How Do Wage Shocks Affect the Labor Supply Decisions of Married Couples?

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Abstract

Do married couples make joint labor supply decisions in response to each other's wage shocks? The study of this question aids in understanding the link between the recent rise in earnings volatility and household decisions. Existing studies on household insurance either focus on consumption smoothing and take labor supply as a given, or only focus on wives' labor responses to husbands' transitory shocks. I develop an intra-household insurance model based on the collective framework, which allows for insurance against both permanent and transitory wage shocks from both partners. Estimation using Survey of Income and Program Participation (SIPP) shows that individuals increase labor supply in response to spouse's adverse wage shocks and such labor supply responses are larger when shocks are permanent than transitory. This intra-household insurance reduces earnings volatility by about 4.3% to 9.5%. These results suggest that joint labor supply decisions provide an extra smoothing effect on shocks to earnings and household income.

JEL classification: D12; D13; D81; J22

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1 Introduction

Rising earnings volatility over the last few decades in the U.S. has been well documented in existing studies (Moffitt and Gottschalk 2008, Haider 2001). This has been of concern to policymakers, since it is associated with an increase in risk and a reduction in welfare. Government provides social insurance, transfers, and taxation, to buffer the welfare loss caused by income volatility. Meanwhile, individuals who live in the same household may also provide insurance against each other's income shocks by making joint decisions, such as asset accumulation and depletion, durable goods replacement, and ex-post labor supply adjustments, etc.

The goal of this paper is to examine whether, and how, married couples make joint decisions to insure against each other's income shocks. In doing so, I aim to answer the following three questions: how married couples adjust labor supplies in response to each other's wage shocks, whether they respond to permanent and transitory wage shocks differently, and what the implications of such household decisions are for overall income volatility.[1] The answer to these questions will provide a better understanding of intra-household insurance as a risk-coping strategy in reaction to rising earnings volatility. Understanding the degree to which couples are willing to insure is important for assessing the performance of private insurance markets as well as the efficiency of government insurance policies. Moreover, the distinction between permanent shocks and transitory shocks will provide implications for policies that target shocks at different persistency levels. For instance, Social Security Disability Insurance (SSDI) provides income to people who are disabled with a condition expected to last at least twelve months. Unemployment insurance, on the other hand, protects people from temporary income loss. These policies could have different impacts on household labor supply decisions. Also, intra-household insurance would have aggregate implications. For example, household members may respond to individual earnings volatility by making joint decisions, so that income at the household level becomes less volatile. Intra-household insurance may also lead to a more smoothed consumption profile, which affects consumption inequality or the transmission from income to consumption inequality.

[1]Permanent shocks are defined as shocks that people expect to persist into the future which are not mean-reverting. Transitory shocks are caused by temporary and random influences which are mean-reverting.

Studies on insurance for income shocks have a long history in both macroeconomics and labor economics. In macroeconomic theory, the complete market hypothesis assumes that both permanent and transitory income shocks are fully insured, while the permanent income hypothesis assumes that only transitory shocks are insured and consumption depends primarily on permanent income. Empirical studies using both micro and aggregate data find mixed evidence (Cochrane 1991, Altonji et al. 1992, Townsend 1994, Attanasio and Pavoni 2007, Blundell, Pistaferri and Preston 2008). These studies of insurance for income shocks focus on consumption smoothing over time, via inter-temporal savings and borrowing. They take labor supply decisions as given, which could be another important insurance mechanism. In labor economics, studies on insurance for income shocks focus on temporary changes in wives' labor supply in response to husbands' unemployment or transitory earnings shocks, also known as "added worker effect" in the literature. Lundberg (1985) has found a small added worker effect from the Seattle and Denver Income Maintenance Experiments. Juhn and Potter (2007) use matched March Current Population Survey (CPS) files, and find that the added worker effect is still important among a subset of couples, but that the overall value of marriage as a risk-sharing arrangement has diminished, due to the greater positive co-movement of employment among couples. Using the Panel Study of Income Dynamics (PSID), Garcia-Escribano (2004) finds that the smoothing resulting from the wives' labor response is significant for households with limited access to credit. These studies on insurance via labor supply decisions have focused on wives' responses to husbands' shocks, but not the reverse. Yet with women's labor supply and participation rising so sharply in the past quarter century, this reverse response is arguably just as important.

In order to investigate how married couples adjust labor supply to insure against each other's wage shocks, I build a theory based on the collective framework developed by Chiappori (1988, 1992) and Donni (2003). The main advantage of this model is that under a minimal set of assumptions, individual preferences and intra-household allocations can be uncovered, without imposing any specific structure on the decision process.[2] The weighted maximization of household members' utilities can be decentralized, subject to a lump-sum income transfer, also known

[2]The basic assumptions include household allocations are Pareto efficient and preferences are either egotistic or caring.

as the “sharing rule”, which specifies how to allocate household resources. This sharing rule depends on each agent’s wage in the existing collective models. I expand the scope of the sharing rule to act as a function of permanent and transitory wage shocks. In addition to the standard income and substitution effect that wage shocks have on individual’s own labor supply, these shocks also affect spousal labor supply, through this sharing rule. This is the main channel through which I examine how individual wage shocks affect spousal labor supply.

This paper makes both theoretical and empirical contributions to the existing literature on insurance for income shocks and collective models. First, I develop an intra-household insurance model based on collective models by Chiappori (1988, 1992) and Donni (2003), to examine whether and how married couples insure against each other’s shocks by making joint labor supply decisions. I modify the static collective models along the following dimensions: I introduce permanent and transitory wage shocks into the function of the sharing rule, extend the single-period collective model over a multi-period context, and incorporate savings decisions. Second, this paper also contributes to the empirical studies using collective models by examining labor supply with non-participation using high-frequency data in the U.S. for the first time.[3] Third, I provide structural explanations of how much of the overall individual and household earnings volatility can be explained by such intra-household decisions.

This paper uses the Survey of Income and Program Participation (SIPP) and the main findings are as follows: An individual increases his or her labor supply when the spouse receives an adverse wage shock, no matter permanent or transitory. Such labor supply response is larger when the shock is permanent. There is little evidence of insurance when the husband becomes unemployed. Couples make less transfer to the agent who has more volatile income, which can be considered as a price for insurance. Estimation results also suggest that intra-household insurance reduces earnings volatility by about 4.3% to 9.5%.

Section 2 presents stylized facts on individual and household income volatility. In Section 3, a collective model is formulated, which allows for insurance against permanent and transitory wage shocks. Section 4 describes the data, and discusses

[3]For empirical studies using collective models with non-participation, Blundell et al. (2007) use U.K. data, Bloemen (2004) uses Dutch data, Hourriez (2005) uses French data and Vermeulen (2005) uses Belgian data.

empirical strategies and estimation results. Section 5 uses estimation results of the model to provide structural explanations to the stylized facts. Section 6 concludes.

2 Stylized facts on income volatility and intra-household insurance

In this section, I present some important stylized facts concerning income volatility at both the household and individual level, for married couples and single individuals. These stylized facts are consistent with the story of intra-household insurance, which motivates this paper.

Table 1 documents household income volatility, household earnings volatility, and individual earnings volatility for singles versus married couples, using SIPP 2001 panel, the primary data source for this paper. Income volatility is measured as the variance of a transitory component of income, which is commonly used in the existing literature. The formula given at the end of Table 1 follows Gottschalk and Moffitt (1994), which calculates variances for either each household or each individual over an entire sample period, and then takes the average across these households or individuals. The sample used is individuals between 20 to 59 years old, who work positive hours with non-missing wages.

Of particular interest are the following three features of the data: First, transitory variance in log household income for married couples (0.085) is much lower than for single individuals (0.152 for males and 0.158 for females). The same pattern can be found for log household earnings. To take into account the covariance of a two-person income, I also randomly match a single male and a single female to form "household income", as the sum of these two, and compare its transitory variance with that of married couples. These randomly-matched individuals do not have the household smoothing behavior that married couples might have. Still, married couples have lower household income and lower household earnings volatility than randomly-matched single individuals. This may be due to the marriage choice itself, such as individuals with higher wage or work-hour fluctuations are less likely to get married. However, I further compute transitory variance in hourly wage rate and work-hour and show that, on the contrary, singles have even lower wage and work-hour fluctuations than married individuals. Second, this higher work-hour fluctuation for married individuals is consistent with the hypothesis that married couples not only adjust labor supply in response to their own wage shocks, but they also adjust labor supply in response to their spouse's wage shocks. Third, Table 1 also shows that, for married couples, their household earnings volatility (0.092) is lower than individual earnings volatility (0.169 for married men and 0.224 for married women). This is also consistent with the story of household insurance, that couples absorb each other's individual earnings shocks so that household earnings do not fluctuate very much. To see whether such a fact is still true over a longer horizon, I also use Panel Study of Income Dynamics (PSID) 1982-2002 to compare married couple's household earnings volatility with individual earnings volatility in each year of that study. Figure 1 is adapted from Figure 6 in Zhang (2008). Over the past twenty years, household earnings volatility is always lower than either male or female earnings volatility.

The descriptive analysis presented in this section has highlighted several important stylized facts for modeling the link between income volatility and decisions within a household. Married couples' household earnings volatility is lower than individual earnings volatility, while married couples have lower household income volatility than single individuals. These facts could have several other possible explanations, such as marital sorting, or selection into participation. My contribution is to take one plausible explanation, the intra-household insurance, and develops a model to examine the link between earnings volatility and intra-household insurance.

3 The model

I build a theory that allows for intra-household insurance, based on the collective models of household decision-making developed by Chiappori (1988, 1992) and Donni (2003). The main advantage of their collective models is that they emphasize individual preferences and analyze the decision-making process within the household, without imposing any specific structure on the decision process. Such collective models start from basic assumptions that household allocations are Pareto efficient and preferences are egotistic or caring. The unobserved intra-household allocation, also known as "sharing rule", and individual preferences can be uncovered from observed labor supply. I modify the basic collective model along three dimensions, to address intra-household insurance against permanent and transitory shocks. First, I introduce permanent and transitory wage shocks into the sharing rule.[4] Second, since permanent shocks are defined as shocks that persist over time, I extend the single-period collective model over a multi-period context. Third, I incorporate a savings decision into the model. Following Blundell and Walker (1986), I separate savings and labor supply decisions into two stages. In the second stage, within-period decision is the same as the static collective model for a single period.

