How Do Wage Shocks Affect the Labor Supplies of Married Couples? -Evidence from the Collective Model

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September 2, 2008

Abstract

This paper examines the link between income volatility and household decision. I develop a collective model to study how married couples insure against each other's permanent and transitory wage shocks by making joint labor supply decision. Estimation using SIPP 2001 panel provides some evidence on household insurance. Couples insure against both permanent and transitory wage shocks via household labor supply, while labor response is larger to the shocks which are permanent. There is little evidence of insurance by labor supply for liquidity constrained households, and little evidence of insurance against high individual wage volatility.

JEL Codes: D12, D13, D81, J22.

Keywords: Collective Labor Supply, Permanent Shocks, Transitory Shocks, Intra-household Allocation, Household Insurance.

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1 Introduction

There have been extensive studies that document the significant increase in earnings and household income volatility in the last couple decades (Moffitt and Gottschalk 2008, Haider 2001, Hacker 2006). Such increase in income volatility have been of concern to policy makers since it is associated with increase in risk and reduction in welfare. Government insurance programs such as social security or unemployment benefit help to buffer the welfare loss caused by income volatility. Meanwhile, individuals who live in the same household could also provide insurance against each other's adverse shocks by making joint decisions such as labor supply decision, self-insurance, durable goods replacement, etc. The goal of this paper is to examine the link between rising income volatility and household joint labor supply decision. In particular, this paper looks at whether and how married couples make joint labor supply decisions and intra-household allocations in response to each other's permanent and transitory wage shocks. The answer to this question matters for the following reasons: First, it provides a better understanding of intra-household insurance in reaction to rising income volatility. Second, if permanent shocks and transitory shocks do have different impacts on labor supply, public policies that target on shocks of different durability would have different implications. Third, the presence of mechanisms that allow households to smooth individual shocks also has implications on aggregate results such as the link between individual income volatility and household income volatility, or the shifts in the consumption distribution and income distribution.

Studies on insurance to income shocks has a long history in both macroeconomics and labor economics. In macroeconomic theory, complete market hypothesis assumes that consumption is fully insured against both permanent and transitory income shocks. This hypothesis is usually rejected using micro data (Cochrane 1991, Altonji et al. 1992, Townsend 1994). On the other hand, permanent income hypothesis assumes that consumption depends primarily on permanent income, since consumers use saving and borrowing to smooth consumption in response to transitory changes in income. Empirical studies using both aggregate and micro data show consumption reacts too little to permanent shocks (Attanasio and Pavoni 2006) or excess sensitive to transitory shocks (Hall and Mishkin 1982). Recent studies by Blundell et al. (2008) do not impose any *priori* on which of the above hypothesis is true but allow for partial insurance and estimate the degree of insurance against permanent or transitory income shocks. Using panel data in income and imputed non-durable consumption, they find some partial insurance of permanent income shocks and little evidence against full insurance for transitory income shocks.

Studies on insurance against income shocks in labor economics mostly focus on labor supply decision and also find mixed evidence. The "Added Worker Effect" literature examines temporary change in wives' labor supply (hours worked or participation) in response to husbands' unemployment or transitory earnings shocks. Lundberg (1985) has found a small but significant added worker effect from the Seattle and Denver Income Maintenance Experiments. Juhn and Potter (2007) use matched March CPS files and find that added worker effect is still important among a subset of couples but the overall value of marriage as a risk-sharing arrangement has diminished due to the greater positive co-movement of employment within couples. Garcia-Escribano (2004) finds that the smoothing resulting from the wives' labor response is larger for households with limited access to credit using Panel Study of Income Dynamics (PSID). Most of these studies focus on wives' response to husbands' shocks and mainly unemployment shocks. Yet little is known about how husbands respond to wives' income shocks at the same time and whether the response would be different for permanent and transitory shocks.

This paper investigates household insurance via labor supply theoretically and empirically. I build a theory based on the collective framework first developed by Chiappori (1988). Such a model starts from a basic assumption that household members jointly make Pareto efficient decisions. The unobserved intra-household allocation (sharing rule) can be recovered from the observations of labor supply. In this paper I allow this sharing rule to depend on permanent and transitory wage shocks of each agent. It is important to distinguish shocks of different durability because they are determined by different economic factors thus may have different policy implications. For instance, the permanent shocks is mainly determined by changes in skill prices and transitory shocks are usually caused by job instability, unexpected illness, etc. Another advantage of this model is it does not impose any *priori* on how shocks should affect household labor supply. Estimation of this sharing rule uncovers to what extent joint labor supply insure against husbands and wives' wage shocks, both permanent and transitory. I also allow the sharing rule to switch when one of the partners is not working. The comparison of sharing rules across employment status sheds light on how couples share resources and risks when there are unemployment shocks in addition to wage shocks.

Most collective models are static and uses (repeated) cross-sectional data. Mazzocco (2004, 2005, 2007) develops a series of intertemporal collective model but without endogenous labor supply. As permanent shocks are measurement of long-run wage changes, I extend existing static collective model to a simple dynamic collective model with labor supply. I make an assumption that savings decision is made ex-ante according to expectation of future shocks, while labor supply decision is made ex-post after shocks are realized. Blundell and Walker (1986) proved that by separating savings and labor supply decision into two stages, the second stage problem only involves within-period leisure and consumption decision taken first stage intertemporal savings decision as given. This separation between savings and labor supply decision allows me to directly apply the theory of static collective labor supply with nonparticipation into the second stage of my dynamic model.

This paper is closely related to the studies on insurance to income shocks, added worker effect, collective models, and makes the following contributions to existing literature: First, I build a simple dynamic collective model to study whether and how household labor supply insure against wage shocks. I allow permanent shocks and transitory shocks from both husbands and wives to affect labor supply differently, but do not specify any *priori* such as full-insurance assumption. Second, I examine how insurance mechanism changes when one of the partner is not working. Third, this paper also contributes to empirical collective models by introducing wage shocks into the sharing rules and first estimating collective labor supply model both on extensive and intensive margin using U.S. panel data.[1]

Section 2 presents some stylized facts on income volatility which suggests some evidence of household insurance via labor supply. In Section 3 I formulate a collective model that allows for insurance against permanent and transitory shocks and discuss identification strategy for recovering unobserved sharing rule from observed labor supply and participation. Section 4 first describes data, then I estimate permanent and transitory wage shocks for each individual, and estimate household labor supply using a regime switching regression and recover sharing rules. Estimation results from high frequency panel data Survey and Income Program Participation (SIPP) provide some evidence on household insurance: Couples make joint

[1]Bloemen (2004) estimate Donni (2003)'s model using Dutch data. Hourriez (2005) estimate Donni (2003)'s model with French data, and only considers female nonparticipation. Vermeulen (2005) estimates discrete choice model for female labor supply with nonparticipation.

labor supply decisions and intra-household allocations to insure against both permanent and transitory wage shocks, while labor response is larger for permanent shocks. When the husband is not working, sharing rule changes significantly and no longer reflects household insurance. There is little evidence of insurance within liquidity constrained households, and no evidence of insure against high individual wage volatility. Section 5 concludes.

2 Stylized Facts of Income Volatility and Household Insurance

This section presents the stylized facts of household income volatility and individual income volatility. The comparison between income volatility at household level and individual level and the comparison of household income volatility between married couples and single individuals suggest some evidence of insurance against income shocks through household labor supply, which motivates this paper.

Figure 1 compares household earnings volatility with individual earnings volatility for married households, using PSID 1982-2002.[2] I measure earnings volatility as the variance of transitory component of earnings using Moffitt and Gottschalk (2008)'s error components model.[3] Over the past twenty years household earnings volatility is always lower than either male or female earnings volatility, which suggests married couples may insure each other against individual earnings volatility so that income fluctuations at household level are lower. Since earnings depend on wage and hours worked, labor supply as an insurance mechanism is a plausible

[2] I focus on labor earnings instead of total income to avoid the issue that some joint asset income or transfers may not be assigned to individuals properly.

