonseparable preferences, assets, progressive taxation and government transfers, we find no 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 35 cents of consumption "insured" against permanent shocks to the male’s wage through behavioral responses, about 60% comes from family labor supply and only about 20% comes from self-insurance through savings, with the rest explained by taxes and transfers. We find a smaller insurance role for the husband’s labor supply, calculating that of the 10 cents of consumption "insured" against the shock to her wage, about half can be attributed to conventional insurance sources (savings) and the other half to family labor supply effects. 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 wages 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. Here we suggest a few 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, intra-family allocation issues have been neglected. This is not because we think they are unimportant, but because identification is extremely challenging and is only now started to being confronted with more appropriate data (i.e., spending on "exclusive" goods) and methodologies. 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.

References


## Table 1: Descriptive Statistics

<table>
<thead>
<tr>
<th>Sample</th>
<th>1998</th>
<th>2000</th>
<th>2002</th>
<th>2004</th>
<th>2006</th>
<th>2008</th>
<th>All years</th>
<th>All years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consumption</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>28,447</td>
<td>32,994</td>
<td>36,482</td>
<td>42,873</td>
<td>49,165</td>
<td>44,995</td>
<td>39,209</td>
<td>38,715</td>
</tr>
<tr>
<td>Non durable Cons.</td>
<td>6,907</td>
<td>7,870</td>
<td>7,906</td>
<td>8,929</td>
<td>10,002</td>
<td>9,392</td>
<td>8,509</td>
<td>8,433</td>
</tr>
<tr>
<td>Food at home</td>
<td>5,489</td>
<td>5,818</td>
<td>5,961</td>
<td>6,307</td>
<td>6,673</td>
<td>6,734</td>
<td>6,168</td>
<td>6,119</td>
</tr>
<tr>
<td>Gasoline</td>
<td>1,419</td>
<td>2,052</td>
<td>1,945</td>
<td>2,622</td>
<td>3,328</td>
<td>2,657</td>
<td>2,341</td>
<td>2,314</td>
</tr>
<tr>
<td>Services</td>
<td>21,540</td>
<td>25,124</td>
<td>28,576</td>
<td>33,944</td>
<td>39,163</td>
<td>35,603</td>
<td>30,700</td>
<td>30,282</td>
</tr>
<tr>
<td>Food out</td>
<td>2,034</td>
<td>2,270</td>
<td>2,377</td>
<td>2,582</td>
<td>5,040</td>
<td>2,601</td>
<td>2,110</td>
<td>1,575</td>
</tr>
<tr>
<td>Health ins.</td>
<td>1,011</td>
<td>1,257</td>
<td>1,450</td>
<td>1,720</td>
<td>1,882</td>
<td>2,110</td>
<td>1,575</td>
<td>1,547</td>
</tr>
<tr>
<td>Health serv.</td>
<td>894</td>
<td>1,044</td>
<td>1,138</td>
<td>1,433</td>
<td>1,610</td>
<td>1,765</td>
<td>1,317</td>
<td>1,331</td>
</tr>
<tr>
<td>Utilities</td>
<td>2,284</td>
<td>2,653</td>
<td>2,705</td>
<td>4,683</td>
<td>5,085</td>
<td>5,632</td>
<td>3,851</td>
<td>3,821</td>
</tr>