3.1 Basic setting

3.1.1 Preferences and household problem

Consider a two-member household consisting of a husband (m) and a wife (f). Let h_{it}^f and h_{it}^m denote f and m's labor supply, between 0 and 1 for household i in period t. Let c_{it}^f and c_{it}^m denote f and m's individual consumption of a private Hicksian commodity. The price of the consumption good is set to 1. Assume no home production, so that leisure and labor supply add up to 1.[5] Assume individual preferences are of "egotistic" type, so that utilities can be written as $U_{it}^j(1-h_{it}^j, c_{it}^j)$ ($j = f, m$), where U_{it}^j is continuously differentiable, strictly monotone, strictly quasi-concave, and inter-temporally additive-separable over the life cycle.[6] The household problem is to choose labor supply, consumption, and savings, in order to maximize the discounted, weighted, linear, social welfare function, subject to

[4] I look at wage shocks instead of income shocks because the main component of income is labor earnings, which are endogenous to labor supply.

[5] Most empirical studies using the collective model make this assumption because most datasets that include labor supply information do not include home production.

[6] Chiappori (1992) shows that the main results for egoistic preference also hold in a more general case of "caring" agents, whose preferences are represented by utility functions that depend on both their egoistic utility and their spouses'. I focus on egoistic preferences only. Each individual may care about the overall welfare of their partner, but not by the way in which this welfare is generated.

the household's budget constraint:

$$\max_{h_{it}^f, c_{it}^f, h_{it}^m, c_{it}^m, A_{i,t+1}} E_0[\sum_{t=1}^{T} \beta^{t-1}(\mu_{it} U^f(1-h_{it}^f, c_{it}^f) + U^m(1-h_{it}^m, c_{it}^m))]$$

$$s.t. c_{it}^f + c_{it}^m + A_{i,t+1} \leq w_{it}^f h_{it}^f + w_{it}^m h_{it}^m + y_{it} + A_{it} \qquad \forall t \qquad (1)$$

$$w_{it}^f = \overline{w}_{it}^f + \delta_{it}^f + \nu_{it}^f, \quad w_{it}^m = \overline{w}_{it}^m + \delta_{it}^m + \nu_{it}^m$$

$$\mu_{it} = f(w_{it}^f, w_{it}^m, y_{it}, z_{it})$$

where w_{it}^f and w_{it}^f denote f and m's hourly wage rate, respectively, in period t. Wage contains three components: expected wages, $\overline{w}_{it}^f$ and $\overline{w}_{it}^m$, which are perceived by both partners; permanent shocks, δ_{it}^f, δ_{it}^m, which are unexpected, but once the shocks occur, both agents know the shocks will last for a long time; transitory shocks, ν_{it}^f and ν_{it}^m, which are also unexpected, but both partners know these influences are temporary.[7] A_{it} denotes net wealth in period $t-1$, and y_{it} denotes non-labor income, which includes asset income and transfers.[8][9] The non-negative scalar μ_{it} defines the wife's decision weight within the household. In the existing collective models, μ_{it} depends on both of the partners' wages, non-labor income, and some distribution factors that affect the outside environment of the household (Chiappori, Fortin and Lacroix 2002). Underlying the function μ_{it}, there exists some intra-household allocation mechanism. In my model, since wages are subject to stochastic fluctuations, these shocks also affect the household allocation outcome, the main channel of intra-household insurance of interest in this paper.

3.1.2 Two-Stage decision process

To solve the household problem in equation (1) and uncover how couples share risks and resources, I apply theory from the collective model derived by Chiappori (1988, 1992), and the extended results by Blundell et al. (2007) and Donni (2003),

[7] An example would be, when the husband gets an unexpected injury, both he and his spouse knows whether the injury is going to persist for a long time or will recover very soon.

[8] Interest income $r_t A_{it}$ is already included in y_{it}, by definition.

[9] I do not explicitly introduce shocks to the non-labor income. In this model, I assume couples pool non-labor income and decide how to divide it according to the sharing rule, which is what most existing studies using collective models assume. Given this assumption of non-labor income pooling, shocks to non-labor income and the non-stochastic non-labor income enter the decision weight hence the sharing rule in the same manner. Therefore, people share risks to non-labor income in the exact same way as they share non-labor income.

which allow for corner solutions, to decentralize household decisions into individual decisions. I also apply the two-stage budgeting of Blundell and Walker (1986), to separate inter-temporal savings decisions from within-period labor supply and consumption decisions, so that decentralization in the multi-period environment can still hold.

The static collective model by Chiappori (1988, 1992) has shown that under the assumption of Pareto efficiency with egoistic preferences, according to the Second Welfare Theorem, a weighted maximization of household utility functions can be decentralized, given a lump sum income transfer (sharing rule). In the first stage, the household members decide jointly how to allocate pooled resources to each individual, usually non-labor income, according to a sharing rule. In the second stage, given the allocated non-labor income, each agent chooses individual consumption and leisure by maximizing individual utility subject to his or her earnings plus the amount of the non-labor income that is allocated to him or her. However, when extending the static collective model into a dynamic context, an inter-temporal savings decision with a corner solution to labor supply makes decentralization no longer feasible. Mazzocco (2004) develops a two-period collective model with income shocks. His model treats income as exogenous; hence the model does not incorporate labor supply decisions. To the best of my knowledge, Mazzocco and Yamaguchi (2006) are the only researchers who develop a dynamic collective model with endogenous labor supplies and corner solutions. They consider three discrete choices of labor supply: full-time, part-time, and non-participation, while, in this paper, I consider the continuous hours' choice. I also allow the household decision weight to depend on wage shocks. Mazzocco and Yamaguchi (2006) simulate a model to capture the empirical features of labor supply, savings, and marital choices. Although marital status and the commitment issue affect labor supply and savings decisions, I focus on intact families only, to study their joint decisions, in response to each other's wage shocks. Marriage decision is beyond the scope of this paper and is left to future research.

I apply the theory developed in Blundell and Walker (1986), to separate the inter-temporal savings decision from the within-period labor supply decision. An inter-temporally separable life-cycle model under uncertainty can be viewed as a two-stage budgeting process: in the first stage, the household optimally allocates full life-cycle wealth over each period, to equalize marginal utility of income across periods, and readjusts wealth according to realized shocks in the previous period. In the second stage, the current period's allocation of income, net of savings, is distributed between consumption and leisure; thus, the second stage becomes a within-period decision.[10] Therefore, the theory derived in the single-period collective model can be applied in this second stage, which involves only within-period consumption and the leisure decision, under the assumption that the decision is within-period Pareto efficient.

Incorporating both collective models of decentralization and Blundell and Walker's (1986) separation of savings and labor supply decisions, I specify a two-stage collective decision process as follows: at the beginning of a marriage, a husband and wife optimally allocate expected life-cycle wealth in each period according to their expectations of future shocks, and they agree upon a sharing rule to allocate future resources, conditional on both partners' wage shocks in each period. Given a savings decision in the first stage, the second stage involves only within-period consumption and leisure choices: once shocks are realized, conditional on the savings decision in the first stage, the husband and wife allocate non-labor income, net of savings, according to the realized sharing rule, and each agent chooses private consumption and labor supply, subject to earnings, plus their share of non-labor income:

$$\begin{aligned}
&\max_{h^j_{it}, c^j_{it}} U^j_{it}(1 - h^j_{it}, c^j_{it}) \\
&s.t. \quad c^j_{it} \leq (\overline{w}^j_{it} + \delta^j_{it} + \nu^j_{it}) h^j_{it} + \phi^j_{it} \qquad j = f, m \qquad \forall t \\
&\phi^f_{it} = \phi_{it}, \quad \phi^m_{it} = y_{it} - s_{it} - \phi_{it}
\end{aligned} \tag{2}$$

where ϕ^f_{it} is the amount of non-labor income, net of savings, allocated to the wife, and ϕ^m_{it} is the remaining amount, allocated to the husband. s_{it} is the active savings in period t.

Without corner solutions, the second-stage problem in equation (2) can be solved from first-order conditions. Marshallian labor supply can be derived as a function of one's own wage plus the amount of non-labor income that is assigned

[10] Blundell and Walker's (1986) model is based on single decision-maker households, but it can be applied to collective models (Chiappori, Fortin and Lacroix 2002, Blundell et al. 2007).

to him or her:

$$
\begin{aligned}
h_{it}^{f} &= h_{it}^{f}(\overline{w}_{it}^{f} + \delta_{it}^{f} + \nu_{it}^{f}, \phi_{it}) \\
h_{it}^{m} &= h_{it}^{m}(\overline{w}_{it}^{m} + \delta_{it}^{m} + \nu_{it}^{m}, y_{it} - s_{it} - \phi_{it})
\end{aligned} \tag{3}
$$

3.1.3 Sharing rule

In this section, I specify a sharing rule that allows for intra-household insurance for permanent and transitory wage shocks. Sharing rules in existing collective models are assumed to depend on non-labor income, each individual's wage, and distribution factors which influence household decision weight without affecting preferences. This paper aims to examine how shocks affect a household's joint decisions and how long-run shocks and short-term shocks affect joint decisions differently. Therefore, I allow permanent shocks and transitory shocks of both agents to enter the sharing rule. Wage shocks not only affect one's own labor supply through budget constraint by the standard income and substitution effect, but they also affect spousal labor supply through this sharing rule. I specify the sharing rule to be a function of husbands' and wives' expected wage, permanent shocks, transitory shocks, pooled income - which is non-labor income net of savings - and a vector of distribution factors z. The outcome comes from this sharing rule could be larger than the total amount of non-labor income, net of savings, in which case the husband not only transfers all the non-labor income, but also transfers part of his own earnings to the wife. This sharing rule can also be a negative value, in which case the wife transfers some of her earnings to the husband.

$$
\phi_{it} = \phi(y_{it} - s_{it}, \overline{w}_{it}^{f}, \overline{w}_{it}^{m}, \delta_{it}^{f}, \delta_{it}^{m}, \nu_{it}^{f}, \nu_{it}^{m}, z_{it}) \tag{4}
$$

This sharing rule allows expected wages, unexpected permanent wage shocks, and unexpected transitory wage shocks to affect intra-household allocation differently. The expected wages are the wage component that caught much attention in the existing static collective model (Blundell et al.'s 2007), under the assumption that changes in this non-stochastic wage component may affect the bargaining position in the household. In my model, I allow unexpected shocks to affect the sharing rule in a different way than the expected wage, as the response to shocks reflects intra-household insurance, i.e., how couples share the risks. Furthermore, I also allow permanent shocks and transitory shocks to affect intra-household insurance differently. As noted in the introduction, existing studies on insurance against income shocks provide mixed evidence on whether there exists more insurance to permanent shocks or transitory shocks. The estimation of this model provides new evidence on this long-debated question.

The sharing rule is not only affected by the characteristics within the household, but is also likely to be affected by outside environment, the distribution factors. I specify local sex ratio and divorce law index as two distribution factors, as in Chiappori, Fortin and Lacroix (2002). Local sex ratio measures the marriage market tightness and the divorce law index measures. Both factors do not affect household budget constraint or individual preferences, but could affect their opportunities outside marriage therefore affect their decision weight within the household.

