Wage Shocks, Household Labor Supply, and Income Instability

Sisi Zhang[1]

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 rising income instability and household insurance. Existing studies on household insurance either focus on consumption smoothing and take labor supply as a given, or only focus on wife's labor responses to husband's unemployment shocks. This article develops an intra-household insurance model that allows for insurance against permanent and transitory wage shocks from both partners. Estimation using the Survey of Income and Program Participation shows that wife increases labor supply in response to husband's adverse wage shocks when both of them are working, and wife gets more non-labor income when she is out of work. This intra-household insurance reduces earnings instability by about two to nine percent. These results suggest that joint labor supply decisions provide an extra smoothing effect on income instability.

JEL classification: D12; D13; D81; J22

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[1] School of Economics, Shanghai University of Finance and Economics, 770 Guoding Road, Shanghai, China, 200433. Email: sisi.zhang@gmail.com.

1. Introduction

Rising earnings and income instability over the last few decades in the United States has been well documented in the existing studies (Dahl et al. 2008; Dynan et al. 2012; Gottschalk and Moffitt 1994; Haider 2001; Hyslop 2001; Moffitt and Gottschalk 2002, 2012; Shin and Solon 2011). This has been of concern to policymakers, because it is associated with an increase in risk, a reduction in welfare, and sometimes causes an unstable consumption profile in lack of savings. Government provides social insurance, transfers, and taxation, to buffer the welfare loss caused by income instability. 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, or labor supply adjustments.

The goal of this article is to examine whether, and how, married couples make joint labor supply decisions to smooth out each other's income shocks, and ultimately smooth out the distribution of consumption between spouses as well as smooth out total household consumption over time. In doing so, this article aims to answer the following three questions: (1) Do married couples adjust labor supplies in response to each other's wage shocks? (2) Do they respond to permanent and transitory wage shocks differently? (3) What are the implications of such household decisions for overall income instability?[2] Answers to these questions would provide a better understanding of intra-household insurance as a risk-coping and consumption smoothing strategy in reaction to rising earnings instability. Understanding the degree to which couples are willing to insure and smooth out consumption is important for assessing the performance of private insurance markets as well as the efficiency of government insurance policies. In addition, the distinction between permanent shocks and transitory shocks provides implications for policies that target unexpected income loss at different persistency levels. For instance, Social Security Disability Insurance (SSDI) provides income to people who are disabled with a condition expected to persist 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 instability by

[2] Permanent shocks are defined as shocks that are expected to persist into the future. Transitory shocks are caused by temporary and random influences. Permanent shocks are not mean-reverting and transitory shocks are mean reverting.

making joint decisions, so that income at the household level becomes more stable. Intra-household insurance may also lead to a more smoothed consumption profile, which affects consumption inequality or the transmission from income inequality to consumption inequality.

Studies on insurance for income shocks have a long history in both macroeconomics and labor economics. In macroeconomics, the complete market hypothesis assumes that both permanent and transitory income shocks are fully insured, while 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 2011). For example, Altonji et al. (1992) find no evidence of risk sharing, while Cochrane (1991) find full insurance hypothesis is not rejected for some shocks (e.g., spells of unemployment and involuntary moves) and not for others (e.g., long illness). These studies on insurance for income shocks typically focus on consumption smoothing and very few studies examine labor supply response as an insurance mechanism. Blundell et al. (2008) examine the degree of insurance to income shocks through consumption and other alternatives, and they find that family labor supply plays an important role in insuring permanent shocks.

In labor economics, there is a large body of literature that examine insurance for income shocks through temporary changes in wives' labor supply in response to husbands' unemployment or transitory income shocks, also known as "added worker effect" (Lundberg 1985; Bingley and Walker 2001; Juhn and Potter 2007; Kohara 2010, among others). Lundberg (1985) finds 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 a greater positive co-movement of employment among couples. Using Japanese panel data from 1993 to 2004, Kohara (2010) finds that when husbands experience involuntary job loss, working wives raise their work hours and nonworking wives start to participate in the labor market. These studies on insurance via labor supply decisions focus on wives' responses to husbands' shocks, but not the reverse. Yet with women's labor supply and participation rising sharply in the past quarter century, this reverse response is arguably just as important.

To examine how married couples adjust labor supply to insure against each other's wage shocks, we develop a model based on the collective framework developed by Chiappori (1988, 1992) and Donni (2003). The main advantage of the collective framework 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.[3] The weighted maximization of household members' utilities can be decentralized, subject to a lump-sum income transfer, also known as the "sharing rule", which specifies how to allocate household resources. This sharing rule depends on each individual's wage in the existing collective models. We expand the scope of the sharing rule to be 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. The effects of the sharing rule for income and consumption smoothing are two folds: first, when a spouse experiences a wage shock, the sharing rule redistributes resources within a household so that each spouse smoothes consumption; second, labor supply is adjusted in response to changes in the sharing rule, which reduces household earnings instability and household consumption instability. This is the main channel through which we examine how individual wage shocks affect spousal labor supply and to what extent such intra-household insurance reduces overall income instability and consumption instability.

This article makes both theoretical and empirical contributions to the existing literature on insurance for income shocks, added worker effect, and collective labor supply: First, we 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. The classic collective model is modified by introducing permanent and transitory wage shocks into the sharing rule. Second, based on empirical results of our intra-household insurance model, we provide structural explanations of how much of the overall individual and household earnings instability can be explained by household labor supply. Third, this article also contributes to the empirical studies using collective models by

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

examining labor supply with non-participation using triannual data in the United States for the first time.[4]

We use the Survey of Income and Program Participation (SIPP) 2004 panel and the main findings are as follows: When both spouses are working and the husband gets an adverse wage shock, he is compensated with additional non-labor income and the wife increases her labor supply. The wife gets more non-labor income when she is out of work. The effect of permanent wage shocks and transitory wage shocks on the sharing rule does not differ significantly. Estimation results also suggest that intra-household insurance reduces earnings instability by about two to nine percent.

Section 2 presents stylized facts on individual and household income instability. In Section 3, a collective model is formulated, which allows for insurance against permanent and transitory wage shocks. Section 4 describes the data. Section 5 discusses empirical strategies and estimation results. Section 6 uses estimation results of the collective model to provide structural explanations to the stylized facts. Section 7 concludes.

2. Stylized facts on income instability and intra-household insurance

In this section, we present several stylized facts on income instability at both the household level and the individual level, for married couples and single individuals. These stylized facts provide empirical evidence that is consistent with intra-household insurance hypothesis, which motivates this study.

Table 1 documents household income instability, household earnings instability, and individual earnings instability for singles versus married couples using the SIPP 2004 panel. Income and earnings instability are measured as the variance of the transitory component, which is commonly used in the existing literature (e.g. Gottschalk and Moffitt 1994, 2009).[5] **<Insert table 1 here>**

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[4] Among empirical studies using collective labor supply models with non-participation, Blundell et al. (2007) use Great Britain data, Bloeman (2010) uses Dutch data, Hourriez (2005) uses French data, Vermeulen (2006) uses Belgian data, Lacroix and Radtchenko (2011) use Russian data, and Zamora (2011) uses Spanish data.

[5] Transitory variances are calculated as $\frac{1}{N}\sum_{i=1}^{N}\frac{1}{(T_i-1)}\sum_{i}^{T_i}(y_{it}-\overline{y_i})^2$. First we calculate variances for either each household or each individual over an entire sample period, and then take the average across these households or individuals.

