

Essays on Income Volatility and Household Behavior

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ESSAYS ON INCOME VOLATILITY AND HOUSEHOLD BEHAVIOR

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by

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ESSAYS ON INCOME VOLATILITY AND HOUSEHOLD BEHAVIOR

ABSTRACT

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This dissertation contains two essays in labor economics. It provides a descriptive analysis on income volatility and develops a microeconomic model to study how married couples make joint decisions in response to such income volatility.

The first essay examines the recent trends in household income volatility in the United States, West Germany and Great Britain, and compares household income volatility with individual income volatility. I estimate a formal error components model using the Cross-national Equivalence File from 1979 to 2004. I find that household income volatility, measured by the transitory variance of household income, accounts for more than half of the total income variance for all three countries. Despite the differences in the total household income variances among the three countries, the permanent variances converges since the late 1990s. The household earnings volatility is always lower than the individual earnings volatility for married couples, which suggests some evidence of intra-household insurance.

In the second essay I examine whether married couples make joint labor supply decisions in response to each other's wage shocks. The study of this question aids in understanding the link between the recent rise in earnings volatility and household joint decisions. I develop an intra-household insurance model based on the collective framework, which allows for insurance against both permanent and transitory wage

shocks from both partners. Estimation using Survey of Income and Program Participation shows that individuals increase labor supply in response to spouse's adverse wage shocks and such labor supply responses are larger when shocks are permanent than transitory. A household makes less transfer to the individual with more volatile income, which can be considered as a price for insurance. This intra-household insurance reduces earnings volatility by about 1.2% to 7.7%. These results suggest that joint labor supply decisions provide a smoothing effect on shocks to earnings and household income.

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Chapter 1

Recent Trends in Household Income Dynamics for the United States, Germany and Great Britain

1.1 Introduction

Rising inequality in individual earnings and household income has been an important economic feature in the United States over the past several decades as well as in many other advanced industrial countries (Levy and Murnane, 1992; Gottschalk and Smeeding, 1997). Such an increase in the cross-sectional income inequality could arise either from an increase in the dispersion of permanent income, or a larger income fluctuations from year to year (income volatility). In this paper I apply a formal error components model to examine the following questions: How much of the household income inequality reflect income volatility rather than the dispersion of permanent income and how has this changed over time? How does household income volatility differ from individual income volatility? Are these trends in the United States

different from other advanced industrial countries?

It is important to distinguish between the dispersion in permanent income and income volatility to understand the causes of the growing cross-sectional income inequality. For labor earnings dynamics, rising dispersion in permanent income is usually attributable to a skill-biased technological change or trade increase with developing countries (Katz and Autor, 1999), while rising earnings volatility are more related to the instability of the labor market (Gottschalk and Moffitt, 2002). For household income dynamics, permanent income dispersion and income volatility may be attributable to many other economic and social factors because they involve income sources and joint decisions of more than one person. The causes of the dispersion in permanent household income may also be affected by marital sorting. If higher educated women become more likely to marry higher educated men, this could enlarge the income gap between rich and poor households. The causes of household income volatility, on the other hand, are subject to changes in family structure and joint decisions (household labor supply, joint job search, family formation and dissolution, etc.) of household members. For instance, the “added worker effect” literature (Lundberg, 1985; Stephens, 2002; Juhn and Potter, 2007) have found that married women are more likely to participate in the labor market when their husbands become temporarily unemployed. Such intra-household insurance could reduce household income volatility. On the other hand, changes in family structure, such as the recent increase in cohabitation and divorce, a decline in first age at marriage (Stevenson and Wolfers, 2007) would probably increase household income volatility. The descriptive analysis of the trends in household income dynamics with a comparison in individual income dynamics is an important initial step to understand the causes of permanent income dispersion and income volatility.

Although most studies of income inequality implicitly focus on explaining the

permanent income dispersion, recent studies have found that earnings volatility plays an important role in explaining the rising cross-sectional income inequality. Earlier work by Gottschalk and Moffitt (1994) decompose the cross-sectional earnings variance into a permanent and a transitory component. They find that the income volatility, using the classical definition of the variance for a transitory component of earnings, accounts for about one third to one half of the total variance of male earnings and such transitory variance also has increased over time. Male earnings dynamics have been well studied in the United States (Haider, 2001; Moffitt and Gottschalk 2002, 2008, among many others). These studies have shown that earnings volatility increased substantially in the 1980s and then remained at this new higher level through 2004. Permanent earnings dispersion also increased over time and accelerate its increase in the early 2000s.

There are fewer studies on household income dynamics (Hacker, 2006; Hertz, 2006; Bollinger and Ziliak, 2007; Bania and Leete, 2007; Dynan, Elmendorf and Sichel, 2008; Dahl, Deleire and Schwabish, 2008). Most of these studies use graphical non-structural approaches, which either impose strong assumptions on income dynamics, or only estimate either income volatility or permanent income dispersion, but not both. Dynan, Elmendorf and Sichel (2008) measures household income volatility as the cross-sectional distribution of income changes. Bania and Leete (2007) use coefficient of variation. Hacker (2006) apply a simple decomposition method that are consistent with formal income dynamics model only under a particular maintained assumption. In this paper I apply Moffitt and Gottschalk (2008) latest method to estimate a formal error-component model of life cycle income dynamics with calendar time shifts for household income using panel data. Estimation of such model identifies how permanent and transitory variance in household income or earnings evolve over time and over the life cycle.

This paper also compares income dynamics in the United States with two other industrial countries: Germany and Great Britain. A few studies have explored the income dynamics in industrial countries other than the United States. An increase in both permanent and transitory variances in earnings dynamics are also found in Germany (Burkhauser et al. 1997), Canada (Baker and Solon, 2003; Beach et al., 2003, 2008), Great Britain (Dickens 1996), and Sweden (Gustavsson 2004). However, due to the lack of comparable data sets, comparisons in income dynamics among these industrial countries are rarely examined. Given their similarities in income level and economic development but differences in educational and wage-setting institutions as well as family structure, such cross-national comparisons could provide important benchmarks of how income inequality and volatility in the United States differs from or is similar to other industrial countries, and how different social policies cope with income volatility or permanent income dispersion. Gottschalk and Smeeding (1997) uses Luxembourg Income Study (LIS) to examine cross-sectional inequality in earnings and family income up to the early 1990s. LIS contains comparable income measures from repeated cross-sectional data, but it is not feasible for the study of income volatility, which requires longitudinal data sets. To the best of my knowledge, Cross-national Equivalence File (CNEF) is the only available longitudinal data file that contains equivalently constructed income variables in the United States and other industrial countries. I use the latest CNEF from 1979 to 2006 which consists of comparable income measures from longitudinal data sets in the United States (the Michigan Panel Study of Income Dynamics), Germany (German Socio-Economic Panel) and Great Britain (British Household Panel Study). From CNEF I can examine how the trends in household income volatility and permanent income dispersion in the United States differ from other advanced industrial countries.

Estimation of a formal error components model shows the following results:

First, transitory variance accounts for more than half of the total variance in household income, about 56-78 percent in the United States, 67-85 percent in West Germany and 51-68 percent in the Great Britain. Second, despite the differences in cross-sectional income inequality among the three countries, the permanent household income dispersion converges since the late 1990s, while the household income volatility does not converge. Third, comparison between married couple's individual earnings volatility and their combined household earnings volatility suggests some evidence of household smoothing: In all three countries, household earnings volatility is lower than the average of the individual earnings volatility. When female and male earnings volatility goes to the opposite direction, household earnings usually more stable. Such household smoothing evidence is stronger in the United States than West Germany and Great Britain.

1.2 Literature review

There has been a substantial literature on the income dynamics of individual earnings or household income in the United States, as well as in other industrial countries. Most of these studies examine the changes in overall cross-sectional inequality. Gottschalk and Danziger (2005) analyze distributional changes in hourly wage rates, annual earnings and family income from 1975 to 2002. Both male wage rate inequality and family income inequality rose up sharply during the early 1980s, increased at a slower rate through the early 1990s then stabilized at a high level through the early 2000s. The increase family income primarily reflects increased inequality of wage rates. Such increases in income inequality are also found in other industrial countries (Gottschalk and Smeeding, 1997, among others).

The rise in income inequality is often assumed to be caused by the larger

dispersion of permanent income, but a cross-sectional variance can also increase if the variance of year-to-year fluctuations, the transitory variance, rises. The study of the trends in permanent and transitory variance in income helps to understand the causes of growing overall income inequality. Several methods are used to decompose the cross-sectional variances into permanent variances and transitory variances. Gottschalk and Moffitt (1994) estimate the permanent and transitory variances with standard random effects models within each nine-year time window. Moffitt and Gottschalk (1998) develop an approximate nonparametric method and a formal error components model to estimate the permanent and transitory variances based on the variance-covariance matrix of log earnings. Their nonparametric method is based on the definition that the transitory variance fades out if time lag is long enough. The formal error components model allows the permanent component follows a random walk, and the transitory component follows an ARMA (1,1) process, so that transitory shocks are serially correlated. This error component model is further modified in Moffitt and Gottschalk (2008) to allow for left censoring, and a random growth in the permanent component in addition to random walk. Haider (2001) develops a heterogeneous growth model where earnings are decomposed as a mean-reverting earnings shock and a permanent component, including a period-specific factor loading with heterogeneous growth term. Different methods come to similar conclusions that the transitory variance in male earnings increases from the 1970s to 1980s.

An increase in both permanent and transitory variances in earnings dynamics are also found in some other developed countries, but not all. Baker and Solon (2003) use longitudinal income tax records from Canada. They find that the substantial increase in male earnings inequality over the sample period of 1976 to 1992 stemmed from upward trends in both permanent and transitory components, while the permanent component plays a somewhat more significant role. Beach et al. (2008) examines

male and female earnings variability in Canada over the period of 1982 to 2000 using the random effects model within the moving calendar time windows of fixed length . From the Longitudinal Administrative Database, they find that permanent variance has generally increased over the sample period, but the transitory variance has pretty steadily decreased, except during the early 1990s recession, which is quite different from the trends in transitory variance in the United States, using different methods. Changes in the cross-sectional earnings inequality have been driven primarily by the permanent inequality. Dickens (1996) studies the dynamic structure of male wages in Great Britain using the New Earnings Survey Panel from 1975 to 1995. He finds that a permanent component of earnings has increased over the life cycle and the transitory component is highly persistent and serially correlated. The estimated variances of both components have risen over this period, and each explains about half the rise in inequality. Gustavsson (2004) uses the Longitudinal Individual Data for Sweden to examine the transitory and permanent variances of male annual earnings in Sweden between 1960 and 1990. The permanent variance displays a downward trend during the entire sample period, with the rate of decline more rapid until the early 1980s, than afterwards. The transitory variance has increased until early 1970s, decreased slightly through the late 1970s, and then rose again through the 1980s.

Cross-national comparisons are rarely examined due to the lack of comparable data. The estimation of the transitory variance requires longitudinal data instead of cross-sectional data. To my knowledge there are only two longitudinal data files available for such cross-national studies. One is CNEF which contains equivalently defined variables from the United States, Germany, Great Britain, Australia, Switzerland and Canada. Daly and Valletta (2008) use a heterogeneous growth model to compare male permanent and transitory earnings in the United States, Germany and Great Britain. They find substantial convergence in both permanent and transitory components of

male earnings inequality in these three countries during the 1990s. This convergence is primarily driven by the declining inequality in the United States and rising inequality in Germany at the same time. Another longitudinal data file feasible for cross-national comparison is the European Community Household Panel (ECHP), which contains European countries only. Sologon and O'Donogue (2009) use ECHP to explore the male earnings dynamics for 14 European Union countries. Increases in inequality appear to reflect increases in permanent earnings variance in Luxembourg, Italy, Greece and Finland, and increases in both permanent and transitory variances in Portugal and Netherlands. Decreases in inequality appear to result from decreases in the transitory variances in Germany, France, the United Kingdom and Ireland, in permanent variance in Belgium and Spain, and in both components in Denmark and Austria. ECHP contain more countries than CNEF, but have relatively shorter panel (eight years). I use CNEF because my primary research interest focus on the comparison of income dynamics in the United States with other countries, and CNEF contains longer panel.

1.3 Model specification of income dynamics

I use a formal error components model to estimate the permanent and the transitory variance in income dynamics. There is a large literature on the formulations of such models (Lillard and Willis, 1978; MaCurdy, 1982; Abowd and Card, 1989; for a review see MaCurdy, 2007). These studies suggest that the permanent component evolves over the life cycle, and the transitory component is serially correlated, usually represented by a low-order ARMA process. I specify a model similar to Moffitt and

Gottschalk (2008) which contains all above features:

$$\begin{aligned}
y_{iat} &= \alpha_t \mu_{ia} + v_{iat} \\
\mu_{ia} &= \mu_{i,a-1} + \omega_{ia} \\
v_{iat} &= \rho v_{i,a-1,t-1} + \beta_t \xi_{ia} + \theta(\beta_{t-1} \xi_{i,a-1})
\end{aligned} \tag{1.1}$$

where y_{iat} is the log income residuals after a first-stage regression, for individual or household i at age a in calendar year t . It is composed of a permanent component $\alpha_t \mu_{ia}$, where α_t is loading factor, and a transitory component v_{iat} . Random walk ω_{ia} arrives randomly and it is not mean-reverting. The transitory shock evolves with an ARMA (1,1) process typically found in the literature, fading out at rate ρ and deviating from that smooth fade-out rate by θ in the next period.¹ The transitory shock is mean-reverting.

Assume $E(\mu_{ia}) = E(\omega_{ia}) = E(\xi_{ia}) = 0$, these three variables are all orthogonal from each other, and initial conditions $\mu_{i0} \neq 0$, $v_{i0} = 0$. Assume all forcing errors to be i.i.d. except ξ_{ia} , as transitory shocks are likely to be greater at younger ages. Two other assumptions include: μ evolves over the life cycle but not with calendar time, and the transitory shock ξ is a function of a and t , but not with i . Although all the parameters in the model could shift with calendar time, I follow the literature and only allow calendar time shifts appear in the loading factor of the permanent component α_t and the forces of the transitory component β_t .

The identification of the parameters is as follows: when ρ is not too high, the covariances becomes small within the finite lifetime of an individual. The permanent variance can be identified primarily by the long autocovariances and also through

¹This model is the same as specification in Moffitt and Gottschalk (2008) except that their permanent component also allows for a random growth factor in addition to random walk. The variance of random growth is very small (0.000038) in their estimation. In another version of this study, we also use a random growth model, which is the same as in Moffitt and Gottschalk (2008).

extrapolation. The calendar time shifts can be identified from changes in parameters across multiple cohorts.

Time-varying parameters also introduce the left-censoring problem since these parameters cannot be identified prior to the initial year when we start observing the data, but their evolutions before the initial year affect the variances and covariances after the initial year. To address this issue, Moffitt and Gottschalk (2008) introduce a new parameter γ which allows the transitory variances in the initial year to deviate from what they would be if $\beta_t = 1$ for year prior to the initial year, with $\gamma = 0$ implying no deviation. The initial conditions and normalizations for equation (1.1) are defined as follows:

$$\alpha_1 = 1; \beta_1 = 1$$

$$Var(\mu_{i1}) = \sigma_{\mu 1}^2; Var(\omega_{iat}) = \sigma_{\omega}^2$$

Define a_1 as household head's age in initial year, let age 20 equals to $a = 1$

if $a_1 \leq 1$ (non-left-censored), then assume: (1.2)

$$v_{i1t} = \rho v_{i,0,t-1} + \xi_{it}, \quad Var(v_{i1t}) = \sigma_{v1}^2 + \sigma_{\xi t}^2$$

if $a_1 > 1$ (left-censored), then assume:

$$Var(v_{i,a_1,1}) = \sum_{p=1}^P \gamma_0 + \sigma_{\xi 1}^2$$

The parameters need to be estimated in equation (1.1) and (1.2) are: α_t , β_t , $\sigma_{\xi 1}^2$, ρ , θ , $\sigma_{\mu 1}^2$, $\sigma_{\omega}^2, \sigma_{v1}^2$ and γ . I estimate the model using minimum distance estimation developed by Chamberlain (1984).² The parameters are estimated by minimizing the sum of squared deviations between the observed elements in the variance-covariance matrix and the predicted elements implied in the theoretical model, with an identity

²I thank Peter Gottschalk for generously share his STATA MATA program of estimating the formal error components model.

weighting matrix. Let $s_{im} = y_{ij}y_{ik}$, where y_{ij} and y_{ik} are the log income residuals for each age-year cell j and k , and where $m = 1, \dots, M$ indexes the individual moments for the products of residuals j and k . Denote θ as the set of unknown parameters. I choose θ to minimize the sum of squared residuals:

$$\text{Min} \sum_{i=1}^N \sum_{m=1}^M [s_{im} - f(\theta, j, k)]^2 \quad (1.3)$$

The standard errors are obtained by a method illustrated in Moffitt and Gottschalk (2008): denote e_{im} as residuals from equation (1.3) to form an M by M covariance matrix Ω , each element of Ω is estimated by:

$$\hat{\sigma}_{mm'} = (1/N) \sum_{i=1}^N e_{im}e_{im'} \quad (1.4)$$

Define Δ as the NM by NM covariance matrix of residuals which is a block diagonal matrix with the matrix Ω on the diagonals. Then

$$\text{cov}(\hat{\theta}) = (G'G)^{-1}G'\Delta G(G'G)^{-1} \quad (1.5)$$

where G is a matrix of gradients of $f(\theta, j, k)$ over θ .