3.1.4 Specification and identification of the sharing rules

Before discussing identification of the sharing rules, I specify functional forms for labor supply and the sharing rule. As in most empirical studies with collective models, I specify log-linear functional form for the Marshallian labor supplies in equation (3):

$$\begin{aligned} \log h_{it}^{f} &= \alpha_0 + \alpha_1 \log w_{it}^{f} + \alpha_2 \phi_{it} \\ \log h_{it}^{m} &= \beta_0 + \beta_1 \log w_{it}^{m} + \beta_2 (y_{it} - s_{it} - \phi_{it}) \end{aligned} \tag{5}$$

I do not impose the logarithm on the sharing rule, since, in theory, it could be negative: when the wife transfers not only all non-labor income, but also some of her earnings. One limitation of this linear functional form is its lack of flexibility, since the labor supply curve is monotonic. I specify a sharing rule to be a linear function in all its arguments and include two distribution factors z_{1i} and z_{2i}:

$$\phi_{it} = k_0 + k_1 (y_{it} - s_{it}) + k_2 \overline{w}_{it}^{f} + k_3 \overline{w}_{it}^{m} + k_4 \delta_{it}^{f} + k_5 \delta_{it}^{m} + k_6 \nu_{it}^{f} + k_7 \nu_{it}^{m} + k_8 z_{1i} + k_9 z_{2i} \tag{6}$$

In Appendix A, I show that labor supply functions in equation (5) imply the following indirect utility functions, from which one can perform intra-household welfare analysis of changes in exogenous variables:

$$
\begin{aligned}
v^f(w_{it}^f, \phi_{it}^f) &= \frac{e^{-\alpha_2 \phi_{it}^f}}{\alpha_2} + \frac{(w_{it}^f)^{\alpha_1+1}}{\alpha_1+1} \\
v^m(w_{it}^m, \phi_{it}^m) &= \frac{e^{-\beta_2 \phi_{it}^m}}{\beta_2} + \frac{(w_{it}^m)^{\beta_1+1}}{\beta_1+1}
\end{aligned}
\tag{7}
$$

Also in Appendix A, by following propositions in Browning, Chiappori and Lewbel (2007), I can derive the Pareto weight, in the planner's problem (1), which is a one-to-one mapping of the sharing rule in the decentralized problem (2). The Pareto weight has the following form:

$$
\mu_{it} = e^{\alpha_2+\beta_2[(k_0+(k_1-1)(y_{it}-s_{it})+k_2\overline{w}_{it}^f+k_3\overline{w}_{it}^m+k_4\delta_{it}^f+k_5\delta_{it}^m+k_6\nu_{it}^f+k_7\nu_{it}^m+k_8z_{1i}+k_9z_{2i}]}
\tag{8}
$$

This exponential expression in equation (8) ensures the decision weight to be always a positive scalar, which is consistent with the theory. Wage shocks from both partners also show up in the Pareto weight.

3.1.5 Identification of the sharing rule when both partners work

From observed labor supply, it is possible to uncover the unobserved sharing rule, up to an additive constant (Chiappori 1988, 1992). The intuition for identification is that changes in non-labor income and the wife's wage and shocks affect only the husband's labor supply, through the sharing rule, and vice versa. Substituting sharing rule (6) into Marshallian labor supply functions (5), yields the corresponding reduced-form labor supply functions, when both partners are working:

$$
\begin{aligned}
\log h_{it}^f =& a_0 + a_1(y_{it}-s_{it}) + a_2\overline{w}_{it}^f + a_3\overline{w}_{it}^m + a_4\delta_{it}^f + a_5\delta_{it}^m + a_6\nu_{it}^f \\
& + a_7\nu_{it}^m + a_8z_{1i} + a_9z_{2i} \\
\log h_{it}^m =& b_0 + b_1(y_{it}-s_{it}) + b_2\overline{w}_{it}^f + b_3\overline{w}_{it}^m + b_4\delta_{it}^f + b_5\delta_{it}^m + b_6\nu_{it}^f \\
& + b_7\nu_{it}^m + b_8z_{1i} + b_9z_{2i}
\end{aligned}
\tag{9}
$$

The partial derivatives of the sharing rule are derived as a function of the reduced-form labor supply parameters:

$$\begin{aligned} k_1 &= \frac{a_1 b_8}{\Delta}, k_2 = \frac{a_8 b_2}{\Delta}, k_3 = \frac{a_3 b_8}{\Delta}, k_4 = \frac{a_8 b_4}{\Delta}, k_5 = \frac{a_5 b_8}{\Delta} \\ k_6 &= \frac{a_8 b_6}{\Delta}, k_7 = \frac{a_7 b_8}{\Delta}, k_8 = \frac{a_8 b_8}{\Delta}, k_9 = \frac{a_9 b_8}{\Delta} \end{aligned} \tag{10}$$

where $\Delta = a_1 b_8 - b_1 a_8$. Only the constant k_0 in the sharing rule is not identified. The within-period Pareto efficiency assumption also generates the following restrictions:

$$\frac{a_8}{a_9} = \frac{b_8}{b_9} \tag{11}$$

$$\frac{a_8}{b_8} = \frac{a_4 - a_2}{b_4 - b_2} = \frac{a_5 - a_3}{b_5 - b_3} = \frac{a_6 - a_2}{b_6 - b_2} = \frac{a_7 - a_3}{b_7 - b_3} \tag{12}$$

Equation (11) is a standard restriction in the existing collective models. The intuition of this restriction is that, since the distribution factors only affect both agents' labor supply, through the sharing rule, the effect of distribution factor z_{1i} versus z_{2i} on wives is proportional to the effect of z_{1i} versus z_{2i} on husbands. Equation (12) is a specific restriction in my model. Since I decompose wage into three components (expected wage, permanent shocks, and transitory shocks), the model generates additional restrictions than standard collective models, which do not distinguish these three components.

3.1.6 Identification of the sharing rule when one of the partners does not work

The model described thus far does not involve corner solutions. This paper not only looks at how couples insure each other's wage shocks when both of them are working, but also considers how one agent adjusts his/her work hours when their spouse does not work. I focus on the case where the wife works but the husband does not, which is the case that "added worker effect" literature focuses on.[11]

Donni (2003) and Blundell et al. (2007) have shown that the sharing rule changes when male labor market participation changes. The intuition for switching the sharing rule is as follows: when the husband works, his wage affects both

[11] The reason why I focus on the male participation frontier instead of both is mainly due to statistical incoherency, which will be explained in section 4.3.

household budget constraint and the sharing rule; when he does not work, his expected wage can still be observed, and while it no longer has any impact on household budget constraint, it can still have an impact on the sharing rule. Note that this is a crucial difference between the collective model and the alternative unitary model, where a household can be viewed as a single decision-maker, and the weight does not depend on prices, such as wage. In the unitary model, when a household member is not working, changes in his or her "potential" wage, or expected wage, do not matter. However, in the collective setting, the expected wage of an unemployed member could affect bargaining positions, such as threat point.

Identification of the sharing rule when one of the partners is not working is possible via an examination of female continuous hours' choice and the male participation corner. Donni (2003) and Blundell et al. (2007) deal with non-participation in the static collective labor supply models. Blundell et al. (2007) estimate the model when men have only a discrete choice of working 40 hours a week or not working at all, while women can choose continuous hours. Donni (2003) develops the theory, allowing both household members to choose any hours and, also, to choose not to work. In this paper, I apply collective theory from Donni (2003). Both Donni (2003) and Blundell et al. (2007) show that the reservation wage is characterized by "double indifference": at the wage when one agent is indifferent between working and not working, Pareto efficiency of household decisions requires that the spouse must be indifferent as well.[12] Both studies also derive restrictions that ensure the uniqueness of a pair - of the husband and wife's reservation wages.

In my model, when the husband is not working, the sharing rule no longer depends on the husband's transitory wage shocks, but still depends on his expected wage and permanent wage shocks, as well as on all three of his wife's wage components. For example, when the husband receives a negative wage shock of either \$100 or \$1, as long as both shocks drive his wage below the reservation wage, he stops working. These two shocks are not separately identified and would have the same effect on the sharing rule. Thus, the sharing rule does not depend on how large the husband's transitory wage shock is, it only depends on the fact that this

[12]Suppose not: if the wife is indifferent between working or not, but her participation yields a positive gain for her spouse, then she will choose to participate, otherwise the decision is not Pareto-optimal.

shock drives him to stop working. When the husband is not working, his expected wage is still assumed to be observable by the economist, as, in practical terms, wages can generally be estimated by an auxiliary equation. Furthermore, as long as the husband is not unemployed for the entire period, his permanent shocks from other periods, while he is working, can also be observed.

Denote the sharing rule in the male non-participation set as ϕ_{it}^{NP} and denote parameters with upper case:[13]

$$\phi_{it}^{NP} = K_0 + K_1(y_{it} - s_{it}) + K_2\overline{w}_{it}^f + K_3\overline{w}_{it}^m + K_4\delta_{it}^f + K_5\delta_{it}^m + K_6\nu_{it}^f + K_7 z_{1i} + K_8 z_{2i} \quad (13)$$

As Marshallian labor supply is a function of one's wage rate and the sharing rule, this also suggests that reduced-form labor supply switches as well:[14]

$$\log h_{it}^f = A_0 + A_1(y_{it} - s_{it}) + A_2\overline{w}_{it}^f + A_3\overline{w}_{it}^m + A_4\delta_{it}^f + A_5\delta_{it}^m + A_6\nu_{it}^f + A_7 z_{1i} + A_8 z_{2i} \quad (14)$$

Define female labor supply as h_{it}^{fNP}, when the male is working. Donni (2003) shows the following continuity condition must hold:

$$h_{it}^{fNP} = h_{it}^f + s h_{it}^m \quad (15)$$

(15) where s is a scalar that can be estimated. Along the male participation frontier, the last term in (15) equals zero. Consequently, $h_{it}^{fNP} = h_{it}^f$, which implies that female labor supply is continuous. The sharing rule also follows a similar continuity condition:

$$\phi_{it}^{NP} = \phi_{it} + q h_{it}^m \quad (16)$$

(16) This suggests that the sharing rule is also continuous along the participation frontier. A Pareto-efficient decision implies that there is no discrete jump in the amount of non-labor income that the wife receives when there is a discrete jump in the husband's participation. The relation between s and q can be derived from

[13] Notice that the sharing rule on the male non-participation set does not depend on the husband's transitory shocks, which means the coefficient on transitory shocks is zero.

[14] Since the sharing rule does not depend on the husband's transitory shocks, female labor supply, as a function of the wife's wage plus the amount of non-labor income originating from the sharing rule, also does not depend on the husband's transitory shocks.

equations (6), (11) and (12):

$$q = \frac{sb_8}{\Delta} \tag{17}$$

(17) Parameters K, which are the partial derivatives of the sharing rule on the male non-participation set, can be identified via (18) and (19). Only the constant K_0 is not identified.