Of particular interest are the following three features of the data. First, transitory variance in log household income for married couples (0.053) is much lower than for single individuals (0.113 for single males and 0.111 for single females). The log household earnings for married couples is also lower than for single individuals. In addition, to take into account the covariance of a two-person income, we randomly match a single male and a single female to form household earnings or household income, as the sum of the two, and compare their transitory variance with that of married couples.[6] These randomly matched individuals do not have the behavioral smoothing response that married couples might have. Married couples have lower household earnings instability as well as household income instability than randomly matched single individuals (0.057 versus 0.149 for earnings).[7] Second, the variation in labor supply (log hours) is higher for married women than single women. This higher work-hour fluctuation for married women is consistent with the hypothesis that married women 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. We do not find the same pattern for married men though. Third, Table 1 also shows that, for married couples, their household earnings instability (0.057) is lower than individual earnings instability for married women (0.088) and it is no higher than individual earnings instability for married men (0.057). This is also consistent with the story of household insurance, that couples could absorb each other's individual earnings shocks so that household earnings fluctuations are reduced.

Our descriptive analysis presented in this section highlights several important stylized facts for modeling the link between income instability and joint decisions within a household. Married couples' household earnings instability is lower than individual earnings instability, and married couples have lower household income instability than single individuals. These facts are consistent with our hypothesis of intra-household insurance. The next section develops a model to examine the link between earnings instability and intra-household decisions.

[6] We randomly match single males and single females by merging the sample of single males and sample of single female as it is in the original order in the SIPP data, by time period.

[7] 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, we further compute transitory variance in hourly wage rate and work-hour and show that, on the contrary, singles do not have significant higher wage and work-hour fluctuations than married individuals.

3. The model

In this section, we develop a model that allows for intra-household insurance, based on the collective models of household decision-making developed by Chiappori (1988, 1992) and Donni (2003). To address intra-household decisions in response to permanent and transitory shocks, we modify existing collective models by introducing permanent and transitory wage shocks into the sharing rule, a decision rule that allocates household resources.[8]

3.1. **Preferences and household problem**

Consider a household consisting of two working age individuals (*m* for husband and *f* for wife). Assume no home production or public consumption, the price of the consumption good is one, and preferences are of "egoistic" type.[9] The household problem is to choose labor supply, consumption, and savings, to maximize the discounted weighted utility function subject to the household's budget constraint:

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

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

$$w_{it}^f = f(\overline{w}_{it}^f, \delta_{it}^f, v_{it}^f), \qquad w_{it}^m = f(\overline{w}_{it}^m, \delta_{it}^m, v_{it}^m)$$

$$\eta_{it} = f(w_{it}^f, w_{it}^m, y_{it}, z_{it}) \tag{1}$$

where h_{it}^f and h_{it}^m denote wife's and husband's labor supply, c_{it} denotes consumption, and w_{it} denotes hourly wage rate. A_{it} denotes net worth in period *t-1*,[10] and $\mathrm{y_{it}}$ denotes non-labor income, which includes asset income and transfers.[11] The non-negative scalar η_{it} represents wife's decision weight within the household.

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[8] We examine wage shocks instead of income shocks because the main component of income is labor earnings, which are endogenous to labor supply.

[9] Chiappori (1992) shows that the main results for egoistic preference also hold in a more general case of "caring" individuals, preferences of whom are represented by utility functions that depend on both their egoistic utility and their spouses'. We 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. Some studies incorporate household production in empirical collective models, for example, Aronsson et al. (2001) and Rapoport et al. (2011).

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

[11] We do not explicitly introduce shocks to non-labor income. This model assumes couples pool non-labor income and decide how to allocate it according to the sharing rule. This is also the assumption that existing studies using collective models usually make. Given this assumption of non-labor income pooling, shocks to non-labor income

Wages contain three components: expected wages $\overline{w}_{it}^{f}$ and $\overline{w}_{it}^{m}$, which are perceived by both partners; permanent shocks, δ_{it}^{f} and δ_{it}^{m}, which are unexpected wage, but once the shocks occur, both partners know the shocks are permanent; transitory shocks, v_{it}^{f} and v_{it}^{m}, which are also unexpected, but both partners know their influences are temporary.[12] It is 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), thus may have different effects on household labor supply.

Under the assumption of Pareto efficiency, the weighted maximization of household utility functions in equation (1) can be decentralized, given a lump sum income transfer (sharing rule). The maximization problem can be formulated as individual utility maximization:

$$
\begin{aligned}
&\max U_{it}^{j}(1 - h_{it}^{j}, c_{it}^{j}) \\
&\text{s.t. } c_{it}^{j} \le \left(\overline{w}_{it}^{j} + \delta_{it}^{j} + v_{it}^{j}\right)h_{it}^{j} + \psi_{it}^{j}, \qquad j = f, m \\
&\psi_{it}^{f} = \psi_{it},\ \psi_{it}^{m} = y_{it} - \psi_{it} \qquad (2)
\end{aligned}
$$

where ψ_{it}^{f} is the amount of non-labor income allocated to the wife, and ψ_{it}^{m} is the remaining amount, allocated to the husband.

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 to him or her:

$$
\begin{aligned}
h_{it}^{f} &= h_{it}^{f}(\overline{w}_{it}^{f} + \delta_{it}^{f} + v_{it}^{f}, \psi_{it}) \\
h_{it}^{m} &= h_{it}^{m}(\overline{w}_{it}^{m} + \delta_{it}^{m} + v_{it}^{m}, y_{it} - \psi_{it}) \qquad (3)
\end{aligned}
$$

3.2. Sharing Rule

We specify a sharing rule that incorporates permanent and transitory wage shocks. Wage shocks not only affect one's own labor supply through budget constraint by the standard income and substitution effect, but also affect spousal labor supply through the outcome of this intra-

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and the non-stochastic non-labor income enter the decision weight and 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.

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

household sharing. The sharing rule is specified as a function of husbands' and wives' expected wages, permanent shocks, transitory shocks, pooled income which is the non-labor income net of savings, and a vector of distribution factors z, which are environmental factors that do not affect preferences but affect the sharing rule.[13]

$$\psi_{it} = \psi(y_{it}, \overline{w}_{it}^{f}, \delta_{it}^{f}, v_{it}^{f}, \overline{w}_{it}^{m}, \delta_{it}^{m}, v_{it}^{m}, z_{it}) \tag{4}$$

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 (e.g., Blundell et al. 2007), under the assumption that changes in this non-stochastic wage component may affect the bargaining power in the household. What is new in our model is that we allow unexpected shocks to affect the outcome of the sharing rule in a different way than the expected wage, as the response to shocks could reflect how couples share risks. In addition, we also allow permanent shocks and transitory shocks to affect intra-household insurance differently. Existing studies on insurance against income shocks provide mixed evidence on whether there exists more insurance to permanent shocks than 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. We specify local sex ratio and divorce law index as two distribution factors, as in Chiappori et al. (2002). Such distribution 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.

3.3. Specification of the labor supply function and the sharing rules

We specify log-linear functional form for the Marshallian labor supplies as in equation (5) below. Since the outcome of the sharing rule could be a negative value (i.e., when husband not only transfers all the non-labor income, but also part of his own earnings to the wife), we do not impose the logarithm on the sharing rule and specify a linear function as in equation (6):

[13] The outcome comes from this sharing rule could be larger than the total amount of non-labor income, in which case the husband not only transfers all the non-labor income, but also transfers part of his 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.

$$logh_{it}^{f} = \alpha_0 + \alpha_1 logw_{it}^{f} + \alpha_2 \psi_{it}$$

$$logh_{it}^{m} = \beta_0 + \beta_1 logw_{it}^{m} + \beta_2 (y_{it} - \psi_{it}) \quad (5)$$

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

where log wage can be decomposed into expected wage, permanent shock and transitory shock:

$$logw_{it}^{j} = \overline{w}_{it}^{j} + \delta_{it}^{j} + v_{it}^{j}, j = f, m \quad (7)$$

The choice of functional form is not arbitrary. It can be shown that the above labor supply specifications imply a well-defined indirect utility functions and a Pareto weight in the planner's problem (1) that maps one-to-one to the sharing rule in the decentralized problem (2). The Pareto weight has an exponential expression which 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.[14]