Such a formal error components model has several advantages over other estimation methods used in the income dynamics literature. Earlier work by Gottschalk and Moffitt (1994) use a standard random effects model, where the permanent component for each individual is the average of his or her earnings across a 9-year period, then calculate the variance across all individuals. The transitory variance is calculated from the variance of the residuals from each individual mean, then average across all individuals. This method is applied in Beach et al. (2003, 2008) and is modified with a moving calendar time windows of fixed length. This method does not account for

serial correlation in the transitory component. Another method is an approximate nonparametric method. It defines covariance of income between “long” periods as the permanent variance, and defines the difference between variance and covariance as the transitory variance. This method is applied in Moffitt and Gottschalk (2002, 2008), Hacker (2006), and it is based on the following model:

$$y_{it} = \mu_i + \nu_{it} \tag{1.6}$$

where μ_i is a time invariant component with variance σ_μ^2 and ν_{it} is a white noise transitory component with variance σ_ν^2 . Two components are independent of each other. Given $cov(\nu_{it}, \nu_{it'}) = 0$, the cross-sectional variances and covariances of residuals y_{it} are given by:

$$Var(y_{it}) = \sigma_\mu^2 + \sigma_\nu^2 \tag{1.7}$$

$$Cov(y_{it}, y_{it'}) = \sigma_\mu^2 \tag{1.8}$$

From the variance-covariance matrix of log income, the permanent variance is estimated through the off-diagonal elements, and the transitory variance is the difference between the total variance and the permanent variance. Such method is nonparametric because it makes no assumption about how the permanent component evolves over time, for instance, random walk or random growth. This is only an approximate method. If the transitory component is serially correlated, then the effects of past transitory shocks are never equal to zero. Therefore, a long lag is needed to get a good approximation.

1.4 Data

This paper uses the Cross National Equivalent File (CNEF) prepared by the Department of Policy Analysis and Management at Cornell University. I use the 1980-2006 CNEF data, which consists of equivalently defined income variables from the Michigan Panel Study of Income Dynamics (PSID) 1979-2002, the German Socio-Economic Panel (GSOEP) 1983-2004, and the British Household Panel Survey (BHPS) 1990-2000.³ I only include the West Germany sample in GSOEP because data for East Germany (former German Democratic Republic) before 1990 is not available.⁴ All years are referred to the income years. PSID skipped interviews every other year starting interview year 1998, so the last four observations are for income years 1996, 1998, 2000 and 2002. All three data sets are longitudinal so that I observe income over time for the same household or same individual.

CNEF constructed equivalently defined income variables across countries. The codebook of CNEF provides a description of how each variable is created, the algorithm used to create each variable from the original panel data, and it also provides a reliability code which tells the degree of cross-national comparability, with “1” represents completely comparable. All income variables I use in this paper are completely comparable between three countries.

The household income variable used in this paper is post-tax and transfer annual household income. It is the sum of the total household income from the labor earnings of all household members, asset flows, private retirement income, private

³In addition to above three data sets I use, CNEF also includes the Household Income and Labor Dynamics in Australia (HILDA) 2001-2005, the Swiss Household Panel (SHP) 1999-2005, and the Canadian Survey of Labor and Income Dynamics (SLID) 1993-2005. HILDA and SHP are too short to identify the transitory variance as it requires observing income changes for sufficient long time. The access to SLID data is partly restrictive.

⁴Therefore, for those individuals who moved from East Germany to West Germany at some point, I only observe their income after they moved.

transfers, public transfers, and social security pensions net of total household taxes.⁵ The total household income is divided by an equivalence scale which is adjusted based on household size to account for economies of scale of household members compared to single individuals.⁶

For the comparison of income at the household level and the individual level, I use household labor income variable and individual labor earnings variable. The household labor income variable includes the combined labor income of the head, partner and other family members. The individual labor earnings include wages and salary from all employment including self-employment. Unlike household income, household labor income and individual labor earnings do not have negative values.

For the main analysis of cross-national comparison of household income, I follow household heads aged between 20 and 59 with positive household income. Household income is adjusted for inflation using the consumer price index in each country, and set year 1996 as base year. I include every observation for each household that meet these restrictions, hence households might drop out and reappear in the sample over time. I also trim the top and bottom 1 percent outliers of the household income within year-age group (20-29, 30-39, 40-49, 50-59) cell to reduce noise, which is a standard procedure in the income inequality literature. The sample includes 5,239 households with a total of 115,022 household-year observations in the United States; 4,248 households with 88,312 observations in West Germany; and 3,672 households with 37,571 observations in the Great Britain. Summary statistics are presented at Table 1.1. Average household income is higher in the United States than the other

⁵Total household taxes includes income taxes of the head, partner and other family members, as well as payroll taxes of the head and partner. The PSID data do not provide information on payroll taxes. They are calculated by bracketing labor income and applying the average payroll tax rate for that bracket as reported by the Social Security Bulletin, Annual Statistical Supplement, 1990, page 33.

⁶I use general official United States Equivalence Weight that is computed based on household size. This equivalence scale is available in CNEF data.

two countries. In Great Britain the proportion of individuals who are married is the highest, with more children and larger family size than the United States and West Germany. The standard deviation of the household income across all years is higher in the United States than in West Germany and Great Britain.

A variance-covariance matrix is formed based on residuals from regressions of log earnings on household head's age, age square, a dummy for whether he is married and the number of children in the household. A separate regression is run for each year.⁷ This first stage regression controls for the changes in the mean household income, thus the analysis in the next section examines the within group variances. I calculate the covariance between income at age a and a' and between year t and year t' , indexed with year, age and lag length.

1.5 Household income dynamics in the United States, West Germany and Great Britain

I estimate the income dynamics model in equation (1.1) and compute the permanent and transitory variances, in each year, for each age group. Table 1.2 presents the estimated α s of household income dynamics, Table 1.3 presents the estimated β s, and Table 1.4 presents estimates of other parameters. These time-varying coefficients of α s and β s are the main driving force of the trends in permanent variance and transitory variance, respectively. The transitory shocks in household income are significantly serially correlated at a rate of 0.78 in the United States, 0.76 in West Germany and 0.70 in the Great Britain.

Figure 1.1 plots the actual and predicted cross-sectional variances in log house-

⁷The first stage regression does not include education variable, as in the Great Britain education information is missing from BHPS.

hold income in three countries, taking an average across the four age groups. The predicted variances from the model match empirical variance from the data very well. The United States has the highest overall inequality among all three countries, and West Germany has the lowest inequality for the past two decades. Household income inequality in the United States increased since the 1980s, declined in the late 1990s and then rose up again in the 2000s. This trend is consistent with other studies such as Gottschalk and Smeeding (1997) (Figure 4) and Nichols and Zimmerman (2008). In West Germany, income inequality gradually increases over time, with the largest jump around the reunification in 1990. In Great Britain household income inequality does not change much in the 1990s.

Figure 1.2 plots the permanent variance and transitory variance in each year, taking an average across four age groups. The top figure plots the permanent variance for three countries. In the United States, the permanent variance steadily increased through the 1980s, gradually decreased since the mid 1990s. In West Germany, the permanent variance mildly increased through the late 1990s, then leveled off afterwards. The permanent variance in Great Britain rose in the early 1990s then declines.

Despite the large difference among three countries in the 1980s, the permanent dispersion of household income converges since the late 1990s. In addition, the permanent dispersion does not increase since the mid 1990s in all three countries. The rank for the three countries in terms of permanent household income dispersion changes over time. West Germany always has the lowest permanent income dispersion, while the Great Britain have a higher permanent income dispersion than the United States for most of the sample period (1992 to 1999).

The bottom figure in Figure 1.2 shows the evolution of household income transitory variances. Unlike the permanent variances, the transitory variances do not have a clear convergence pattern in these three industrial countries. Transitory variance

goes up in the long run but is subject to cyclical changes in the United States and West Germany. In the Great Britain it goes up more steadily. Such income volatility seems to be more dramatic in the United States than in European countries, especially after the 1990s.

I also examine how much of the overall cross-sectional inequality is attributable to income volatility rather than the permanent dispersion. Figure 1.4 compares the total variance, the permanent variance and the transitory variance in the United States. Figure 1.5 and 1.6 presents trends in three variances in West Germany and Great Britain. The transitory variance accounts for at least half of the overall inequality, about 56 to 78 percent in the United States, 67 to 85 percent in West Germany and 51 to 68 percent in Great Britain. For the same period of 1990-2000, transitory variance accounts for 70 percent of total variation in the United States, 73 percent in the West Germany and 58 percent in the Great Britain. Trends in transitory variance are mostly coincide with trends in overall inequality, when comparing with Figure 1.1. This is a pattern that is consistently found in other studies for the United States. Moffitt and Gottschalk (2008) plot the transitory variance against the unemployment rate. They find that transitory variances are largely cyclical, thus it is more difficult to sort out the trend in the transitory variance, especially when there is a cycle at the end of the period. In my study of household income dynamics, that trends in transitory variance are also cyclical.

Now I discuss the findings in my paper with other studies that focus on male individual earnings. Daly and Valletta (2008) apply a heterogeneous growth model as in Haider (2001) to examine the cross-national trends in the transitory and permanent variances in the United States, Germany and the Great Britain, using CNEF from 1979 to 1999. The age cuts are male heads 25-61, while age cuts in my paper is households with heads aged 20-59. The trends in household income transitory vari-

ance in my paper are very similar to their findings of male earnings for the United States and West Germany, but quite different for the Great Britain. This suggests that the driving forces of household income volatility mainly come from male earnings volatility in the United States and West Germany. Household income volatility in Great Britain maybe more attributable to other factors such as female earnings volatility, or volatility in unearned income such as transfer income or asset income. In the next section, I further compare the transitory variances in household income and in individual earnings in each country.

1.6 Compare the income volatility at the household level and at the individual level for married couples

Household income is the sum of all household members' individual income, thus it could involve joint decisions of more than one person. In this section I examine whether the trends and magnitude of the household income volatility differs from the individual volatility, which could potentially provide some evidence on intra-household insurance behavior.

The sample in this section contains only married couples. The main goal in this section is to examine if there is any evidence of household smoothing, while single or divorced individuals would not have spousal smoothing behavior. In addition, household income volatility in these intact families would not involve in family formations and dissolutions.

The household level variable I use is household earnings, which is the combined labor earnings of a married couple, instead of the total household income used in the

previous section. The main reason for this switch is that the total household income also includes property income and transfers, in addition to labor earnings. Some of these transfers are given to the entire household, and couples may not equally divide transfers or property income. It is difficult to construct a proper measure of individual income to assign pooled non-labor income. Therefore, I use household earnings variable so that it is comparable to male and female individual earnings variables.

Figure 1.6 compares the male earnings volatility, the female earnings volatility with their combined earnings volatility in the United States. Figure 1.7 presents the results in West Germany and Figure 1.8 presents the results in Great Britain. Female earnings volatility are much higher than either male or household earnings volatility. This is not a surprising result, as many married women are the secondary workers in the household, thus, are more likely to change participation status (full-time, part-time) or hours of working. Note that since the estimation is based on log earnings, the sample excludes those who have zero earnings for the entire year. However, married women who change participation status within a year still contribute to the transitory variance in their earnings. Figure 1.9 compares the trends in transitory variance of female earnings in three countries. Married women's income volatility constantly increased over the past two decades, in the United States as well as in European countries. From Figure 1.6 to 1.8 I also find that such increases in female earnings volatility are much larger than male earnings volatility.

Comparing the magnitude of earnings volatility at the household level and at the individual level, I find that the household earnings volatility is always much lower than the average of the male and female individual earnings volatility. In the United States, household earnings volatility is even lower than male earnings volatility, although this is not true in West Germany and Great Britain.

Several stories could explain why household earnings volatility is lower than individual earnings volatility. One possible explanation is intra-household insurance hypothesis: an individual may adjust his or her earnings by change work hours or switch jobs, to buffer the changes in a partner's earnings, so that their combined earnings are more stable. Existing literature suggest that transitory shocks might be insurable (Dynarski and Gruber, 1997; Blundell et al., 2008). Another possible explanation is individuals seek spouses whose earnings shocks are negatively correlated with their own earnings shocks. For instance, people who work in the financial industry may prefer to find a spouse with a more stable job, say a faculty position.

Next I compare the trends in household earnings volatility and the individual earnings volatility. In the United States, from 1980s to mid-1990s, male and female earnings volatility always move with an opposite direction: a sharp rise in female earnings volatility from 1982 to 1984 is accompanied by a decline in male earnings volatility at the same time. Likewise, a decline in female earnings volatility from 1990 to 1992 is accompanied by a rise in male earnings volatility. However, such counter-movement pattern is replaced by a co-movement from mid-1990s to early 2000s. In West German and Great Britain, male and female earnings volatility usually move in the same direction, but there are also some periods of counter-movement, 1992-1997 in West Germany and 1993-1995 in Great Britain. From this descriptive analysis we do not know what is the causes of such counter-movement, but intra-household insurance seems to be one plausible explanations.

Another pattern is that, the trends in household earning volatility are more similar to the trends in male earnings volatility rather than female earnings volatility. My interpretation is that male average earnings are higher than female average earnings, therefore male earnings have a larger weight in determining the the movement of household earnings. However, the increase in household earnings volatility

is usually less than the increase in male earnings volatility. Again, this is in favor of the intra-household insurance story. Spousal smoothing behavior help household earnings volatility change less than individual earnings volatility.

1.7 Conclusion

In this paper I examine the recent trends of household income dynamics in the United States, West Germany and Great Britain, using CNEF 1979-2006 file. I estimate a formal error-components model as in Moffitt and Gottschalk (2008), to study how permanent variances and transitory variances change over time and how these trends differ in three countries. I find that the permanent household income dispersion converges among three countries in the late 1990s, while transitory variance displays a more cyclical pattern. Household income volatility accounts for more than half of the overall cross-sectional inequality in all three countries. Comparison of income volatility at the household level with the individual level for married families also suggest some evidence of household smoothing, especially in the United States. These findings deserve further investigation with formal economic models of household behavior.