3.2 The unitary model

In previous sections, I derive restrictions that labor supply functions should satisfy under the collective setting. The alternative household decision model, the unitary model, assumes that the household is the primary decision unit, as opposed to individuals themselves. Additionally, with this model, a household behaves like an individual to maximize utility, which does not depend on prices such as wages or non-labor income. Two restrictions are imposed on the unitary model: income pooling restriction and Slustky restrictions. The income pooling restriction suggests that household members pool income together, which fully insure themselves against all shocks. The other restriction is the Slutsky symmetry of the substitution matrix and positive semi-definiteness of the substitution matrix. The unitary model generates different testable restrictions from the collective model. As in the previous setting, I also assume households make savings decisions in the first stage, and the second stage involves only within-period consumption and labor supply decisions.

$$\begin{aligned} &\max_{h^f_{it}, h^m_{it}, c^f_{it}, c^m_{it}} U(1 - h^f_{it}, 1 - h^m_{it}, c^f_{it}, c^m_{it}) \\ &s.t. \quad c^f_{it} + c^m_{it} \leq w^f_{it} h^f_{it} + w^m_{it} h^m_{it} + y_{it} - s_{it} \qquad \forall t \end{aligned} \tag{18}$$

Labor supply functions can still be derived as in equation (9). Slusky symmetry implies the following restriction:

$$b_8 = -a_8 \tag{19}$$

Another restriction for the unitary model comes from participation decisions. In the collective model, when the husband does not work, his potential wage still affects the sharing rule. It therefore affects labor supply as well. In the unitary model, this effect no longer exists. This implies that the effect of male potential wage on female labor supply is zero, when the husband is not working:

$$A_3 = 0 \Rightarrow a_3 + sb_3 = 0 \tag{20}$$

3.3 Further discussions of the model

Given the specifications of the model, it is worth discussing the restrictions it imposes. First, this model does not consider marriage or divorce decisions, while a large adverse shock from one partner may lead to divorce. Thus, my estimation uses the most committed families, which would overestimate individuals' willingness to insure against spouse's shocks in the population. Second, this model only distinguishes shocks at different persistency levels, but does not distinguish shocks from different causes, such as wage loss from injury or job transition. These, however, could have different impacts on labor supply.[15] Third, this model implicitly assumes agents can adjust labor supply freely. In reality, though, hours might be constrained for a given job, and, since it takes time to find another job, the labor-supply adjustments by switching jobs might not be reflected in the current period. Therefore, empirical work might underestimate the effect of wage shocks on labor supply. Fourth, I assume that there is no external insurance for wage shocks. Hence I do not consider the interaction between social insurance programs such as an unemployment benefit and intra-household insurance. Adding external insurance will result in an adverse selection problem.[16] Last but not least, one implicit assumption is that couples have the same preference for risk, as husbands and wives have the same utility functions. Preferences for risks, however, could be a factor that influences couples' willingness to insure. For instance, couples who are more risk averse may be more likely to insure each other's transitory shocks to smooth consumption, or if a husband and wife have different preferences for risk, they may respond to spousal shocks differently. Mazzocco (2004) considers savings decisions and finds that household members transfer more to the agent that is more risk averse.

[15] Coile (2003) studies how health shocks affect married couples' labor supply decisions.

[16] There are some other studies that examine how external insurance affects labor supply. Cullen and Gruber (2000) show that a generous unemployment benefit has a crowding out effect on spousal labor supply.

Notwithstanding these limitations, given the ability of the model to capture the intra-household insurance from spouses' joint labor supply decisions, together with its tractability and flexibility, it is useful to analyze the link between income volatility and household decisions. Above discussions also suggest some interesting avenues for future research.

4 Data and empirical results

4.1 Data

This study uses the Survey of Income and Program Participation (SIPP) 2001 panel, a national representative longitudinal dataset in the U.S. For the study of short-run labor supply response to wage changes, SIPP offers substantial advantage over other panel datasets, such as PSID or the Health and Retirement Study (HRS). First, SIPP interviews three times a year, while other datasets include annual, or biennial, data.[17] Thus, SIPP provides high frequency labor supply fluctuation.[18] Another advantage of SIPP is that high frequency interviews also yield better quality of wage information. With annual interviews, it is not possible to obtain wage changes for jobs that last for less than a year. In PSID, if a job change occurs some time during the year, then wages computed from annual earnings and hours are the mixture of wages on the new and the old jobs. SIPP directly reports hourly wage for hourly-wage employees. Further, I use wage data purged of measurement error, as in Gottschalk (2005).[19] Under the assumption that nominal wages adjust in discrete steps - while working for the same employer, Gottschalk identifies the structural breaks in individual wage series and separates the effect of measurement error from that of true changes in wages.

The SIPP 2001 panel consists of nine waves, from December 2000 to February 2003. The primary sample cuts in the estimation include married couples with heads 20-59 years old, at some point in the panel. Excluded are households who have children less than 18 years of age, because the model does not account for

[17] In addition, HRS only contains sample of older people.

[18] SIPP also contains monthly data on wage and labor supply. But monthly data has the well-documented seam bias problem (Gottschalk 2005). Respondents are more likely to report a wage change between interviews instead of within an interview period.

[19] I thank Peter Gottschalk for generously providing SIPP wage data with his correction of measurement error.

home production or public consumption, which is likely to change with the number of children. This yields a sample of 4,749 households with 41,622 observations. All income variables are placed into January 2000 Consumer Price Index Research Using Current Methods Series (CPI-U-RS) dollars.[20]

The dependent variable is the total number of hours of work in each wave. The measure of wage is hourly wage rate, defined as the observed hourly wage for hourly-wage employees, or, alternatively, as the total wage earnings divided by the number of hours of work. Household non-labor income includes property income, transfer income, and other income. Savings is constructed by taking the difference between net wealth in period t and t-1.[21] Information on net wealth is available only in the 3rd, 6th and 9th wave of the SIPP 2001 panel. I use linear interpolation to fill in for the remaining waves.[22] This variable is treated as endogenous with the measurement error reported in the empirical section.

The local sex ratio is computed using the 5% Public Use Microdata Sample (IPUMS) from the 2000 census. It corresponds to the number of males of the same age as the husband in each household divided by the number of males and females of the same age, for each state and each one of the three racial groups (white, black, others). This sex ratio represents the tightness of the local marriage market, under the assumption that people married within their own racial group. I also experimented with alternative definitions of sex ratio: the number of males divided by the number of males and females of the same age group (20-24, 25-29, etc.). The other distribution factor, divorce law index, considers four of the following features of divorce legislation in each state: property division (community property =1), mutual consent versus unilateral divorce (mutual consent =1), contribution to education (=1), and non-monetary contribution (=1).[23] These features are likely to favor women. All four features did not change within states, during my sample period. Table 2 presents summary statistics. There are some extreme values in the sex ratio index, but there is less than 1% percent either below 0.38 or above 0.59, and all are due to minority groups in states with small populations, which is

[20]The deflator can be found at http://www.census.gov/hhes/www/income/income05/cpiurs.html

[21]I acknowledge that savings constructed by this method includes active and passive savings, as well as measurement error. In my model, only active savings is considered.

[22]The PSID data only contains wealth information every-other five years before 1996, and biennially afterwards. HRS data only includes wealth information every-other year, also.

[23]From Family Law Quarterly, Winter 2000, Winter 2001, Winter 2002, Charts 4 and 5.

still reasonable.

Panel E in Table 2 describes the joint participation status for husbands and wives. In 54.5% of the total person-wave observations, both husbands and wives work positive hours. Most empirical studies using a collective model restrict their sample to these working couples only. There is 8.6% of the sample where neither the husband, nor the wife, is working. In this case, the sharing rule is not identified, since there is no variation in labor supply from either partner. 25.7% of the sample contains non-working wives with working husbands, and 10.9% of the sample contains non-working husbands with working wives. In this paper, I include non-working husbands with working wives, in addition to working couples. By focusing on the male participation frontier, I am also able to examine how wives adjust their labor supply in response to their husbands' unemployment, which is similar to the "added worker effect".[24]

4.2 Estimates of permanent and transitory wage shocks

To study how wage shocks affect couples' labor supply, it is crucial to obtain good estimates of wage shocks. It is also important to distinguish between permanent shocks and transitory shocks, as they are each likely to be determined by different factors (change in skill prices versus job instability, for instance), and hence have different impacts on household labor supply. Moffitt and Gottschalk (2008) specify an error component model to estimate the variance of permanent and transitory shocks of log male earnings. In their model, permanent shocks follow a random walk with a loading factor, while transitory shocks follow an ARMA (1,1) process with variances changed in each period. The estimation of this model matches with the empirical evolutions of variances and covariances. Zhang (2008) estimates a similar model using panel data in the U.S., West Germany and the U.K.. She finds that estimation of this model matches with the panel data in all three countries. In this section, I first apply Moffitt and Gottschalk's (2008) method to estimate an error component model, and I further identify the individual component of shocks

[24]The disadvantage of focusing on male participation instead of female, of course, is that dropping more observations might cause larger selection bias. There is some evidence that the selection bias is not likely to be a problem. For instance, as discussed in Chiappori, Fortin and Lacroix (2002), Moroz (1987) could not reject the hypothesis of no selection bias in female labor supply function, using PSID data.

in each time period. The wage decomposition model is specified as follows:[25]

$$logw_{it}^{j} = \overline{w}_{it}^{j} + \gamma_t^j \mu_i^j + \nu_{it}^{j} \quad j = f, m \tag{21}$$

In equation (2), we see $\overline{w}_{it}^{j}$ and ν_{it}^{j}, expected wages and transitory shocks respectively. The product of γ_t^j and μ_i^j makes up the permanent shocks in equation (2), where γ_t^j is the loading factor, a time-varying aggregate component, and is a time-invariant individual component.[26] Loading factors represent aggregate skill prices on human capital. The introduction of a loading factor on permanent wage component implies that permanent inequality could also change over time, which is consistent with a wide body of evidence that some of recent increase in wage inequality is attributable to the increase of permanent factors. The loading factor measures aggregate shocks. I distinguish the aggregate shocks between men and women, so that couples can still insure each other against shocks.

I obtain $\overline{w}_{it}^{j}$ from the predicted value of first-stage Mincer regressions for each period. The dependent variable is log wage rate, and independent variables include age, age square, four education dummies (high school diploma, some college, college degree, graduate school), and education dummies that interact with age, all with time-varying coefficients. These education-time and age-time interactions are excluded in equation (9), thus they serve as the exclusion restrictions for labor supply equations. The intuition is that differences in the preferences and the sharing rule, across education group, remain constant over time. The identification of labor supply relies on the assumption that the returns to education have changed over time, but such changes do not affect labor supply decisions. This assumption is consistent with empirical studies on income inequality, such as the increasing wage premium between college and high school degree (Katz and Autor 1999, among others).