3.4. Identification of the sharing rules when both spouses work

From observed labor supply, one can uncover the unobserved sharing rule, up to an additive constant (Chiappori 1988, 1992). Substituting sharing rule (6) into Marshallian labor supply functions (5) yields the corresponding reduced-form labor supply functions, when both partners are working:

$$logh_{it}^{f} = a_0 + a_1 y_{it} + a_2 \overline{w}_{it}^{f} + a_3 \overline{w}_{it}^{m} + a_4 \delta_{it}^{f} + a_5 \delta_{it}^{m} + a_6 v_{it}^{f} + a_7 v_{it}^{m} + a_8 z_{1i} + a_9 z_{2i}$$

$$logh_{it}^{m} = b_0 + b_1 y_{it} + b_2 \overline{w}_{it}^{f} + b_3 \overline{w}_{it}^{m} + b_4 \delta_{it}^{f} + b_5 \delta_{it}^{m} + b_6 v_{it}^{f} + b_7 v_{it}^{m} + b_8 z_{1i} + b_9 z_{2i} \quad (8)$$

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

$$k_1 = \frac{a_1 b_8}{\Delta}, k_2 = \frac{a_8 b_2}{\Delta}, k_3 = \frac{a_3 b_8}{\Delta}, k_4 = \frac{a_8 b_4}{\Delta}, k_5 = \frac{a_5 b_8}{\Delta}, k_6 = \frac{a_8 b_6}{\Delta}, k_7 = \frac{a_7 b_8}{\Delta}, k_8 = \frac{a_8 b_8}{\Delta}, k_9 = \frac{a_9 b_8}{\Delta} \quad (9)$$

where $\Delta = a_1 b_8 - a_8 b_1$. Only the constant k_0 in the sharing rule is not identified. The Pareto efficiency assumption also generates the following restrictions (10) and (11):

$$\frac{a_8}{a_9} = \frac{b_8}{b_9} \quad (10)$$

[14] Derivation is available upon request.

$$\frac{a_8}{b_8} = \frac{a_4 - a_2}{b_4 - b_2} = \frac{a_5 - a_3}{b_5 - b_3} = \frac{a_6 - a_2}{b_6 - b_2} = \frac{a_7 - a_3}{b_7 - b_3} \tag{11}$$

Since wage is decomposed into three components (i.e., expected wage, permanent shocks, and transitory shocks), the effect of wage shocks on the sharing rule is allowed to be different than that of the expected wages. As the sharing rule also enters labor supply functions, these wage components could have different effects on labor supply. Nonetheless, the Pareto efficiency assumption imposes restrictions on these effects. Equation (10) is the Distribution Factor Proportionality property (Chiappori et al. 2002). The effect of a distribution factor on labor supply is the product of an income effect (the effect of sharing rule on labor supply) and a bargaining effect (the effect of distribution factor on the sharing rule). The bargaining effect is the same for husbands and wives (with opposite sign) determines the restriction equation (10). Since the distribution factors only affect both spouses' labor supply through the sharing rule, the effect of distribution factor z_{1i} versus z_{2i} on the wife is proportional to the effect of z_{1i} versus z_{2i} on the husband.

Equation (11) is a specific restriction in our model due to the fact that expected wages are separated from wage shocks, and wage could have both bargaining effect and marriage insurance effect. The expected wage and wage shocks affect labor supply through the standard income and substitution effect, as well as through the sharing rule. This restriction also suggests that the bargaining effect limits the transmission of the marriage insurance effect. For example, the first segment of the equation, $\frac{a_8}{b_8} = \frac{a_4 - a_2}{b_4 - b_2}$, suggests that the insurance effect coming from the permanent wage shocks cannot be much larger than the bargaining effect from the expected wage, as the effect needs to be proportional to the bargaining effect coming from the distribution factor.

3.5. Identification of the sharing rules when one spouse does not work

Our model not only looks at how a couple respond to each other's wage shocks when both of them participate in the labor market, but also considers how one adjusts work hours when his or her spouse does not work. The basic identification strategy follows Donni (2003) and Blundell et al. (2007): the sharing rule switches when one of the partners changes his or her participation. By doing so, we reexamine the "added worker effect" through looking at whether a wife changes labor supply when her husband does not work, or vice versa, whether a husband changes labor supply when his wife does not work. In addition, we examine whether a household changes rule of resource sharing when one of the spouses does not work.

We explain the model by taking husband's non-working status as an example. When the husband is working, his wage affects both household budget constraint and the sharing rule. When he is not working, his "potential" wage - what he could have earned - no longer affects the household budget constraint, but still affects the sharing rule.[15] Donni (2003) and Blundell et al. (2007) show that the reservation wage is characterized by "double indifference": at the wage when one partner is indifferent between working and not working, Pareto efficiency of household decisions requires that the spouse must be indifferent as well.[16] Both studies discuss that the uniqueness of reservation wage does not come from the theoretical model, but need to be explicitly assumed. The assumption *R1* from Donni (2003) provides the condition that ensures the uniqueness of the reservation wage. The reservation wage, defined as the marginal rate of substitution between labor supply and consumption, is a contraction mapping with respect to wage. The intuition of this assumption is that the impact of wage on the sharing rule is small enough.

Our model incorporates wage shocks and imposes additional assumptions: when the husband is not working, the sharing rule no longer depends on the husband's transitory wage shocks. Since the magnitude of the shock is not observed by the wife, all that matters is that he stops working. On the other hand, his expected wage and permanent shocks still affect the sharing rule. The husband's expected wage is always observed by the wife, and in practice, can generally be estimated by an auxiliary equation. The husband's permanent shocks can be identified from other periods while he is working, as long as the husband is not out of work for the entire sample period.

Denote the sharing rule in the male non-participation set as ψ_f^{NP}:

$$\psi_f^{NP} = K_0 + K_1 y_{it} + K_2 \overline{w}_{it}^f + K_3 \overline{w}_{it}^m + K_4 \delta_{it}^f + K_5 \delta_{it}^m + K_6 v_{it}^f + K_7 z_{1i} + K_8 z_{2i} \qquad (12)$$

[15] Note that this is a key difference between the collective model and the alternative unitary model: in the unitary model a household can be viewed as a single decision maker, and the weight does not depend on prices such as wage. 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 a non-working member could affect bargaining positions, such as the threat point.

[16] 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.

As Marchallian labor supply is a function of one's wage rate and the sharing rule, a switch in sharing rule implies a switch in the reduced-form labor supply:[17]

$$logh_{it}^{f} = A_0 + A_1 y_{it} + A_2 \overline{w}_{it}^{f} + A_3 \overline{w}_{it}^{m} + A_4 \delta_{it}^{f} + A_5 \delta_{it}^{m} + A_6 v_{it}^{f} + A_7 z_{1i} + A_8 z_{2i} \quad (13)$$

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

$$h_{it}^{fNP} = h_{it}^{f} + s_f h_{it}^{m} \quad (14)$$

where s_f is a scalar to be estimated. Along the male participation frontier, the last term in equation (14) becomes 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:

$$\psi_f^{NP} = \psi_{it} + q_f h_{it}^{m} \quad (15)$$

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_f and q_f can be derived from equations (6), (14) and (15). The derivation of the following equation (16) can be found in the Appendix:

$$q_f = \frac{s_f b_8}{\Delta} \quad (16)$$

Parameters *K*s, the partial derivatives of the sharing rule on the male non-participation set, can be identified via (12) and (13). Only the constant K_0 is not identified.

