# Spousal Insurance, Precautionary Labor Supply, and the Business Cycle

Kathrin Ellieroth*

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**Abstract**

I document that married women are less likely to leave the labor force and are more attached to employment in recessions. Using a two-person household incomplete assets markets model with labor market frictions, I show that married women exhibit precautionary labor supply in response to their husband's higher threat of job loss in recessions. Quantitative analysis shows that married women's precautionary labor supply is an important mechanism of intra-household risk sharing and accounts for 62% of married women's low employment cyclicality. Furthermore, I show that spousal insurance reduces consumption volatility in married households by 67% over the business cycle.

*Address: Department of Economics, Diamond Hall, 3rd Floor, 5230 Mayflower Hill, Waterville, Maine 04901. I would like to thank my dissertation committee Amanda Michaud, Bulent Guler, and Gerhard Glomm, as well as Alexander Bick, Serdar Birinci, Andreas Hornstein, John Bailey Jones, Todd Schoellman, participants at SED, brown bag participants at the FRB of Richmond, brown bag participants at the FRB of Minneapolis and participants at the IU Macro brown bag for helpful comments.

The cyclicality of aggregate hours in the United States differs substantially by gender and marital status. Married women have a significantly lower cyclicality of hours worked in the aggregate than married men, single men, and single women. This paper evaluates

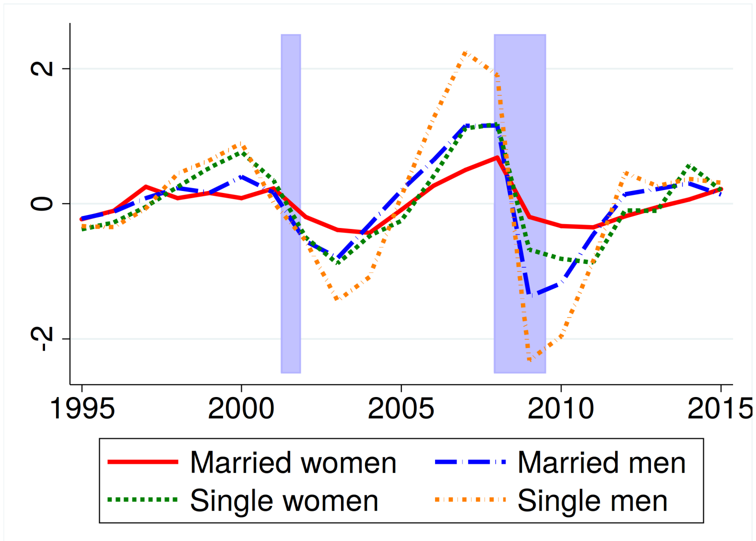


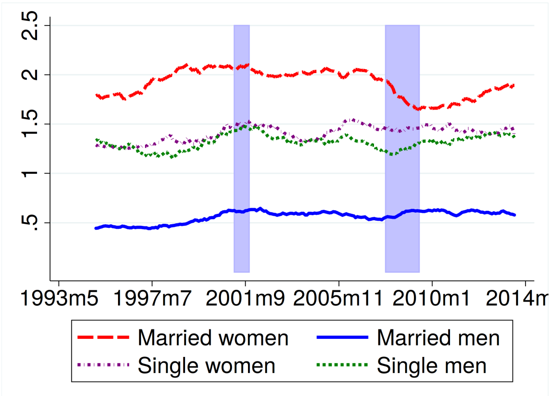

Figure 1: Married women have lowest cyclicality of aggregate hours worked

the hypothesis that spousal insurance and intra-household risk sharing contribute to the low cyclicality of married women's employment. In particular, I argue that married women adjust their labor supply in response to an increase in job loss risk faced by their husbands, which in the aggregate will dampen the hours cyclicality for married women. In light of this finding, I ask the following question: Do married women provide spousal insurance over the business cycle? And related, how do they insure the household and how much insurance do they provide?

I document that much of married women's low cyclicality of hours is a result of procyclical employment (E) to not in the labor force (N) transition rates.[1] Using Current Population Survey (CPS) data, I find that married women are less likely to leave the labor force and are more attached to employment in recessions relative to normal times. (See figure 2a). The higher attachment to employment in recessions then leads to acyclical employment to employment (E-to-E) transition rates for married women (See figure 2b).[2]

[1]Recent work by Doepke and Tertilt (2016), Albanesi (2017), and Fukui, Nakamura and Steinsson (2018) also documents the low hours cyclicality for married women. I complement their work by showing that the employment to not in the labor force margin is the crucial margin contributing to the low cyclicality.

[2]See the empirics section for a detailed analysis of transition rates and their cyclicality.




(a) Employment-to-Not in the labor force (E-to-N)


(b) Employment-to-Employment (E-to-E)

Figure 2: Monthly transition rates

This empirical finding motivates the analysis of an additional and novel mechanism of spousal insurance over the business cycle in this paper: precautionary labor supply. Precautionary labor supply refers to an increase in labor supply in the presence of increased income risk. In particular, I show that an already employed wife will remain employed and not leave the labor force in recessions in response to an increase in job loss risk for the primary earner, the husband.