<tr>
<td>Transportation</td>
<td>3,204</td>
<td>3,786</td>
<td>4,681</td>
<td>3,893</td>
<td>4,026</td>
<td>3,783</td>
<td>3,896</td>
<td>3,805</td>
</tr>
<tr>
<td>Education</td>
<td>2,105</td>
<td>2,414</td>
<td>2,592</td>
<td>2,719</td>
<td>2,866</td>
<td>2,802</td>
<td>2,585</td>
<td>2,475</td>
</tr>
<tr>
<td>Child care</td>
<td>594</td>
<td>651</td>
<td>687</td>
<td>724</td>
<td>724</td>
<td>917</td>
<td>717</td>
<td>694</td>
</tr>
<tr>
<td>Home ins.</td>
<td>429</td>
<td>479</td>
<td>554</td>
<td>619</td>
<td>687</td>
<td>716</td>
<td>582</td>
<td>576</td>
</tr>
<tr>
<td>Rent (or rent eq.)</td>
<td>8,984</td>
<td>10,570</td>
<td>12,392</td>
<td>15,571</td>
<td>17,241</td>
<td>15,276</td>
<td>13,356</td>
<td>13,311</td>
</tr>
<tr>
<td><strong>Assets</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>314,809</td>
<td>329,889</td>
<td>360,704</td>
<td>449,327</td>
<td>248,473</td>
<td>423,287</td>
<td>354,583</td>
<td>380,476</td>
</tr>
<tr>
<td>Housing and RE</td>
<td>162,875</td>
<td>183,428</td>
<td>210,492</td>
<td>275,751</td>
<td>244,635</td>
<td>259,517</td>
<td>222,997</td>
<td>226,537</td>
</tr>
<tr>
<td>Financial assets</td>
<td>152,029</td>
<td>146,670</td>
<td>150,454</td>
<td>173,895</td>
<td>3,980</td>
<td>164,060</td>
<td>131,811</td>
<td>154,211</td>
</tr>
<tr>
<td>Total debt</td>
<td>73,446</td>
<td>83,393</td>
<td>99,893</td>
<td>117,483</td>
<td>135,129</td>
<td>142,673</td>
<td>108,892</td>
<td>106,396</td>
</tr>
<tr>
<td>Mortgage</td>
<td>66,965</td>
<td>75,266</td>
<td>90,712</td>
<td>107,840</td>
<td>123,621</td>
<td>128,676</td>
<td>99,024</td>
<td>96,407</td>
</tr>
<tr>
<td>Other debt</td>
<td>6,648</td>
<td>8,293</td>
<td>9,388</td>
<td>9,951</td>
<td>12,132</td>
<td>14,559</td>
<td>10,187</td>
<td>10,301</td>
</tr>
<tr>
<td><strong>First earner (head)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earnings (head)</td>
<td>55,709</td>
<td>61,927</td>
<td>63,440</td>
<td>67,748</td>
<td>74,233</td>
<td>78,414</td>
<td>67,001</td>
<td>63,495*</td>
</tr>
<tr>
<td>Hours worked (head)</td>
<td>2,371</td>
<td>2,326</td>
<td>2,322</td>
<td>2,313</td>
<td>2,309</td>
<td>2,176</td>
<td>2,302</td>
<td>2,202*</td>
</tr>
<tr>
<td><strong>Second earner</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation rate</td>
<td>0.79</td>
<td>0.80</td>
<td>0.80</td>
<td>0.79</td>
<td>0.80</td>
<td>0.79</td>
<td>0.80</td>
<td>0.79</td>
</tr>
<tr>
<td>Earnings</td>
<td>Work</td>
<td>26,017</td>
<td>28,447</td>
<td>31,661</td>
<td>34,203</td>
<td>36,723</td>
<td>40,517</td>
<td>32,980</td>
</tr>
<tr>
<td>Hours worked</td>
<td>Work</td>
<td>1,676</td>
<td>1,693</td>
<td>1,707</td>
<td>1,717</td>
<td>1,668</td>
<td>1,667</td>
<td>1,688</td>
</tr>
<tr>
<td>Observations</td>
<td>1,720</td>
<td>1,755</td>
<td>1,742</td>
<td>1,730</td>
<td>1,753</td>
<td>1,793</td>
<td>10,493</td>
<td>12,265</td>
</tr>
</tbody>
</table>