Similarly, a switching regression also applies to the situation where husband works and wife does not work. The corresponding equation for (14) and (15) become:

$$h_{it}^{mNP} = h_{it}^{m} + s_m h_{it}^{f} \quad (17)$$

$$\psi_m^{NP} = \psi_{it} + q_m h_{it}^{f} \quad (18)$$

And the relation between s_m and q_m is:

[17] Since the sharing rule does not depend on the husband's transitory shocks, female labor supply as a function of the sharing rule does not depend on the husband's transitory shocks either.

$$q_m = \frac{s_m a_8}{\Delta} \quad (19)$$

3.6. Further discussions of the model

Several restrictions have been imposed for tractability of the model. First, our model does not incorporate intertemporal decisions such as the level of commitment, risk preference, or marital dissolution. Mazzocco and his coauthors have recently developed a series of intertemporal collective models which address these issues (Mazzocco 2004; Mazzocco 2007; Mazzocco et al. 2007), though most of these studies take labor supply as exogenous, with the exception of Mazzocco et al. (2007). We acknowledge that our sample is restricted to the most committed families, which might overestimate individuals' willingness to insure against spouse's shocks in the population.[18] Second, this model implicitly assumes that individuals can adjust labor supply freely. In reality, though, work 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. Third, we do not model external insurance for wage shocks hence do not examine the interaction between social insurance programs such as an unemployment benefit and intra-household insurance. Adding external insurance could result in an adverse selection problem.[19] Last but not least, as in other existing collective models, our model does not make distinction between non-participation and unemployment.[20] As discussed in Bloemen (2010), introducing fixed costs of work or demand side conditions will cause difficulty in developing an empirical model that is continuous around the participation frontier.

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

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[18] Some studies examine the consequence of job loss on marriage. For example, Eliason (2012) finds that husband's job loss increases risk of divorce by 13% using Swedish data. Doiron and Mendolia (2012) also find that couples are more likely to divorce when the husband experiences a job loss, using British Household Panel Survey.

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

[20] Our model incorporates both male non-working and female non-working cases. There are 23.6% of the sample which wife does not work and husband works. Most of these cases are likely to be a participation choice rather than involuntary unemployment.

4. Data

This study uses the Survey of Income and Program Participation (SIPP) 2004 panel, a national representative longitudinal dataset that provides comprehensive information about the income and program participation of individuals and families in the United States. One unique advantage of SIPP is that it interviews three times a year, hence provides high frequency wage and hours information.[21]

The SIPP 2004 panel consists of 12 waves from February 2004 to January 2008. Our sample includes married couples with husbands and wives 20-64 years old. Excluded are households who have children under 18 years old, because the model does not account for home production or public consumption, which is likely to change with the number of children. Our final sample includes 10,857 households with 75,664 household-wave observations.[22] Income and wage variables are deflated to January 2004 dollars using the Consumer Price Index Research Using Current Methods Series (CPI-U-RS).[23]

We use wage data purged of measurement error, as in Gottschalk (2005).[24] Under the assumption that nominal wages adjust in discrete steps while working for the same employer, Gottschalk (2005) identifies the structural breaks in individual wage series and separates the effect of measurement error from that of true changes in wages.

The dependent variable is total hours of work in each wave (four months). Household non-labor income includes property income, transfer income, other unearned income, and is net of total household savings. Savings is constructed by taking the difference between net wealth in period t and t-1. Information on net wealth is available only in the 3rd and 6th wave of the SIPP 2004 panel. We use linear interpolation to fill in for the remaining waves.

The local sex ratio is constructed using the 2004-2008 American Community Survey (ACS) from the Public Use Microdata Sample (IPUMS). The ratio corresponds to the number of

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[21] SIPP also contains monthly data on wage ad labor supply. However, monthly data have the well-documented seam bias problem (Gottschalk 2005, among others). Respondents are more likely to report a wage change between interviews instead of within an interview period.

[22] We do not have a balanced panel due to sample attrition, and people who are over 64 years old at any point in the panel are also dropped out of our sample. The SIPP documentation suggests that the loss rate for SIPP 2004 Panel is 36.6 percent by the end of wave 12. The rate of sample loss in SIPP is usually high in wave 2, then with a lower rate of attrition at each subsequent wave. (http://www.census.gov/sipp/usrguide/ch2_nov20.pdf)

[23] We use the deflator from http://www.census.gov/hhes/www/income/income05/cpiurs.html.

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

unmarried males of the same age as husband divided by the number of unmarried males and unmarried females of the same age, for each state and each one of the three racial groups (white, black, other). This sex ratio represents the tightness of the local marriage market, under the assumption that people married within their own racial group. We also experiment with alternative definitions of sex ratio, such as the ratio including both married and unmarried individuals, or by same age group (20-24, 25-29, etc.) instead of same age. The other distribution factor, divorce law index, considers four of the following features of divorce legislation in each state: property division, mutual consent versus unilateral divorce, contribution to education, and non-monetary contribution.[25] This index is an indicator of the extent to which state divorce laws are favorable to women. All four features did not change over time within states during our sample period. Table 2 presents the summary statistics of main analysis variables. **<Insert table 2 here>**

5. Empirical specification and results

5.1. Wage decomposition and estimates of permanent and transitory wage shocks

Our wage decomposition takes three steps: (1) estimate expected wage using Mincer regression; (2) estimate parameters in an error component model with permanent and transitory shocks; and (3) identify individual permanent and transitory shocks in each period.

We first obtain expected wage $\overline{w}_{it}^{j}$ *(j=f, m)* from the predicted value of first-stage Mincer regressions for each period. The dependent variable is the log wage rate, and independent variables include age, age square, four education dummies (high school diploma, some college, college degree, graduate school) with omitted category of no high school degree, and education dummies that interact with age, all with time-varying coefficients. These education-time and age-time interactions are excluded when estimating wife and husband's labor supply functions, thus they serve as the exclusion restrictions for labor supply equations.[26]

After we obtain wage residuals from the first stage regression, we estimate an error component model for which permanent and transitory wage shocks evolves. We specify an error

[25] From Family Law Quarterly, Winter 2003, Winter 2004, Winter 2005, Charts 4 and 5.

[26] The intuition of identification 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).

component model following Moffitt and Gottschalk (2012): permanent shocks δ_{it}^{j} consists of an individual time-unvarying component with time-varying loading factor, and transitory shocks v_{it}^{j} follow an ARMA (1,1) process:

$$\delta_{it}^{j} = \gamma_t^j \mu_i^j;\ v_{it}^{j} = \rho^j v_{i,t-1}^{j} + \xi_{it}^{j} + \theta^j \xi_{i,t-1}^{j} \quad j = f, m \tag{20}$$

Loading factors γ_t^j is usually interpreted as aggregate skill prices on human capital in the covariance structural model on earnings (For example, Haider 2001; Hyslop 2001, Moffitt and Gottschalk 2012).[27] They measure aggregate shocks. We distinguish aggregate shocks between men and women, so that couples can insure against each other's aggregate shocks to skill prices. We estimate parameters γ_t^j, ρ^j, θ^j, σ_μ^j and σ_ξ^j using Minimum Distance Estimation method.

In the third step we identify individual component of permanent and transitory shocks by regressions for each individual. The identification comes from the assumption that individual permanent component μ_i^j is time invariant, thus it can be treated as a fixed coefficient.

$$\hat{e}_{it}^{j} = \mu_i^j \hat{\gamma}_t^j + v_{it}^{j} \quad j = f, m \tag{21}$$

where $\hat{e}_{it}^{j}$ is the residual after the first stage Mincer regression on log wage and $\hat{\gamma}_t^j$ comes from estimation of the error component model. Now $\hat{\gamma}_t^j$ becomes an independent variable rather than a parameter, and this regression produces estimated coefficient $\hat{\mu}_i^j$. Permanent shocks are computed as $\hat{\mu}_i^j \hat{\gamma}_t^j$, and transitory shocks are simply the difference between wage residuals for each period and permanent shocks. The estimated permanent and transitory shocks are shown at the bottom of Table 2. [28]

[27] There is also a debate in empirical research on returns to education and wage inequality that whether the movements reflect changes in skills prices (such as price differential between college and high school), or changes in the composition of college and high school graduates (such as from increasing enrollment in college and people self-selected to college). Some studies decompose these two effects (Carneiro and Lee, 2009). In this article we are not trying to distinguish or decompose these effects. Rather, we simply allow aggregate movements to differ from individual movements, and distinguish shocks to male and females so that couple can insure for this aggregate risk.