[3] Let $y_{it} = \alpha_t \mu_i + \nu_{it}$ where ν_{it} is transitory component for income or earnings following an ARMA(1,1)process.

explanation to this figure.

If there exists insurance in multi-person households, then married couples would behave differently than single individuals. Table 1 compares income volatility for singles versus married couples using SIPP 2001 panel, the primary data source in this paper.[4] If married couples can insure each other against income shocks, then their income fluctuation at household level should be smaller than singles who can not provide such insurance. Since household income for married couples is the sum of two person individual income, to make it comparable, I calculate household income volatility for singles by randomly matching single males and single females and sum up each two agents' income to get "household income" or "household earnings". These random matched individuals do not have household smoothing behavior while married couples might have. The first two rows of Table 1 compares randomly matched singles with married couples household income or household earnings volatility, married couples have much lower volatility than randomly matched single individuals (0.141 v.s. 0.092, and 0.135 v.s. 0.085 respectively). However, this may because married couples have lower wage or hours fluctuations which are the primary component of household income. The bottom rows shows that on the opposite, married couples actually have higher wage and hours fluctuations.[5] This finding is consistent with the hypothesis that married couples not only adjust labor supply in response to their own wage shocks, but also adjust labor supply in response to spouse's wage shocks.

In short, from PSID and SIPP, two most comprehensive panel data in the United States, evidence shows that income volatility at household level are much

[4]Table 1 applies method in Gottschalk and Moffitt (1994), which uses entire sample period(three years) to compute a single variance. I measure transitory income fluctuations by calculating variances for each household over time, then take the average across all households. I use the same sample cuts as in estimation section.

[5]I take logarithm thus the statistics does not include those who do not work.

smaller than at individual level for married couples, and married couples have lower household income volatility than single individuals. These stylized facts suggest some evidence of household insurance through labor supply, which the following sections provide both theoretical and empirical investigation.

3 Model

I build theory based on collective models developed by Chiappori (1988), Mazzocco (2004) and Donni(2003). Household members jointly make ex-ante savings decision and ex-post labor supply decision to maximize a weighted sum of individual utility function over life-cycle. The unobserved intra-household allocation mechanism (sharing rule) depends on husbands' and wives' permanent wage shocks and transitory wage shocks, and this sharing rule can be identified from observed labor supply and participation decision up to a constant. This model provides a framework to examine how household make joint labor supply decision in respond to each other's permanent and transitory wage shocks.

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 sum up to 1.[6] Assume individual

[6] Most empirical studies using collective model make this assumption because most data are lack of information on home production.

preferences are "egoistic", 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 intertemporal additive separable over life-cycle.[7] Let w_{it}^f and w_{it}^m denote f and m's stochastic wage rate in period t respectively. Let y_{it} denotes non-labor income, which includes asset income and transfers and A_{it} denotes net wealth in period $t-1$. Household decision process is assumed to be Pareto efficient, which is the main assumption for collective models, and this implies agents fully commit to the future allocations of resources. The Pareto problem is to choose labor supply, consumption and savings to maximize discounted weighted utilities of two agents over life-cycle:

$$\begin{aligned} \max_{h_{it}^f, c_{it}^f, h_{it}^m, c_{it}^m, A_{i,t+1}} \quad & E_0[\sum_{t=1}^{T} \beta^{t-1}(\mu_{it} U_{it}^f(1-h_{it}^f, c_{it}^f) + U_{it}^m(1-h_{it}^m, c_{it}^m))] \\ s.t. c_{it}^f + c_{it}^m + A_{i,t+1} \leq & \; w_{it}^f h_{it}^f + w_{it}^m h_{it}^m + y_{it} + A_{it} \qquad \forall t \\ w_{it}^f = \overline{w}_{it}^f + \delta_{it}^f + \nu_{it}^f, & \quad w_{it}^m = \overline{w}_{it}^m + \delta_{it}^m + \nu_{it}^m \end{aligned} \tag{1}$$

where the non-negative scalar μ_{it} defines the wife's Pareto weight, which could depend on both agents' wage, non-labor income and some distribution factors that affect outside environment of the household (Chiappori et al. 2002).[8] Since wages are stochastic, I allow μ_{it} to depend on both fixed component of wage $\overline{w}_{it}^f$ and $\overline{w}_{it}^m$, as well as stochastic shocks: permanent shocks $\delta_{it}^f, \delta_{it}^m$ and transitory shocks ν_{it}^f, ν_{it}^m. Underlying the function μ_{it} is some intra-household resource allocation mechanism that leads to Pareto efficient allocations.

[7]Chiappori (1992) show that main results for egotistic preference also hold in a more general case of "caring" agents, whose preferences are represented by a utility function that depends on both their egotistic utility and their spouses'. For estimation purposes, I focus on egotistic preferences only.

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

3.1.2 Two-Stage Budgeting

Chiappori (1988) and Mazzocco (2004) have shown that under the assumption of Pareto efficiency, according to the Second Welfare Theorem, a weighted maximization of household utility function can be decentralized given intra-household transfers (sharing rule). By entering marriage a husband and a wife first agree upon a sharing rule to allocate the pooled household resources, then each member maximize his or her own utility given allocated resources.

Existing collective models are either static (Chiappori 1988, Donni 2003) or intertemporal but without endogenous labor supply (Mazzocco 2004).[9] I extend the static collective model into a simple dynamic context by making an assumption that household make savings decision ex-ante and labor supply decision ex-post. Blundell and Walker (1986) showed that when preferences are intertemporally separable, decision-making 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 money across periods, and reallocate wealth according to realized shocks in previous period. In the second stage, 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]

Incorporating both collective models' two-step decision and Blundell and Walker (1986)'s separation between savings and labor supply, I specify a two-stage collec-

[9]To my knowledge, Mazzocco and Yamaguchi (2006) are the only one who develop dynamic collective model with endogenous labor supply and participation. They consider three discrete choice of labor supply: full-time, part-time and nonparticipation while I consider continuous hours choice in this paper. They simulate a model to capture the empirical features of labor supply, saving and marital choices. Although marital status and commitment issue affects labor supply and savings decision, 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.

[10]Their model are based on single decision maker households, but it can be applied to collective models (Chiappori, Fortin and Lacroix 2002).

tive decision process as follows: at the beginning of marriage, a husband and a wife optimally allocate life-cycle wealth in each period according to their expectation to the future shocks, and commit to a sharing rule to allocate future resources conditional on both partners' wage shocks in each period. The second stage is a within-period decision: once shocks are realized, the husband and the wife allocate non-labor income net of savings according to the sharing rule, and each agent chooses private consumption and labor supply subject to earnings plus the allocated non-labor income net of savings:

$$\begin{aligned} &\max_{h_{it}^j, c_{it}^j} U_{it}^j(1-h_{it}^j, c_{it}^j) \\ &s.t. \quad c_{it}^j \leq (\overline{w}_{it}^j + \delta_{it}^j + \nu_{it}^j)h_{it}^j + \phi_{it}^j \qquad j=f,m \qquad \forall t \\ &\phi_{it}^f = \phi_{it}, \quad \phi_{it}^m = y_{it} - s_{it} - \phi_{it} \end{aligned} \tag{2}$$

where ϕ_{it}^f is the amount of non-labor income net of savings allocated to the wife, and ϕ_{it}^m is the rest amount allocated to the husband.