Labor supply adjustments by one spouse as a form of intra-household risk sharing in the presence of aggregate risk have been studied in the past but the focus has been on the added-worker effect. The added-worker effect occurs when a wife joins the labor force in response to her husband's job loss. The recent literature only finds a small added-worker effect in recessions and therefore, concludes that household insurance from the added-worker effect is limited.[3] The distinction between the two mechanisms is that the added-worker effect focuses on the non-employed wife's transition into the labor force in response to actual spousal job loss, whereas precautionary labor supply is a response of an already employed wife to the increased risk of spousal job loss.

In order to derive implications of married women's labor supply choices for intra-household risk sharing and the cyclicality of employment, I develop a quantitative model of married women's labor supply over the business cycle. The model features incomplete

[3] See e.g. Gorbachev (2016) or Birinci (2018)

assets markets, labor market frictions, aggregate risk, and endogenous movements between employment, unemployment, and not in the labor force for married women. Married women's labor supply decisions are determined by the interaction of aggregate risk and idiosyncratic shocks. Aggregate risk results from rising job loss and falling job finding probabilities in recessions. Changes in aggregate risk along with incomplete assets markets directly impact married women's precautionary labor supply. Furthermore, married women face idiosyncratic earnings risk and stochastic disutility of working and searching which affect their labor supply independent of the aggregate state of the economy.

In the quantitative model, I find that the channel of precautionary labor supply accounts for about 62 percent of the procyclical E-to-N transition rate for married women in the data. In a counterfactual analysis, I compute the contribution of gender-specific job loss and job finding probabilities. I find that about half of the precautionary labor supply response by married women is due to differences in the cyclicality of risk between married men and women but the other half is due to insurance motives.

Spousal insurance is potentially important for households to smooth consumption in response to the large income shocks resulting from increased separation rates in recessions. In order to answer how much spousal insurance married women provide over the business cycle, I compute consumption volatility in the model and compare it to consumption volatility in a single-earner married household model. I find that spousal insurance reduces consumption volatility in married households by about 67 percent.

The structure of the paper is as follows. Section 1 reviews the existing empirical and quantitative literature on the added-worker effect and female labor supply. Section 2 presents empirical evidence on the cyclicality of different labor market outcomes for married women, married men, and single individuals. The quantitative model is presented in section 3. Section 4 presents the calibration of model parameters. Sections 5 and 6 present the main results of the quantitative analysis. Section 7 presents an extension of the model and section 8 concludes.

## 1 Related Literature

This paper relates to a relatively large empirical literature on the added-worker effect (AWE) and determinants of female labor supply as well as a more recent strand of literature which focuses on female labor supply and its impact on the macroeconomy in structural quantitative models. Furthermore, this paper relates to papers focusing on the labor supply of individuals on the extensive and intensive margin.

Starting with the seminal work by Lundberg (1985), there has been a significant empirical literature focusing on the added-worker effect, however, more recent studies find only little or no evidence of the importance of the added-worker effect during recessions (Mankart and Oikonomou (2016*b*), Starr (2014), Juhn and Potter (2007), Gorbachev (2016)). Similarly, the model in this paper allows for an AWE, but finds it is not important during recessions.

This paper is probably closest related to Mankart and Oikonomou (2016*a*) who analyze the cyclicality of the labor force participation rate in the United States focusing on the differential response of singles, married men and married women to aggregate risk. This work complements their paper by focusing in more detail on spousal insurance and labor supply and disentangles the channels through which households respond to increased labor market risk. Furthermore, this paper allows to quantify spousal insurance over the business cycle and its impact on Macro outcomes, such as employment and hours.

Recent work by Wang (2019) shows that the added-worker effect and comparative advantage among spouses leads to a countercyclical search intensity of married women. Birinci (2018) studies the spousal response to a displacement of the household head and the interplay with government transfers. Similarly, to other papers in the line of research, the author finds a positive, but small response of the secondary earner to job loss by the primary earner. Choi and Valladares-Esteban (2019) study spousal insurance and unemployment insurance in a model similar to mine, but abstract from aggregate risk and business cycle implications and mainly focus on the interplay of the added-worker effect and unemployment insurance. Bardoczy (2020) shows that spousal insurance can dampen the amplification of business cycles. This paper complements the previous by further highlighting the importance of female labor supply to households and their ability to share risks but focuses in particular on precautionary labor supply by carefully calibrating the model to match married women in the U.S.

A relatively recent strand of literature analyzes female labor supply over time in order to explain the trend in female labor supply as well as to identify crucial determinants explaining female labor supply and differences in labor market outcomes between men and women such as Albanesi (2017), Albanesi and Sahin (2018), Attanasio, Low and Sanchez-Marcos (2005), Attanasio, Low and Sanchez-Marcos (2008), Fukui, Nakamura and Steinsson (2018), Jones, Manuelli and McGrattan (2015), Blundell, Pistaferri and Saporta-Eksten (2016). This paper greatly builds on their advances, but specifically focuses on business cycle fluctuations and cyclicality of labor supply while abstracting from the trend.