Transitory shocks ν_{it}^{j} follow an ARMA(1,1) process. The error component

[25] This model is also estimated on the dimension of age effect, thus wage are also index with age a. For the simplicity of notation, I drop the dimension on age.

[26] Moffitt and Gottschalk (2008) specify permanent shocks to follow a random walk:$\mu_{ia}^{j} = \mu_{i,a-1}^{j} + \omega_{ia}$. In this paper, I drop the random walk because I need to further identify individual shocks, while identification requires that μ_{ia}^{j} be time invariant. I also estimate the model with a random walk; it turns out that the variance of the random walk σ_ω is very small, thus dropping the random walk would not affect results much.

model is specified as follows:

$$\hat{e}^j_{it} = \gamma^j_t \mu^j_i + \rho^j \nu^j_{i,t-1} + \xi^j_{it} + \theta^j \xi^j_{i,t-1} \quad j = f, m \tag{22}$$

where $\hat{e}^j_{it}$ are wage residuals from first-stage regressions. I estimate the parameters in this error component model using minimum distance estimation.[27] Then, I identify the individual component of permanent and transitory shocks by regressions for each individual. The identification comes from the assumption that individual permanent component μ^j_i is time invariant, so it can be treated as a fixed coefficient.

$$\hat{e}^j_{iat} = \mu^j_i \hat{\gamma}^j_t + \nu^j_{iat} \quad j = f, m \tag{23}$$

(23) where $\hat{\gamma}^j_t$ becomes an independent variable, and this regression produces the estimated coefficient $\hat{\mu}^j_i$. Permanent shocks can be computed using the predicted value from (23), and transitory shocks are simply the difference between wage residuals and permanent shocks.

The estimated permanent and transitory shocks are shown in Table 3. Women have larger standard deviations and larger ranges between minimum and maximum, in both permanent shocks and transitory shocks, than men do. This is consistent with the stylized facts from Table 1, that women's wages are more volatile than men's wages.

4.3 Estimates of couple's labor supply functions and the sharing rule

In this section, I estimate labor supply functions for husbands and wives jointly, and recover unobserved sharing rules. The sharing rule divides total non-labor income net of savings from the first stage. Savings are treated as endogenous with the measurement error. The savings variable is instrumented using the housing price index interacted with home ownership and birth cohort dummies.[28] Control variables include education dummies and a quadratic in age, for both partners.[29]

[27]Thanks to Peter Gottschalk and Robert Moffitt for kindly sharing their program for estimating this error components model.

[28]Lise and Seitz (2007) use similar instruments. Housing price index quarterly data, by state, can be found at http://www.ofheo.gov/hpi_download.aspx.

[29]In the data, savings information is noisy. In the regression, I use only the middle 90% observations, and predict for the entire sample.

Table 4 shows estimates of savings regression. Predicted savings is used in the labor supply functions. The mean and standard deviation of predicted savings are shown in Table 2, Panel C.

The model in the theoretical section does not incorporate unobserved heterogeneity, since introducing unobserved heterogeneity with non-participation would raise the issue of whether the model is identifiable from available data (Blundell et al. 2007). Following existing studies using collective models with non-participation, I specify labor supply functions with additives in the heterogeneity terms. Estimation of household labor supply when both partners participate (equation 11) and female labor supply when the husband does not work (equation 17) suggest a switching regression model:

$$\begin{aligned} \log h_{it}^{f*} &= a'x_{it} + u_{it}^{f} + (1 - I(h_{it}^{m*} > 0))s(b'x + u_{it}^{m}) \\ \log h_{it}^{m*} &= b'x_{it} + u_{it}^{m} \end{aligned} \tag{24}$$

where $h_{it}^{j*}(j = f, m)$ is a latent variable representing the desire to work. $I(h_{it}^{m*} > 0)$ is an indicator for male participation. The same control variables are included in both male and female labor supply functions: four education dummies and a quadratic in age for both partners, race of head-of-household, and time dummies. u_{it}^{f} and u_{it}^{m} are unobserved preference shocks to leisure, and I allow them to be correlated and follow a joint normal distribution. The male participation condition is summarized as follows:

$$\log h_{it}^{m} = \begin{cases} \log h_{it}^{m*} & \text{if } \log h_{it}^{m*} > 0 \\ = 0 & \text{otherwise.} \end{cases} \tag{25}$$

Equations (24) and (25) are estimated using Full Information Maximum Likelihood (FIML). Likelihood function is given in Appendix B.

The above econometrics model allows me to derive the sharing rule when the husband is not working. Theoretically, I can also jointly estimate a third sharing rule where the wife is not working. However, in the empirical estimation, a simultaneous regime-switching model generates a statistical coherency problem.

Suppose I have the simultaneous regime-switching model as follows:

$$\begin{aligned} \log h_{it}^{f*} &= a' x_{it} + u_{it}^{f} + (1 - I(h_{it}^{m*} > 0)) s(b' x + u_{it}^{m}) \\ \log h_{it}^{m*} &= b' x_{it} + u_{it}^{m} + (1 - I(h_{it}^{f*} > 0)) S(a' x + u_{it}^{f}) \end{aligned} \tag{26}$$

Consider two cases: $h_{it}^{f*} > 0, h_{it}^{m*} < 0$ and $h_{it}^{f*} < 0, h_{it}^{m*} > 0$. When $s < 0$ and $S < 0$, both these two cases hold. In reality, however, these two situations are mutually exclusive. Bloemen (2004) also discusses that, without any further restrictions, the double-switching model may generate multiple outcomes for the participation status of a husband and wife in a household. Imposing coherency in such model is either quite complicated or greatly reduces the generality of the model. Therefore, I only focus on one participation frontier, in which the husband chooses whether or not to work.

4.3.1 Estimates of reduced-form supply functions

Table 5 presents FIML estimates of reduced-form female and male labor supply functions.[30] One's wage shocks, either permanent or transitory, have a significant negative effect on spousal labor supply, while permanent shocks have a larger impact than transitory shocks. The elasticity of husbands' permanent wage shocks on wives' labor supply is -0.165, while transitory wage shocks have an elasticity of -0.04. A similar effect can be found in the estimation of male labor supply functions: a 1% drop in the wife's permanent wage shock increases male labor supply by 0.194%, while the same drop in transitory shock increases male labor supply by 0.126%. This provides some evidence that household members insure each other by increasing labor supply in response to spousal adverse shocks, and such an insurance effect is stronger for more persistent shocks. The estimate of ρ is -0.058, which suggests couples' unobserved shocks to leisure are negatively correlated.

Unlike wage shocks, the expected wage has a positive effect on spousal labor supply. A 1% increase in male expected wage tends to increase female labor supply by 0.21%, while the same increase in female expected wage tends to increase male

[30] In this version of the paper, all inferences are approximate since in the calculation of the standard errors in the final step I do not take into account the uncertainty added in previous steps. In the future version I will bootstrap standard errors in the last stage taking the entire estimation process into account.

labor supply by 0.45%.

4.3.2 Recover structural parameters and interpretation of the results

To see whether these empirical results are consistent with the collective hypothesis, I test the restrictions implied by the collective model and the alternative unitary model. Testing restrictions for the collective model are presented in equations (11) and (12). The Wald statistic from a joint test is 5.96 with a p-value of 0.31, which indicates that the collective hypothesis cannot be rejected at the conventional level. Testing the restrictions for the unitary model, equations (19) and (20), yields a statistic of 10.34 and p-value of 0.006, which indicates that the unitary model can be rejected at the 1% level. The collective model cannot be rejected, while the unitary model can be rejected. These test statistics provide support for the collective hypothesis.

From the estimation of reduced-form labor supply functions, I recover the Marshallian labor supply of equation (5), up to an additive constant. Table 6 presents female and male Marshallian labor supply estimates. The income effect is precisely estimated for male labor supply, the negative sign suggests male leisure is a normal good. Female income effect is also negative, but is not precisely estimated. Both male and female own wage effects are significantly positive. The implied wage elasticity is 0.528 for females and 1.460 for males. Both male and female Marshallian labor supplies satisfy the Slusky condition of individual utility maximization.

Table 7 presents estimates of the two sharing rules: the first estimate is when both partners work, the second is associated with when only the wife works but the husband does not.[31] Asymptotic standard errors are computed using the delta method. Some of the parameters are not precisely estimated. From equation (10), we can see that each parameter in the sharing rule relies on five parameters from the reduced-form labor supply, and every sharing rule parameter depends on the estimates of $\Delta = a_1 b_8 - b_1 a_8$. Furthermore, even if each coefficient is estimated precisely, Δ may still appear insignificant, especially when $a_1 b_8$ and $b_1 a_8$ have the same sign.

[31] As discussed in Section 3.2.2, in the male non-participation set, male transitory wage shocks are missing, thus the sharing rule ϕ_{it}^{NP} does not depend on male transitory shocks. Permanent wage shocks are also missing for those males who never work in the sample. For identification purposes, the estimation only includes those who work at least two periods to identify the permanent shocks.

When both partners are working, a household makes a greater transfer to the agent with the larger adverse shocks, and makes the largest transfer to the agent with shocks that are permanent. The first set of estimates of the sharing rule in Table 7, together with estimates of the Marshallian labor supply in Table 6, can be interpreted as follows: when the wife's hourly permanent wage goes down by 10%, her share of non-labor income from intra-household allocation increases by \$387, which means that the husband's share of non-labor income decreases by the same amount. Now, combined with the sharing rule estimates, the coefficient of non-labor income on male log hours is -0.005, which suggests that a drop of \$387 in the husband's share of non-labor income will translate into an increase in his labor supply of 1.9%. In short, a 10% permanent shock to the wife's hourly wage results in an increase of 1.9% in the husband's labor supply. The estimates of the sharing rule provide insights on how shocks affect intra-household allocation, and the estimates of the Marshallian labor supply provide insights on how that intra-household transfer translates into the changes in spousal labor supply. When the shocks are transitory, the same shocks to the wife's labor supply result in a drop in the husband's share of non-labor income of \$250, which, in turn, increases his labor supply by 1.25%. All these effects are precisely estimated. I also test whether a wife's permanent and transitory shocks have the same effect on intra-household allocation. A p-value of 0.09 suggests that a wife's permanent wage shocks have a significantly larger impact on intra-household insurance than do transitory wage shocks.

Now let us look at the reverse, that is, how husbands' permanent and transitory shocks affect wives' labor supply through intra-household transfer. When there is a 10% negative permanent shock to the husband's wage, the wife's labor supply increases by 1.7%. Given the same transitory shocks to the husband's wage, the wife's labor supply increases by 0.4%. Unfortunately, these effects are not precisely estimated. Compared to previous results of male labor-supply response to female wage shocks, here female labor supply responds less to male wage shocks. But it is not clear whether this is due to the imprecise estimates of some parameters.