3.1.3 Sharing Rule

Sharing rules in existing collective models depend on each agent's wage, non-labor income and distribution factors. This paper aims to examine how shocks affect household joint decision and how shocks at different persistency level affect joint decision differently. Therefore, I allow both permanent shocks and transitory shocks of each agent to enter the sharing rule. Wage shocks not only affect labor supply through household budget constraint but also through this sharing rule. I specify the sharing rule as a function of husbands' and wives' fixed component of wage, permanent shocks, transitory shocks, non-labor income net of savings and a vector of distribution factors z:

$$\phi_{it} = \phi(y_{it} - s_{it}, \overline{w}_{it}^f, \overline{w}_{it}^m, \delta_{it}^f, \delta_{it}^m, \nu_{it}^f, \nu_{it}^m, z_{it}) \tag{3}$$

where s_{it} is active savings in period t. As defined in Equation (2), ϕ_{it} is the amount of non-labor income net of savings that allocates to the wife. It 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.

3.1.4 Identification of the Sharing Rule when Both Partners Are Working

When both partners work positive hours, the second stage problem in equation (2) can be solved by First Order Conditions. I derive Mashallian labor supply as a function of one's own wage rate and the sharing rule:

$$\begin{aligned} h_{it}^f &= h_{it}^f(w_{it}^f, \phi(y_{it} - s_{it}, \overline{w}_{it}^f, \overline{w}_{it}^m, \delta_{it}^f, \delta_{it}^m, \nu_{it}^f, \nu_{it}^m, z)) \\ h_{it}^m &= h_{it}^m(w_{it}^m, y_{it} - s_{it} - \phi(y_{it} - s_{it}, \overline{w}_{it}^f, \overline{w}_{it}^m, \delta_{it}^f, \delta_{it}^m, \nu_{it}^f, \nu_{it}^m, z)) \end{aligned} \tag{4}$$

From observed labor supply, one can identify the unobserved sharing rule up to an additive constant (Chiappori 1988). The intuition for identification is that changes in non-labor income and the wife's wage and shocks only affect the husband's labor supply through the sharing rule, and vice versa. In Section 3.2 I specify functional form for Mashallian labor supply and the sharing rule, these structural parameters can be recovered as a function of reduced form parameters.

3.1.5 Identification of the Sharing Rule When One of the Parters Is Not Working

The identification strategy described so far does not involve corner solutions. In this paper I not only look at how couples insure each other's wage shocks when both of them are working, but also look at how one agent adjust labor supply when the spouse is not working. I apply identification strategy from Donni (2003). When one of the partners does not participate, the sharing rule switches regime from when both partners participate. Identification comes from the characterization of the reservation wage by "double indifference": at the wage when one agent is indifferent between working and not working, Pareto efficiency requires that the spouse must be indifferent as well.[11] The sharing rule when one of the partners is not working can still be identified (up to an additive constant) from spousal continuous labor supply.[12]

3.2 Specification

For estimation purposes, I specify a log-linear labor supply and a linear sharing rule. There are two advantages of these specifications: First, linear or log-linear function is usually assumed in the collective model with nonparticipation and unobserved heterogeneity (Blundell et al. 2007, Bloemen 2004). Second, I can also prove the existence of a Pareto weight which is always positive and depends on wage shocks.

[11]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.

[12]When neither husband or wife works, sharing rule is not identified as there is no variations in labor supply.

3.2.1 Labor Supply, Sharing Rule and Indirect Utility Functions

I specify a log-linear Mashallian labor supply functions as follows:

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

The log-wage specification is consistent with Mincer model. I do not impose 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. I choose log hours specification to ensure the corresponding Pareto weight is consistent with theory. One limitation of this linear functional form is the lack of flexibility since labor supply curve is upward sloping everywhere.

Following collective literature, I specify a sharing rule as a linear function in all its arguments and include two distribution factors:

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

where z_{1i} and z_{2i} are two distribution factors that affect spouses' opportunities outside marriage without affecting their preferences.[13]

Labor supply functions in equation (5) suggest the following indirect utility functions, which one can perform intrahousehold welfare analysis of changes in

[13]The two distribution factors I choose is local sex ratio and divorce law index, both are time invariant in the data.

exogenous variables:

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

Following propositions in Browning, Chiappori and Lewbel (2007), I derive the Pareto weight μ_{it} given labor supply in (5) and sharing rule in (6). Details are given in the Appendix A. The Paretio weight is derived as follows:

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

This exponential expression in equation (10) ensures Pareto weight to be a positive scalar. Wage shocks from both partners show up in the Pareto weight, and they affect Pareto weight in the same direction as in the sharing rule.[14]

3.2.2 Deriving Sharing Rules and Testable Restrictions

Substituting sharing rule (6) into Mashallian labor supply functions (5), I get the corresponding reduced form labor supply functions when both parters are working:

$$\begin{aligned} \log h_{it}^f =& a_0 + a_1(y_{it}-s_{it}) + a_2\overline{w}_{it}^f + a_3\overline{w}_{it}^m + a_4\delta_{it}^f + a_5\delta_{it}^m + a_6\nu_{it}^f \\ &+ a_7\nu_{it}^m + a_8 z_{1i} + a_9 z_{2i} \\ \log h_{it}^m =& b_0 + b_1(y_{it}-s_{it}) + b_2\overline{w}_{it}^f + b_3\overline{w}_{it}^m + b_4\delta_{it}^f + b_5\delta_{it}^m + b_6\nu_{it}^f \\ &+ b_7\nu_{it}^m + b_8 z_{1i} + b_9 z_{2i} \end{aligned} \tag{9}$$

[14]Many other labor supply functions or utility functions, however, could not generate a Pareto weight which is a function of wage shocks. For instance, a Cobb-Douglas utility function generates Pareto weight that is independent of wage shocks.

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. Pareto efficiency assumption in the collective model implies the following restrictions:

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

The intuition of this restriction is that since the distribution factors only affect 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.

Furthermore, since I decompose wage into three components (group specific wage, permanent shocks and transitory shocks), the model generates additional over-identification restrictions:

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

Then I derive the sharing rule when one of the partners is not working. In the empirical section I only focus on the case when the husband is not working while the wife is. This is similar to the case in “Added Worker Effect”, where they study how wives adjust labor supply in response to husbands unemployment. Theoretically three sharing rules can be jointly estimated: working couples, working wives with non-working husbands, working husbands with non-working wives. However, in the empirical estimation, simultaneous regime switching model generates coherency problem. As Bloemen (2004) pointed out, without any further restrictions, the double switching model may generates multiple outcomes for the participation of 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 allows for one agent participation status to change.

Donni (2003) proposes a switching model for labor supply of the wife. When the husband is not working, female labor supply switches regime:

$$\begin{aligned} \log h^f_{it} =& A_0 + A_1(y_{it} - s_{it}) + A_2\overline{w}^f_{it} + A_3\overline{w}^m_{it} + A_4\delta^f_{it} + A_5\delta^m_{it} + A_6\nu^f_{it} \\ &+ A_7\nu^m_{it} + A_8 z_{1i} + A_9 z_{2i} \end{aligned} \tag{13}$$

When the husband is unemployed, the sharing rule changes because he no longer brings income into the household and he could not adjust labor supply to insure against the wife's shocks either. Denote sharing rule in male nonparticipation set as ϕ^{NP}_{it} and denote parameters with upper-case:

$$\phi^{NP}_{it} = K_0+K_1(y_{it}-s_{it})+K_2\overline{w}^f_{it}+K_3\overline{w}^m_{it}+K_4\delta^f_{it}+K_5\delta^m_{it}+K_6\nu^f_{it}+K_7\nu^m_{it}+K_8z_{1i}+K_9z_{2i} \tag{14}$$

Abbreviate male labor supply function in (11) as $h^m = b'x$, female labor supply when the husband is working as $a'x$ and when the husband is not working as $A'x$. Donni (2003) shows the following continuity condition must hold:

$$A'x = a'x + s(b'x) \tag{15}$$

where s is a scalar that can be estimated. When the husband is on the participation frontier, the last item on the right hand side disappears. The sharing rule also follows a similar continuity condition:

$$K'x = k'x + q(b'x) \tag{16}$$

The relation between s and q can be derived from (6), (11), (12):

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

Parameters K's, which are the partial derivatives of sharing rule on male nonparticipation set, can be identified via equation (18) and (19).