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Table 1.1: Descriptive Statistics

	Mean	Std Dev	Min	Max
United States				
Log household income	9.80	0.785	-1.05	15.03
Age of head	40.0	10.38	20	59
Married	0.55	0.50	0	1
Number of children	0.91	1.14	0	9
Family size	2.71	1.48	1	14
West Germany				
Log household income	9.65	0.638	0.63	2.81
Age of head	41.0	10.65	20	59
Married	0.54	0.50	0	1
Number of children	0.61	0.92	0	10
Family size	2.51	1.34	1	17
Great Britain				
Log household income	9.26	0.693	-0.80	2.39
Age of head	41.0	10.39	20	59
Married	0.68	0.47	0	1
Number of children	1.12	1.53	0	16
Family size	2.82	1.36	1	11

Note: Log household income is divided by equivalence of scale;
Means taken before trimming and over all household-year observations

Table 1.2: Estimates of Alphas in the Error Components Model of Log Household Income

Year	United States		West Germany		Great Britain	
	Coef	Std Err	Coef	Std Err	Coef	Std Err
Alpha's						
1980	1.027	0.054				
1981	1.058	0.061				
1982	1.192	0.075				
1983	1.238	0.080				
1984	1.277	0.092	1.027	0.183		
1985	1.317	0.100	1.005	0.192		
1986	1.313	0.099	1.095	0.201		
1987	1.364	0.101	1.210	0.256		
1988	1.429	0.102	1.198	0.358		
1989	1.487	0.110	1.223	0.390		
1990	1.493	0.114	1.369	0.315		
1991	1.522	0.120	1.505	0.414	1.190	0.091
1992	1.497	0.122	1.534	0.397	1.145	0.086
1993	1.465	0.122	1.535	0.417	1.244	0.113
1994	1.443	0.127	1.660	0.457	1.249	0.149
1995	1.425	0.119	1.513	0.408	1.194	0.142
1996	1.237	0.103	1.463	0.453	1.164	0.151
1997			1.668	0.407	1.145	0.145
1998	0.814	0.086	1.539	0.406	1.065	0.114
1999			1.404	0.464	1.007	0.123
2000	0.907	0.088	1.398	0.389	1.020	0.268
2001			1.634	0.478		
2002	0.928	0.096	1.638	0.439		
2003			1.781	0.457		
2004			1.539	0.380		

Table 1.3: Estimates of Betas in the Error Components Model of Log Household Income

Year	United States		West Germany		Great Britain	
	Coef	Std Err	Coef	Std Err	Coef	Std Err
Beta's						
1980	1.116	0.287				
1981	1.396	0.436				
1982	1.471	0.433				
1983	1.534	0.466				
1984	1.535	0.437	0.893	0.284		
1985	1.500	0.452	0.738	0.224		
1986	1.558	0.434	0.640	0.207		
1987	1.421	0.425	0.612	0.207		
1988	1.368	0.388	0.483	0.176		
1989	1.575	0.453	0.631	0.271		
1990	1.384	0.400	0.570	0.204		
1991	1.668	0.478	0.522	0.201	0.958	0.227
1992	2.008	0.627	0.757	0.293	1.085	0.314
1993	2.616	0.747	0.732	0.248	0.921	0.297
1994	2.334	0.723	0.770	0.326	0.951	0.352
1995	1.797	0.657	0.721	0.345	0.892	0.264
1996	2.278	0.585	0.734	0.281	0.914	0.340
1997			0.816	0.313	1.013	0.314
1998	2.706	0.686	0.807	0.296	1.111	0.444
1999			1.023	0.337	1.164	0.298
2000	2.176	0.556	0.767	0.242	1.360	0.810
2001			0.816	0.261		
2002	3.060	0.775	0.812	0.255		
2003			0.806	0.272		
2004			0.767	0.310		

Table 1.4: Estimates of Other Parameters in the Error Components Model of Log Household Income

Year	United States		West Germany		Great Britain	
	Coef	Std Err	Coef	Std Err	Coef	Std Err
$\sigma_{\xi 1}^2$	0.086	0.022	0.152	0.042	0.116	0.023
$\sigma_{\mu 1}^2$	0.058	0.008	0.021	0.010	0.094	0.015
ρ	0.779	0.028	0.757	0.048	0.697	0.110
θ	-0.433	0.031	-0.375	0.050	-0.349	0.126
$\sigma_{\omega}^2 * 100$	0.001	0.000	0.000	0.000	-0.001	0.001
γ_0	0.054	0.073	-0.055	0.028	0.034	0.072

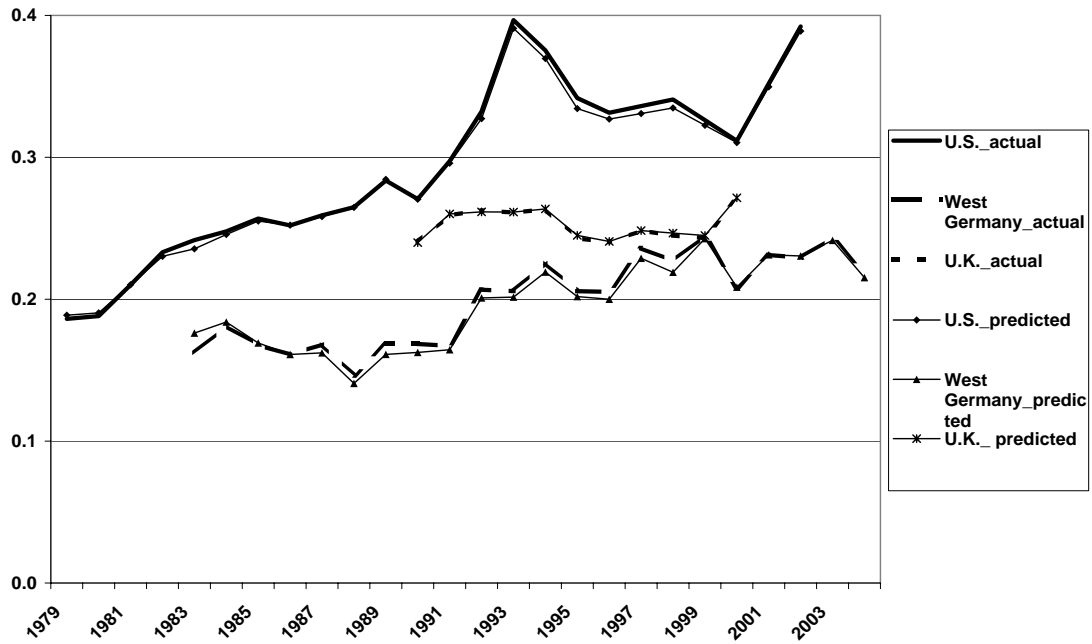


Figure 1.1: Actual and predicted cross-sectional variance in log household income in the United States, West Germany and Great Britain

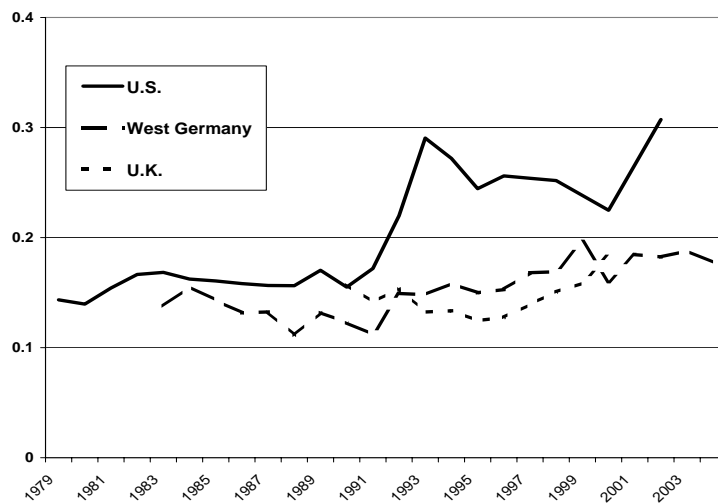
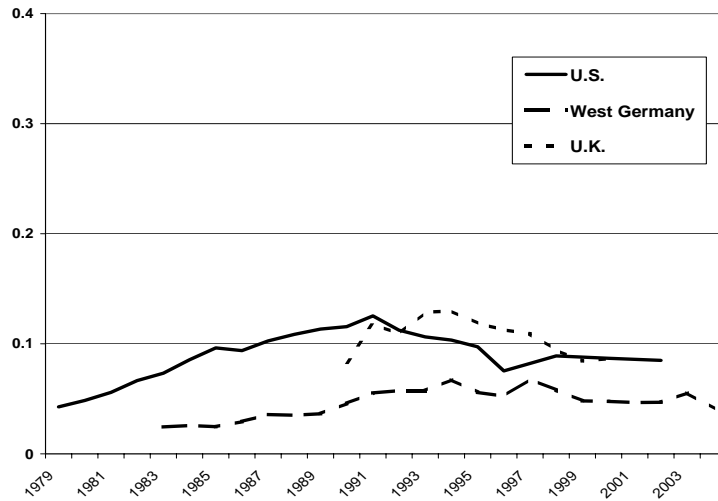


Figure 1.2: Trends in the permanent variance (top) and transitory variance (bottom) of log household income in the United States, West Germany and Great Britain

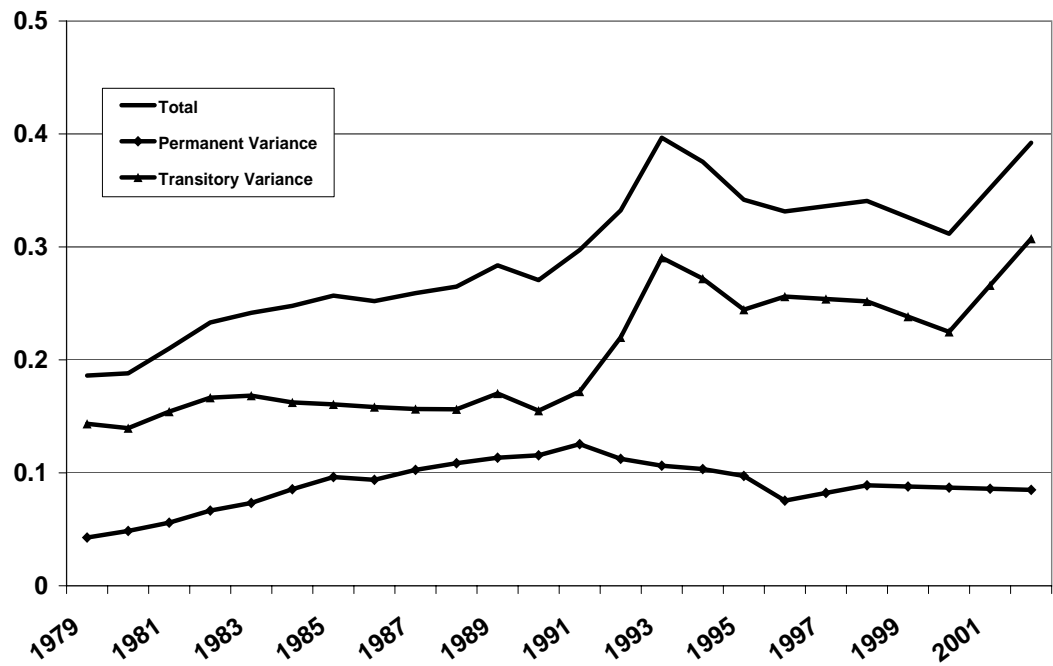


Figure 1.3: Total variance, permanent variance and transitory variance of log household income in the United States, 1979-2002

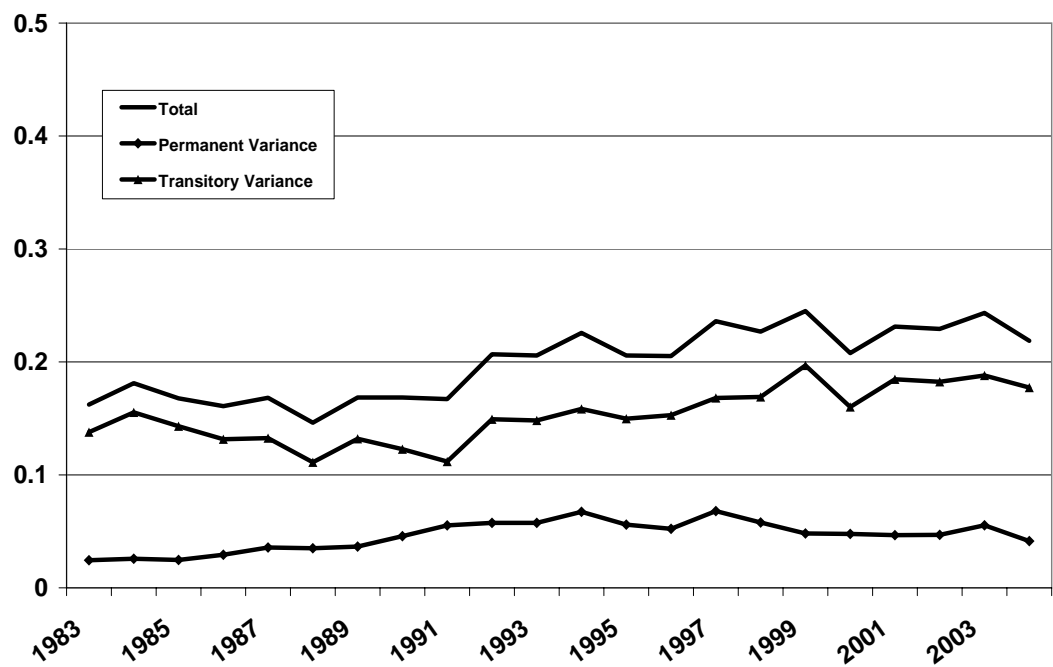


Figure 1.4: Total variance, permanent variance and transitory variance of log household income in West Germany, 1983-2004

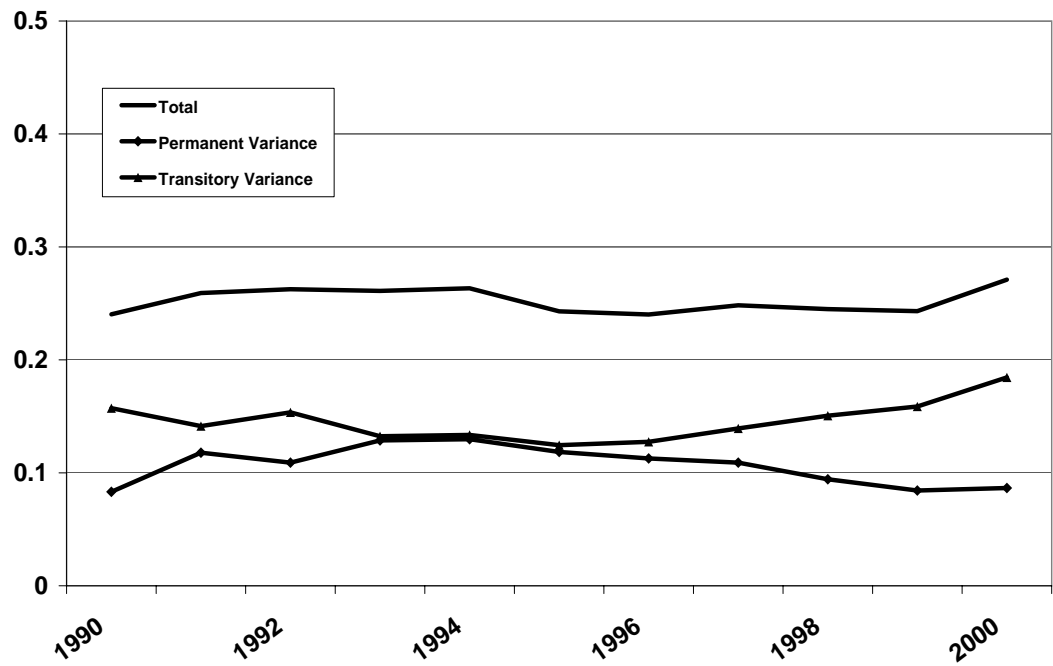


Figure 1.5: Total variance, permanent variance and transitory variance of log household income in Great Britain, 1990-2000

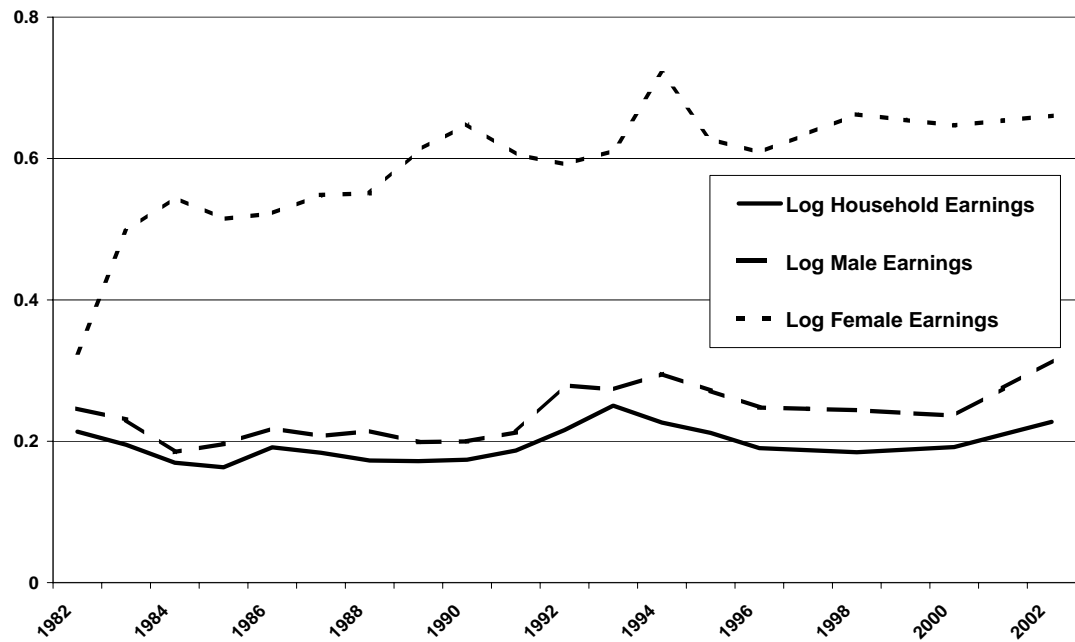


Figure 1.6: Earnings volatility for married men, married women and household earnings volatility in the United States