The increase of female expected wage or the decrease of male expected wage, on the other hand, increases the proportion of household pooled income allocated to the wife. This result is also found in the collective labor supply estimation in Blundell et al. (2007). Their interpretation is that higher wage increases one's bargaining power within the household, thus the individual could obtain more resources from intra-household allocation. However, this effect is not precisely determined.

The sharing rule for a working wife with a non-working husband is quite different from the rule for working couples. This is partly due to the large value of the estimate of q in equation (16). When the wife receives an adverse shock, no matter whether it is permanent or transitory, her share of household non-labor income no longer increases. The intuition behind this result is that now the husband is not able to adjust his labor supply. Therefore, even if the wife has adverse shocks, the husband cannot provide insurance through labor supply, thus she has to insure against this shock by herself. The estimate of this sharing rule also indicates that there is no evidence of the added worker effect. Added worker effects in my model would suggest that when the husband becomes unemployed, the wife works more, to compensate for his income loss, such as his permanent shocks. This is contrary to what the sharing rule shows. However, the estimates of this sharing rule are not significant, even at the 10% level, partly due to the insignificant estimates of q. The coefficient estimate of non-labor income has a value of 1.23, which is outside the usual range of between 0 and 1, as this represents a dollar increase of non-labor income, i.e., how much of the increase goes to the wife.

The distribution factors do not have the expected sign on the sharing rule. Increase in the local sex ratio (the relative scarcity of women) and changes in the divorce law - in favor of women, should increase the female share of non-labor income, but I find either no significant effect or the opposite sign. Alternative measurements of sex ratio, such as compute ratio by dividing into four racial groups instead of three, or measuring the number of men divided by the number of men plus women within a 5- to 10- year age range, or measuring the number of unmarried males over unmarried males and females, do not change the results qualitatively. One possible explanation is, it maybe not the sex ratio at the current period that affects intra-household allocation, instead, the sex ratio at the time of marriage matters, since that is the time when they agree upon a sharing rule. Unfortunately, it is difficult to back up the sex ratio at the time of marriage from the available data. This unexpected sign for distribution factors is also found in Hourriez (2005). He argues that such an effect may be a consequence of home production. When the wife's options outside marriage improve, she may want to negotiate both the share of non-labor income and a reduction in her housework. This explanation is also compatible with results in Table 7. Increased scarcity of women decreases the male share of non-labor income when the husband participates in the labor market, as couples may bargain over housework. The higher bargaining power the husband has, the more he can negotiate to do less of the housework; therefore he might increase his labor supply. When the husband does not participate, such an effect of the sex ratio on the sharing rule is no longer significant. This might be due to the fact that the husband devotes zero hours on market work, and therefore his time on home production is almost fixed. As a result, the wife does not need to negotiate over home production, but only on intra-household allocation. This may be why I find a positive effect of distribution factors on the sharing rule when the husband does not participate in the labor market.

4.4 Comparison with baseline models that do not include shocks

This paper introduces permanent and transitory wage shocks into the sharing rule of the collective model. Here, I estimate the baseline model in the existing collective literature, which does not distinguish between the deterministic component of wage and its stochastic shocks. Table 8 displays sharing rule estimates that treat wage as a single component, given everything else the same as in my main sample and method. The effect of female wage on the sharing rule is significant and negative. Chiappori, Fortin and Lacroix (2002) interpret this result as altruism. The male mean wage effect is not significant. Two distribution factors now have the expected positive sign, but are still not precisely estimated. Comparing this result with the main results in Table 7, the effect of expected wage reverses the sign. This shows the importance of distinguishing wage and wage shocks, and distinguishing between shocks that are permanent and transitory.

Table 9 displays results that only consider the case when both partners are working, which is the sample defined in Chiappori, Fortin and Lacroix (2002). Again, female wage has a negative effect on the sharing rule; male wage effect is not significant. Comparing the estimated coefficient of distribution factors in Tables 8 and 9, the coefficient reverses sign. This also shows that incorporating non-participation into the sharing rule might be important.

4.5 Individual income volatility and intra-household allocation

Previous sections examined how married couples adjust labor supplies in response to each other's wage shocks. Another question of interest is how they adjust labor supplies in response to each other's individual income volatility, which is measured as the variances of the wage shocks for each individual. The analysis in this section suggests that individual income volatility can be considered as a measurement of price for intra-household insurance.[32]

Table 10 displays estimates of sharing rules including individual variance of wage shocks. Permanent shocks and transitory shocks still affect the sharing rule in the same direction as in Table 7. The point estimates show that one's higher individual wage volatility results in a lower proportion of non-labor income allocated to him or her. My interpretation is such individual income volatility can be considered as a measure of price for insurance. Take female volatility as an example, if her income is very volatile, she has extra gain from the marriage by getting intra-household insurance against her volatile income, compared to insuring all by herself if she remained single. A possible consequence is, she needs to compensate her spouse by transferring some of her income as a price for such insurance. This is reflected in the estimation of the sharing rule that she transfers more income to her husband when her income is more volatile. This result, from another perspective, provides evidence in support of intra-household insurance.

4.6 Robustness check and estimation for subgroups

I estimate the main model using several alternative specifications. I further restrict the sample to include only those households with heads between 35 and 59 years old, since this age range would typically be less likely to have children, or their children would have already left home. The qualitative results do not change. I also try to estimate the model using the sample of hourly workers only. This

[32]Note that, in Section 2, regarding stylized facts, income volatility is estimated using the entire sample. Here, wage volatility is computed at the individual level. These are two different notations and that is why I call the latter one "individual wage volatility".

eliminates the measurement error caused by imputed wage from earnings for those who earned a salary on an annual basis. Unfortunately, the parameters are very poorly estimated, mainly because of the very small sample size. In SIPP data, the flag for imputed wage has many missing values, and when the sample is restricted to both partners who are hourly workers, it only yields a pool of 886 households, while the main sample contains 4,749 households. Overall, these specification checks show that the main results are robust to various specifications and sample cuts.

I also look at intra-household insurance for certain subgroups of the sample, such as households with low wealth or low education. When households have limited access to borrowing and cannot adjust savings to insure against income shocks, household members may be more likely to adjust labor supply to smooth consumption. Such liquidity constraints are difficult to measure and also have an endogeneity problem. Therefore, I do not measure liquidity constraints directly, but look at the subgroups that might have liquidity problems, to see how their behavior differs from the main sample. Garcia-Escribano (2004) uses data from PSID and finds that wives' labor response to transitory shocks in husbands' earnings is larger for households with limited access to credit. Dynarski and Gruber (1997) use data from the PSID and Consumer Expenditure Survey (CEX) and find that the sample drawn from the PSID response of spousal labor supply is insignificant. In the CEX sample, though, wives' labor response is not significant for high school dropouts, but it is significant, and an even larger effect, for higher-educated groups, which seems to contradict the liquidity constraints theory.

Table 11 displays results of reduced-form labor supply estimation for households whose net wealth in the third wave is less than the 50th percentile.[33] Table 12 displays estimation results for the sharing rules. Reduced-form estimates show that one's permanent shocks have significant effect on spousal labor supply at the 1% level, while transitory shocks do not, even at the 10% level. This is different from estimation over the entire sample, where both permanent and transitory shocks have significant effect on spousal labor supply at the 1% level. In Table 12, parameters on sharing rules are poorly estimated, thus they could not be compared with previous results using the entire sample. I also estimate this model

[33]I choose the third wave because this is the first wave where net wealth is observed instead of interpolated.

on households where the head-of-household's educational level was a high school diploma or below, or on households with a net wealth less than the 50th percentile and who do not own a house or apartment. Results do not change qualitatively. These empirical findings are not exactly consistent with the liquidity constraints theory, but many factors could explain these results: People with lower wealth or lower education may have a lower ability to find jobs or adjust their labor supply quickly. This also explains why couples with lower wealth only respond to permanent shocks, but not to transitory shocks.

5 A structural explanation to the stylized facts

According to the stylized facts presented in Section 2, household earnings volatility is lower than individual earnings volatility for married couples, and household earnings volatility for married couples, who might have an intra-household insurance mechanism, are lower than that of singles who would not have an intra-household insurance mechanism. To what extent do the results of my structural model provide explanations to these empirical facts? In this section I conduct the following two exercises: First, I recalculate transitory variances of log household earnings and log individual earnings, given the structural responses of labor supply to both partner's transitory shocks from the model. Second, I calculate the same variances but without any structural response of intra-household insurance, and compare the number with the first exercise. The difference explains what proportion of earnings volatility is due to intra-household insurance.

The estimation results of my model provide partial derivatives of labor supply with respect to wage shocks. To take these structural responses into account, I use Taylor expansion to derive earnings as a function of partial derivatives with respect to husbands' and wives' wage shocks. Derivations are presented in Appendix C. Then, I calculate the variance of such expansions for log household earnings and individual earnings. From expressions in equations (36) and (37) in Appendix C, the variances depend on parameters in the sharing rule and Marshallian labor supply functions, estimates of transitory wage shocks, and observed labor supply. I plug estimated parameters, transitory shocks and labor supply into (36) and (37). Table 13 presents estimated earnings volatility. Log earnings volatility for married men is 0.266, which is higher than married couples' household earnings volatility, at 0.135. Log earnings volatility for married women is 0.134, almost the same as that of household earnings volatility. Therefore, household earnings volatility is much lower than the average of the individual earnings volatility. This lower household earnings volatility is consistent with the stylized facts presented at the beginning of this paper.[34]

In the second exercise, I compute transitory variance in log individual or household earnings without intra-household insurance and compare this with the previous results. Without intra-household insurance, wage shocks no longer affect intra-household allocation. Therefore, the term k_6, k_7 becomes zero. Now the log individual earnings volatility is recalculated as 0.294 for married men and 0.140 for married women, while married couples' log household earnings volatility becomes 0.141. Compared to the previous results with insurance, this suggests that intra-household insurance to transitory shocks reduces household earnings volatility by 4.3%. It also reduces individual earnings volatility by 9.5% for married men and 4.3% for married women. These numbers may seem to be small, but given the fact that the earnings volatility is mainly caused by fluctuations in wages, such intra-household insurance already plays a significant role in explaining the remaining earnings fluctuations. Both these exercises confirm that the model developed in this paper provides empirical evidence that is consistent with the stylized facts: household earnings volatility is lower than individual earnings volatility, and earnings volatility for those who have intra-household insurance mechanism are lower for those who do not.