3.3 Unitary Model

In previous sections I derive restrictions that labor supply functions should satisfy under the collective setting. The alternative household decision model is called unitary model, where household decision is made by a single agent. Household members pool resources together and fully insure against all shocks. Consumption is not separable into individual consumption, and household problem is represented by a single utility function instead of weighted sum of individual utility functions. This unitary model generates different testable restrictions. To be comparable with collective model, I still assume ex-ante savings decision and ex-post labor supply decision are separable in two stages. Once couples decide how much to save in the first stage, the second stage they choose labor supply and joint consumption to maximize a single household utility:

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

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 unitary model comes from nonparticipation. When the husband does not work, in the collective model, his potential wage still affects the sharing rule therefore affects labor supply, while 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:

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

4 Data and Empirical Results

4.1 Data

This study uses Survey of Income and Program Participation (SIPP) 2001 panel, a national representative longitudinal data set in the U.S. To study how short-run labor supply react to wage shocks, SIPP has substantial advantage over other panel datasets such as PSID or the Health and Retirement Study (HRS), because SIPP interviews every other four month, while others are annual or biennial data.[15] Another advantage of SIPP is that high frequency interview also gives better quality of wage data. I further use wage data purged of measurement error as in

[15]SIPP has monthly data but monthly data has the well-documented seam bias problem. Respondents are more likely to report a wage change between interviews instead of within interview period.

Gottschalk (2005).[16] Under the assumption that nominal wages adjust in discrete steps while working for the same employer, he identifies the structural breaks in individual wage series and separates the effect of measurement error from that of true changes in wages.

SIPP 2001 panel consists of nine waves from December 2000 to February 2003. The main sample cuts in the estimation include married couples with heads 20 to 59 years old. I also excludes households who have children less than 18 years old because the model does not account for home production or public consumption and children is a big part of it. This gives a sample of 4,749 households with 41,622 observations. All income are put into January 2000 CPI-U-RS dollars.[17]

The dependent variable is total number of hours of work in each wave. The measure of wage is hourly wage rate, defined as observed hourly wage for hourly workers or the total wage earnings divided by number of hours of work otherwise. Household non-labor income includes property income, transfer income and other income.

Savings variable is constructed by taking the difference between net wealth in period t and $t-1$.[18] Information on net wealth is only available in the 3rd, 6th and 9th wave in SIPP 2001 panel. I use linear interpolation to fill in for the rest waves.[19] This variable is treated as endogenous with measurement error in the empirical section.

Following Chiappori et al. (2002), I construct two measures of distribution

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

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

[18]I acknowledge savings constructed by this method includes both active and passive savings while in my model only active savings is needed.

[19]This shortcoming can not be overcome by switching to PSID data since it only has wealth information every other five years before 1996, and biennial afterwards, and HRS data also only has wealth information every other year.

factors: local sex ratio and divorce law index. The local sex ratio is computed at the state level using 5 Percent Public Use Microdata Sample of the 2000 census. Local sex ratio corresponds to the number of males of the same age of the husband in each household over 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 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 over the number of males and females of the same age group (20-24, 25-29, etc.). The divorce legislation index considers four of the following features of divorce laws in each state: property division (community = 1), mutual consent versus unilateral divorce (mutual consent = 1), contribution to education (= 1) and nonmonetary contribution (= 1).[20] These features are likely to favor women. All four features did not change within state during my sample period. Table 2 presents summary statistics. There are some extreme values in the sex ratio index, but there are less than 1% which is either below 0.38 or above 0.59 and all are due to minority group in states with small population, which is still reasonable.

Panel E in Table 2 describes joint participation status for husbands and wives. There are 54.5% out of total person-wave observations where both husbands and wives work positive hours. Most empirical studies using collective model restrict their sample to these working couples only. There are 8.6% of the sample where neither husbands or wives are working. This is the case where the sharing rule is not identified as there is no variation in labor supply from either partners. 25.7% of the sample contains nonworking wives with working husbands and 10.9% of

[20]From Family Law Quarterly Winter 2000, Winter 2001, Winter 2002 Chart 4 and 5.

the sample contains nonworking husbands with working wives.[21] In this paper I include nonworking husbands with working wives, in addition to working couples. By focusing on male participation frontier I am also able to examine how wives adjust their labor supply in response to husbands' unemployment, which is similar to "Added Worker Effect". The disadvantage of focusing on male participation frontier instead of female one, of course, is dropping more observations might cause larger selection bias. In empirical section I estimate the same model using sample of working couples and working husbands and nonworking wives as a robustness check.

4.2 Estimate Permanent and Transitory Wage Shocks

To study how wage shocks affect couples's labor supply, one crucial step is to get good estimates of wage shocks. It is also important to distinguish between permanent shocks and transitory shocks as these two components of the shocks because they are likely to be determined by different factors (skill prices change versus job instability, for instance), hence have different impact 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. Permanent shocks follows a random walk with loading factor, while transitory shocks follows an ARMA(1,1) process. I apply their method to estimate parameters in the error components model, and I further identify the individual component of shocks by individual regressions based on estimated parameters. The wage decomposition

[21] These numbers are slightly higher than what is usually found in the literature, because there the working hours is sum up every four month, unlike every year or every two years in other datasets.

model is similar to Moffitt and Gottschalk (2008):

$$logw^j_{iat} = \overline{w}^j_{it} + \gamma^j_t \mu^j_i + \nu^j_{iat} \quad j = f, m \tag{21}$$

where $\overline{w}^j_{it}$ is the group-specific wage component. γ^j_t is loading factor on time invariant component μ_i. Loading factor represents aggregate skill price changes on human capital, it can be considered as a measure of aggregate shock. I allow this aggregate shock to differ between men and women, thus couples can still insure each other against this shock. Permanent shocks δ^m_{it} in equation (2) come from the product of γ_t and μ_i. ν_{it} are transitory shocks. Shocks not only move with calendar time but also move along with age (subscript with a), so that age effect is also taken into account.

I obtain $\overline{w}^j_{it}$ from predicted value of first stage Mincer regressions in each period. Dependent variable is log wage rate, and independent variables include age, age square, four education dummies (high school degree, some college, college degree, graduate school) and interaction between education dummies with age. These education-age interactions are excluded in equation (9) thus they are the basic exclusion restriction in labor supply equations. This implies differences in the preferences and the sharing rule across education group remain constant over life-cycle. The identification of labor supply does not rely on the exclusion of education, instead, it relies on the way that the returns to education have changed.

Transitory shocks ν_{it} follow an ARMA(1,1) process:

$$\nu^j_{iat} = \rho^j \nu^j_{i,t-1} + \xi^j_{iat} + \theta^j \xi^j_{ia,t-1} \quad j = f, m \tag{22}$$

I estimate the parameters γ^j_t, ρ^j, θ^j, σ_{ξ^j}, σ_{μ^j} using minimum distance estimation following Gottschalk and Moffitt (2008).[22] To identify individual component of permanent and transitory shocks, I run GLS regressions for each individual, allowing errors to follow ARMA(1,1) process. The identification comes from the assumption that individual permanent component μ_i is time invariant, so that I can treat it as a fixed coefficient.[23]

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

where $\hat{\gamma}_t$ is independent variable and this regression produces estimated coefficient $\hat{\mu}_i$. Permanent shocks can be computed using predicted value from (23), and transitory shocks are simply the difference between wage residuals $\hat{e}_{iat}$ and permanent shocks $\hat{\mu}_i \hat{\gamma}_t$. The estimated permanent shocks and transitory shocks are shown in Table 3. Shocks are all mean zero subject to small rounding errors. Women has larger standard deviation and larger range between minimum and maximum in both permanent shocks and transitory shocks than men, which is consistent with stylized facts from Figure 1 that women's wage are more volatile than men's wage.