[28] The variance for transitory shocks is comparable with existing studies. For example, in Moffitt and Gottschalk (2012), the variance of transitory shocks is between 0.15 and 0.2 for male log annual (their Figure 3), for male age 30-59 in the early 2000s using the PSID. The variation in permanent shocks is a bit larger than existing studies, and the main reason is that the estimates of permanent shocks come from individual regressions of up to 12 observations. The small sample size could cause a larger variation.

5.2. Joint estimation of labor supply functions

We estimate husbands and wives' labor supply functions jointly and recover unobserved sharing rules that allocate non-labor income. Following Chiappori et al. (2002), we define non-labor income as unearned income net of savings.[29] We treat savings as endogenous with measurement error, and instrument it using the home price index interacted with homeownership and birth cohort dummies.[30] Control variables in the savings equation include both partners' four education dummies (same as in wage regression) and a quadratic in age.[31] Table 3 presents estimates of savings regression. The mean and standard deviation of predicted savings are shown in Table 2. Predicted savings is included in the labor supply functions. **<Insert table3 here>**

The theoretical model does not incorporate unobserved heterogeneity, as introducing unobserved heterogeneity with non-participation would raise the issue of whether the model is identified from the available data (Blundell et al. 2007). Following existing studies using collective models with nonparticipation, we specify labor supply functions with additives in the heterogeneity terms. A joint estimation of household labor supply when both partners work nonzero hours (equation 8) and female or male labor supply when spouse does not work (equations 14 and 17), suggest the following switching regression model:

$$\log\ h_{it}^{f*} = a'x_{it} + u_{it}^{f} + \left(1 - I(h_{it}^{m*} > 0)\right)s_f(b'x_{it} + u_{it}^{m})$$
$$\log\ h_{it}^{m*} = b'x_{it} + u_{it}^{m} + \left(1 - I\left(h_{it}^{f*} > 0\right)\right)s_m\left(a'x_{it} + u_{it}^{f}\right) \tag{22}$$

where $h_{it}^{j*}(j = f, m)$ is a latent variable representing the desire to work. $I(h_{it}^{j*} > 0)$ is an indicator for whether participate.

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 the household, and

[29] Excluding savings from non-labor income is consistent with a two-step budgeting process such as in Blundell and Walker (1986). In our model, at the beginning of a marriage, a couple optimally allocate life-cycle wealth for each period according to expected wage shocks; in the second stage, when shocks are realized in each period, a couple allocate non-labor income, net of savings, according to the sharing rule.

[30] Lise and Seitz (2011) use similar instruments. Housing price index quarterly data by state can be found at: http://www.ofheo.gov/hpi_download.aspx.

[31] Due to large variation in savings data, we run regression by trimming the top and bottom five percent, but predict savings for the entire sample.

time dummies. u_{it}^{f} and u_{it}^{m} are unobserved preference shocks to leisure, and we allow them to be correlated and follow a joint normal distribution. The participation condition is:

$$\log\ h_{it}^{j} = \begin{cases} \log\ h_{it}^{j*}\ if\ h_{it}^{j*} > 0 \\ 0\ \text{otherwise} \end{cases} \quad j = f, m \tag{23}$$

Equation (22) and (23) are estimated using Full Information Maximum Likelihood (FIML).[32] The likelihood function is provided in the Appendix.

The double switching model may general multiple outcomes for husband and wife's participation. Bloemen (2010) derives the sufficient condition for the coherence of the model. This condition also applies to our model: $|s_m s_f| < 1$.

5.3. Estimates of reduced-form household labor supply functions

Table 4 presents FIML estimates of reduced-form female and male labor supply functions. Standard errors have been bootstrapped to account for the fact that wage components and savings are predicted. Male expected wage has a positive effect on spousal labor supply. A 1% increase in male expected wage, due to the observed changes in age and education, tends to increase female labor supply by 1.51%. This positive effect is consistent with collective labor supply literature (Blundell et al. 2007, for example). A 1% increase in female expected wage tends to increase male labor supply by 0.28%, but the effect is not statistically significant. **<Insert table 4 here>**

Wife's wage shocks, either permanent or transitory, do not have a significant effect on husband's labor supply. Husband's wage shocks, on the other hand, have significant positive effect on wife's labor supply. The estimate of ρ, correlation between couples unobserved shocks to leisure, is insignificant.

The estimates of s_m and s_f, which determine the labor supply when the spouse does not work, satisfy the coherence constraint $|s_m s_f| < 1$. The estimate of s_f is insignificant and is close to zero, while s_m is much larger and significant. As will be discussed later, the close to zero

[32] We acknowledge that using predicted regressors in the FIML may yield biased estimates due to measurement error. Therefore, our estimates serve as a lower bound of the true estimates. The advantage of using FIML, versus alternative estimation method such as non-linear GMM, is that FIML allows for full distribution assumption of error terms. Other empirical studies on collective labor supply with nonparticipation also use FIML (for example, Blundell et al. 2007; Bloemen 2010).

estimate of s_f causes sharing rule with only-wife-working to be very similar to the estimates of sharing rule for dual earners.

Our set of instruments has good predictive power in the wage equations and the savings equation. Instruments are all jointly statistically significant at the 1% level. The F-statistic is 18.1 for the male wage equation, 20.4 for the female wage equation, and 171.2 for the savings equation. These F-statistics are all larger than 10, suggesting instruments are sufficiently strong.

5.4.Test the hypothesis of collective model and the alternative unitary model

To see whether our empirical results are consistent with the hypothesis of collective model, we test the restrictions implied by the collective model and the alternative unitary model. The unitary model, where household members act as a single decision maker, is presented in the Appendix. Testing restrictions for the collective model are presented in equations (10) and (11). The Wald statistic from a joint test is 5.18 with a p-value of 0.39, which indicates that the collective hypothesis cannot be rejected at any conventional significant level. Testing the restrictions for the unitary model, equations (35) - (37), yields a statistic of 19.03 and p-value of 0.004. This indicates that the unitary model can be rejected at one percent level. In summary, the collective model could not be rejected while the unitary model could. These test statistics provide support for the collective hypothesis.[33]

5.5. Estimates of the collective model parameters and sharing rules

Based on estimates from reduced-form labor supply functions, we recover the Marshallian labor supply (equation 5) up to an additive constant. Table 5 presents the structural female and male Marshallian labor supply estimates. The income effect (as shown in Table 5 of estimated coefficients on sharing rule) is small and significant for male labor supply (-0.001), and the negative sign suggests that male leisure is a normal good. The income effect on female labor supply is also small (0.001). Both male and female own wage effects are positive. The implied wage elasticity is 2.183 for females and 0.738 for males. **<Insert table 5 here>**

When the husband and the wife are both working, the household transfers a larger amount to the husband when he gets an adverse wage shock. The first two columns of Table 6 present estimates of the sharing rule for dual earners. When the husband's hourly permanent wage goes

[33] We acknowledge that our test statistics for the unitary and the collective model could be underestimated due to the potential measurement error by using predicted regressors in the FIML.

down by 1%, wife's share of non-labor income from intra-household allocation drops by $400, which means husband's share of non-labor income increases by $400. A 1% decrease in husband's transitory wage results in an increase in the husband's share of non-labor income of $433. These effects are not significant (the p-value is 0.11 for male permanent shock and 0.12 for male transitory shock). The reallocation of non-labor income between the husband and the wife compensates for the husband's wage loss, thus he is able to maintain a smoother consumption profile through the reallocation. At the same time, as wife's share of non-labor income increases, her labor supply thus her earnings also increases. Such adjustment in labor supply stabilizes household earnings over time and a smoother consumption profile is obtained. Test of equality of permanent and transitory wage shock suggests that permanent and transitory wage shocks do not differ significantly in their effects on the sharing rule. **<Insert table 6 here>**

The effects of female wage shocks on sharing rule are insignificant, and do not provide evidence of income and consumption smoothing. As presented in the stylized facts in section 2, married women have higher fluctuation in labor supply than single women, but married men do not have higher labor supply fluctuation than single men. The asymmetric response from husband and wife in our collective model estimation is consistent with this stylized fact, that when husband get a negative wage shock, wife will adjust labor supply to compensate for his wage loss, but no evidence of such effect from husband's labor supply.