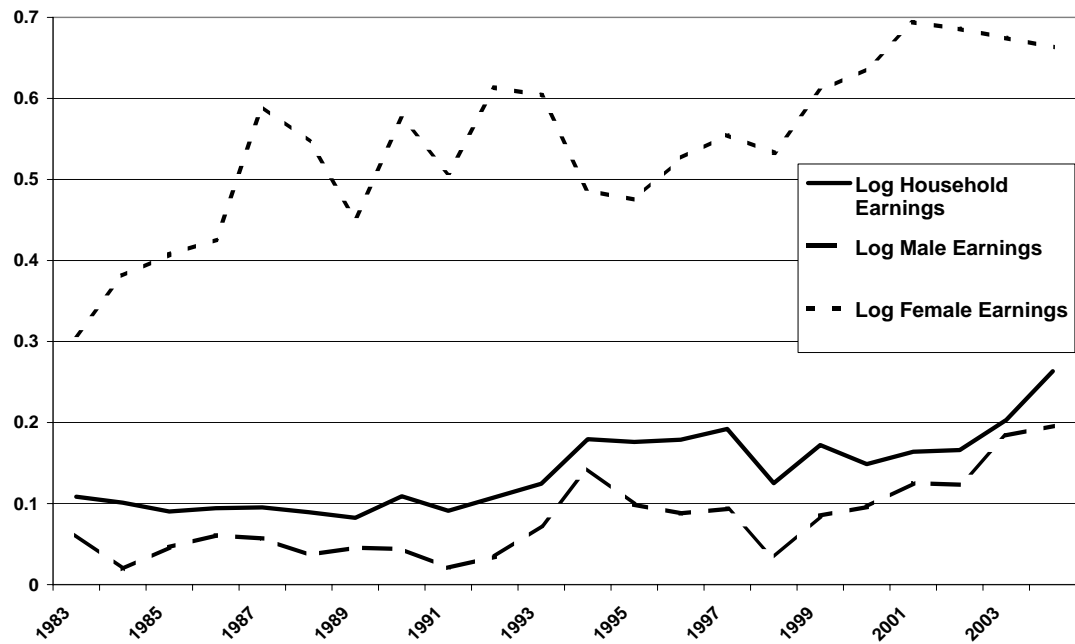


Figure 1.7: Earnings volatility for married men, married women and household earnings volatility in West Germany

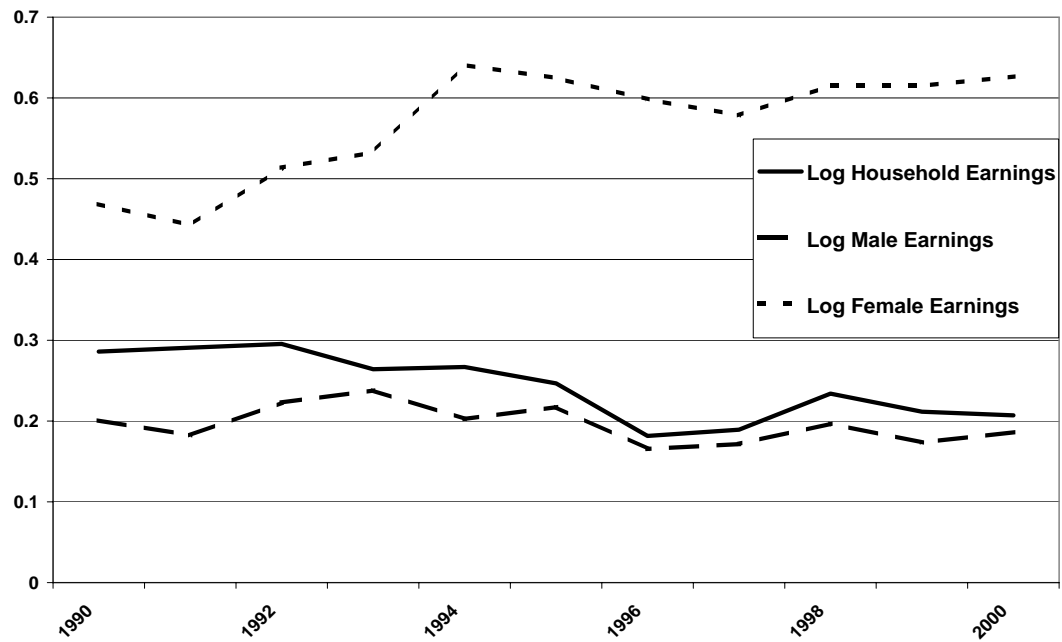


Figure 1.8: Earnings volatility for married men, married women and household earnings volatility in Great Britain

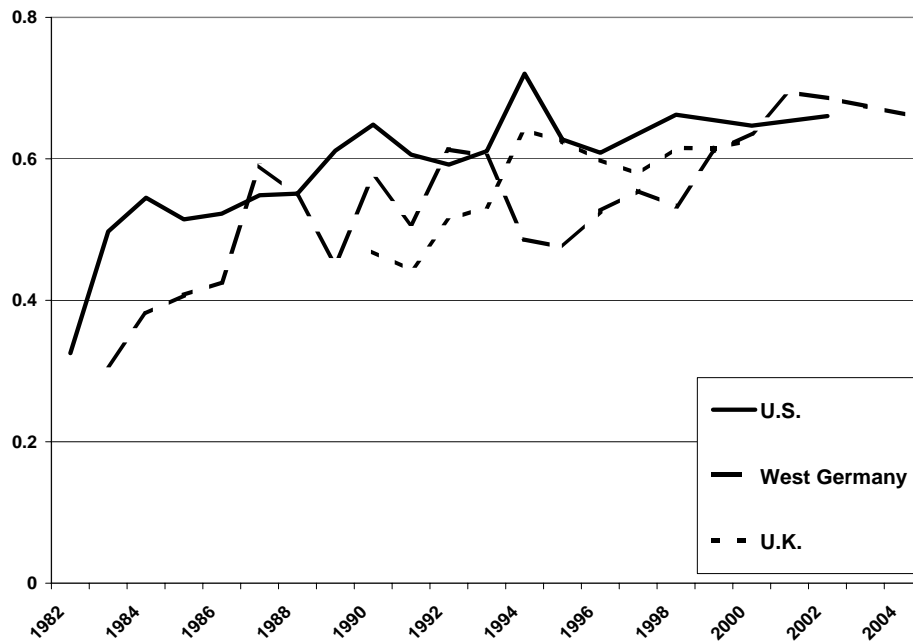


Figure 1.9: Transitory variances in married women's log earnings in the United States, West Germany and Great Britain

Chapter 2

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

2.1 Introduction

Rising earnings and income volatility over the last few decades in the United States has been well documented in existing studies (Gottschalk and Moffitt, 1994; Moffitt and Gottschalk, 1998, 2002, 2008; Haider 2001; Hyslop, 2001; Dahl et al., 2008; Dynan et al., 2008; Shin and Solon, 2008). This has been of concern to policymakers, since it is associated with an increase in risk and a reduction in welfare. Government provides social insurance, transfers, and taxation, to buffer the welfare loss caused by income volatility. Meanwhile, individuals who live in the same household may also provide insurance against each other's income shocks by making joint decisions, such as asset accumulation and depletion, durable goods replacement, and ex-post labor supply adjustments, etc.

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

Studies on insurance for income shocks have a long history in both macroeconomics and labor economics. In macroeconomic theory, the complete market hypothesis assumes that both permanent and transitory income shocks are fully insured, while

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

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

In order to investigate how married couples adjust labor supply to insure against each other's wage shocks, I build a theory based on the collective framework developed by Chiappori (1988, 1992) and Donni (2003). The main advantage of this model is that under a minimal set of assumptions, individual preferences and intra-household allocations can be uncovered, without imposing any specific structure

on the decision process.² The weighted maximization of household members' utilities can be decentralized, subject to a lump-sum income transfer, also known as the "sharing rule", which specifies how to allocate household resources. This sharing rule depends on each agent's wage in the existing collective models. I expand the scope of the sharing rule to act as a function of permanent and transitory wage shocks. In addition to the standard income and substitution effect that wage shocks have on individual's own labor supply, these shocks also affect spousal labor supply, through this sharing rule. This is the main channel through which I examine how individual wage shocks affect spousal labor supply.

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

This paper uses the Survey of Income and Program Participation (SIPP) and

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

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

the main findings are as follows: An individual increases his or her labor supply when the spouse receives an adverse wage shock, no matter permanent or transitory. Such labor supply response is larger when the shock is permanent. There is little evidence of insurance when the husband becomes unemployed. Couples make less transfer to the individual with more volatile income, which can be considered as a price for insurance. Estimation results also suggest that intra-household insurance reduces earnings volatility by about 1.1% to 7.7%.

Section 2.2 provides a literature review on related studies. Section 2.3 presents stylized facts on individual and household income volatility. In Section 2.4, a collective model is formulated, which allows for insurance against permanent and transitory wage shocks. Section 2.5 describes the data, and discusses empirical strategies and estimation results. Section 2.6 uses estimation results of the model to provide structural explanations to the stylized facts. Section 2.7 concludes.

2.2 Literature review

If markets are complete, then individuals' consumption would not respond to idiosyncratic income shocks. Several studies test this full risk sharing assumption within households or extended families using data from U.S. as well as developing countries. Cochrane (1991) presents cross-sectional regressions of consumption growth on a variety of idiosyncratic variables using food consumption from PSID. Full insurance is rejected for shocks such as long illness and involuntary job loss, but not for spells of unemployment, loss of work due to strike, and an involuntary move. Altonji et al. (1992) focus on risk sharing within American families but find no evidence of risk sharing. In developing countries especially in rural area, where income volatilities are higher, insurance and credit markets are imperfect for the poor, there are

more evidence in favor of risk sharing. Townsend (1994) found that household consumption in village India are not much influenced by contemporaneous own income, sickness, unemployment, or other idiosyncratic shocks, controlling for village level risk. Fafchamps and Lund (2001) examine data in rural Philippines, they find that shocks have a strong effect on gifts and informal loans, but little effect on sales of live-stock and grain. Mutual insurance does not appear to take place at the village level; rather, households receive help primarily through networks of friends and relatives. Dercon and Krishnan (2000) testing risk sharing within households using unpredicted illness shocks as a measure of individual idiosyncratic shocks. They find that in most households full risk sharing of illness shocks takes place.

The above risk sharing studies focus on consumption smoothing, where utility only depends on one dimensional consumption, and risk sharing comes from ex-ante savings decision. While there is another stream of literature that studies how people share income risk via ex-post labor supply adjustment. This is usually referred as “added worker effect” literature (Lundberg, 1985; Maloney, 1987; Stephens, 2002; Juhn and Potter, 2007), which studies a temporary increase in the labor supply of married women whose husbands have become unemployed. These studies only examines one-sided effect, namely, women’s participation decision in response to husbands’ unemployment, under the assumption that husbands are the primary earners in the households and most of them work full-time, thus they do not respond to wive’s unemployment shocks. Although labor supply elasticities for married women are higher than married men, it is still worth to explore labor supply responses from both sides as a result of household smoothing or risk sharing mechanism.

In order to examine how household members make joint decisions, a particular attractive model is the collective model first developed by Chiappori(1988). To maximize household welfare as a whole, household members have to decide who gets what

share of the total. Chiappori (1988), Browning et al. (1996), and Chiappori et al. (2002) developed the theoretical framework in which household members jointly taking Pareto-efficient decisions. They show that if preferences are egoistic and budget constraints are linear, under the very weak assumption of Pareto efficiency, allocations can be decentralized into a two-stage budgeting process, according to the Second Welfare Theorem. In a two-member household, the husband and wife first decide how to allocate the pooled resources according to certain sharing rule. Then each member separately chooses labor supply and private consumption. This setting is shown to generate testable restrictions on labor supplies. Moreover, the observations of labor supply behavior is sufficient to recover the individual preferences and the sharing rule (up to a constant). This model provides an useful tool in analyzing intra-household behavior.

Most studies based on collective model are static and uses cross-sectional data. Recent studies extend such collective framework to the stochastic world, where household members not only share income but also share risks. Mazzocco (2004), Mazzocco (2005), Mazzocco and Yamaguchi (2006) and Mazzocco (2007) develop a series of intertemporal collective models. He shows that the main conclusion in the static collective model still holds when introducing stochastic shocks. In his model household members can save jointly by using a risk-free asset thus he focuses on savings decision as an insurance mechanism. He has not yet addressed the interesting issue of joint labor supply decision as a mechanism for intra-household insurance. In Mazzocco (2005) the efficient risk sharing is characterized by Euler equations for public and private consumptions. Leisure Euler equations could be added but they are satisfied only if corresponding agent supplies a positive amount of labor in each period and each state of nature, which is an excessively strong assumption. Therefore, this intertemporal framework can not be generalized to the study of labor supply as a

mechanism of intra-household risk sharing.⁴

Most collective labor supply models assume both household members supply positive hours, since corner solutions largely complicates the model. As static models only requires cross-sectional data, this is not a quite restrictive assumption although it causes selection bias. However, when examining household behavior over time using panel data, every individual participates in each period would be a very restrictive assumption. Blundell et al. (2007) derive the restrictions for collective model when male can only choose to work full time or stay home, while female can choose continuous labor supply. They estimate this model and test the restrictions using the U.K. data. The estimates of the sharing rule show that male wages and employment have a strong influence on bargaining power within couples. Donni (2003) develops a more general framework in which both male and female labor supply functions are continuous and either of them can choose nonparticipation. The identification strategy is that when someone does not participate in the labor market, the sharing rule and preferences can still be identified from spouse's labor supply.

2.3 Stylized facts on income volatility and intra-household insurance

In this section, I present some important stylized facts concerning income volatility at both the household and individual level, for married couples and single individuals.

These stylized facts are consistent with the story of intra-household insurance, which

⁴In Mazzocco (2007) and Mazzocco and Yamaguchi (2006), they relax the ex-ante Pareto efficiency assumption, so that individual members need not to commit to future allocations at the time of household formation. Their empirical testing shows household members cannot commit to future plans, and households renegotiate their decisions over time. This is a potential interesting question which relates to marriage decisions. Marriage decision is beyond the scope of this paper although it causes selection issue in this model.

motivates this paper.

Table 2.1 documents household income volatility, household earnings volatility, and individual earnings volatility for singles versus married couples, using SIPP 2001 panel, the primary data source for this paper. Income volatility is measured as the variance of a transitory component of income, which is commonly used in the existing literature. The formula given at the end of Table 2.1 follows Gottschalk and Moffitt (1994), which calculates variances for either each household or each individual over an entire sample period, and then takes the average across these households or individuals. The sample used is individuals between 20 to 59 years old, who work positive hours with non-missing wages.

Of particular interest are the following three features of the data: First, transitory variance in log household income for married couples (0.085) is much lower than for single individuals (0.152 for males and 0.158 for females). The same pattern can be found for log household earnings. To take into account the covariance of a two-person income, I also randomly match a single male and a single female to form “household income”, as the sum of these two, and compare its transitory variance with that of married couples. These randomly-matched individuals do not have the household smoothing behavior that married couples might have. Still, married couples have lower household income and lower household earnings volatility than randomly-matched single individuals. This may be due to the marriage choice itself, such as individuals with higher wage or work-hour fluctuations are less likely to get married. However, I further compute transitory variance in hourly wage rate and work-hour and show that, on the contrary, singles have even lower wage and work-hour fluctuations than married individuals. Second, this higher work-hour fluctuation for married individuals is consistent with the hypothesis that married couples not only adjust labor supply in response to their own wage shocks, but they also adjust labor

supply in response to their spouse's wage shocks. Third, Table 1 also shows that, for married couples, their household earnings volatility (0.092) is lower than individual earnings volatility (0.169 for married men and 0.224 for married women). This is also consistent with the story of household insurance, that couples absorb each other's individual earnings shocks so that household earnings do not fluctuate very much. To see whether such a fact is still true over a longer horizon, I also use Panel Study of Income Dynamics (PSID) 1982-2002 to compare married couple's household earnings volatility with individual earnings volatility in each year of that study. Figure 2.1 is adapted from Figure 1.6 in Chapter 1. Over the past twenty years, household earnings volatility is always lower than either male or female earnings volatility.