4.3 Estimation of Couple's Labor Supply Functions and Sharing Rule

This section estimates second stage labor supply decision and recover unobserved sharing rules. Sharing rule depends on non-labor income net of savings from first stage. I treat savings as endogenous with measurement error. Savings variable

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

[23]In Moffitt and Gottschalk (2008) they specify permanent shocks to follow a random walk: $\mu_{ia} = \mu_{i,a-1} + \omega_{ia}$. In this paper I drop random walk because I need to further identify individual shocks, while identification requires μ_{ia} to be time invariant. I also estimate the model with random walk, it turns out the variance of random walk σ_ω is very small (0.002 for men and 0.007 for women), thus dropping it would not affect results much.

is instrumented using an indicator for positive net wealth, whether the household own the house (or apartment), property income with time varying coefficients, education dummies and quadratic in age for both partners, and interaction term between education dummies and age.[24] Since there is large measurement error in wealth therefore in savings, in the regression I only use the middle 90% observations and predict for the entire sample. Table 4 shows estimates of savings regression, most coefficients are significant. Predicted savings is used in the labor supply functions. The mean and standard deviation of predicted savings are shown in Table 2 Panel C.

I introduce observed and unobserved heterogeneity to labor supply functions. 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:

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

where $I(h_{it}^{m*} > 0)$ is an identification for male participation. g_{it} denotes observed heterogeneity, which includes the same set of variables in both male and female labor supply functions: four education dummies and a quadratic in age for both partners, race of head and time dummies. u^f and u^m are unobserved preference shocks to leisure and I allow them to be correlated and follows a joint normal distribution. Male participation condition is summarized as follows:

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

[24]Lise and Seitz (2007) use similar variables to instrument non-labor income.

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

4.3.1 Estimates of Reduced Form Supply Functions

Table 5 presents FIML estimates of reduced form female and male labor supply functions. One's wage shocks, either permanent or transitory, have significant negative effect on spousal labor supply, while permanent shocks have a larger impact than transitory shocks. When the husband gets a one percent negative permanent shock in his hourly wage, the wife increases her labor supply by 0.16 percent.[25] When his transitory wage drops one percent, on the other hand, the wife's labor supply increases by 0.04 percent. Similar effect can be found in male labor supply functions: a one percent drop in the wife's permanent wage shock increases male labor supply by 0.18 percent, while same drop in transitory shock increases male labor supply by 0.13 percent. This suggests that household members insure each other by increasing labor supply in response to spousal adverse shocks, and such insurance effect is stronger for more persistent shocks. The estimate of ρ is -0.058, which suggests couples' unobserved preference shocks to leisure are negatively correlated.

Unlike wage shocks, the predicted wage $\overline{w}_{it}^{j}$, has positive effect on spousal labor supply. One percent increase in $\overline{w}_{it}^{m}$ tends to increase female labor supply by 0.21 percent, while same increase in $\overline{w}_{it}^{f}$ tends to increase male labor supply by 0.45 percent.

[25]Notice both wage rate and labor supply are logarithm, the estimates represent elasticity.

4.3.2 Recover Parameters on Mashallian Labor Supply and Sharing Rules

To find out whether empirical results are consistent with collective hypothesis, I test the restrictions implied by collective model and unitary model. Testing restrictions for collective model is stated in equation (11) and (12). Wald statistic from a joint test is 6.29 with a p-value of 0.279, which suggests that I cannot reject collective hypothesis at 1%, 5% or even 10% level. Testing restrictions for unitary model, equation (19) and (20), has a statistic of 11.93 and p-value of 0.0026, which means the unitary model can be significantly rejected at 1 percent level. Collective model can not be rejected while unitary model can be rejected. This provide support for the collective hypothesis.

From estimation of reduced form labor supply functions, I recover Mashallian labor supply of equation (5) up to an additive constant. Table 6 presents female and male Mashallian labor supply estimates. The income effect is precisely estimated and is negative for male labor supply, which suggests male leisure is a normal good. Female income effect is also negative but is not precisely estimated. Both male and female wage effect are significantly positive. The implied wage elasticity is 0.605 for female and 1.604 for male at the sample mean. Both male and female Mashallian labor supplies satisfy Slusky condition of individual utility maximization, which is a requirement from theory.

Table 7 presents estimates of the two sharing rules, the first one is associated with when both partners are working, the second one is associated with only the wife is working but the husband is not.[26] Standard errors are computed using delta method. Some of the estimates are not precisely determined. Looking at

[26]On male nonparticipation set, transitory wage shock is missing, thus the sharing rule ϕ_{it}^{NP} does not depend on male transitory shock.

equation (10) we may find that each parameter in the sharing rule rely 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 coefficients are estimated significantly, Δ still may show up insignificant, especially when $a_1 b_8$ and $b_1 a_8$ have the same sign (Bloemen 2004). Thus it is particularly important to obtain good estimates of nonlabor income to get a_1 and b_1 and the first distribution factor to get a_8 and b_8.[27]

When both partners are working, a household makes more transfer to the agent with adverse shocks, and makes larger transfer to the agent with shocks that are permanent. A \$1 negative permanent shock to female hourly log wage, which is equivalent to a \$10 drop in hourly wage or \$7,200 drop in her earnings over four months full-time work, increases her share of non-labor income over four months by \$90.9. Meanwhile, same unit negative transitory shock increases her share of non-labor income by \$63.7. The effects are significant at 1 percent level. When the husband gets adverse wage shocks, he also gets more pooled income from this intra-household allocation, but the effects are not significant, with p-value of 0.12 and 0.18 respectively. Estimation of the sharing rule on working couples provides some evidence on insurance against permanent and transitory shocks by making intra-household allocation and labor supply.

The increase of female group specific wage $\overline{w}_{it}^{f}$ or the decrease of male group specific wage $\overline{w}_{it}^{m}$, on the other hand, increases the proportion of household pooled income allocated to the wife. This result is also found in collective labor supply estimation in Blundell et al. (2007). Their interpretation is that higher wage increases one's bargaining power within household, thus he or she could get more

[27]Table 7 use local sex ratio as the first distribution factor, I also tried using divorce law index as the first distribution factor, the results do not change much.

resources from intra-household allocation. This effect is precisely determined for female but not well determined for male.

The sharing rule for a working wife with a nonworking husband is quite different from the rule for working couples, due to the large value of the estimate of q in equation (16). When the wife gets an adverse shock, no matter 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 shock, the husband could not provide insurance through labor supply. The estimates of this sharing rule also suggests that I do not find added worker effect in the data. Added worker effect suggests when the husband gets unemployed, the wife works more to compensated for his income loss, which is contrary to what the sharing rule shows. However, the estimates of this sharing rule are not significant even at 10% level, partly due to the insignificant estimates of q. The coefficient estimate of non-labor income has a value of 1.31, which is outside the reasonable range between 0 and 1.[28]

The distribution factors does not have expected sign on the sharing rule. Increase in local sex ratio (the relative scarcity of women) and the change of divorce law that in favor of women should increase female share of non-labor income, but I find either no significant effect or opposite effect. I also tried alternative measurement of sex ratio, such as divided into four racial groups instead of three, or measure the number of men over men plus women within 5-year-old group or 10-year-old group. Results do not change qualitatively. This unexpected sign for distribution factors is also found in Hourriez (2005). They argue that such effect

[28]I also perform test to see whether permanent shocks and transitory shocks have the same impact on intra-household allocation or labor supply, and whether there is a symmetric response from the husband and the wife. However, since estimates of sharing rule only significant for female permanent shocks and transitory shocks when both partners are working, I only test this effect and the null hypothesis of equal effect can not be rejected.

may be a consequence of home production. When the wife's options outside marriage become better off, 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. Increase of scarcity of women decrease 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, he can negotiate to get less housework, therefore might increases his labor supply. Such effect of sex ratio on sharing rule is no longer significant when the husband does not participate. This might due to the fact that husband devotes zero hours on market work therefore his time on home production is almost fixed, thus the wife does not need to negotiate over home production, then only negotiate on intra-household allocation. This is why I find a positive effect of distribution factors on sharing rule when the husband does not participate in labor market.