Comparing the estimates of non-labor income across sharing rules with different working status provides further evidence of compensation to the spouse in adverse event: the wife gets more non-labor income when she does not work. Table 6 presents three sets of sharing rules: when both partners work, when wife works but husband does not, and when husband works but wife does not. The estimates of non-labor income in the sharing rule shows that, for each one dollar of the non-labor income, the wife keeps 70 cents when she does not work, compared with 20 cents when she works. This provides further evidence of consumption smoothing, that the wife keeps more non-labor income when she has no earnings to consume. Such added worker effect is not found in the estimate of non-labor income when the husband does not work.

When the husband is out of work, the sharing rule is very similar to dual earner's sharing rule. In contrary, when the wife is out of work, the sharing rule changed significantly. This is mainly due to the small value of q_f and large value of q_m. This pattern is also found in Bloemen (2010), where they use data in Netherlands in 1990 to 2011 and do not distinguish between expected wage and wage shocks. They interpret the result as the reservation wage of men is usually low with little variation. This interpretation also applies to U.S. data.

When the wife is out of work, a drop in husband's permanent or transitory wage shock is no longer compensated with additional non-labor income, as the wife is not increasing her labor supply to compensate for his wage loss. On the other hand, a 1% decrease in wife's permanent wage shock, measured by wage loss from other periods when she is working, increases her share of non-labor income by $3,143. As a result the husband increases his labor supply by about 3.1%. Again, a smoother consumption profile is achieved both through reallocation of non-labor income between husband and wife, and an increase of spousal labor supply which reduces household earnings instability.

The increase of female expected wage increases the proportion of household pooled income allocated to the wife when both partners work or husband does not work, though the result is not precisely determined. Higher expected wage increases wife's bargaining power within the household, thus she could obtain more resources from intra-household allocation. These results are also found in other empirical collective labor supply studies, such as Blundell et al. (2007).

6. Examine the role of intra-household insurance on income instability

According to the stylized facts presented in Section 2, household earnings instability is lower than individual earnings instability for married couples, and household earnings instability for married couples, who might have an intra-household insurance mechanism, is lower than that of singles that would not have an intra-household insurance mechanism. Do empirical results from our intra-household insurance model provide consistent explanation to the stylized facts? In this section we conduct the following two exercises: First, we recalculate transitory variances of log household earnings and log individual earnings, given the structural responses of labor supply to both partners' transitory shocks from the model. Second, we calculate the same variances but without any structural response of intra-household insurance, and compare the result with the first exercise, which incorporates insurance. The difference between the variance with and without insurance explains what proportion of earnings instability is due to intra-household insurance through joint labor supply decisions.[34]

Estimation of our model provides partial derivatives of labor supply with respect to wage shocks. To take these structural responses into account, we use Taylor expansion to derive earnings as a function of partial derivatives with respect to husbands' and wives' wage shocks. Derivations are presented in the Appendix. Then, we calculate the variance of the Taylor expansions for log household earnings and log individual earnings. From expressions in equations (39) - (41), the variances of individual earnings or household earnings depend on estimated parameters in the sharing rule and Marshallian labor supply functions, estimates of transitory wage shocks, and observed labor supply. Substituting these estimates, the first row of Table 7 presents estimated earnings instability: log earnings instability is 0.098 for married men and 0.089 for married women; both are higher than married couples' household earnings instability, 0.066. This lower household earnings instability is consistent with the stylized facts presented at the beginning of this article. The magnitude differs from stylized facts though. One difference is that stylized facts in Table 1 include all couples, with and without children, while our collective model estimation and thus the exercise in this section excludes couples with children. Another reason for the discrepancy is that in this exercise as well as in the model, we 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, wife may switch to a job with a higher wage in response to her husband's adverse wage shock, in which case we observe that wife has a positive wage shock. **<Insert table 7 here>**

In the second exercise, we calculate the transitory variance in log individual or household earnings with and without intra-household insurance. The result in the first row, as discussed in the first exercise, is the result that with intra-household insurance from collective labor supply model. Without intra-household insurance, wage shocks no longer affect intra-household allocation. Therefore, the term k_6, k_7 in equation (39) and (41) becomes zero. Now the log individual earnings instability is recalculated as 0.108 for married men and 0.091 for married women, while married couples' log household earnings instability becomes 0.068. Compared to

[34] Note our exercise in this section is based on estimates with dual earner couples only. The estimates of the sharing rule and labor supply functions are available upon request.

the results with insurance, this suggests that intra-household insurance to transitory shocks reduces household earnings instability by 2.9%. It also reduces individual earnings instability by 9.3% for married men and 2.2% for married women. These numbers may seem to be small. However, given that the earnings instability is mainly driven 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 instability is lower than individual earnings instability, and earnings instability for those who have intra-household insurance mechanism are lower for those who do not.

7. Conclusion

The literature on insurance for income shocks either focus on consumption smoothing via savings decisions, or focused on one-sided labor supply response. This article develops a new intra-household insurance model and examines the link between income instability and household labor supply decisions. Using the SIPP 2004 panel, we provide new findings on the degree of intra-household insurance with respect to each other's wage shocks.

We find some evidence of household smoothing: When both spouses are working and the husband gets an adverse wage shock, he is compensated with additional non-labor income and the wife increases her labor supply. The wife gets more non-labor income when she is out of work. We do not find significant difference between the effect of permanent shocks and transitory shocks on the sharing rule. This article also contributes to the empirical studies using collective models by examining high-frequency data in the United States and expands the scope of the sharing rule to include permanent and transitory wage shocks.

Our analyses also provide aggregate implications on individual and household earnings instability. Intra-household insurance through labor supply reduces earnings instability by about two to nine percent. These results suggest that joint labor supply decisions provide an extra smoothing effect on shocks to earnings and household income.

Appendix

Derivation of Equation (16)

Based on Donni (2003) equation in his section 3.2.3 and our functional form, a partial differential equation that identifies the nonparticipation set gives:

$$A_1K_3=K_1A_3 \tag{24}$$

From equation (14) we have $A_1=a_1+s_fb_1$, and $A_3=a_3+s_fb_3$. From equation (15) we have $K_3=k_3+q_fb_3$, and $K_1=k_1+q_fb_1$. Plug these into the above equation (24) together with the expression of k_3 and k_1 derived from equation (9), we have:

$$\left(a_1+s_fb_1\right)\left(\frac{a_3b_8}{\Delta}+q_fb_3\right)=\left(\frac{a_1b_8}{\Delta}+q_fb_1\right)\left(a_3+s_fb_3\right) \tag{25}$$

This can be further simplified to equation (16): $q_f=\frac{s_fb_8}{\Delta}$.

Derivation of likelihood function

This section derives log likelihood function for male and female labor supply when both partners are working, and female labor supply when husband is out of work. Assume preference shocks u_{it}^f and u_{it}^m in labor supply function (equation 22) follow a joint normal distribution with zero mean and the following covariance matrix:

$$\begin{pmatrix} \sigma_f^2 & \rho\sigma_f\sigma_m \\ \rho\sigma_f\sigma_m & \sigma_m^2 \end{pmatrix} \tag{26}$$

The log-likelihood function takes the form:

$$\mathcal{L}=\sum_{i\in P}log\mathcal{L}_i(h^f,h^m)+\sum_{i\in fNP}log\mathcal{L}_i(h^f)+\sum_{i\in mNP}log\mathcal{L}_i(h^m)+\sum_{i\in fmNP}log\mathcal{L}_i(h^f=0,h^m=0) \tag{27}$$

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

$$\mathcal{L}_i=\frac{1}{\sigma_f\sigma_m}\phi\left(\frac{h^f-a'x}{\sigma_f},\frac{h^m-b'x}{\sigma_m},\rho\right) \tag{28}$$

where ϕ is the density function of standard normal distribution.