Notes: PSID data from 1999-2009 PSID waves. Panel A refers to the main sample: married couples with working male aged 30-57. SEO sample excluded. Panel B reports averages for all years and all males aged 30-57. For this panel head’s earnings and hours are reported conditional on work (marked with a *). PSID rent is imputed as 6% of reported house value. Missing values in consumption and assets subcategories are treated as zeros.
### Table 2: Comparison of PSID data with NIPA

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PSID Total</td>
<td>3,276</td>
<td>3,769</td>
<td>4,285</td>
<td>5,058</td>
<td>5,926</td>
<td>5,736</td>
</tr>
<tr>
<td>NIPA Total</td>
<td>5,139</td>
<td>5,915</td>
<td>6,447</td>
<td>7,224</td>
<td>8,190</td>
<td>9,021</td>
</tr>
<tr>
<td>Ratio</td>
<td>0.64</td>
<td>0.64</td>
<td>0.66</td>
<td>0.70</td>
<td>0.72</td>
<td>0.64</td>
</tr>
<tr>
<td>PSID Nondurables</td>
<td>746</td>
<td>855</td>
<td>887</td>
<td>1,015</td>
<td>1,188</td>
<td>1,146</td>
</tr>
<tr>
<td>NIPA Nondurables</td>
<td>1,330</td>
<td>1,543</td>
<td>1,618</td>
<td>1,831</td>
<td>2,089</td>
<td>2,296</td>
</tr>
<tr>
<td>Ratio</td>
<td>0.56</td>
<td>0.55</td>
<td>0.55</td>
<td>0.55</td>
<td>0.57</td>
<td>0.50</td>
</tr>
<tr>
<td>PSID Services</td>
<td>2,530</td>
<td>2,914</td>
<td>3,398</td>
<td>4,043</td>
<td>4,738</td>
<td>4,590</td>
</tr>
<tr>
<td>NIPA Services</td>
<td>3,809</td>
<td>4,371</td>
<td>4,829</td>
<td>5,393</td>
<td>6,101</td>
<td>6,725</td>
</tr>
<tr>
<td>Ratio</td>
<td>0.66</td>
<td>0.67</td>
<td>0.70</td>
<td>0.75</td>
<td>0.78</td>
<td>0.68</td>
</tr>
</tbody>
</table>

Note: We use PSID weights (we have a total of 47,206 obs. for 1999-09). Total consumption is defined as Nondurables + Services (in billion dollar 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.

### Table 3: Wage Variance Estimates

<table>
<thead>
<tr>
<th>Sample</th>
<th>30-37</th>
<th>38-42</th>
<th>43-47</th>
<th>48-52</th>
<th>53-57</th>
<th>All ages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males Trans.</td>
<td>$\sigma^2_{u_1}$</td>
<td>0.0431***</td>
<td>0.0216*</td>
<td>0.0359**</td>
<td>$-0.0003$</td>
<td>0.0471***</td>
</tr>
<tr>
<td>Males Perm.</td>
<td>$\sigma^2_{v_1}$</td>
<td>0.0273***</td>
<td>0.0230***</td>
<td>0.0157</td>
<td>0.0497***</td>
<td>0.0344***</td>
</tr>
<tr>
<td>Females Trans.</td>
<td>$\sigma^2_{u_2}$</td>
<td>0.0253**</td>
<td>0.0060</td>
<td>0.0146</td>
<td>0.0118</td>
<td>$-0.0186$</td>
</tr>
<tr>
<td>Females Perm.</td>
<td>$\sigma^2_{v_2}$</td>
<td>0.0457***</td>
<td>0.0454***</td>
<td>0.0246***</td>
<td>0.0357***</td>
<td>0.0500***</td>
</tr>
<tr>
<td>Covariance of shocks Trans.</td>
<td>$\sigma_{u_1,v_2}$</td>
<td>0.0127* (0.0076)</td>
<td>0.0054 (0.0055)</td>
<td>0.0010 (0.0056)</td>
<td>0.0002 (0.0049)</td>
<td>0.0121*** (0.0045)</td>
</tr>
<tr>
<td>Covariance of shocks Perm.</td>
<td>$\sigma_{v_1,v_2}$</td>
<td>$-0.0010$ (0.0067)</td>
<td>0.0027 (0.0048)</td>
<td>0.0045 (0.0038)</td>
<td>0.0074* (0.0043)</td>
<td>0.0008 (0.0063)</td>
</tr>
</tbody>
</table>

Notes: Wage process parameters estimated using GMM. *, **, *** = Significant at 10%, 5%, and 1%. Block bootstrap standard errors in parenthesis.
Table 4: Parameters Estimates