4.4 Insurance for Liquidity Constrained Households

When households have limited access to borrowing and could not adjust savings to insure against income shocks, household members may be more likely to adjust labor supply to smooth consumption. Added worker effect literature have found mixed evidence on the relationship between the smoothing role of spousal labor supply and liquidity constraints. 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) uses 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, while in the CEX sample her labor response is not significant for high school dropouts, but significant and even larger effect for higher educated groups, which seems to contradict the liquidity constraints story. This section explores whether and how couples adjust labor supply to insure against wage shocks when they face liquidity constraints.

I define liquidity constraints as households whose net wealth in the third wave is less than the 50th percentile.[29] Table 8 displays results of reduced form labor supply and Table 9 displays results for the sharing rules. Reduced form estimates show that one's permanent shocks have significant effect on spousal labor supply at 1 percent level, while transitory shocks do not even at 10 percent level. This is different from estimation over the whole sample, where both permanent shocks and transitory shocks have significant effect on spousal labor supply at 1 percent level. In Table 9, parameters on sharing rules are poorly estimated thus I could not compare it with previous results using entire sample. Alternative measures of liquidity constraints are also tried as robustness checks: household income in the first wave is less than the 50th percentile; household head's education with high school degree or below, or households with net wealth less than the 50th percentile and do not own house or apartment. Results do not change qualitatively. These empirical findings are not exactly consistent with liquidity constraints theory, but many factors could explain these results: liquidity constrained households are more likely to have lower income, lower education, which restrict household members' ability of finding jobs or adjust labor supply in short period. This also explains why couples with limited liquidity only respond to permanent shock but not to transitory shock.

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

4.5 Do Couples Insure against Shocks or Volatility?

Previous sections examine whether and how married couples insure against each other's adverse wage shocks. Another question of interest is whether they also insure against individual wage volatility, which can be measured as the variance of wage shocks for each individual.

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 higher individual wage volatility causes a lower proportion of non-labor income, both for the husband and the wife. One explanation is that agent with higher income uncertainty might have lower bargaining power in the household. On the contrary, when the husband is not working, the higher the variation of his shocks in other periods, the more resources he will get from intra-household allocation. However, due to the insignificancy of the effect of female wage volatility on male labor supply, the sharing rule parameters are not precisely estimated. Recall that the sample only covers three years data, and the variance of wage shocks over such short period might not provide a sufficient statistic for actual wage volatility.[30] In the meantime, as existing studies in marital sorting literature have pointed out, people tend to search for spouse who has negative income covariance with themselves, or look for someone who has stable job and stable income. Income volatility might already be insured via marriage decision, and after getting married there is little we can see about insurance against this uncertainty. Overall, Table 10 shows little evidence of household insurance against wage volatility.

[30] Note that in the section of stylized facts, income volatility is estimated using entire sample, here wage volatility is computed at individual level. These are two different notations and that's why I call the latter one "individual wage volatility".

4.6 Comparison with Baseline Model that Does not Including Shocks

This paper introduces permanent shocks and transitory shocks into the sharing rule of collective model. In this section I estimate the baseline model in existing collective literature, which do not distinguish between wage with its stochastic shocks. Table 11 displays sharing rule estimates which treat wage as single component, given everything else same as my main sample and method. The effect of female wage on sharing rule is significant negative, Chiappori et al. (2002) interpret this result as altruism. Male 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 wage component $\widehat{w}_{it}$ reverses the sign. This shows the importance of distinguish wage and wage shocks, and distinguish between shocks that are permanent and transitory.

Table 12 displays results that only consider the case when both partners are working, which is the sample defined in Chiappori et al. (2002). Again female wage has negative effect on the sharing rule, male wage effect is not significant. Compare the estimated coefficient of distribution factors in Table 11 and Table 12, the coefficient reverses sign. This also shows incorporating nonparticipation into the sharing rule might be important.

4.7 Robustness Check and Further Discussion

As an alternative to including male nonparticipation, I also estimate model including continuous labor supply with female nonparticipation only. Table 13 displays reduced form labor supply estimates and Table 14 displays sharing rule estimates. Unfortunately all parameters in the sharing rule are poorly determined, mainly due to the imprecise estimates of both distribution factors. The sign of the point estimators for permanent and transitory shocks of each agent are still the same as main results in Table 7, where the sample includes nonworking husbands but not nonworking wives. This provides a robustness check of the main results.

I also estimate the main model using several alternative specifications. First I redefine the sample to exclude households with children less than 6 years old instead of excluding households with children less than 18 years old in the main sample. This gives me a larger sample size but qualitative results do not change. I use weekly hours worked instead of total hours worked in period t, and the estimation results do not change either. I also try to estimate the model using the sample of hourly workers only. This will get rid of the endogeneity problem caused by imputed wage from earnings. Unfortunately, the parameters are very poorly estimated, mainly because of very small sample size. In SIPP data the flag for imputed wage has lots of missing values, and when restrict sample on both partners who are hourly workers, it only gives me a pool of 886 households, while the main sample contains 4,749 households. Overall, these specification checks show that main results are robust to various specifications and sample cuts.

I acknowledge some limitations both from theory and empirical work in this paper. This model assumes agents can adjust labor supply freely, while in reality hours might be constrained for a given job, and it takes time to get another job so that the labor supply adjustments by switching jobs are not reflected in the current period. Therefore, empirical work might underestimate the effect of wage shocks on labor supply. On the other hand, a huge negative shock from one partner may leads to divorce, which drops that households out of my sample. Thus my estimation uses the most committed families and this tends to overestimate households' willingness on insurance. Focusing on married couples without children and excludes sample of nonworking wives may also cause selection bias. Estimation results in this paper only have policy implications on married couples without children.

Another limitation comes from the estimation of wage shocks. This model takes wage shocks as given, but some shocks could be endogenous to one's own labor supply or spousal labor supply. This limitation can be resolved if I have some measure of exogenous wage shocks. It is also possible that wage changes because of location change. If an individual moves from a big city to a small town and gets a better job, the nominal wage might still drop because the living standard is much lower in small town, but the agent does not think of it as an adverse shock and would not response to that.

This model does not consider the interaction between social insurance program such as unemployment benefit and intra-household insurance.[31] For the convenience of estimation, utility functions does not have risk aversion parameters. But preference to risk could be a factor that influence couples' willingness to insure. For instance, more risk averse households may be more likely to insure each other's transitory shocks to smooth consumption, or if a husband and a wife have different preference for risk, they may respond to spousal shocks differently. Above discussions in this section suggest some important avenues for future research.

5 Conclusion

The aim of this paper has been to evaluate the link between income volatility and household decision through the degree of household labor supply insurance with respect to wage shocks, both permanent and transitory. I develop a life-cycle collective model, where wage are stochastic and the intra-household allocation de-

[31] Cullen and Gruber (2000) show that the generous unemployment benefit has a crowd out effect on spousal labor supply.

pends on both permanent and transitory wage shocks. I first estimate permanent and transitory wage shocks for each individual, then estimate couples labor supplies using SIPP 2001 panel and recover the unobserved intra-household allocation mechanism. Estimation results provide some evidence on household insurance via labor supply: married couples making 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 gets unemployed and could not adjust his labor supply. There is little evidence of insurance from labor supply for liquidity constrained households, and little evidence of insurance against high individual wage volatility. This paper not only provides structural explanation of household insurance through labor supply, but also contributes to the empirical studies using collective model by using high-frequency data in the U.S. and incorporating nonparticipation. Estimation and the comparison with existing collective models shows the importance of stochastic wage components therefore the importance of developing formal dynamic collective models with labor supply both on extensive and intensive margin.