The likelihood function in the male non-participation set is different. First, based on equation (14), the error term in female labor supply function when husband does not work is now $u_{it}^f+s_fu_{it}^m$. This suggests the upper left element in the covariance matrix is $\sigma_f^2+2s_f\rho\sigma_f\sigma_m+s_f^2\sigma_m^2$.

The covariance between $(u_{it}^{f} + s_f u_{it}^{m})$ and u_{it}^{m} is $\rho\sigma_f\sigma_m + s_f\sigma_m^2$. Therefore, the covariance matrix becomes:

$$\begin{pmatrix} \sigma_f^2 + 2s_f\rho\sigma_f\sigma_m + s_f^2\sigma_m^2 & \rho\sigma_f\sigma_m + s_f\sigma_m^2 \\ \rho\sigma_f\sigma_m + s_f\sigma_m^2 & \sigma_m^2 \end{pmatrix} \tag{29}$$

The likelihood in male nonparticipation set becomes:

$$\mathcal{L}_i = \frac{1}{\sigma_{v_f}}\phi\left(\frac{h^f - a'x - s_f b'x}{\sigma_{v_f}}\right)\Phi\left(\frac{-\frac{b'x}{\sigma_m} - r_f\frac{h^f - a'x - s_f b'x}{\sigma_{v_f}}}{\sqrt{1-r_f^2}}\right) \tag{30}$$

where Φ stands for the cumulative distribution function of standard normal distribution, σ_{v_f} is abbreviation for the square root of the upper left element in covariance matrix, and r_f is the correlation parameter in the nonparticipation set $\left(\frac{\rho\sigma_f + s_f\sigma_m}{\sigma_{v_f}}\right)$.

Similarly, the likelihood in female nonparticipation set becomes:

$$\mathcal{L}_i = \frac{1}{\sigma_{v_m}}\phi\left(\frac{h^m - b'x - s_m a'x}{\sigma_{v_m}}\right)\Phi\left(\frac{-\frac{a'x}{\sigma_f} - r_m\frac{h^m - b'x - s_m a'x}{\sigma_{vm}}}{\sqrt{1-r_m^2}}\right) \tag{31}$$

And the likelihood in the set where neither husband nor wife participates follows a bivariate normal distribution:

$$\mathcal{L}_i = \Phi\left(\frac{-a'x}{\sigma_f}, \frac{-b'x}{\sigma_m}, \rho\right) \tag{32}$$

Unitary Model

In this section we derive an alternative household decision model, the unitary model, which assumes that a household as a unit, rather than two individuals, makes decision and maximizes utility. The unitary model implies a different set of testable restrictions. In Section 5.4 we test hypothesis of both collective model and unitary model. There are two restrictions imposed on the unitary model without corner solution: income pooling restriction and Slutsky restrictions. The income pooling restriction assumes 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. The unitary model becomes:

$$\max_{h_{it}^f, h_{it}^m, c_{it}^m, c_{it}^f} U(1-h_{it}^f, 1-h_{it}^m, c_{it}^f, c_{it}^m)$$
$$s.t.\, c_{it}^f + c_{it}^m \leq w_{it}^f\, h_{it}^f + w_{it}^m\, h_{it}^m + y_{it} \tag{33}$$

Labor supply functions will be derived the same as in equation (8). Slutsky symmetry of compensated cross wage effects can be expressed as follows:

$$S_{fm}=S_{mf} \tag{34}$$

where $S_{ij} = \frac{\partial h^i}{\partial w^j} - h^j \frac{\partial h^i}{\partial y}, i, j = f, m$

Based on the Slutsky symmetry (34) and the labor supply functions (equation 8), we derive the following testable restrictions:

$$\begin{gathered} a_3 - a_1 b_0 = b_2 - b_1 a_0 \\ a_1 b_2 = a_2 b_1 \\ a_1 b_3 = a_3 b_1 \\ a_1 b_4 = a_4 b_1 \\ a_1 b_5 = a_5 b_1 \\ a_1 b_6 = a_6 b_1 \\ a_1 b_7 = a_7 b_1 \end{gathered} \tag{35}$$

In addition, nonparticipation generates another set of restrictions for the unitary model. In the collective model, when the husband is out of work, his potential wage still affects the sharing rule thus labor supply. In the unitary model, his potential wage no longer affects labor supply. This implies that the effect of male potential wage on female labor supply is zero, when the husband is out of work:

$$A_3 = 0 \Longrightarrow a_3 + s_f b_3 = 0 \tag{36}$$

Similarly, when the wife is out of work, we have:

$$b_3 + s_m a_3 = 0 \tag{37}$$

Derivation of Log Earnings as a Function of Both Partners' Wage Shocks

In this section, we use Taylor expansions to derive earnings as a function of the partial response to both partners' wage shocks. Based on the specification of the sharing rule in our model, the higher order derivatives of labor supply with respect to wage shocks all become zeros. The first order Taylor expansion for log male earnings is as follows:

$$\log(h^m\epsilon^m) = f(log\epsilon^m, log\epsilon^f)$$
$$= \log(h_0^m\epsilon_0^m) + \frac{\partial logh^m\epsilon^m}{\partial log\epsilon^m}(log\epsilon^m - log\epsilon_0^m) + \frac{\partial logh^m\epsilon^m}{\partial log\epsilon^f}\left(log\epsilon^f - log\epsilon_0^f\right) \tag{38}$$

where ϵ^f and ϵ^m are transitory components of female and male unlogged wage respectively, thus $log\epsilon^m$ is equivalent to v^m in equation (21). Take the variance of equation (38), the constant term on the right hand side drops out.

$$var[logh^m\epsilon^m] = 0 + var\left[\frac{\partial logh^m\epsilon^m}{\partial log\epsilon^m}(log\epsilon^m)\right] + var\left[\frac{\partial logh^m\epsilon^m}{\partial log\epsilon^f}(log\epsilon^f)\right]$$
$$= \left[\left(\frac{\partial logh^m}{\partial log\epsilon^m} + 1\right)^2 var(log\epsilon^m) - \frac{\partial logh^m}{\partial log\epsilon^f} var(log\epsilon^f)\right] = (\beta_1 - \beta_2 k_7 + 1)^2 v^m - (\beta_2 k_6)^2 v^f \tag{39}$$

where $\frac{\partial logh^m}{\partial log\epsilon^m}$ and $\frac{\partial logh^m}{\partial log\epsilon^f}$ are directly derived from labor supply functions (equation 5) and sharing rule (equation 6). All items on the right hand side can be computed using estimates from our model.