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td><strong>No Separable</strong></td>
<td><strong>Stationary</strong></td>
<td><strong>Outside</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimates</td>
<td>Taxes</td>
<td>Preferences</td>
<td>wage process</td>
<td>insurance</td>
<td></td>
</tr>
<tr>
<td><strong>π, s and Frisch own elasticities:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E (π)</strong></td>
<td>0.146***</td>
<td>0.135***</td>
<td>0.146***</td>
<td>0.146***</td>
<td>0.146***</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
</tr>
<tr>
<td><strong>E(s)</strong></td>
<td>0.704***</td>
<td>0.706***</td>
<td>0.704***</td>
<td>0.704***</td>
<td>0.704***</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.011)</td>
<td>(0.011)</td>
<td>(0.011)</td>
<td>(0.011)</td>
</tr>
<tr>
<td><strong>η_{c,p}</strong></td>
<td>0.490***</td>
<td>0.418***</td>
<td>0.613***</td>
<td>0.589***</td>
<td>0.497***</td>
</tr>
<tr>
<td></td>
<td>(0.139)</td>
<td>(0.095)</td>
<td>(0.136)</td>
<td>(0.179)</td>
<td>(0.122)</td>
</tr>
<tr>
<td><strong>η_{b1,w1}</strong></td>
<td>0.600***</td>
<td>0.531***</td>
<td>0.490***</td>
<td>0.576***</td>
<td>0.628***</td>
</tr>
<tr>
<td></td>
<td>(0.157)</td>
<td>(0.120)</td>
<td>(0.116)</td>
<td>(0.149)</td>
<td>(0.157)</td>
</tr>
<tr>
<td><strong>η_{b2,w2}</strong></td>
<td>0.994***</td>
<td>0.903***</td>
<td>0.849***</td>
<td>1.008***</td>
<td>1.000***</td>
</tr>
<tr>
<td></td>
<td>(0.256)</td>
<td>(0.223)</td>
<td>(0.152)</td>
<td>(0.255)</td>
<td>(0.290)</td>
</tr>
<tr>
<td><strong>Frisch cross-elasticities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>η_{c,w1}</strong></td>
<td>-0.164**</td>
<td>-0.144**</td>
<td>-. - -. - . - -. - . -</td>
<td>-0.186**</td>
<td>-0.170**</td>
</tr>
<tr>
<td></td>
<td>(0.076)</td>
<td>(0.069)</td>
<td>(0.079)</td>
<td>(0.079)</td>
<td>(0.077)</td>
</tr>
<tr>
<td><strong>η_{b1,p}</strong></td>
<td>0.127**</td>
<td>0.082**</td>
<td>-. - -. - . - -. - . -</td>
<td>0.144**</td>
<td>0.131**</td>
</tr>
<tr>
<td></td>
<td>(0.060)</td>
<td>(0.040)</td>
<td>(0.059)</td>
<td>(0.059)</td>
<td>(0.060)</td>
</tr>
<tr>
<td><strong>η_{c,w2}</strong></td>
<td>-0.092</td>
<td>-0.062</td>
<td>-. - -. - . - -. - . -</td>
<td>-0.115</td>
<td>-0.082</td>
</tr>
<tr>
<td></td>
<td>(0.102)</td>
<td>(0.077)</td>
<td>(0.097)</td>
<td>(0.097)</td>
<td>(0.085)</td>
</tr>
<tr>
<td><strong>η_{b2,p}</strong></td>
<td>0.145</td>
<td>0.073</td>
<td>-. - -. - . - -. - . -</td>
<td>0.181</td>
<td>0.130</td>
</tr>
<tr>
<td></td>
<td>(0.162)</td>
<td>(0.088)</td>
<td>(0.150)</td>
<td>(0.150)</td>
<td>(0.148)</td>
</tr>
<tr>
<td><strong>η_{b1,w2}</strong></td>
<td>0.149**</td>
<td>0.099*</td>
<td>-. - -. - . - -. - . -</td>
<td>0.148**</td>
<td>0.163**</td>
</tr>
<tr>
<td></td>
<td>(0.072)</td>
<td>(0.054)</td>
<td>(0.068)</td>
<td>(0.068)</td>
<td>(0.068)</td>
</tr>
<tr>
<td><strong>η_{b2,w1}</strong></td>
<td>0.305***</td>
<td>0.201*</td>
<td>-. - -. - . - -. - . -</td>
<td>0.303**</td>
<td>0.333**</td>
</tr>
<tr>
<td></td>
<td>(0.148)</td>
<td>(0.108)</td>
<td>(0.138)</td>
<td>(0.138)</td>
<td>(0.138)</td>
</tr>
</tbody>
</table>

| **Outside Insurance** |                      |                      |                      |                      |                      |
| **β**              | -. - -. - -. - -. - . - |                      |                      | -0.205               |
|                    | (0.226)              |                      |                      | (0.226)              |

| Observ.          | 7,308                | 7,308                | 7,308                | 7,308                | 7,308                |