6 Conclusion

The literature on insurance for income shocks has either focused on consumption smoothing via savings decisions, or focused on one-sided labor supply response. The aim of this paper has been to evaluate the link between income volatility and household labor supply decisions, by examining the degree of intra-household in-

[34] The magnitude differs though. One difference is stylized facts in Table 1 includes all couples, with and without children, while my estimation focus on the sample of couples without children. Another reason for this difference is that in this exercise as well as in the model, I assume all wage shocks are exogenous. The stylized facts from empirical data, however, also capture the possibility that individual's wage shock is a response to a spousal adverse wage shock. For instance, the wife may switch to a job with a higher wage in response to her husband's adverse wage shock, in which case we observe the wife has a positive wage shock.

surance with respect to each other's wage shocks. I develop an intra-household insurance model based on collective models, where wages are stochastic, and the intra-household allocation depends on both permanent and transitory wage shocks. I first estimate permanent and transitory wage shocks for each individual, then estimate couples' labor supplies, using the SIPP 2001 panel, and recover the unobserved intra-household allocation mechanism. Estimation results provide some evidence of household insurance via labor supply: married couples make joint labor-supply decisions to insure against both permanent and transitory wage shocks, while labor response is larger when shocks are permanent. Such household insurance disappears when the husband becomes unemployed and can no longer adjust his labor supply. The negative effect of individual income volatility on intra-household allocation can be considered as a price for insurance. This paper also contributes to empirical studies using collective models, by examining high-frequency data in the U.S. and expand the scope of the sharing rule to act as a function of wage shocks, both permanent and transitory. The comparison with existing static collective models shows the importance of stochastic wage components and, therefore, the importance of developing formal dynamic collective models with labor supply - both on extensive and intensive margin. Furthermore, this model also has aggregate implications on individual and household earnings volatility. The estimation of this model provides a structural explanation for the stylized facts that household earnings volatility is lower than individual earnings volatility, and how such intra-household insurance mechanism reduces household earnings volatility and individual earnings volatility.

Appendix

A Proof of existence of Pareto weight

Browning, Chiappori and Lewbel (2007) prove a dual representation of the household problem. From their Proposition 1, there exists a shadow price vector and a scalar valued sharing rule to solve the household problem in equation (2). By Proposition 2, given the shadow price vector and the sharing rule, there exists a Pareto weight which can be written as a function of indirect utility functions and the sharing rule. Let v^f and v^m denote indirect utility functions for the husband and wife. By Roy's identity:

$$\frac{\partial v^f(w_{it}^f, \phi_{it}^f)/\partial w_{it}^f}{\partial v^f(w_{it}^f, \phi_{it}^f)/\partial \phi_{it}^f} = h_{it}^f, \quad \frac{\partial v^m(w_{it}^m, \phi_{it}^m)/\partial w_{it}^m}{\partial v^m(w_{it}^m, \phi_{it}^m)/\partial \phi_{it}^m} = h_{it}^m \tag{27}$$

First, from the Mashallian labor supply functions in equation (5), the differential equations above can be integrated out to obtain the following indirect utilities:

$$\begin{aligned} v^f(w_{it}^f, \phi_{it}^f) &= \frac{e^{-\alpha_2 \phi_{it}^f}}{\alpha_2} + \frac{(w_{it}^f)^{\alpha_1+1}}{\alpha_1+1} \\ v^m(w_{it}^m, \phi_{it}^m) &= \frac{e^{-\beta_2 \phi_{it}^m}}{\beta_2} + \frac{(w_{it}^m)^{\beta_1+1}}{\beta_1+1} \end{aligned} \tag{28}$$

By Proposition 2 in Browning, Chiappori and Lewbel (2007), the above indirect utility functions imply the following Pareto weight:

$$\mu_{it} = -\frac{\partial v^m(w_{it}^m, \phi_{it}^m)/\partial \phi_{it}}{\partial v^f(w_{it}^f, \phi_{it}^f)/\partial \phi_{it}} = \frac{e^{-\beta_2 \phi_{it}^m}}{e^{-\alpha_2 \phi_{it}^f}} = e^{(\alpha_2+\beta_2)\phi_{it} - \beta_2(y_{it}-s_{it})} \tag{29}$$

Substituting ϕ_{it} with equation (6) we get:

$$\mu_{it} = e^{\alpha_2+\beta_2[(k_0+(k_1-1)(y_{it}-s_{it})+k_2\overline{w}_{it}^f+k_3\overline{w}_{it}^m+k_4\delta_{it}^f+k_5\delta_{it}^m+k_6\nu_{it}^f+k_7\nu_{it}^m+k_8z_{1i}+k_9z_{2i}]} \tag{30}$$

B Derivation of likelihood function

First, assume preference shocks u_{it}^f and u_{it}^m in labor supply functions follow a joint normal distribution with zero mean and the following covariance matrix:

$$\begin{pmatrix} \sigma_f^2 & \rho\sigma_f\sigma_m \\ \rho\sigma_f\sigma_m & \sigma_m^2 \end{pmatrix}$$

The log-likelihood function takes the form:

$$L = \sum_{i \in P} logL_i(h_{it}^f, h_{it}^m) + \sum_{i \in NP} logL_i(h_{it}^f) \tag{31}$$

Likelihood function, when both partners are working, follows a joint normal distribution:

$$L_i(h_{it}^f, h_{it}^m) = \frac{1}{\sigma_f\sigma_m}\varphi(\frac{u_{it}^f}{\sigma_f}, \frac{u_{it}^m}{\sigma_m}, \rho) \tag{32}$$

where φ is standard normal distribution function. The likelihood function in the male non-participation set NP is different. First, the covariance matrix becomes:

$$\begin{pmatrix} \sigma_f^2 + 2s\rho\sigma_f\sigma_m + s^2\sigma_m^2 & \rho\sigma_f\sigma_m + s\sigma_m^2 \\ \rho\sigma_f\sigma_m + s\sigma_m^2 & \sigma_m^2 \end{pmatrix}$$

Denote the first element in the above matrix as σ_v. The correlation parameter in this covariance matrix becomes:

$$r = \frac{\rho\sigma_f + s\sigma_m}{\sigma_v} \tag{33}$$

Let $v_i = r\frac{\sigma_v}{\sigma_m}u_{it}^m + \sigma_v\sqrt{1-r^2}\omega_{it}$, where ω_{it} is standard normal and independent of u_{it}^m. The likelihood in NP becomes:

$$\int_{-\infty}^{-b'x/\sigma_m} \frac{1}{\sigma_m}\varphi(\frac{u^m}{\sigma_m})\frac{1}{\sigma_v\sqrt{1-r^2}}\varphi(\frac{h^f - a'x - sb'x - r\frac{\sigma_v}{\sigma_m}u^m}{\sigma_v\sqrt{1-r^2}})\partial u^m \tag{34}$$

which can be simplified as:

$$L_i = \frac{1}{\sigma_v}\varphi(\frac{h^f - a'x - sb'x}{\sigma_v})\Phi(\frac{-\frac{b'x}{\sigma_m} - r\frac{h^f - a'x - sb'x}{\sigma_v}}{\sqrt{1-r^2}}) \tag{35}$$

where Φ stands for the cumulative distribution function of standard normal distribution.

C Derivations of log earnings as function of both partners' wage shocks

To write earnings as a function of the partial response to both partners' wage shocks, I use Taylor expansions. Based on the specification of the sharing rule in this model, the higher order derivatives of labor supply respect to wage shocks all become zero. First I present the first order Taylor expansion for log male earnings.

$$\begin{aligned} log(h^m\epsilon^m) = f(log\epsilon^m, log\epsilon^f) = log(h_0^m\epsilon_0^m) + \frac{\partial log h^m\epsilon^m}{\partial log\epsilon^m}(log\epsilon^m - log\epsilon_0^m) \\ + \frac{\partial log h^m\epsilon^m}{\partial log\epsilon^f}(log\epsilon^f - log\epsilon_0^f) \end{aligned} \tag{36}$$

where ϵ^m and ϵ^f are transitory shocks to male and female wage, respectively. $log\epsilon^m$ is equivalent to ν^m in my model (equation 21), as the wage decomposition is based on log hourly wage rate. Take the variance of this log earnings, the constant terms drops out:

$$\begin{aligned} var(log h^m\epsilon^m) &= var(\beta_1 - \beta_2 k_7 + 1)log\epsilon^m - \beta 2k_6 log\epsilon^f) \\ &= var[(\beta_1 - \beta_2 k_7 + 1)\nu^m - \beta 2k_6\nu^f] \end{aligned} \tag{37}$$

Similarly, variance of log household earnings with first order Taylor expansion can be derived as follows:

$$\begin{aligned} var(log(h^m\epsilon^m + h^f\epsilon^f)) &= var\{\frac{1}{h^m\epsilon^m + h^f\epsilon^f}(h^m\epsilon^m(\beta_1 - \beta_2 k_7 + 1) + h^f\epsilon^f\alpha_2 k_7)log\epsilon^m \\ &+ (-h^m\epsilon^m\beta_2 k_6 + h^f\epsilon^f(1 + \alpha_1 + \alpha_2 k_6)log\epsilon^f\} \\ &= var\{\frac{1}{h^m exp(\nu^m) + h^f exp(\nu^f)}(h^m exp(\nu^m)(\beta_1 - \beta_2 k_7 + 1) \\ &+ h^f exp(\nu^f)\alpha_2 k_7)\nu^m + (-h^m exp(\nu^m)\beta_2 k_6 + h^f exp(\nu^f) \\ &(1 + \alpha_1 + \alpha_2 k_6)\nu^f\} \end{aligned} \tag{38}$$

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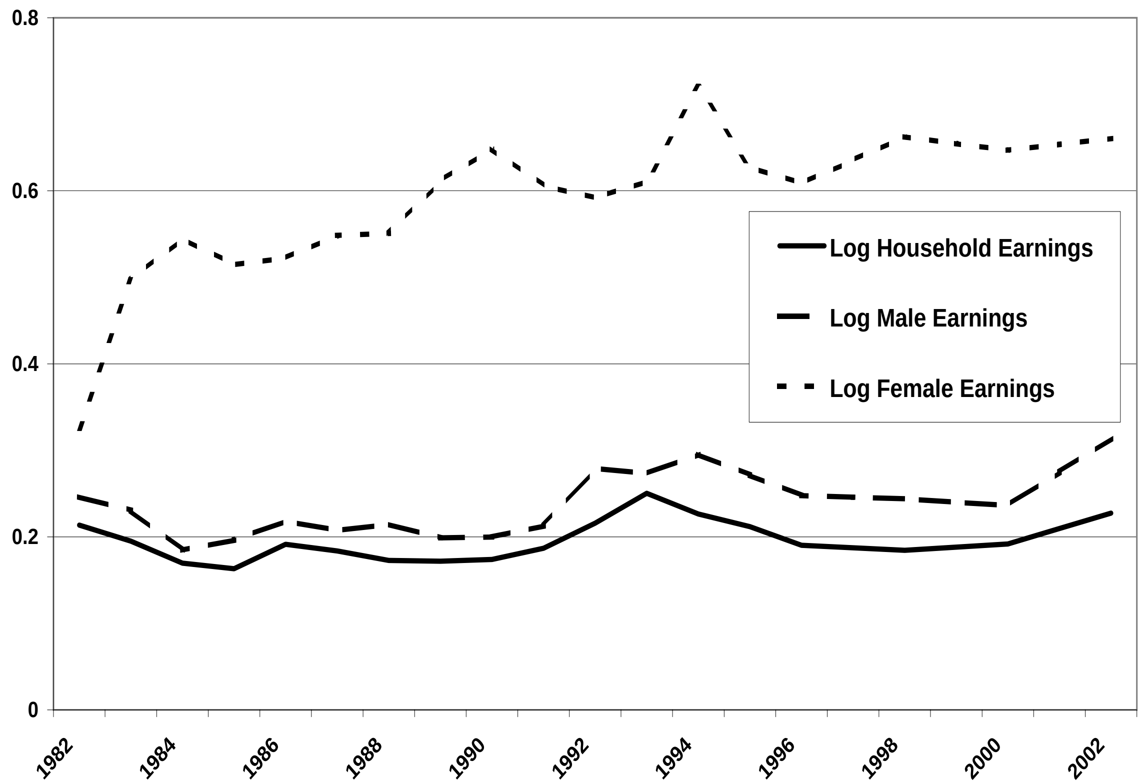