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

2.4 The model

I build a theory that allows for intra-household insurance, based on the collective models of household decision-making developed by Chiappori (1988, 1992) and Donni (2003). The main advantage of their collective models is that they emphasize individual preferences and analyze the decision-making process within the household, without imposing any specific structure on the decision process. Such collective mod-

els start from basic assumptions that household allocations are Pareto efficient and preferences are egotistic or caring. The unobserved intra-household allocation, also known as “sharing rule”, and individual preferences can be uncovered from observed labor supply. I modify the basic collective model along three dimensions, to address intra-household insurance against permanent and transitory shocks. First, I introduce permanent and transitory wage shocks into the sharing rule.⁵ Second, since permanent shocks are defined as shocks that persist over time, I extend the single-period collective model over a multi-period context. Third, I incorporate a savings decision into the model. Following Blundell and Walker (1986), I separate savings and labor supply decisions into two stages. In the second stage, within-period decision is the same as the static collective model for a single period.

2.4.1 The Basic setting

Preferences and household problem

Consider a two-member household consisting of a husband (m) and a wife (f). Let h_{it}^f and h_{it}^m denote f and m 's labor supply, between 0 and 1 for household i in period t . Let c_{it}^f and c_{it}^m denote f and m 's individual consumption of a private Hicksian commodity. The price of the consumption good is set to 1. Assume no home production, so that leisure and labor supply add up to 1.⁶ Assume individual preferences are of “egotistic” type, so that utilities can be written as $U_{it}^j(1 - h_{it}^j, c_{it}^j)$ ($j = f, m$), where U_{it}^j is continuously differentiable, strictly monotone, strictly quasi-concave, and inter-temporally additive-separable over the life cycle.⁷ The household problem is to

⁵I look at wage shocks instead of income shocks because the main component of income is labor earnings, which are endogenous to labor supply.

⁶Most empirical studies using the collective model make this assumption because most datasets that include labor supply information do not include home production.

⁷Chiappori (1992) shows that the main results for egoistic preference also hold in a more general case of “caring” agents, whose preferences are represented by utility functions that depend on both

choose labor supply, consumption, and savings, in order to maximize the discounted, weighted, linear, social welfare function, subject to the household's budget constraint:

$$\begin{aligned}
& \max_{h_{it}^f, c_{it}^f, h_{it}^m, c_{it}^m, A_{i,t+1}} E_0 \left[\sum_{t=1}^T \beta^{t-1} (\mu_{it} U^f(1 - h_{it}^f, c_{it}^f) + U^m(1 - h_{it}^m, c_{it}^m)) \right] \\
& \text{s.t. } c_{it}^f + c_{it}^m + A_{i,t+1} \leq w_{it}^f h_{it}^f + w_{it}^m h_{it}^m + y_{it} + A_{it} \quad \forall t \quad (2.1) \\
& w_{it}^f = \bar{w}_{it}^f + \delta_{it}^f + \nu_{it}^f, \quad w_{it}^m = \bar{w}_{it}^m + \delta_{it}^m + \nu_{it}^m \\
& \mu_{it} = f(w_{it}^f, w_{it}^m, y_{it}, z_{it})
\end{aligned}$$

where w_{it}^f and w_{it}^m denote f and m 's hourly wage rate, respectively, in period t . Wage contains three components: expected wages, \bar{w}_{it}^f and \bar{w}_{it}^m , which are perceived by both partners; permanent shocks, δ_{it}^f , δ_{it}^m , which are unexpected, but once the shocks occur, both agents know the shocks will last for a long time; transitory shocks, ν_{it}^f and ν_{it}^m , which are also unexpected, but both partners know these influences are temporary.⁸ A_{it} denotes net wealth in period $t - 1$, and y_{it} denotes non-labor income, which includes asset income and transfers.^{9,10} The non-negative scalar μ_{it} defines the wife's decision weight within the household. In the existing collective models, μ_{it} depends on both of the partners' wages, non-labor income, and some distribution factors that affect the outside environment of the household (Chiappori, Fortin and Lacroix 2002). Underlying the function μ_{it} , there exists some intra-household allocation mechanism.

their egoistic utility and their spouses'. I focus on egoistic preferences only. Each individual may care about the overall welfare of their partner, but not by the way in which this welfare is generated.

⁸An example would be, when the husband gets an unexpected injury, both he and his spouse knows whether the injury is going to persist for a long time or will recover very soon.

⁹Interest income $r_t A_{it}$ is already included in y_{it} , by definition.

¹⁰I do not explicitly introduce shocks to the non-labor income. In this model, I assume couples pool non-labor income and decide how to divide it according to the sharing rule, which is what most existing studies using collective models assume. Given this assumption of non-labor income pooling, shocks to non-labor income and the non-stochastic non-labor income enter the decision weight hence the sharing rule in the same manner. Therefore, people share risks to non-labor income in the exact same way as they share non-labor income.

In my model, since wages are subject to stochastic fluctuations, these shocks also affect the household allocation outcome, the main channel of intra-household insurance of interest in this paper.

Two-Stage decision process

To solve the household problem in equation (2.1) and uncover how couples share risks and resources, I apply theory from the collective model derived by Chiappori (1988, 1992), and the extended results by Blundell et al. (2007) and Donni (2003), which allow for corner solutions, to decentralize household decisions into individual decisions. I also apply the two-stage budgeting of Blundell and Walker (1986), to separate inter-temporal savings decisions from within-period labor supply and consumption decisions, so that decentralization in the multi-period environment can still hold.

The static collective model by Chiappori (1988, 1992) has shown that under the assumption of Pareto efficiency with egoistic preferences, according to the Second Welfare Theorem, a weighted maximization of household utility functions can be decentralized, given a lump sum income transfer (sharing rule). In the first stage, the household members decide jointly how to allocate pooled resources to each individual, usually non-labor income, according to a sharing rule. In the second stage, given the allocated non-labor income, each agent chooses individual consumption and leisure by maximizing individual utility subject to his or her earnings plus the amount of the non-labor income that is allocated to him or her. However, when extending the static collective model into a dynamic context, an inter-temporal savings decision with a corner solution to labor supply makes decentralization no longer feasible. Mazzocco (2004) develops a two-period collective model with income shocks. His model treats income as exogenous; hence the model does not incorporate labor supply decisions. To

the best of my knowledge, Mazzocco and Yamaguchi (2006) are the only researchers who develop a dynamic collective model with endogenous labor supplies and corner solutions. They consider three discrete choices of labor supply: full-time, part-time, and non-participation, while, in this paper, I consider the continuous hours' choice. I also allow the household decision weight to depend on wage shocks. Mazzocco and Yamaguchi (2006) simulate a model to capture the empirical features of labor supply, savings, and marital choices. Although marital status and the commitment issue affect labor supply and savings decisions, I focus on intact families only, to study their joint decisions, in response to each other's wage shocks. Marriage decision is beyond the scope of this paper and is left to future research.

I apply the theory developed in Blundell and Walker (1986), to separate the inter-temporal savings decision from the within-period labor supply decision. An inter-temporally separable life-cycle model under uncertainty can be viewed as a two-stage budgeting process: in the first stage, the household optimally allocates full life-cycle wealth over each period, to equalize marginal utility of income across periods, and readjusts wealth according to realized shocks in the previous period. In the second stage, the current period's allocation of income, net of savings, is distributed between consumption and leisure; thus, the second stage becomes a within-period decision.¹¹ Therefore, the theory derived in the single-period collective model can be applied in this second stage, which involves only within-period consumption and the leisure decision, under the assumption that the decision is within-period Pareto efficient.

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

¹¹Blundell and Walker's (1986) model is based on single decision-maker households, but it can be applied to collective models (Chiappori, Fortin and Lacroix 2002, Blundell et al. 2007).

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

$$\begin{aligned}
& \max_{h_{it}^j, c_{it}^j} U_{it}^j(1 - h_{it}^j, c_{it}^j) \\
& s.t. \quad c_{it}^j \leq (\bar{w}_{it}^j + \delta_{it}^j + \nu_{it}^j)h_{it}^j + \phi_{it}^j \quad j = f, m \quad \forall t \\
& \quad \phi_{it}^f = \phi_{it}, \quad \phi_{it}^m = y_{it} - s_{it} - \phi_{it}
\end{aligned} \tag{2.2}$$

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

Without corner solutions, the second-stage problem in equation (2.2) 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:

$$\begin{aligned}
h_{it}^f &= h_{it}^f(\bar{w}_{it}^f + \delta_{it}^f + \nu_{it}^f, \phi_{it}) \\
h_{it}^m &= h_{it}^m(\bar{w}_{it}^m + \delta_{it}^m + \nu_{it}^m, y_{it} - s_{it} - \phi_{it})
\end{aligned} \tag{2.3}$$

Sharing rule

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

$$\phi_{it} = \phi(y_{it} - s_{it}, \bar{w}_{it}^f, \bar{w}_{it}^m, \delta_{it}^f, \delta_{it}^m, \nu_{it}^f, \nu_{it}^m, z_{it}) \quad (2.4)$$

This sharing rule allows expected wages, unexpected permanent wage shocks, and unexpected transitory wage shocks to affect intra-household allocation differently. The expected wages are the wage component that caught much attention in the existing static collective model (Blundell et al., 2007), under the assumption that changes in this non-stochastic wage component may affect the bargaining position in the household. In my model, I allow unexpected shocks to affect the sharing

rule in a different way than the expected wage, as the response to shocks reflects intra-household insurance, i.e., how couples share the risks. Furthermore, I also allow permanent shocks and transitory shocks to affect intra-household insurance differently. As noted in the introduction, existing studies on insurance against income shocks provide mixed evidence on whether there exists more insurance to permanent shocks or transitory shocks. The estimation of this model provides new evidence on this long-debated question.

The sharing rule is not only affected by the characteristics within the household, but is also likely to be affected by outside environment, the distribution factors. I specify local sex ratio and divorce law index as two distribution factors, as in Chiapori, Fortin and Lacroix (2002). Local sex ratio is also used in Lise and Seitz (2007) and Choo et al. (2008) to measure the marriage market tightness. 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.

Specification and identification of the sharing rules

Before discussing identification of the sharing rules, I specify functional forms for labor supply and the sharing rule. As in most empirical studies with collective models, I specify log-linear functional form for the Marshallian labor supplies in equation (2.3):

$$\begin{aligned}\log h_{it}^f &= \alpha_0 + \alpha_1 \log w_{it}^f + \alpha_2 \phi_{it} \\ \log h_{it}^m &= \beta_0 + \beta_1 \log w_{it}^m + \beta_2 (y_{it} - s_{it} - \phi_{it})\end{aligned}\tag{2.5}$$

I do not impose the logarithm on the sharing rule, since, in theory, it could be negative: when the wife transfers not only all non-labor income, but also some of her earnings.

One limitation of this linear functional form is its lack of flexibility, since the labor supply curve is monotonic. I specify a sharing rule to be a linear function in all its arguments and include two distribution factors z_{1i} and z_{2i} :

$$\phi_{it} = k_0 + k_1(y_{it} - s_{it}) + k_2\bar{w}_{it}^f + k_3\bar{w}_{it}^m + k_4\delta_{it}^f + k_5\delta_{it}^m + k_6\nu_{it}^f + k_7\nu_{it}^m + k_8z_{1i} + k_9z_{2i} \quad (2.6)$$

In Appendix 2.8.1, I show that labor supply functions in equation (2.5) imply the following indirect utility functions, from which one can perform intra-household welfare analysis of changes in exogenous variables:

$$\begin{aligned} v^f(w_{it}^f, \phi_{it}^f) &= \frac{e^{-\alpha_2\phi_{it}^f}}{\alpha_2} + \frac{(w_{it}^f)^{\alpha_1+1}}{\alpha_1+1} \\ v^m(w_{it}^m, \phi_{it}^m) &= \frac{e^{-\beta_2\phi_{it}^m}}{\beta_2} + \frac{(w_{it}^m)^{\beta_1+1}}{\beta_1+1} \end{aligned} \quad (2.7)$$

Also in Appendix 2.8.1, by following propositions in Browning, Chiappori and Lewbel (2007), I can derive the Pareto weight, in the planner's problem (2.1), which is a one-to-one mapping of the sharing rule in the decentralized problem (2.2). The Pareto weight has the following form:

$$\mu_{it} = e^{\alpha_2+\beta_2[(k_0+(k_1-1)(y_{it}-s_{it})+k_2\bar{w}_{it}^f+k_3\bar{w}_{it}^m+k_4\delta_{it}^f+k_5\delta_{it}^m+k_6\nu_{it}^f+k_7\nu_{it}^m+k_8z_{1i}+k_9z_{2i})]} \quad (2.8)$$

This exponential expression in equation (2.8) ensures the decision weight to be always a positive scalar, which is consistent with the theory. Wage shocks from both partners also show up in the Pareto weight.

Identification of the sharing rule when both partners work

From observed labor supply, it is possible to uncover the unobserved sharing rule, up to an additive constant (Chiappori 1988, 1992). The intuition for identification is that changes in non-labor income and the wife's wage and shocks affect only the husband's labor supply, through the sharing rule, and vice versa. Substituting sharing rule (2.6) into Marshallian labor supply functions (2.5), yields the corresponding reduced-form labor supply functions, when both partners are working:

$$\begin{aligned}
 \log h_{it}^f &= a_0 + a_1(y_{it} - s_{it}) + a_2\bar{w}_{it}^f + a_3\bar{w}_{it}^m + a_4\delta_{it}^f + a_5\delta_{it}^m + a_6\nu_{it}^f \\
 &\quad + a_7\nu_{it}^m + a_8z_{1i} + a_9z_{2i} \\
 \log h_{it}^m &= b_0 + b_1(y_{it} - s_{it}) + b_2\bar{w}_{it}^f + b_3\bar{w}_{it}^m + b_4\delta_{it}^f + b_5\delta_{it}^m + b_6\nu_{it}^f \\
 &\quad + b_7\nu_{it}^m + b_8z_{1i} + b_9z_{2i}
 \end{aligned} \tag{2.9}$$

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

$$\begin{aligned}
 k_1 &= \frac{a_1b_8}{\Delta}, k_2 = \frac{a_8b_2}{\Delta}, k_3 = \frac{a_3b_8}{\Delta}, k_4 = \frac{a_8b_4}{\Delta}, k_5 = \frac{a_5b_8}{\Delta} \\
 k_6 &= \frac{a_8b_6}{\Delta}, k_7 = \frac{a_7b_8}{\Delta}, k_8 = \frac{a_8b_8}{\Delta}, k_9 = \frac{a_9b_8}{\Delta}
 \end{aligned} \tag{2.10}$$

where $\Delta = a_1b_8 - b_1a_8$. Only the constant k_0 in the sharing rule is not identified. The within-period Pareto efficiency assumption also generates the following restrictions:

$$\frac{a_8}{a_9} = \frac{b_8}{b_9} \tag{2.11}$$

$$\frac{a_8}{b_8} = \frac{a_4 - a_2}{b_4 - b_2} = \frac{a_5 - a_3}{b_5 - b_3} = \frac{a_6 - a_2}{b_6 - b_2} = \frac{a_7 - a_3}{b_7 - b_3} \tag{2.12}$$

Equation (2.11) is a standard restriction in the existing collective models. The intuition of this restriction is that, since the distribution factors only affect both agents' labor supply, through the sharing rule, the effect of distribution factor z_{1i} versus z_{2i} on wives is proportional to the effect of z_{1i} versus z_{2i} on husbands. Equation (2.12) is a specific restriction in my model. Since I decompose wage into three components (expected wage, permanent shocks, and transitory shocks), the model generates additional restrictions than standard collective models, which do not distinguish these three components.