Notes: Parameters estimated by GMM. Column 1 reports the estimates assuming non-separable preferences, non-linear 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". *, **, *** = Significant at 10%, 5%, and 1%. Block bootstrap standard errors in parenthesis.
Table 5: The Sensitivity of Consumption and Labor Supply Elasticities to the Treatment of Taxes

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Response</td>
<td>Response</td>
<td>Ignoring</td>
</tr>
<tr>
<td></td>
<td>to a before-tax wage change</td>
<td>to an after-tax wage change</td>
<td>taxes</td>
</tr>
<tr>
<td><strong>Frisch Own-Elasticities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male labor supply</td>
<td>0.51***</td>
<td>0.60***</td>
<td>0.53***</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.16)</td>
<td>(0.12)</td>
</tr>
<tr>
<td>Female labor supply</td>
<td>0.92***</td>
<td>0.99***</td>
<td>0.90***</td>
</tr>
<tr>
<td></td>
<td>(0.23)</td>
<td>(0.26)</td>
<td>(0.22)</td>
</tr>
<tr>
<td><strong>Frisch Cross-elasticities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male labor supply/Female wage</td>
<td>0.10*</td>
<td>0.15**</td>
<td>0.10*</td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
<td>(0.07)</td>
<td>(0.05)</td>
</tr>
<tr>
<td>Female labor supply/Male wage</td>
<td>0.15</td>
<td>0.31**</td>
<td>0.20*</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
<td>(0.15)</td>
<td>(0.11)</td>
</tr>
<tr>
<td>Consumption/Male wage</td>
<td>-0.13**</td>
<td>-0.16**</td>
<td>-0.14**</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td>(0.08)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>Consumption/Female wage</td>
<td>-0.08</td>
<td>-0.09</td>
<td>-0.06</td>
</tr>
<tr>
<td></td>
<td>(0.09)</td>
<td>(0.10)</td>
<td>(0.08)</td>
</tr>
<tr>
<td><strong>Marshallian Own-Elasticities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male labor supply</td>
<td>-0.03</td>
<td>-0.04</td>
<td>-0.06</td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td>(0.11)</td>
<td>(0.09)</td>
</tr>
<tr>
<td>Female labor supply</td>
<td>0.41***</td>
<td>0.40***</td>
<td>0.39***</td>
</tr>
<tr>
<td></td>
<td>(0.09)</td>
<td>(0.10)</td>
<td>(0.09)</td>
</tr>
<tr>
<td><strong>Marshallian Cross-Elasticities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male labor supply/Female wage</td>
<td>-0.20***</td>
<td>-0.21***</td>
<td>-0.21***</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.04)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>Female labor supply/Male wage</td>
<td>-0.73***</td>
<td>-0.75***</td>
<td>-0.77***</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.15)</td>
<td>(0.13)</td>
</tr>
<tr>
<td>Consumption/Male wage</td>
<td>0.35***</td>
<td>0.38***</td>
<td>0.37***</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.06)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>Consumption/Female wage</td>
<td>0.20***</td>
<td>0.22***</td>
<td>0.21***</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.04)</td>
<td>(0.03)</td>
</tr>
<tr>
<td><strong>Observ.</strong></td>
<td>7,308</td>
<td>7,308</td>
<td>7,308</td>
</tr>
</tbody>
</table>

Notes: Parameters estimated using GMM. Column 1 reports the elasticities with respect to before-tax wage changes. Note that these are the average $\kappa$'s from equation (12)). Column 2 reports the elasticities with respect to after-tax wage changes. Both use the results from the baseline model of Table 4, column 1. In Column 3 we reports the elasticities for the nonseparable case without taxes (as in Table 4, column 2). *, **, *** = Significant at 10%, 5%, and 1%. Block bootstrap standard errors in parenthesis.
Table 6: Additional Specifications