Similarly, Taylor expansion of log household earnings becomes:

$$\log(h^m\epsilon^m + h^f\epsilon^f) = f(log\epsilon^m, log\epsilon^f) = \log\left(h_0^m\epsilon_0^m + h_0^f\epsilon_0^f\right) + \frac{\partial\log(h^m\epsilon^m + h^f\epsilon^f)}{\partial log\epsilon^m}(log\epsilon^m - log\epsilon_0^m) + \frac{\partial log(h^m\epsilon^m + h^f\epsilon^f)}{\partial log\epsilon^f}\left(log\epsilon^f - log\epsilon_0^f\right) \tag{40}$$

Taking the variance of equation (40), variance of the constant terms becomes zero. Again substitute partial derivatives using the estimated coefficients from equation (5) and (6), the variance becomes:

$$
\begin{aligned}
var\left[\log\left(h^m\epsilon^m + h^f\epsilon^f\right)\right] &= var\left(\frac{\partial log(h^m\epsilon^m + h^f\epsilon^f)}{\partial log\epsilon^m} log\epsilon^m\right) + var\left(\frac{\partial log(h^m\epsilon^m + h^f\epsilon^f)}{\partial log\epsilon^f} log\epsilon^f\right) \\
&= var[\frac{1}{h^m\epsilon^m + h^f\epsilon^f}\left(\frac{\partial(h^m\epsilon^m + h^f\epsilon^f)}{\partial log\epsilon^m} log\epsilon^m + \frac{\partial(h^m\epsilon^m + h^f\epsilon^f)}{\partial log\epsilon^f} log\epsilon^f)\right] \\
&= var[\frac{1}{h^m\epsilon^m + h^f\epsilon^f}\left(\frac{\partial exp(logh^m\epsilon^m) + \partial exp(logh^f\epsilon^f)}{\partial log\epsilon^m} log\epsilon^m\right. \\
&\left. + \frac{\partial exp(logh^m\epsilon^m) + \partial exp(logh^f\epsilon^f)}{\partial log\epsilon^f} log\epsilon^f\right)] \\
&= var[\frac{1}{h^m\epsilon^m + h^f\epsilon^f}\left(h^m\epsilon^m(\beta_1 - \beta_2 k_7 + 1) + h^f\epsilon^f\alpha_2 k_7\right)log\epsilon^m \\
&+ \left(-h^m\epsilon^m\beta_2 k_6 + h^f\epsilon^f(1 + \alpha_1 + \alpha_2 k_6\right)log\epsilon^f\Big] \\
&= var\left[\frac{1}{h^m exp(v^m) + h^f \exp(v^f)}\left(h^m \exp(v^m)\,(\beta_1 - \beta_2 k_7 + 1)\right.\right. \\
&\left. + h^f \exp(v^f)\alpha_2 k_7\right) v^m + (-h^m \exp(v^m)\,\beta_2 k_6 + h^f \exp(v^f)(1 + \alpha_1 + \alpha_2 k_6)v^f]
\end{aligned}
\tag{41}
$$

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Table 1. Comparison of Transitory Variances for Married and Single Households

	Variance of transitory component		
	Log household earnings	Log household income	
Single males	0.129	0.113	
Single females	0.135	0.111	
Married couples	0.057	0.053	
Random matched singles	0.149	0.130	
	Log wage rate	Log earnings	Log hours
Single males	0.047	0.060	0.039
Single females	0.043	0.065	0.046
Married males	0.046	0.057	0.039
Married females	0.052	0.088	0.059

Source : Author's calculations from the Survey of Income and Program Participation 2004 panel.

Note : (1) Transitory variances are calculated as variances for each household or individual over the entire sample period, and then take the average across these households or individuals. (2) Sample includes individuals between 20 and 64 years old, who work positive hours with non-missing wages.

Table 2. Summary Statistics

Individual Characteristics	Female		Male	
	Mean	Std Dev	Mean	Std Dev
Hours of work	388.3	348.4	525.3	372.2
Hourly wage	13.6	14.1	20.3	25.5
Age	42.3	10.7	44.6	10.8
Years of education	18.6	6.1	19.2	5.9
Race is white	0.8	0.4	0.8	0.4
Household Characteristics	Mean		Std Dev	
Non-labor income	$1,938		$4,470	
Savings (predicted)	$11,172		$7,252	
Own home	0.79		0.41	
Marriage Market	Mean		Std Dev	
Sex ratio	0.49		0.05	
Divorce index	2.43		0.72	
Participation Status	Wife working		Wife not working	
Husband working	47.0%		23.6%	
Husband not working	14.8%		14.8%	
Log Wage Decomposition	Female		Male	
	Mean	Std Dev	Mean	Std Dev
Expected wage	2.233	0.382	2.698	0.315
Permanent Shocks	0.011	0.722	0.002	0.718
Transitory Shocks	0.000	0.250	0.001	0.249

Source: Author's calculations from the Survey of Income and Program Participation 2004 panel.

Table 3. Estimates of Savings Equation

	Coef	Std Err
House price	29.53***	1.16
Birth cohort dummy 1 (born between 1950-59)	-5418.7***	1001.35
Birth cohort dummy 2 (born between 1960-69)	-8769.8***	1513.30
Birth cohort dummy 3 (born between 1970-79)	-8645.8***	1961.50
Husband's race is white	1161.8**	524.30
Age of husband	-19.49	316.30
Age of husband, squared	-4.06	3.49
Age of wife	1162.3***	229.80
Age of wife, squared	-11.7***	2.59

Source : Author's calculations from the Survey of Income and Program Participation 2004 panel.

Note: Other control variables include four education dummies for both partners (high school degree, some college, college degree, above college) and time dummies.

*** p<0.01, ** p<0.05, * p<0.1

Table 4. Estimates of Reduced Form Labor Supply Functions

	Female lablor supply			Male labor supply		
	Coef		Std Err	Coef		Std Err
Non-labor income net of savings	0.0002		0.0005	-0.001	*	0.000
Female expected wage	2.52	***	0.45	0.28		0.37
Male expected wage	1.51	***	0.56	2.01	***	0.55
Female permanent shocks	2.18	***	0.04	0.01		0.02
Male permanent shocks	0.43	***	0.04	1.63	***	0.04
Female transitory shocks	1.69	***	0.08	0.06		0.05
Male transitory shocks	0.46	***	0.08	1.37	***	0.11
Local sex ratio	-0.32		0.22	-0.27	*	0.15
Divorce law index	-0.11	***	0.03	-0.04	*	0.02
Estimated parameters						
sf	-0.00001		0.0001			
sm	0.46	***	0.00			
rho	0.00		0.85			

Source : Author's calculations from the Survey of Income and Program Participation 2004 panel.

Note: Other control variables include four education dummies for both partners (high school degree, some college, college degree, above college), a quadratic in age for both partners, race of head of the household, and time dummies.
*** p<0.01, ** p<0.05, * p<0.1

Table 5. Estimates of Marshallian Labor Supply Functions

	Femlae lablor supply			Male labor supply		
	Coef		Std Err	Coef		Std Err
Log wage	2.183	***	0.44	0.738		0.85
Sharing rule	0.001	*	0.0007	-0.001	***	0.0003

Source : Author's calculations from the Survey of Income and Program Participation 2004 panel.
*** p<0.01, ** p<0.05, * p<0.1

Table 6. Estimates of the Sharing Rules

	Both partners working		Husband is not working		Wife is not working		
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient		Standard Error
Non-labor income net of savings	0.2	0.4	0.2	0.4	0.7		0.6
Female expected wage	311.6	430.4	311.6	430.4	-2170.6	*	1296.8
Male expected wage	1401.9	1015.6	1401.8	1015.6	-2984.8	**	1401.1
Female permanent shocks	8.0	24.0	8.0	23.9	-3142.7	**	1455.1
Male permanent shocks	400.2	249.2	400.1	249.2	-2020.0	***	770.3
Female transitory shocks	70.5	62.2	70.5	62.2			334.7
Male transitory shocks	432.7	278.5	-	-	-670.0	**	
Local sex ratio	-299.2	190.6	-299.2	190.5	463.2		298.8
Divorce law index	-98.5	67.0	-98.5	67.0	95.9	**	48.8
q_f	-	-	0.0	0.0	-		-
q_m	-	-	-	-	-510.4	***	196.2

Source : Author's calculations from the Survey of Income and Program Participation 2004 panel.

*** p<0.01, ** p<0.05, * p<0.1

Table 7. Estimated Transitory Variance With and Without Insurance

	Log Male Earnings	Log Female Earnings	Log Household Earnings
With insurance	0.098	0.089	0.066
Without insurance	0.108	0.091	0.068
Percentage change	9.3%	2.2%	2.9%

Source : Author's calculations from the Survey of Income and Program Participation 2004 panel.

Note : Calculation method is described in the Appendix.