Figure 1: Transitory variances of log household earnings, log male earnings and log female earnings in the U.S., married households from PSID 1982-2002. Adapted from Figure 6 in Zhang (2008)

Table 1: Comparison of transitory variances for married and single agents

	Variance in Transitory Component		
	Log Household Earnings	*Log Household Income*	
Single Males	0.174	0.152	
Single Females	0.180	0.158	
Married Couples	0.092	0.085	
Singles (random match)	0.141	0.135	
	Log Wage Rate	*Log Earnings*	*Log Hours*
Single Males	0.044	0.174	0.036
Single Females	0.047	0.180	0.040
Married Males	0.058	0.169	0.041
Married Females	0.074	0.224	0.065

Note: Transitory variances are calculated as: $var(\epsilon_{it}) = \frac{1}{N}\sum_{i}^{N}\frac{1}{(T_i-1)}\sum_{i}^{T_i}(y_{it}-\overline{y}_i)^2$

Table 2: Descriptive statistics

	Mean	Standard Deviation	Minimum	Maximum
	A. Women			
Hours of work	411.1	344.9	0	2,358
Hourly wage	12.4	13.66	0.0001	705.7
Age	38.8	9.37	20	59
Schooling	18.5	5.91	1	26
White	0.87	0.33	0	1
	B. Men			
Hours of work	613.3	350.2	0	2,592
Hourly wage	18.3	15.05	0.003	401.8
Age	40.9	9.36	20	59
Schooling	18.7	5.95	1	26
White	0.88	0.33	0	1
	C. Household Characteristics			
Nonlabor income	1,154.4	3,004.5	0	90,967
Savings (predicted)	6,227.7	5810.2	-46,788	116,815
Own living quarters	0.79	0.4	0	1
	D. Marriage Market			
Sex ratio	0.498	0.021	0.227	0.813
Divorce index	2.410323	0.718819	1	4
	E. Participation Status			
	Wife works		Wife not working	
Husband works	54.5%		25.7%	
Husband not working	10.9%		8.6%	

Table 3: Summary of log wage decomposition

	Mean	Standard Deviation	Minimum	Maximum
Female Expected Wage ($\overline{w}_{it}^{f}$)	2.17	0.368	0.82	2.80
Male Expected Wage ($\overline{w}_{it}^{m}$)	2.67	0.297	1.73	3.23
Female Permanent Shocks (δ_{it}^{f})	-0.0002	0.815	-10.57	3.14
Male Permanent Shocks (δ_{it}^{m})	-0.0008	0.660	-8.60	3.03
Female Transitory Shocks (ν_{it}^{f})	0.0002	0.253	-8.26	7.27
Male Transitory Shocks (ν_{it}^{m})	0.0001	0.231	-6.09	3.59

Table 4: Estimates from savings equation

	Coefficient	Standard Error
House_price	13.40***	1.421
Birth_cohort 1950	2,476.1**	1,034.4
Birth_cohort 1960	2,569.8*	1,504.1
Birth_cohort 1970	-136.76	1801.0
White	897.4*	510.1
Age of husband	-396.2**	339.23
Age square of husband	4.273	4.146
Age of wife	397.61*	222.61
Age square of wife	-4.258	2.751

Note: (1)***significant at 1%; **significant at 5%; *significant at 10%. (2)Other variables: age and four education dummies for both partners and time dummies.

Table 5: Reduced-form labor supply functions

	Female Labor Supply		Male Labor Supply	
	Coef	Std Err	Coef	Std Err
Non-labor income net of savings	-0.00018	0.0001	-0.0047***	0.00036
Female expected wage	0.366***	0.067	0.281	0.184
Male expected wage	0.209	0.144	1.095***	0.398
Female permanent shocks	0.308***	0.006	-0.194***	0.017
Male permanent shocks	-0.165***	0.007	1.287***	0.016
Female transitory shocks	0.081***	0.014	-0.126***	0.039
Male transitory shocks	-0.040**	0.016	0.701***	0.043
Local sex ratio	0.241**	0.111	-0.419	0.306
Divorce law index	0.006	0.005	-0.049***	0.013
Joint parameters				
s	0.714***	0.045		
ρ	-0.058***	0.009		

Note: ***significant at 1%; **significant at 5%; *significant at 10%.

Table 6: Marshallian labor supply functions

Female Labor Supply		Male Labor Supply	
$logw_{it}^{f}$	0.528***	$logw_{it}^{m}$	1.460***
	(0.183)		(0.572)
ϕ_{it}	-0.0029	$y_{it} - s_{it} - \phi_{it}$	-0.005***
	(0.0023)		(0.0005)

Note: ***significant at 1%; **significant at 5%; *significant at 10%.

Table 7: Estimates of the sharing rules

	Both partners work		Wife works, husband not	
	Coef	Std Err	Coef	Std Err
Non-labor income ($y_{it} - s_{it}$)	0.061	0.064	1.228	0.968
Female expected wage ($\overline{w}_{it}^{f}$)	55.92	37.30	-13.59	58.27
Male expected wage ($\overline{w}_{it}^{m}$)	-72.57	76.02	-343.77	292.19
Female permanent shocks (δ_{it}^{f})	-38.69***	4.882	9.40	39.89
Male permanent shocks (δ_{it}^{m})	57.22	45.31	-261.51	207.85
Female transitory shocks (ν_{it}^{f})	-25.03***	8.04	6.082	25.88
Male transitory shocks (ν_{it}^{m})	13.95	12.32	-	-
Local sex ratio	-83.52*	57.91	20.29	98.82
Divorce law index	-2.03	2.27	10.01	8.89
q	-	-	-247.6	196.51

Note: ***significant at 1%; **significant at 5%; *significant at 10%. Asymptotic standard errors are computed using delta method.

Table 8: Baseline sharing rules that do not distinguish wage and shocks

	Both partners work		Husband works, wife does not	
	Coef	Std Err	Coef	Std Err
Non-labor income	-0.007	0.27	-0.012	0.031
Female wage	-57.13***	10.69	-28.8***	9.13
Male wage	-29.20	97.82	-47.77	98.37
Local sex ratio	52.73	171.3	86.27	169.8
Divorce law index	0.906	3.12	1.48	3.28
q	-	-	107.9***	12.26

Note: ***significant at 1%; **significant at 5%; *significant at 10%. Asymptotic standard errors are computed using delta method.

Table 9: Baseline sharing rules that do not distinguish wage and shocks and exclude non-participation

	Coef	Std err
Non-labor income	0.091	0.206
Female wage	-18.11***	4.826
Male wage	9.44	21.21
Local sex ratio	-17.52	38.14
Divorce law index	-0.54	1.26

Note: ***significant at 1%; **significant at 5%; *significant at 10%. Asymptotic standard errors are computed using delta method.

Table 10: Estimates of the sharing rules, including individual income volatility

	Both partner works		Husband works, wife not	
	Coef	Std Err	Coef	Std Err
Non-labor income net of savings	0.140**	0.056	0.929***	0.229
Female expected wage	240.34**	102.95	19.73	64.78
Male expected wage	-120.86	104.71	-580.88**	265.45
Female permanent shocks	-100.60***	14.726	-8.25	7226
Male permanent shocks	115.10***	30.83	-530.78***	146.14
Female transitory shocks	-58.79***	21.74	-4.82	15.92
Male transitory shocks	25.56**	12.52	-	-
Female wage volatility	-41.67***	10.48	-3.419	10.33
Male wage volatility	29.60***	11.40	-86.52***	29.89
local sex ratio	-151.87*	85.73	31.96	165.13
divorce law index	-3.97	3.41	16.13*	8.344
q	-	-	-478.20***	130.32

Note: ***significant at 1%; **significant at 5%; *significant at 10%. Asymptotic standard errors are computed using delta method.

Table 11: Reduced-form labor supply function estimation for households with low wealth

	Female Labor Supply		Male Labor Supply	
	Coef	Std Err	Coef	Std Err
Nonlabor income net of savings	-0.0002	0.0002	-0.004***	0.0005
Female expected wage	0.979***	0.214	0.352	0.564
Male expected wage	0.457	0.432	3.597***	1.134
Female permanent shock	0.309***	0.017	-0.292***	0.044
Male permanent shock	-0.097***	0.024	1.356***	0.045
Female transitory shock	0.188***	0.042	-0.133	0.111
Male transitory shock	-0.029	0.042	0.968***	0.109
Local sex ratio	-0.424	0.268	-0.305	0.709
Divorce law index	-0.005	0.014	-0.094***	0.365

Note: ***significant at 1%; **significant at 5%; *significant at 10%

Table 12: Estimates of the sharing rules for households with low wealth

	Both partners work		Wife works, husband not	
	Coef	Std Err	Coef	Std Err
Non-labor income net of savings	-0.633	3.072	-0.693	3.300
Female expected wage	1627.2	5,418.58	1,686.42	5,683.19
Male expected wage	1523.4	7,190.29	2,128.81	10020
Female permanent shock	-1349.9	3,929.30	-1,399.03	4131.93
Male permanent shock	-322.60	1,493.23	-94.42	655.92
Female transitory shock	-616.51	1,856.5	638.92-	1,952.42
Male transitory shock	-98.30	474.72	-	-
Local sex ratio	-1,412.57	6,340.39	-1,463.95	6,766.21
Divorce law index	-18.14	94.85	-34.02	167.54
q	-	-	168.32	873.60

Note: ***significant at 1%; **significant at 5%; *significant at 10%. Asymptotic standard errors are computed using delta method.

Table 13: Estimated transitory variances with and without insurance

	log male earnings	log female earnings	log household earnings
With insurance	0.266	0.134	0.135
Without insurance	0.294	0.140	0.141
Percentage change	9.5	4.3	4.3