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

The model described thus far does not involve corner solutions. This paper not only looks at how couples insure each other's wage shocks when both of them are working, but also considers how one agent adjusts his/her work hours when their spouse does not work. I focus on the case where the wife works but the husband does not, which is the case that "added worker effect" literature focuses on.¹²

Donni (2003) and Blundell et al. (2007) have shown that the sharing rule changes when male labor market participation changes. The intuition for switching the sharing rule is as follows: when the husband works, his wage affects both household budget constraint and the sharing rule; when he does not work, his expected wage can still be observed, and while it no longer has any impact on household budget constraint, it can still have an impact on the sharing rule. Note that this is a crucial difference between the collective model and the alternative unitary model, where a household can be viewed as a single decision-maker, and the weight does not depend on prices, such as wage. In the unitary model, when a household member is not

¹²The reason why I focus on the male participation frontier instead of both is mainly due to statistical incoherency, which will be explained in section 2.4.3.

working, changes in his or her “potential” wage, or expected wage, do not matter. However, in the collective setting, the expected wage of an unemployed member could affect bargaining positions, such as threat point.

Identification of the sharing rule when one of the partners is not working is possible via an examination of female continuous hours’ choice and the male participation corner. Donni (2003) and Blundell et al. (2007) deal with non-participation in the static collective labor supply models. Blundell et al. (2007) estimate the model when men have only a discrete choice of working 40 hours a week or not working at all, while women can choose continuous hours. Donni (2003) develops the theory, allowing both household members to choose any hours and, also, to choose not to work. In this paper, I apply collective theory from Donni (2003). Both Donni (2003) and Blundell et al. (2007) show that the reservation wage is characterized by “double indifference”: at the wage when one agent is indifferent between working and not working, Pareto efficiency of household decisions requires that the spouse must be indifferent as well.¹³ Both studies also derive restrictions that ensure the uniqueness of a pair - of the husband and wife’s reservation wages.

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

¹³Suppose 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.

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

Denote the sharing rule in the male non-participation set as ϕ_{it}^{NP} and denote parameters with upper case:¹⁴

$$\phi_{it}^{NP} = K_0 + K_1(y_{it} - s_{it}) + K_2\bar{w}_{it}^f + K_3\bar{w}_{it}^m + K_4\delta_{it}^f + K_5\delta_{it}^m + K_6\nu_{it}^f + K_7z_{1i} + K_8z_{2i} \quad (2.13)$$

As Marshallian labor supply is a function of one's wage rate and the sharing rule, this also suggests that reduced-form labor supply switches as well:¹⁵

$$\log h_{it}^f = A_0 + A_1(y_{it} - s_{it}) + A_2\bar{w}_{it}^f + A_3\bar{w}_{it}^m + A_4\delta_{it}^f + A_5\delta_{it}^m + A_6\nu_{it}^f + A_7z_{1i} + A_8z_{2i} \quad (2.14)$$

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

$$h_{it}^{fNP} = h_{it}^f + sh_{it}^m \quad (2.15)$$

where s is a scalar that can be estimated. Along the male participation frontier, the last term in (2.15) equals zero. Consequently, $h_{it}^{fNP} = h_{it}^f$, which implies that female labor supply is continuous. The sharing rule also follows a similar continuity

¹⁴Notice that the sharing rule on the male non-participation set does not depend on the husband's transitory shocks, which means the coefficient on transitory shocks is zero.

¹⁵Since the sharing rule does not depend on the husband's transitory shocks, female labor supply, as a function of the wife's wage plus the amount of non-labor income originating from the sharing rule, also does not depend on the husband's transitory shocks.

condition:

$$\phi_{it}^{NP} = \phi_{it} + qh_{it}^m \quad (2.16)$$

This suggests that the sharing rule is also continuous along the participation frontier. A Pareto-efficient decision implies that there is no discrete jump in the amount of non-labor income that the wife receives when there is a discrete jump in the husband's participation. The relation between s and q can be derived from equations (2.6), (2.11) and (2.12):

$$q = \frac{sb_8}{\Delta} \quad (2.17)$$

Parameters K s, which are the partial derivatives of the sharing rule on the male non-participation set, can be identified via (2.18) and (2.19). Only the constant K_0 is not identified.

2.4.2 The unitary model

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

I also assume households make savings decisions in the first stage, and the second stage involves only within-period consumption and labor supply decisions.

$$\begin{aligned} \max_{h_{it}^f, h_{it}^m, c_{it}^f, c_{it}^m} \quad & U(1 - h_{it}^f, 1 - h_{it}^m, c_{it}^f, c_{it}^m) \\ \text{s.t.} \quad & c_{it}^f + c_{it}^m \leq w_{it}^f h_{it}^f + w_{it}^m h_{it}^m + y_{it} - s_{it} \quad \forall t \end{aligned} \tag{2.18}$$

Labor supply functions can still be derived as in equation (2.9). Slutsky symmetry implies the following restriction:

$$b_8 = -a_8 \tag{2.19}$$

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

$$A_3 = 0 \Rightarrow a_3 + sb_3 = 0 \tag{2.20}$$

2.4.3 Further discussions of the model

Given the specifications of the model, it is worth discussing the restrictions it imposes. First, this model does not consider marriage or divorce decisions, while a large adverse shock from one partner may lead to divorce. Thus, my estimation uses the most committed families, which would overestimate individuals' willingness to insure against spouse's shocks in the population. Second, this model only distinguishes shocks at different persistency levels, but does not distinguish shocks from different causes, such as wage loss from injury or job transition. These, however, could have

different impacts on labor supply.¹⁶ Third, this model implicitly assumes agents can adjust labor supply freely. In reality, though, hours might be constrained for a given job, and, since it takes time to find another job, the labor-supply adjustments by switching jobs might not be reflected in the current period. Therefore, empirical work might underestimate the effect of wage shocks on labor supply. Fourth, I assume that there is no external insurance for wage shocks. Hence I do not consider the interaction between social insurance programs such as an unemployment benefit and intra-household insurance. Adding external insurance will result in an adverse selection problem.¹⁷ Last but not least, one implicit assumption is that couples have the same preference for risk, as husbands and wives have the same utility functions. Preferences for risks, however, could be a factor that influences couples' willingness to insure. For instance, couples who are more risk averse may be more likely to insure each other's transitory shocks to smooth consumption, or if a husband and wife have different preferences for risk, they may respond to spousal shocks differently. Mazzocco (2004) considers savings decisions and finds that household members transfer more to the agent that is more risk averse.

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

¹⁶Coile (2003) studies how health shocks affect married couples' labor supply decisions.

¹⁷There are some other studies that examine how external insurance affects labor supply. Cullen and Gruber (2000) show that a generous unemployment benefit has a crowding out effect on spousal labor supply.

2.5 Data and empirical results

2.5.1 Data

This study uses the Survey of Income and Program Participation (SIPP) 2001 panel, a national representative longitudinal dataset in the United States. For the study of short-run labor supply response to wage changes, SIPP offers substantial advantage over other panel data sets, such as PSID or the Health and Retirement Study (HRS). First, SIPP interviews three times a year, while other data sets conduct interviews either annually or biennially.¹⁸ Thus, SIPP provides high frequency labor supply fluctuation.¹⁹ Another advantage of SIPP is that high frequency interviews also yield better quality of wage information. With annual interviews, it is not possible to obtain wage changes for jobs that last for less than a year. In PSID, if a job change occurs some time during the year, then wages computed from annual earnings and hours are the mixture of wages on the new and the old jobs. SIPP directly reports hourly wage for hourly-wage employees. Further, I use wage data purged of measurement error, as in Gottschalk (2005).²⁰ 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 SIPP 2001 panel consists of nine waves, from December 2000 to February 2003. The primary sample cuts in the estimation include married couples with husbands 20-64 years old and wives younger than 64 years old, at some point in the

¹⁸In addition, HRS only contains sample of older people.

¹⁹SIPP also contains monthly data on wage and labor supply. But monthly data has the well-documented seam bias problem (Gottschalk 2005). Respondents are more likely to report a wage change between interviews instead of within an interview period.

²⁰I thank Peter Gottschalk for generously providing SIPP wage data with his correction of measurement error.

panel. Excluded are households who have children less than 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. This yields a sample of 8,417 households with 51,112 observations. All income variables are placed into January 2000 Consumer Price Index Research Using Current Methods Series (CPI-U-RS) dollars.²¹

The dependent variable is the total number of hours of work in each wave (three months). The measure of wage is hourly wage rate, defined as the observed hourly wage for hourly-wage employees, or, alternatively, as the total wage earnings divided by the number of hours of work. Household non-labor income includes property income, transfer income, and other income. Savings is constructed by taking the difference between net wealth in period t and $t-1$.²² Information on net wealth is available only in the 3rd, 6th and 9th wave of the SIPP 2001 panel. I use linear interpolation to fill in for the remaining waves.²³ This variable is treated as endogenous with the measurement error in the empirical section.

The local sex ratio is constructed using the 2000-2003 American Community Survey (ACS) from the Public Use Microdata Sample (IPUMS). It corresponds to the number of unmarried males of the same age as the husband in each household 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, others). This sex ratio represents the tightness of the local marriage market, under the assumption that people married within their own racial group. I also experimented with alternative definitions of sex ratio: the ratio including both married and unmarried individuals, or the number of males divided by the number of males and females of the same age

²¹The deflator can be found at <http://www.census.gov/hhes/www/income/income05/cpiurs.html>

²²I acknowledge that savings constructed by this method includes both active and passive savings, as well as measurement error. Savings in my model refers to active savings only.

²³The PSID data only contains wealth information every-other five years before 1996, and biennially afterwards. The HRS data only includes wealth information every-other year, also.

group (20-24, 25-29, etc.). The other distribution factor, divorce law index, considers four of the following features of divorce legislation in each state: property division (community property =1), mutual consent versus unilateral divorce (mutual consent =1), contribution to education (=1), and non-monetary contribution (=1).²⁴ These features are likely to favor women. All four features did not change over time within states, during my sample period. Table 2.2 presents the summary statistics. On average, married women work less than men and earn lower hourly wage. Married women's wage variations and hours variations are higher than men. There are large variations in household non-labor income. Savings variable has a very large noise.

2.5.2 Estimates of the permanent and the transitory wage shocks

To study how wage shocks affect couples' labor supply, it is crucial to obtain good estimates of wage shocks. It is also important to distinguish between permanent shocks and transitory shocks, as they are each likely to be determined by different factors (change in skill prices versus job instability, for instance), and hence have different impacts on household joint labor supply decisions. There is a large body of literature that estimates income dynamics models (for a review see MaCurdy 2007). The canonical error components model is as follows:

$$y_{it} = \mu_i + \nu_{it} \tag{2.21}$$

where y_{it} is log income or residual log income for individual i in year t , μ_i is a time-invariant permanent individual component and ν_{it} is a transitory component.

The model can be estimated using either nonparametric or parametric meth-

²⁴From Family Law Quarterly, Winter 2000, Winter 2001, Winter 2002, Charts 4 and 5.

ods. Earlier work by Gottschalk and Moffitt (1994) estimate the permanent component of earnings as the average earnings for each individual over each 9-year window, and the deviations from the average as the transitory component. Such non-structural approach is still used in recent studies of earnings dynamics (Beach et al., 2003, 2008). Moffitt and Gottschalk (2002) use an alternative nonparametric model. Assume the transitory shocks fade out if time period is long enough, they identify the permanent variance as the covariance between two time periods, and identify the transitory variance as the difference between variance and covariances. Other studies specify formal error components models, usually assuming the evolvement of the transitory shocks follow a lower order ARMA process, and the permanent shocks are introduced by a random walk or a random growth. From the estimated parameters one can compute the permanent and transitory variances in each time period for each age cohort.

Using any of the above three methods one can estimate the variances of the permanent and transitory shocks. However, to identify the individual shocks instead of the variances of the shocks, we need stronger identification assumptions. For instance, from a formal error components model, it is impossible to uncover individual random walk or random growth in the permanent component. I need to make a strong assumption that the permanent component does not subject to a random walk or random growth.

In this paper I use a modified version of the non-structural approach developed in Gottschalk and Moffitt (1994). Instead of assuming the permanent component remain constant over time, I allow a linear growth in the permanent component.

$$\log w_{it}^j = \bar{w}_{it}^j + t\mu_i^j + \nu_{it}^j \quad j = f, m \quad (2.22)$$

where $\log w_{it}^j$ is the log hourly wage rate. \bar{w}_{it}^j represents the expected wage, which is

predictable from observed education and age. $t\mu_i^j$ is the permanent wage shock and ν_{it}^j is the transitory wage shock.

I obtain \bar{w}_{it}^j from the predicted value of first-stage Mincer regressions for each period. The dependent variable is log wage rate, and the independent variables include age, age square, four education dummies (high school diploma, some college, college degree, graduate school) all with time-varying coefficients. These time varying parameters are excluded in equation (2.9), thus they serve as the exclusion restrictions for the labor supply equations. The intuition is that the differences in the preferences and the sharing rule 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).

Then, I identify the permanent and transitory shocks for each individual in each time period by individual regressions. The identification comes from the assumption that individual permanent component μ_i^j is time invariant, so it can be treated as a fixed coefficient.

$$\hat{e}_{it}^j = \mu_i^j t + \nu_{it}^j \quad j = f, m \quad (2.23)$$

where t becomes an independent variable, and this regression produces the estimated coefficient $\hat{\mu}_i^j$. The permanent shocks can be computed using the predicted value from (2.23), and the transitory shocks are simply the difference between wage residuals and permanent shocks.

The estimated permanent and transitory shocks are shown in Table 2.3. Women have larger standard deviations and larger ranges between minimum and maximum, in both permanent shocks and transitory shocks, than men do. This is consistent

with the stylized facts from Table 2.1, that women's wages are more volatile than men's wages.

2.5.3 Estimates of couple's labor supply functions and the sharing rules

In this section, I estimate labor supply functions for husbands and wives jointly, and recover unobserved sharing rules. The sharing rule divides total non-labor income net of savings from the first stage. Savings are treated as endogenous with the measurement error. The savings variable is instrumented using the housing price index interacted with home ownership and birth cohort dummies.²⁵ Control variables include education dummies and a quadratic in age, for both partners.²⁶ Table 2.4 shows estimates of savings regression. Predicted savings is used in the labor supply functions.

The model in the theoretical section does not incorporate unobserved heterogeneity, since introducing unobserved heterogeneity with non-participation would raise the issue of whether the model is identifiable from available data (Blundell et al. 2007). Following existing studies using collective models with non-participation, I specify labor supply functions with additives in the heterogeneity terms. Estimation of household labor supply when both partners participate (equation 2.11) and female labor supply when the husband does not work (equation 2.17) suggest a switching

²⁵Lise and Seitz (2007) use similar instruments. Housing price index quarterly data, by state, can be found at http://www.ofheo.gov/hpi_download.aspx.

²⁶In the data, savings information is noisy. In the regression, I use only the middle 90% observations, and predict for the entire sample.

regression model:

$$\begin{aligned}\log h_{it}^{f*} &= a'x_{it} + u_{it}^f + (1 - I(h_{it}^{m*} > 0))s(b'x + u_{it}^m) \\ \log h_{it}^{m*} &= b'x_{it} + u_{it}^m\end{aligned}\tag{2.24}$$

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

$$\log h_{it}^m = \begin{cases} \log h_{it}^{m*} & \text{if } \log h_{it}^{m*} > 0 \\ = 0 & \text{otherwise.} \end{cases}\tag{2.25}$$

Equations (2.24) and (2.25) are estimated using Full Information Maximum Likelihood (FIML). The likelihood function is given in Appendix 2.8.2.

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

$$\begin{aligned}\log h_{it}^{f*} &= a'x_{it} + u_{it}^f + (1 - I(h_{it}^{m*} > 0))s(b'x + u_{it}^m) \\ \log h_{it}^{m*} &= b'x_{it} + u_{it}^m + (1 - I(h_{it}^{f*} > 0))S(a'x + u_{it}^f)\end{aligned}\tag{2.26}$$

Consider two cases: $h_{it}^{f*} > 0, h_{it}^{m*} < 0$ and $h_{it}^{f*} < 0, h_{it}^{m*} > 0$. When $s < 0$ and $S < 0$, both these two cases hold. In reality, however, these two situations are mutu-

ally exclusive. Bloemen (2004) also discusses that, without any further restrictions, the double-switching model may generate multiple outcomes for the participation status of a husband and wife in a household. Imposing coherency in such model is either quite complicated or greatly reduces the generality of the model. Therefore, I only focus on one participation frontier, in which the husband chooses whether or not to work.