The structural analysis of household insurance via labor supply provides an explanation on why individual income volatility does not completely translate into household income volatility, as stylized facts have shown. Meanwhile, lacking of insurance opportunities leads to a greater vulnerability to income shocks. How well household smooth income shocks also provide an important complement to the understanding of public insurance policies and redistributive policies.

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 wife and the husband. By Roy's identify:

$$\frac{\partial v^f(w_{it}^f, \phi_{it}^f)/\partial w_{it}^f}{\partial v^f(w_{it}^f, \phi_{it}^f)/\partial \phi_{it}^f} = h_{it}^f, \quad \frac{\partial v^m(w_{it}^m, \phi_{it}^m)/\partial w_{it}^m}{\partial v^m(w_{it}^m, \phi_{it}^m)/\partial \phi_{it}^m} = h_{it}^m \tag{26}$$

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

$$\begin{aligned} v^f(w_{it}^f, \phi_{it}^f) &= \frac{e^{-\alpha_2 \phi_{it}^f}}{\alpha_2} + \frac{(w_{it}^f)^{\alpha_1+1}}{\alpha_1+1} \\ v^m(w_{it}^m, \phi_{it}^m) &= \frac{e^{-\beta_2 \phi_{it}^m}}{\beta_2} + \frac{(w_{it}^m)^{\beta_1+1}}{\beta_1+1} \end{aligned} \tag{27}$$

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

$$\mu_{it} = -\frac{\partial v^m(w_{it}^m, \phi_{it}^m)/\partial \phi_{it}}{\partial v^f(w_{it}^f, \phi_{it}^f)/\partial \phi_{it}} = \frac{e^{-\beta_2 \phi_{it}^m}}{e^{-\alpha_2 \phi_{it}^f}} = e^{(\alpha_2+\beta_2)\phi_{it} - \beta_2(y_{it}-s_{it})} \tag{28}$$

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

$$\mu_{it} = e^{\alpha_2+\beta_2[(k_0+(k_1-1)(y_{it}-s_{it})+k_2\overline{w}_{it}^f+k_3\overline{w}_{it}^m+k_4\delta_{it}^f+k_5\delta_{it}^m+k_6\nu_{it}^f+k_7\nu_{it}^m+k_8z_{1i}+k_9z_{2i}]} \tag{29}$$

B Derivation of Likelihood Function

First assume preference shocks u_{it}^f and u_{it}^m in labor supply functions follows 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:

$$L = \sum_{i\in P} logL_i(h_{it}^f, h_{it}^m) + \sum_{i\in NP} logL_i(h_{it}^f) \tag{30}$$

Likelihood function when both partners are working is straightforward, following a joint normal distribution:

$$L_i(h_{it}^f, h_{it}^m) = \frac{1}{\sigma_f\sigma_m}\varphi(\frac{u_{it}^f}{\sigma_f}, \frac{u_{it}^m}{\sigma_m}, \rho) \tag{31}$$

where φ is standard normal distribution function. The likelihood function in male nonparticipation 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 above matrix as σ_v. The correlation parameter in this covariance matrix becomes:

$$r = \frac{\rho\sigma_f + s\sigma_m}{\sigma_v} \tag{32}$$

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 independent of u_{it}^m. The likelihood in NP becomes:

$$\int_{-\infty}^{-b'x/\sigma_m} \frac{1}{\sigma_m}\varphi(\frac{u^m}{\sigma_m})\frac{1}{\sigma_v\sqrt{1-r^2}}\varphi(\frac{h^f - a'x - sb'x - r\frac{\sigma_v}{\sigma_m}u^m}{\sigma_v\sqrt{1-r^2}})\partial u^m \tag{33}$$

which can be simplified as:

$$L_i = \frac{1}{\sigma_v}\varphi(\frac{h^f - a'x - sb'x}{\sigma_v})\Phi(\frac{-\frac{b'x}{\sigma_m} - r\frac{h^f - a'x - sb'x}{\sigma_v}}{\sqrt{1-r^2}}) \tag{34}$$

where Φ stands for CDF of standard normal distribution.

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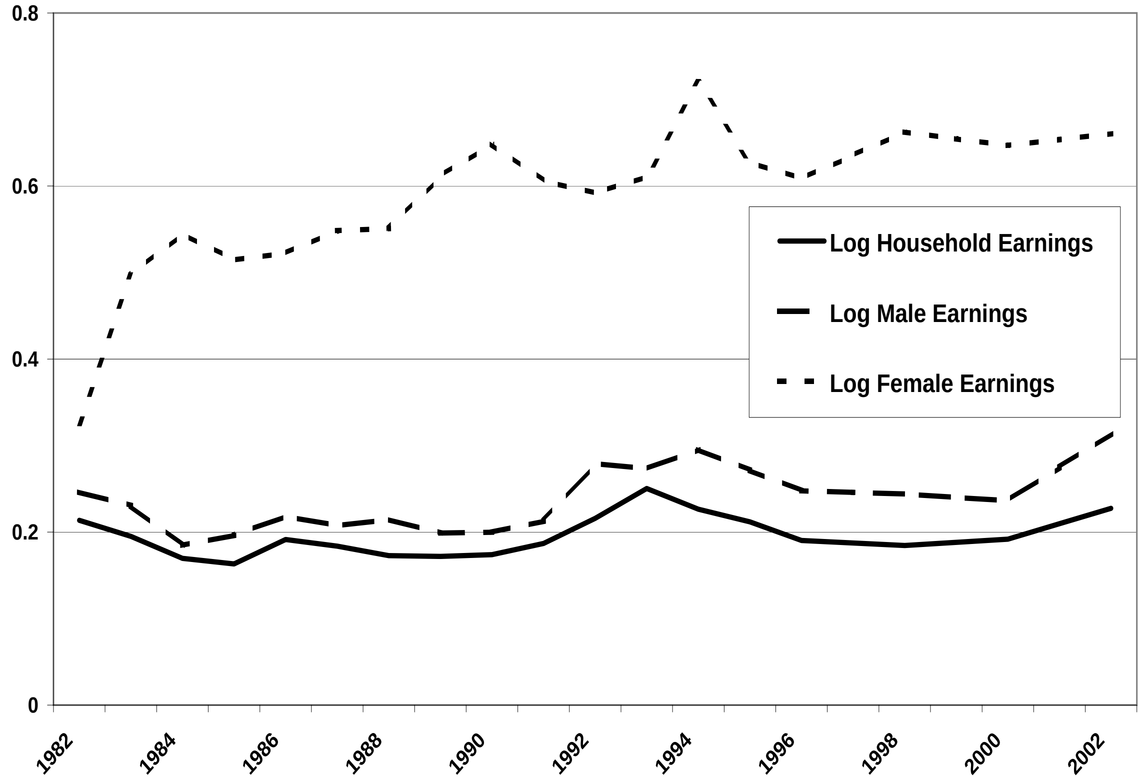

Figure 1: Transitory Variances of Log Household Earnings, Log Male Earnings and Log Female Earnings in the U.S., Married Households from PSID 1979-2002

Table 1: Comparison of Transitory Variances for Married and Single Agents

	Transitory Variances		
	Log Household Earnings	*Log Household Income*	
Singles(random match)	0.141	0.135	
Married Couples	0.092	0.085	
	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 work	
Husband works	54.5%		25.7%	
Husband not work	10.9%		8.6%	