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Specific.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 30-50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No High school dropouts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select. Correct.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No rents</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using Median Assets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>π, s and own elasticities:</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E(π)</td>
<td>0.146***</td>
<td>0.104***</td>
<td>0.153***</td>
<td>0.146***</td>
<td>0.146***</td>
<td>0.117***</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.003)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>E(s)</td>
<td>0.704***</td>
<td>0.702***</td>
<td>0.708***</td>
<td>0.667***</td>
<td>0.704***</td>
<td>0.704***</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.010)</td>
<td>(0.011)</td>
<td>(0.011)</td>
</tr>
<tr>
<td>ηc,p</td>
<td>0.490***</td>
<td>0.486***</td>
<td>0.613***</td>
<td>0.499***</td>
<td>0.672***</td>
<td>0.492***</td>
</tr>
<tr>
<td></td>
<td>(0.139)</td>
<td>(0.216)</td>
<td>(0.244)</td>
<td>(0.159)</td>
<td>(0.259)</td>
<td>(0.133)</td>
</tr>
<tr>
<td>ηh1,w1</td>
<td>0.600***</td>
<td>0.527***</td>
<td>0.489***</td>
<td>0.596***</td>
<td>0.547***</td>
<td>0.610***</td>
</tr>
<tr>
<td></td>
<td>(0.157)</td>
<td>(0.160)</td>
<td>(0.143)</td>
<td>(0.154)</td>
<td>(0.153)</td>
<td>(0.152)</td>
</tr>
<tr>
<td>ηh2,w2</td>
<td>0.994***</td>
<td>1.041***</td>
<td>0.977***</td>
<td>1.043***</td>
<td>0.970***</td>
<td>1.001***</td>
</tr>
<tr>
<td></td>
<td>(0.256)</td>
<td>(0.451)</td>
<td>(0.316)</td>
<td>(0.308)</td>
<td>(0.261)</td>
<td>(0.263)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cross-elasticities:</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ηc,w1</td>
<td>−0.164**</td>
<td>−0.151*</td>
<td>−0.182**</td>
<td>−0.163**</td>
<td>−0.222**</td>
<td>−0.168**</td>
</tr>
<tr>
<td></td>
<td>(0.076)</td>
<td>(0.082)</td>
<td>(0.078)</td>
<td>(0.082)</td>
<td>(0.103)</td>
<td>(0.075)</td>
</tr>
<tr>
<td>ηh1,p</td>
<td>0.127***</td>
<td>0.116*</td>
<td>0.137**</td>
<td>0.126**</td>
<td>0.113**</td>
<td>0.130**</td>
</tr>
<tr>
<td></td>
<td>(0.066)</td>
<td>(0.063)</td>
<td>(0.066)</td>
<td>(0.062)</td>
<td>(0.054)</td>
<td>(0.066)</td>
</tr>
<tr>
<td>ηc,w2</td>
<td>−0.092</td>
<td>−0.085</td>
<td>−0.125</td>
<td>−0.101</td>
<td>−0.148</td>
<td>−0.091</td>
</tr>
<tr>
<td></td>
<td>(0.102)</td>
<td>(0.105)</td>
<td>(0.123)</td>
<td>(0.121)</td>
<td>(0.131)</td>
<td>(0.101)</td>
</tr>
<tr>
<td>ηh2,p</td>
<td>0.145</td>
<td>0.134</td>
<td>0.196</td>
<td>0.159</td>
<td>0.153</td>
<td>0.143</td>
</tr>
<tr>
<td></td>
<td>(0.162)</td>
<td>(0.165)</td>
<td>(0.191)</td>
<td>(0.188)</td>
<td>(0.133)</td>
<td>(0.159)</td>
</tr>
<tr>
<td>ηh1,w2</td>
<td>0.149**</td>
<td>0.170</td>
<td>0.112**</td>
<td>0.162**</td>
<td>0.118</td>
<td>0.156**</td>
</tr>
<tr>
<td></td>
<td>(0.072)</td>
<td>(0.106)</td>
<td>(0.053)</td>
<td>(0.074)</td>
<td>(0.073)</td>
<td>(0.074)</td>
</tr>
<tr>
<td>ηh2,w1</td>
<td>0.305**</td>
<td>0.347*</td>
<td>0.233**</td>
<td>0.331**</td>
<td>0.241</td>
<td>0.318**</td>
</tr>
<tr>
<td></td>
<td>(0.148)</td>
<td>(0.198)</td>
<td>(0.111)</td>
<td>(0.154)</td>
<td>(0.150)</td>
<td>(0.152)</td>
</tr>
</tbody>
</table>

| Observ.                   | 7,308     | 5,459     | 6,483     | 7,308     | 7,308     | 7,308     |