Estimates of the reduced-form supply functions

Table 2.5 presents FIML estimates of reduced-form female and male labor supply functions. The standard errors have been computed using the bootstrap since expected wage, wage shocks and non-labor income are predicted. One's wage shocks, either permanent or transitory, have a significant negative effect on spousal labor supply, while permanent shocks have a larger impact than transitory shocks. The elasticity of husbands' permanent wage shocks on wives' labor supply is -0.158, while transitory wage shocks have an elasticity of -0.075. A similar effect can be found in the estimation of male labor supply functions: a 1% drop in the wife's permanent wage shock increases male labor supply by 0.216%, while the same drop in transitory shock increases male labor supply by 0.111%. This provides some evidence that household members insure each other by increasing labor supply in response to spousal adverse shocks, and such an insurance effect is stronger for more persistent shocks. The estimate of ρ is -0.069, which suggests couples' unobserved shocks to leisure are negatively correlated.

Unlike wage shocks, the expected wage has a positive effect on spousal labor supply. A 1% increase in male expected wage, due to the observed changes in age and education, tends to increase female labor supply by 0.33%, while the same increase in female expected wage tends to increase male labor supply by 0.22%.

Recover the structural parameters and interpretation of the results

To see whether these empirical results are consistent with the collective hypothesis, I test the restrictions implied by the collective model and the alternative unitary model. Testing restrictions for the collective model are presented in equations (2.11) and (2.12). The Wald statistic from a joint test is 1.20 with a p-value of 0.94, which indicates that the collective hypothesis cannot be rejected at any conventional significant level. Testing the restrictions for the unitary model, equations (19) and (20), yields a statistic of 12.88 and p-value of 0.002, which indicates that the unitary model can be rejected at 1% level. The collective model cannot be rejected, while the unitary model can be rejected. These test statistics provide support for the collective hypothesis.

From the estimation of reduced-form labor supply functions, I recover the Marshallian labor supply of equation (2.5), up to an additive constant. Table 2.6 presents female and male Marshallian labor supply estimates. The income effect is precisely estimated for male labor supply, the negative sign suggests male leisure is a normal good. Female income effect is also negative, but is not precisely estimated. Both male and female own wage effects are significantly positive. The implied wage elasticity is 0.893 for females and 3.003 for males. Both male and female Marshallian labor supplies satisfy the Slutsky condition of individual utility maximization.

Table 2.7 presents estimates of the two sharing rules: the first set of estimates are when both partners work, the second is associated with when only the wife works but the husband does not.²⁷ Asymptotic standard errors are computed using the delta method, based on the the bootstrapped standard errors from reduced from

²⁷As discussed in Section 3.2.2, in the male non-participation set, male transitory wage shocks are missing, thus the sharing rule ϕ_{it}^{NP} does not depend on male transitory shocks. Permanent wage shocks are also missing for those males who never work in the sample. For identification purposes, the estimation only includes those who work at least two periods to identify the permanent shocks.

regressions. Some of the parameters are not precisely estimated. From equation (2.10), we can see that each parameter in the sharing rule relies on five parameters from the reduced-form labor supply, and every sharing rule parameter depends on the estimates of $\Delta = a_1b_8 - b_1a_8$. Furthermore, even if each coefficient is estimated precisely, Δ may still appear insignificant, especially when a_1b_8 and b_1a_8 have the same sign.

When both partners are working, a household makes a greater transfer to the agent with the larger adverse shocks, and makes the largest transfer to the agent with shocks that are permanent. The first set of estimates of the sharing rule in Table 2.7, together with estimates of the Marshallian labor supply in Table 2.6, can be interpreted as follows: when the wife's hourly permanent wage goes down by 10%, her share of non-labor income from intra-household allocation increases by \$380, which means that the husband's share of non-labor income decreases by the same amount. Now, combined with the sharing rule estimates, the coefficient of non-labor income on male log hours is -0.005, which suggests that a drop of \$380 in the husband's share of non-labor income will translate into an increase in his labor supply of 1.9%. In short, a 10% permanent shock to the wife's hourly wage results in an increase of 1.9% in the husband's labor supply. The estimates of the sharing rule provide insights on how shocks affect intra-household allocation, and the estimates of the Marshallian labor supply provide insights on how that intra-household transfer translates into the changes in spousal labor supply. When the shocks are transitory, the same shocks to the wife's labor supply result in a drop in the husband's share of non-labor income of \$195, which, in turn, increases his labor supply by 0.98%. All these effects are precisely estimated. I also test whether a wife's permanent and transitory shocks have the same effect on intra-household allocation. Although the wife's permanent wage shocks have a larger effect on intra-household insurance than do transitory wage

shocks, such effect is not statistically significant.

Now let us look at the reverse, that is, how husbands' permanent and transitory shocks affect wives' labor supply through intra-household transfer. When there is a 10% negative permanent shock to the husband's wage, the wife's share of non-labor income drops by \$664, the wife's labor supply increases by 1.3%. Given the same transitory shocks to the husband's wage, the wife's share of non-labor income drops by \$314.5, wife's labor supply increases by 0.6%. Unfortunately, these effects are not precisely estimated. Compared to previous results of male labor-supply response to female wage shocks, here female labor supply responds less to male wage shocks. But it is not clear whether this is due to the imprecise estimates of some parameters.

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

The sharing rule for a working wife with a non-working husband is quite different from the rule for working couples. This is partly due to the large value of the estimate of q in equation (2.16). When the wife receives an adverse shock, no matter whether it is permanent or transitory, her share of household non-labor income no longer increases. The intuition behind this result is that now the husband is not able to adjust his labor supply. Therefore, even if the wife has adverse shocks, the husband cannot provide insurance through labor supply, thus she has to insure against this shock by herself. The estimate of this sharing rule also indicates that there is no evidence of the added worker effect. Added worker effects in my model would suggest that when the husband becomes unemployed, the wife works more, to compensate for

his income loss, such as his permanent shocks. This is contrary to what the sharing rule shows. However, the estimates of this sharing rule are not significant, even at the 10% level, partly due to the insignificant estimates of q . The coefficient estimate of non-labor income has a value of 1.428, which is outside the usual range of between 0 and 1, as this represents a dollar increase of non-labor income, i.e., how much of the increase goes to the wife.

The distribution factors do not have the expected sign on the sharing rule. Increase in the local sex ratio (the relative scarcity of women) and changes in the divorce law - in favor of women, should increase the female share of non-labor income, but I find either no significant effect or the opposite sign. Alternative measurements of sex ratio, such as compute ratio by dividing into four racial groups instead of three, or measuring the number of men divided by the number of men plus women within a 5 to 10 year age range, or measuring the number of all males over all males and females, including both married and unmarried population, do not change the results qualitatively. One possible explanation is, it maybe not the sex ratio at the current period that affects intra-household allocation, instead, the sex ratio at the time of marriage matters, since that is the time when they agree upon a sharing rule. Unfortunately, it is difficult to back up the sex ratio at the time of marriage from the available data. This unexpected sign for distribution factors is also found in Hourriez (2005). He argues that such an effect may be a consequence of home production. When the wife's options outside marriage improve, she may want to negotiate both the share of non-labor income and a reduction in her housework. This explanation is also compatible with results in Table 2.7. Increased scarcity of women decreases the male share of non-labor income when the husband participates in the labor market, as couples may bargain over housework. The higher bargaining power the husband has, the more he can negotiate to do less of the housework; therefore he might increase

his labor supply. When the husband does not participate, such an effect of the sex ratio on the sharing rule is no longer significant. This might be due to the fact that the husband devotes zero hours on market work, and therefore his time on home production is almost fixed. As a result, the wife does not need to negotiate over home production, but only on intra-household allocation. This may be why I find a positive effect of distribution factors on the sharing rule when the husband does not participate in the labor market.

2.5.4 Comparison with the deterministic model

This paper introduces permanent and transitory wage shocks into the sharing rule of the collective model. Here, I estimate the baseline model in the existing collective literature, which does not distinguish between the deterministic component of wage and its stochastic shocks. Table 2.8 displays sharing rule estimates that treat wage as a single component, given everything else the same as in my main sample and method. When both partners are working, female and male wage still have the bargaining effect on the sharing rule, which is consistent with many studies using collective models (Blundell et al, 2008, etc.). The wage effect is not statistically significant though. Divorce law index now have the expected positive sign, but are still not precisely estimated. I also estimate the model using the sample of working couples only, which is the sample defined in Chiappori, Fortin and Lacroix (2002). The results are still similar as in Table 2.8.

2.5.5 Individual income volatility and intra-household allocation

Previous sections examined how married couples adjust labor supplies in response to each other's wage shocks. Another question of interest is how they adjust labor supplies in response to each other's individual income volatility, which is measured as the variances of the wage shocks for each individual. The analysis in this section suggests that individual income volatility can be considered as a measurement of price for intra-household insurance.²⁸

Table 2.9 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 2.7. The point estimates show that one's higher individual wage volatility results in a lower proportion of non-labor income allocated to him or her. My interpretation is such individual income volatility can be considered as a measure of price for insurance. Take female volatility as an example, if her income is very volatile, she has extra gain from the marriage by getting intra-household insurance against her volatile income, compared to insuring all by herself if she remained single. A possible consequence is, she needs to compensate her spouse by transferring some of her income as a price for such insurance. This is reflected in the estimation of the sharing rule that she transfers more income to her husband when her income is more volatile. This result, from another perspective, provides evidence in support of intra-household insurance.

²⁸Note that, in Section 2.2, regarding stylized facts, income volatility is estimated using the entire sample. Here, wage volatility is computed at the individual level. These are two different notations and that is why I call the latter one "individual wage volatility".

2.5.6 Robustness checks and estimation for subgroups

I estimate the main model using several alternative specifications. I further restrict the sample to include only those households with heads between 35 and 64 years old, since this age range would typically be less likely to have children, or their children would have already left home. The qualitative results do not change. I also try to estimate the model using the sample of hourly workers only. This eliminates the measurement error caused by imputed wage from earnings for those who earned a salary on an annual basis. Unfortunately, the parameters are very poorly estimated, mainly because of the very small sample size. In SIPP data, the flag for imputed wage has many missing values, and when the sample is restricted to both partners who are hourly workers, it only yields a pool of 886 households, while the main sample contains 4,749 households. Overall, these specification checks show that the main results are robust to various specifications and sample cuts.

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

labor response is not significant for high school dropouts, but it is significant, and an even larger effect, for higher-educated groups, which seems to contradict the liquidity constraints theory.

Table 2.10 displays results of reduced-form labor supply estimation for households whose net wealth in the third wave is less than the 40th percentile.²⁹ Table 2.11 displays estimation results for the two sharing rules. Reduced-form estimates show that both the permanent and transitory shocks have significant effect on own labor supply and spousal labor supply. Compared to reduced form estimates in Table 2.5, I find that shocks have slightly larger impacts on female labor supply for these households with low wealth. Spousal wage shocks have larger effects on male labor supply for low wealth households than the entire sample, while their own shocks have smaller effects on male labor supply. In Table 2.11, parameters on sharing rules are poorly estimated, thus they could not be compared with previous results using the entire sample. I also estimate this model on households where the head-of-household's educational level was a high school diploma or below, or on households with a net wealth less than the 50th percentile and who do not own a house or apartment. Results do not change qualitatively. These empirical findings are not exactly consistent with the liquidity constraints theory, but many factors could explain these results: People with lower wealth or lower education may have a lower ability to find jobs or adjust their labor supply quickly. This also explains why couples with lower wealth only respond to permanent shocks, but not to transitory shocks.

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

2.6 A structural explanation to the stylized facts

According to the stylized facts presented in Section 2.3, household earnings volatility is lower than individual earnings volatility for married couples, and household earnings volatility for married couples, who might have an intra-household insurance mechanism, are lower than that of singles who would not have an intra-household insurance mechanism. To what extent do the results of my structural model provide explanations to these empirical facts? In this section I conduct the following two exercises: First, I recalculate transitory variances of log household earnings and log individual earnings, given the structural responses of labor supply to both partner's transitory shocks from the model. Second, I calculate the same variances but without any structural response of intra-household insurance, and compare the number with the first exercise. The difference explains what proportion of earnings volatility is due to intra-household insurance.

The estimation results of my model provide partial derivatives of labor supply with respect to wage shocks. To take these structural responses into account, I use Taylor expansion to derive earnings as a function of partial derivatives with respect to husbands' and wives' wage shocks. Derivations are presented in Appendix 2.8.3. Then, I calculate the variance of such expansions for log household earnings and individual earnings. From expressions in equations (2.36) and (2.37) in Appendix 2.8.3, the variances depend on parameters in the sharing rule and Marshallian labor supply functions, estimates of transitory wage shocks, and observed labor supply. I plug estimated parameters, transitory shocks and labor supply into (2.36) and (2.37). Table 2.12 presents estimated earnings volatility from three sets of estimates: main results as in Table 2.6-2.7; results including individual income volatility as in Table 2.10, and estimates using working couples sample only. For the main results, log earnings

volatility for married men is 1.547, which is higher than married couples' household earnings volatility, at 0.596. Log earnings volatility for married women is 0.414. Therefore, household earnings volatility is much lower than the average of the husbands' and the wives' earnings volatility. This lower household earnings volatility is consistent with the stylized facts presented at the beginning of this paper. This is also true for the other two alternative specifications. Using the working couples' sample, log household earnings volatility is even lower than the female earnings volatility.³⁰

In the second exercise, I compute the transitory variance in log individual or household earnings without intra-household insurance and compare this with the previous results. Without intra-household insurance, wage shocks no longer affect intra-household allocation. Therefore, the term k_6 , k_7 becomes zero. For the main specification, now the log individual earnings volatility is recalculated as 1.610 for married men and 0.446 for married women, while married couples' log household earnings volatility becomes 0.603. Compared to the previous results with insurance, this suggests that intra-household insurance to transitory shocks reduces household earnings volatility by 1.2%. It also reduces individual earnings volatility by 4.1% for married men and 7.7% for married women. These numbers may seem to be small, but given the fact that the earnings volatility is mainly caused by fluctuations in wages, such intra-household insurance already plays a significant role in explaining the remaining earnings fluctuations. The magnitude is pretty similar in the other two specifications. Both these exercises confirm that the model developed in this paper provides empirical evidence that is consistent with the stylized facts: household

³⁰The magnitude differs though. One difference is stylized facts in Table 1 includes all couples, with and without children, while my estimation focus on the sample of couples without children. Another reason for this difference is that in this exercise as well as in the model, I assume all wage shocks are exogenous. The stylized facts from empirical data, however, also capture the possibility that individual's wage shock is a response to a spousal adverse wage shock. For instance, the wife may switch to a job with a higher wage in response to her husband's adverse wage shock, in which case we observe the wife has a positive wage shock.

earnings volatility is lower than individual earnings volatility, and earnings volatility for those who have intra-household insurance mechanism are lower for those who do not.

2.7 Conclusion

The literature on insurance for income shocks has either focused on consumption smoothing via savings decisions, or focused on one-sided labor supply response. The aim of this paper has been to evaluate the link between income volatility and household labor supply decisions, by examining the degree of intra-household insurance with respect to each other's wage shocks. I develop an intra-household insurance model based on collective models, where wages are stochastic, and the intra-household allocation depends on both permanent and transitory wage shocks. I first estimate permanent and transitory wage shocks for each individual, then estimate couples' labor supplies, using the SIPP 2001 panel, and recover the unobserved intra-household allocation mechanism. Estimation results provide some evidence of household insurance via labor supply: married couples make joint labor-supply decisions to insure against both permanent and transitory wage shocks, while labor response is larger when shocks are permanent. Such household insurance disappears when the husband becomes unemployed and can no longer adjust his labor supply. The negative effect of individual income volatility on intra-household allocation can be considered as a price for insurance. This paper also contributes to empirical studies using collective models, by examining high-frequency data in the United States and expand the scope of the sharing rule to act as a function of wage shocks, both permanent and transitory. The comparison with existing static collective models shows the importance of stochastic wage components and, therefore, the importance of developing formal dy-

dynamic collective models with labor supply - both on extensive and intensive margin. Furthermore, this model also has aggregate implications on individual and household earnings volatility. The estimation of this model provides a structural explanation for the stylized facts that household earnings volatility is lower than individual earnings volatility, and how such intra-household insurance mechanism reduces household earnings volatility and individual earnings volatility.