Table 3: Summary of Log Wage Decomposition

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

Table 4: Estimates from Savings Equation

	Coefficient	Standard Error
Positive net wealth	-10,960.2**	600.3
Own house	3,8968***	426.5
Male age	750.8***	241.1
Female age	665.6***	224.3
Male age square	-8.61***	2.76
Female age square	-6.09***	2.71
Asset income (t=1)	-0.108	0.298
Asset income (t=2)	-0.890**	0.370
Asset income (t=3)	-0.739**	0.380
Asset income (t=4)	-0.511	0.470
Asset income (t=5)	-0.818	0.558
Asset income (t=6)	1.584***	0.470
Asset income (t=7)	1.702***	0.424
Asset income (t=8)	2.701***	0.475

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

Table 5: Reduced Form Labor Supply Functions

	Female Labor Supply		Male Labor Supply	
	Coef	Std Err	Coef	Std Err
Nonlabor income net of savings	-0.0002***	0.000	-0.002***	0.0002
Female wage (observed component)	0.376***	0.067	0.447**	0.184
Male wage (observed component)	0.214	0.144	1.187***	0.400
Female permanent shock	0.309***	0.006	-0.182***	0.017
Male permanent shock	-0.164***	0.007	1.314***	0.016
Female transitory shock	0.081***	0.014	-0.127***	0.039
Male transitory shock	-0.040**	0.016	0.701***	0.043
Local sex ratio	0.239**	0.111	-0.466	0.307
Divorce law index	0.006	0.005	-0.041***	0.013
Female age	-0.012**	0.006	-0.070***	0.017
Female age square	0.0001*	0.000	-0.008***	0.000
Male age	-0.020**	0.009	0.008	0.026
Male age square	0.0003*	0.000	-0.0003	0.0003
Female edu(high school or GED)	0.006	0.036	-0.401***	0.010
Female edu(some college)	-0.024	0.050	-0.560***	0.138
Female edu(college degree)	-0.041	0.073	-0.866***	0.204
Female edu(graduate school)	-0.024	0.085	-1.050***	0.235
Male edu(high school or GED)	-0.118**	0.048	0.142	0.133
Male edu(some college)	-0.200***	0.071	0.061	0.195
Male edu(college degree)	-0.406***	0.121	-0.178	0.334
Male edu(graduate school)	-0.467***	0.142	-0.345	0.394
Head is white	-0.075***	0.011	-0.023	0.030
Joint parameters				
s	0.709***	0.045		
ρ	-0.058***	0.009		

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

Table 6: Mashallian Labor Supply Functions

Female Labor Supply		Male Labor Supply	
$logw_{it}^{f}$	0.605***	$logw_{it}^{m}$	1.605***
	(0.212)		(0.572)
ϕ_{it}	-0.001	$y_{it} - s_{it} - \phi_{it}$	-0.002***
	(0.001)		(0.000)

Table 7: Estimates of the Sharing Rules

	Both partners work		Wife works, husband not	
	Coef	Std Err	Coef	Std Err
$y_{it} - s_{it}$	0.19	0.13	1.31	0.83
$\overline{w}_{it}^{f}$	223.6**	101.1	-85.7	231.9
$\overline{w}_{it}^{m}$	-209.1	194.0	-1,030.5	725.9
δ_{it}^{f}	-90.9***	19.02	34.8	93.35
δ_{it}^{m}	160.4	103.1	-749.2	484.0
ν_{it}^{f}	-63.8***	22.67	24.4	65.87
ν_{it}^{m}	39.3	29.54	-	-
Local sex ratio	-233.2*	129.9	89.3	288.7
Divorce law index	-6.12	5.97	22.5	18.1
q	-	-	-692.1	446.3

Table 8: Reduced Form Labor Supply Function Estimation for Liquidity Constrained Households

	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 wage (observed component)	0.979***	0.214	0.352	0.564
Male wage (observed component)	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 9: Estimates of the Sharing Rule for Liquidity Constrained Households

	Both partners work		Wife works, husband not	
	Coef	Std Err	Coef	Std Err
$y_{it} - s_{it}$	-0.633	3.072	-0.693	3.300
$\overline{w}_{it}^f$	1627.2	5,418.58	1,686.42	5,683.19
$\overline{w}_{it}^m$	1523.4	7,190.29	2,128.81	10020
δ_{it}^f	-1349.9	3,929.30	-1,399.03	4131.93
δ_{it}^m	-322.60	1,493.23	-94.42	655.92
ν_{it}^f	-616.51	1,856.5	638.92-	1,952.42
ν_{it}^m	-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

Table 10: Estimates of the Sharing Rules including Individual Income Volatility

	Both partner works		Husband works, wife not	
	Coef	Std Err	Coef	Std Err
$y_{it} - s_{it}$	0.140**	0.056	0.929***	0.229
$\overline{w}_{it}^f$	240.34**	102.95	19.73	64.78
$\overline{w}_{it}^m$	-120.86	104.71	-580.88**	265.45
δ_{it}^f	-100.60***	14.726	-8.25	7226
δ_{it}^m	115.10***	30.83	-530.78***	146.14
ν_{it}^f	-58.79***	21.74	-4.82	15.92
ν_{it}^m	25.56**	12.52	-	-
σ_{ν^f}	-41.67***	10.48	-3.419	10.33
σ_{ν^m}	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

Table 11: Baseline Sharing Rules that Does not Distinguish Wage and Shocks

	Both partner works		Husband works, wife not	
	Coef	Std Err	Coef	Std Err
$y_{it} - s_{it}$	-0.007	0.27	-0.012	0.031
w_{it}^f	-57.13***	10.69	-28.8***	9.13
w_{it}^m	-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

Table 12: Baseline Sharing Rules that Does not Distinguish Wage and Shocks and Excludes Nonparticipation

	Coef	Std err
$y_{it} - s_{it}$	0.091	0.206
w_{it}^f	-18.11***	4.826
w_{it}^m	9.44	21.21
Local sex ratio	-17.52	38.14
Divorce law index	-0.54	1.26

Table 13: Reduced Form Labor Supply Function Estimation with Female Nonparticipation

	Female Labor Supply		Male Labor Supply	
	Coef	Std Err	Coef	Std Err
Nonlabor income net of savings	-0.0015***	0.0002	-0.0002***	0.000
Female wage (observed component)	2.863***	0.235	-0.005	0.042
Male wage (observed component)	0.245	0.516	0.129	0.092
Female permanent shock	1.995***	0.017	-0.090***	0.004
Male permanent shock	-0.488***	0.025	0.123***	0.004
Female transitory shock	1.006***	0.050	-0.033***	0.009
Male transitory shock	-0.226***	0.057	0.023***	0.010
Local sex ratio	-0.021	0.016	-0.011***	0.070
Divorce law index	0.418	0.392	-0.016	0.003

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

Table 14: Estimates of the Sharing Rule with Female Nonparticipation

	Both partners work		Husband works, wife not	
	Coef	Std Err	Coef	Std Err
$y_{it} - s_{it}$	0.249	0.796	-1.312	2465
$\overline{w}_{it}^{f}$	-21.33	175.25	2,890.5	3,119.2
$\overline{w}_{it}^{m}$	-39.71	151.95	209.15	590.41
δ_{it}^{f}	-374.61	402.62	1,654.5	1,777.5
δ_{it}^{m}	79.12	252.68	-416.7	781.14
ν_{it}^{f}	-138.71	153.44	884.5	952.2
ν_{it}^{m}	36.72	117.62	-	-
Local sex ratio	3.432	11.32	-18.08	36.77
Divorce law index	-67.86	220.03	357.4	776.5
q	-	-	1016.92	1092.54

Note: Asymptotic standard errors are computed using delta method.