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 Table 4, column 1). 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 that 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). *, **, *** = Significant at 10%, 5%, and 1%. Block bootstrap standard errors in parenthesis.
Table 7: **Added Worker Effect: The Extensive Margin**

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable: Change in wife’s participation ($\Delta P_{i,2,t}$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent shock to husband’s wages ($v_{i,1,t}$)</td>
<td>$-0.197^{**}$</td>
<td>$-0.009$</td>
</tr>
<tr>
<td></td>
<td>(0.101)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>Transitory shock to husband’s wages ($u_{i,1,t}$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$-0.009$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.026)</td>
</tr>
<tr>
<td>$\Delta$ Kids</td>
<td>$-0.021$</td>
<td>$-0.013$</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.012)</td>
</tr>
<tr>
<td>$\Delta$ Age of youngest kid</td>
<td>$0.009^{***}$</td>
<td>$0.008^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>First Stage F-stat</td>
<td>41.45</td>
<td>477.48</td>
</tr>
<tr>
<td>Observations</td>
<td>3,148</td>
<td>4,946</td>
</tr>
</tbody>
</table>

Note: 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, and year effects. *, **, *** = Significant at 10%, 5%, and 1%. Robust standard errors in parenthesis.
Table 8: Conditional Euler Equations

<table>
<thead>
<tr>
<th></th>
<th>Regression results</th>
<th>First stage F-stats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>$\Delta EMP_t(Male)$</td>
<td>0.260*</td>
<td>9.26</td>
</tr>
<tr>
<td></td>
<td>(0.135)</td>
<td></td>
</tr>
<tr>
<td>$\Delta h_t(Male)$</td>
<td>-0.122</td>
<td>-0.178</td>
</tr>
<tr>
<td></td>
<td>(0.127)</td>
<td>(0.156)</td>
</tr>
<tr>
<td>$\Delta EMP_t(Female)$</td>
<td>0.366*</td>
<td>0.419**</td>
</tr>
<tr>
<td></td>
<td>(0.219)</td>
<td>(0.200)</td>
</tr>
<tr>
<td>$\Delta h_t(Female)$</td>
<td>-0.197*</td>
<td>-0.214*</td>
</tr>
<tr>
<td></td>
<td>(0.119)</td>
<td>(0.115)</td>
</tr>
</tbody>
</table>

Sample All EMP$_t$(Male)=1

Observations 6,904 6,420

Notes: The table reports conditional Euler equations estimates. $\Delta h_t$ 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. *, **, *** = Significant at 10%, 5%, and 1%. Robust standard errors are reported in parenthesis.
Table 9: Demand System Estimation

<table>
<thead>
<tr>
<th></th>
<th>Budget shares</th>
<th>First Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>Utilities</td>
<td>Transportation</td>
</tr>
<tr>
<td>$h_t(Male)$</td>
<td>0.0057*</td>
<td>0.0094</td>
</tr>
<tr>
<td></td>
<td>(0.0031)</td>
<td>(0.0068)</td>
</tr>
<tr>
<td>$h_t(Female)$</td>
<td>-0.0104**</td>
<td>0.0189*</td>
</tr>
<tr>
<td></td>
<td>(0.0046)</td>
<td>(0.0100)</td>
</tr>
<tr>
<td>$c_t$</td>
<td>-0.0511***</td>
<td>-0.0665***</td>
</tr>
<tr>
<td></td>
<td>(0.0039)</td>
<td>(0.0082)</td>
</tr>
</tbody>
</table>

J-test p-value 39% 33% 52%
Observations 5,897 5,897 5,897

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, year dummies, and asset income. *, **, *** = Significant at 10%, 5%, and 1%. Robust standard errors reported in parenthesis.
Figure 1: The relationship between $\kappa_{c,v_j}$ and $\eta_{c,w_j}$. 
Figure 2: Approximation of the tax and transfer codes.

Figure 3: Identification of $\eta_{cp}$. 

63
Figure 4: The evolution of $\pi$ by the age of the household head.
Figure 5: The evolution of $s$ by the age of the household head.

Figure 6: Marshallian Elasticities by Age
Response of Consumption to a 10% Permanent Decrease in the Male’s Wage Rate

Figure 7: Decomposing the sources of consumption smoothing.
Figure 8: Fit of the model.
Figure 9: Fit of key moments over the life cycle.