2.8 Appendix

2.8.1 Proof of the existence of the Pareto weight

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

$$\frac{\partial v^f(w_{it}^f, \phi_{it}^f)/\partial w_{it}^f}{\partial v^f(w_{it}^f, \phi_{it}^f)/\partial \phi_{it}^f} = h_{it}^f, \quad \frac{\partial v^m(w_{it}^m, \phi_{it}^m)/\partial w_{it}^m}{\partial v^m(w_{it}^m, \phi_{it}^m)/\partial \phi_{it}^m} = h_{it}^m \quad (2.27)$$

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

$$\begin{aligned} v^f(w_{it}^f, \phi_{it}^f) &= \frac{e^{-\alpha_2 \phi_{it}^f}}{\alpha_2} + \frac{(w_{it}^f)^{\alpha_1+1}}{\alpha_1+1} \\ v^m(w_{it}^m, \phi_{it}^m) &= \frac{e^{-\beta_2 \phi_{it}^m}}{\beta_2} + \frac{(w_{it}^m)^{\beta_1+1}}{\beta_1+1} \end{aligned} \quad (2.28)$$

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

$$\mu_{it} = -\frac{\partial v^m(w_{it}^m, \phi_{it}^m)/\partial \phi_{it}}{\partial v^f(w_{it}^f, \phi_{it}^f)/\partial \phi_{it}} = \frac{e^{-\beta_2 \phi_{it}^m}}{e^{-\alpha_2 \phi_{it}^f}} = e^{(\alpha_2 + \beta_2)\phi_{it} - \beta_2(y_{it} - s_{it})} \quad (2.29)$$

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

$$\mu_{it} = e^{\alpha_2 + \beta_2[(k_0 + (k_1 - 1)(y_{it} - s_{it}) + k_2 \bar{w}_{it}^f + k_3 \bar{w}_{it}^m + k_4 \delta_{it}^f + k_5 \delta_{it}^m + k_6 \nu_{it}^f + k_7 \nu_{it}^m + k_8 z_{1i} + k_9 z_{2i})]} \quad (2.30)$$

2.8.2 Derivation of the likelihood functions

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

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

The log-likelihood function takes the form:

$$L = \sum_{i \in P} \log L_i(h_{it}^f, h_{it}^m) + \sum_{i \in NP} \log L_i(h_{it}^f) \quad (2.31)$$

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

$$L_i(h_{it}^f, h_{it}^m) = \frac{1}{\sigma_f\sigma_m} \varphi\left(\frac{u_{it}^f}{\sigma_f}, \frac{u_{it}^m}{\sigma_m}, \rho\right) \quad (2.32)$$

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

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

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

$$r = \frac{\rho\sigma_f + s\sigma_m}{\sigma_v} \quad (2.33)$$

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

The likelihood in NP becomes:

$$\int_{-\infty}^{-b'x/\sigma_m} \frac{1}{\sigma_m} \varphi\left(\frac{u^m}{\sigma_m}\right) \frac{1}{\sigma_v \sqrt{1 - r^2}} \varphi\left(\frac{h^f - a'x - sb'x - r \frac{\sigma_v}{\sigma_m} u^m}{\sigma_v \sqrt{1 - r^2}}\right) \partial u^m \quad (2.34)$$

which can be simplified as:

$$L_i = \frac{1}{\sigma_v} \varphi\left(\frac{h^f - a'x - sb'x}{\sigma_v}\right) \Phi\left(\frac{-\frac{b'x}{\sigma_m} - r \frac{h^f - a'x - sb'x}{\sigma_v}}{\sqrt{1 - r^2}}\right) \quad (2.35)$$

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

2.8.3 Derivation of log earnings as function of both partners' wage shocks

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

$$\begin{aligned} \log(h^m \epsilon^m) &= f(\log \epsilon^m, \log \epsilon^f) = \log(h_0^m \epsilon_0^m) + \frac{\partial \log h^m \epsilon^m}{\partial \log \epsilon^m} (\log \epsilon^m - \log \epsilon_0^m) \\ &\quad + \frac{\partial \log h^m \epsilon^m}{\partial \log \epsilon^f} (\log \epsilon^f - \log \epsilon_0^f) \end{aligned} \quad (2.36)$$

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

drops out:

$$\begin{aligned}
\text{var}(\log h^m \epsilon^m) &= \text{var}(\beta_1 - \beta_2 k_7 + 1) \log \epsilon^m - \beta_2 k_6 \log \epsilon^f \\
&= \text{var}[(\beta_1 - \beta_2 k_7 + 1) \nu^m - \beta_2 k_6 \nu^f]
\end{aligned} \tag{2.37}$$

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

$$\begin{aligned}
\text{var}(\log(h^m \epsilon^m + h^f \epsilon^f)) &= \text{var}\left\{ \frac{1}{h^m \epsilon^m + h^f \epsilon^f} (h^m \epsilon^m (\beta_1 - \beta_2 k_7 + 1) + h^f \epsilon^f \alpha_2 k_7) \log \epsilon^m \right. \\
&\quad \left. + (-h^m \epsilon^m \beta_2 k_6 + h^f \epsilon^f (1 + \alpha_1 + \alpha_2 k_6)) \log \epsilon^f \right\} \\
&= \text{var}\left\{ \frac{1}{h^m \exp(\nu^m) + h^f \exp(\nu^f)} (h^m \exp(\nu^m) (\beta_1 - \beta_2 k_7 + 1) \right. \\
&\quad \left. + h^f \exp(\nu^f) \alpha_2 k_7) \nu^m + (-h^m \exp(\nu^m) \beta_2 k_6 + h^f \exp(\nu^f) \right. \\
&\quad \left. (1 + \alpha_1 + \alpha_2 k_6)) \nu^f \right\}
\end{aligned} \tag{2.38}$$

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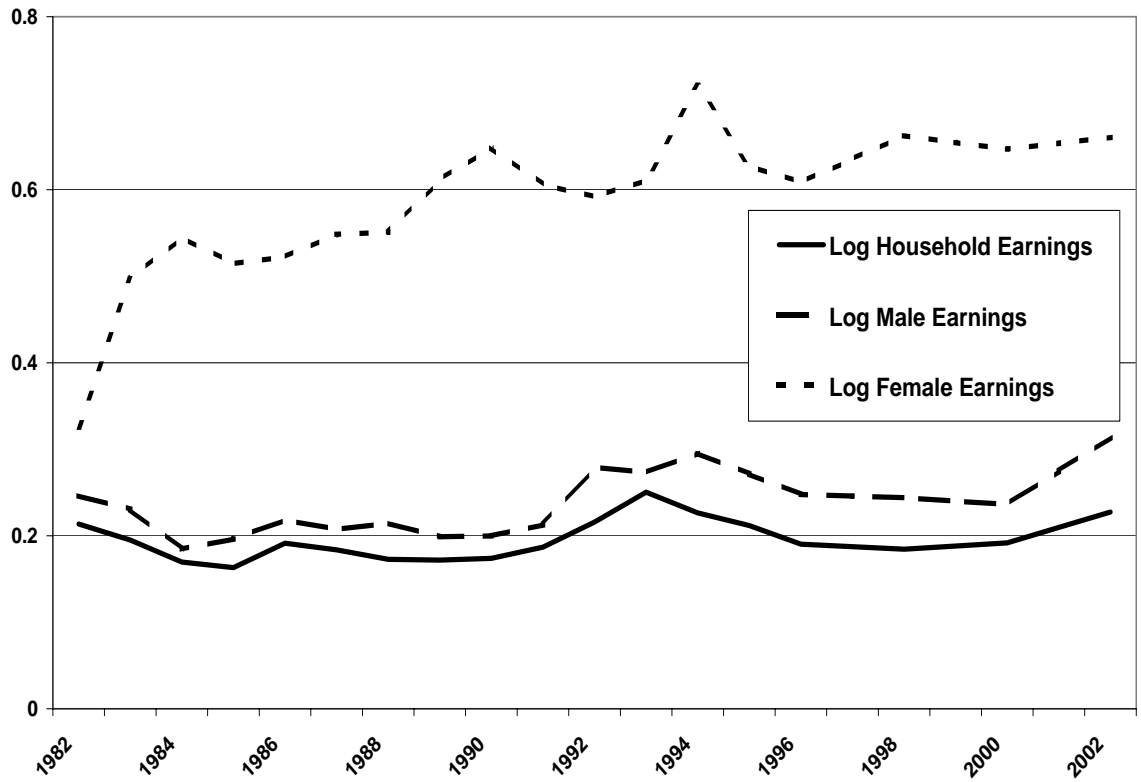


Figure 2.1: Transitory variances of log household earnings, log male earnings and log female earnings in the United States, married households from PSID 1982-2002. Adapted from Figure 6 in Zhang (2008)

Table 2.1: Comparison of transitory variances for married and single agents

	Variance in Transitory Component		
	<i>Log Household Earnings</i>	<i>Log Household Income</i>	
Single Males	0.174	0.152	
Single Females	0.180	0.158	
Married Couples	0.092	0.085	
Singles (random match)	0.141	0.135	
	<i>Log Wage Rate</i>	<i>Log Earnings</i>	<i>Log Hours</i>
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: $var(\epsilon_{it}) = \frac{1}{N} \sum_i \frac{1}{(T_i-1)} \sum_i^{T_i} (y_{it} - \bar{y}_i)^2$

Table 2.2: Descriptive statistics

	Mean	Standard deviation
A. Women		
Hours of work	417.6	342.8
Hourly wage	12.0	11.2
Age	41.1	10.2
Schooling	18.0	6.13
White	0.87	0.34
B. Men		
Hours of work	690.6	284.6
Hourly wage	17.9	15.4
Age	43.3	10.3
Schooling	18.4	6.18
White	0.87	0.33
C. Household Characteristics		
Property income	359.4	1733.7
Transfer income	53.8	483.7
Other income	978.6	2861.5
Savings	2,064.7	748,210
D. Marriage Market		
Sex ratio	0.47	0.09
Divorce index	2.31	1.06

Table 2.3: Summary of log wage decomposition

	Standard			
	Mean	Deviation	Minimum	Maximum
Female Expected Wage (\bar{w}_{it}^f)	2.13	0.373	0.47	2.84
Male Expected Wage (\bar{w}_{it}^m)	2.63	0.310	1.54	3.23
Female Permanent Shocks (δ_{it}^f)	0.0078	0.635	-16.15	4.34
Male Permanent Shocks (δ_{it}^m)	0.0017	0.602	-8.24	3.51
Female Transitory Shocks (ν_{it}^f)	-0.0025	0.419	-9.02	4.55
Male Transitory Shocks (ν_{it}^m)	-0.0022	0.369	-8.77	4.06

Table 2.4: Estimates from savings equation

	Coefficient	Standard Error
House_price	13.87***	1.283
Birth_cohort 1950	1,803.8***	698.3
Birth_cohort 1960	2,388.6**	1038.1
Birth_cohort 1970	-422.0	1509.7
White	686.5	432.9
Age of husband	-278.7	252.9
Age square of husband	1.98	2.68
Age of wife	-96.7	174.5
Age square of wife	2.76	2.00

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

Table 2.5: Reduced-form labor supply functions

	Female Labor Supply		Male Labor Supply	
	Coef	Std Err	Coef	Std Err
Non-labor income net of savings	-0.00028*	0.0002	-0.005***	0.0007
Female expected wage	0.800***	0.128	0.222	0.427
Male expected wage	0.325**	0.140	2.228***	0.589
Female permanent shocks	0.308***	0.012	-0.216***	0.034
Male permanent shocks	-0.158***	0.014	1.398***	0.053
Female transitory shocks	0.188***	0.016	-0.111***	0.035
Male transitory shocks	-0.075***	0.012	0.884***	0.060
Local sex ratio	0.040	0.046	-0.094	0.133
Divorce law index	-0.007	0.005	-0.045***	0.014
Joint parameters				
s	0.622***	0.124		
ρ	-0.069***	0.008		

Note: ***significant at 1%; **significant at 5%; *significant at 10%. Standard errors are bootstrapped.

Table 2.6: Marshallian labor supply functions

Female Labor Supply		Male Labor Supply	
$\log w_{it}^f$	0.893*** (0.294)	$\log w_{it}^m$	3.003** (1.547)
ϕ_{it}	-0.002 (0.004)	$y_{it} - s_{it} - \phi_{it}$	-0.005*** (0.001)

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

Table 2.7: Estimates of the sharing rules

	Both partners work		Wife works, husband not	
	Coef	Std Err	Coef	Std Err
Non-labor income ($y_{it} - s_{it}$)	0.117	0.197	1.428	2.31
Female expected wage (\bar{w}_{it}^f)	39.06	76.02	-18.95	108.3
Male expected wage (\bar{w}_{it}^m)	-136.2	229.0	-717.4	1168.6
Female permanent shocks (δ_{it}^f)	-37.97***	12.04	18.42	98.7
Male permanent shocks (δ_{it}^m)	66.40	106.8	-298.4	486.9
Female transitory shocks (ν_{it}^f)	-19.50***	8.16	9.46	50.85
Male transitory shocks (ν_{it}^m)	31.45	50.9	-	-
Local sex ratio	-16.6	20.9	8.05	52.5
Divorce law index	-2.94	5.25	14.68	24.3
q	-	-	-260.9	424.3

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

Table 2.8: Baseline sharing rules that do not distinguish wage and shocks

	Both partners work		Husband works, wife does not	
	Coef	Std Err	Coef	Std Err
Non-labor income	0.044	0.124	1.85	4.31
Female wage	35.46	54.41	-31.4***	165.0
Male wage	-112.2	259.0	-512.3	1190.7
Local sex ratio	-9.24	16.34	8.20	54.30
Divorce law index	0.671	2.18	6.22	15.00
q	-	-	-189.9***	447.2

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

Table 2.9: Estimates of the sharing rules, including individual income volatility

	Both partner works		Husband works, wife not	
	Coef	Std Err	Coef	Std Err
Non-labor income net of savings	0.126	0.101	1.518	0.950
Female expected wage	49.49	77.67	-29.34	70.08
Male expected wage	-141.77	107.69	-755.3	502.1
Female permanent shocks	-39.82***	9.30	23.61	43.03
Male permanent shocks	71.62*	45.21	-324.8*	209.9
Female transitory shocks	-20.38***	6.64	12.08	22.60
Male transitory shocks	31.84*	20.06	-	-
Female wage volatility	-14.62*	9.09	8.67	21.07
Male wage volatility	6.46	11.40	-34.83	26.31
local sex ratio	-11.64	21.99	11.65	30.57
divorce law index	3.43	3.39	-37.86	28.03
q	-	-	-272.9	173.6

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

Table 2.10: Reduced-form labor supply function estimation for households with low wealth

	Female Labor Supply		Male Labor Supply	
	Coef	Std Err	Coef	Std Err
Nonlabor income net of savings	-0.0003	0.0003	-0.003***	0.0009
Female expected wage	0.520***	0.134	0.149	0.317
Male expected wage	-0.175	0.213	1.429**	0.635
Female permanent shock	0.324***	0.022	-0.197***	0.053
Male permanent shock	-0.167***	0.030	1.515***	0.102
Female transitory shock	0.238***	0.027	-0.102**	0.051
Male transitory shock	-0.078***	0.023	0.925***	0.096
Local sex ratio	-0.084	0.080	-0.528**	0.225
Divorce law index	-0.017**	0.008	-0.043***	0.019

Note: ***significant at 1%; **significant at 5%; *significant at 10%. Standard errors are computed using bootstrap.

Table 2.11: Estimates of the sharing rules for households with low wealth

	Both partners work		Wife works, husband not	
	Coef	Std Err	Coef	Std Err
Non-labor income net of savings	-1.63	7.01	-13.45	47.81
Female expected wage	150.7	524.6	826.6	3,300.3
Male expected wage	-1,120.7	4,527.5	5,378.5	19,577.5
Female permanent shock	-199.3	554.6	-1,093.3	3,719.4
Male permanent shock	-1,065.2	3,784.2	5,823.9	20,767.8
Female transitory shock	-103.2	291.4	-566.1	1,944.7
Male transitory shock	-496.4	1,758.4	-	-
Local sex ratio	-535.0	1,552.0	-2,935.5	10,430.7
Divorce law index	-106.3	385.9	-303.6	1,080.5
q	-	-	4,548.4	16,185.1

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

Table 2.12: Estimated transitory variances with and without insurance

	log male earnings	log female earnings	log household earnings
Main model			
With insurance	1.547	0.414	0.596
Without insurance	1.610	0.446	0.603
Percentage change	4.1	7.7	1.2
Including volatility			
With insurance	1.600	0.405	0.610
Without insurance	1.669	0.435	0.618
Percentage change	4.3	7.4	1.3
Working couples			
With insurance	0.236	0.587	0.216
Without insurance	0.242	0.611	0.219
Percentage change	2.5	7.0	1.4