Furthermore, this paper relates to recent papers featuring models of individual and household labor supply which incorporate labor market frictions in an incomplete markets model. In particular, this paper uses the methodology and builds on to the model developed in a paper by Krusell et al. (2017) and incorporates a richer household structure similar to Mankart and Oikonomou (2016*a*). Compared to Krusell et al. (2017), I add a second spouse to the household rather than focusing on a single-agent household, and model the wife's choices, risks, and constraints to focus on married women's decisions and response to risks and shocks to the household.

## 2 Transition rates

As highlighted in the introduction, contrary to past analyses of married women and spousal insurance, the important margin to consider is the transition from employment to not in the labor force (E-to-N) and employment to employment (E-to-E). I calculate the transition rates by using the short panel structure of the CPS[4]. I link individuals across subsequent months following the methodology by the Bureau of Labor Statistics to calculate gross worker flows for married women, married men, as well as single women and single men. Then I use the gross flows to compute transition rates or transition probabilities similar to

[4]I use monthly CPS data provided by IPUMS, see full citation here: Flood et al. (2018) and see (online) appendix for more information about the data

Shimer (2012) and Elsby, Hobijn and Şahin (2015).[5]

Table 1 presents a measure of cyclicality of the transition rates.[6] It shows the estimation results from regressing each log transition rate on the log unemployment rate. The estimated coefficient, therefore, can be interpreted as the elasticity of each transition rate with regards to business cycle fluctuations in the unemployment rate. There are three things to point out

| | Married Women | Married Men | Single Women | Single Men |
|---|---|---|---|---|
| E-to-E | 0.0023*** | -0.0072*** | -0.0031*** | -0.0086*** |
| | (0.0009) | (0.0007) | (0.0010) | (0.0013) |
| E-to-U | 0.4950*** | 0.7946*** | 0.4633*** | 0.5802*** |
| | (0.0716) | (0.0633) | (0.0854) | (0.0669) |
| E-to-N | -0.2514*** | 0.1863*** | 0.0691 | 0.0628 |
| | (0.0367) | (0.0636) | (0.1911) | (0.0610) |
| NonE-to-E | | | | |

Table 1: Elasticities of transition rates with respect to fluctuations in the unemployment rate

about the elasticities of the transition rates with respect to fluctuations in the unemployment rate: (1) While the magnitudes of the estimated coefficients may appear small, in the recent recession the unemployment rate more than doubled and therefore, increased by more than 100 percent. This implies that for married women an increase in the unemployment rate by 100 percent is associated with a decrease in the E-to-N transition rate by 25.14 percent, while the other groups experience an increase between 6 and 18 percent. This finding directly motivates the study of precautionary labor supply in the quantitative model. (2) The last row shows the non-Employment to Employment elasticity which directly relates to the added-worker effect. There is no evidence that married women are more likely to join employment than the other groups during recessions as the coefficient is negative. (3) Married women experience an increase in job loss risk during recessions similar to single women, thus, there is no indication that the low employment cyclicality is a result of married women not losing their jobs in recessions.[7]

[5] I address the problems which commonly arise using the CPS to compute transition rates and discuss possible solutions. See the appendix for a detailed explanation of my computation of transition rates.

[6] See the appendix for figures of each transition rate.

[7] Women in general experience a lower job loss risk in recessions than men, I will analyze the asymmetry in job loss risk between men and women in more detail in the quantitative model.

## 3 Model

As documented in the previous section, much of the oberved low cyclicality for married women stems from movements between employment and not in the labor force which appears to be related to the cyclicality of labor market risk faced by their husband. Therefore, I model an economy with two-person households, incomplete asset markets, and labor market frictions which generate endogenous movements between employment, unemployment, and not in the labor force. Recessionary and normal times in the model directly affect labor market frictions to study the cyclicality of transitions for married women.

This model is similar to Mankart and Oikonomou (2016*a*) and Krusell et al. (2017) by combining labor market frictions similar to a standard search model with an incomplete markets heterogeneous agents model similar to a Bewley-Huggett model. In particular, while Krusell et al. (2017) model an individual making labor supply and consumption choices facing job loss and job finding frictions, I extend their framework by adding a second potential worker to the household and address the resulting household interactions and choices. Thus, my model is similar to Mankart and Oikonomou (2016*a*), who model two-person households, but model the two household members identically and do not distinguish between primary and secondary earners. I show that it is crucial to model the differences in frictions faced by men and women to understand the behavior of married women in respond to aggregate and individual shocks.

The economy is populated by a continuum of infinitely lived unit measure of ex-ante identical households, and each household $i$ is comprised of husband ($j = 1$) and wife ($j = 2$).[8] Time $t$ is discrete and runs forever.

The unitary household has a joint consumption choice $c_t$, saving choice $a_{t+1}$, as well as a discrete labor supply $e_{2,t}$ and discrete search choice $s_{2,t}$ for the wife. Married women in the model only make extensive labor supply decisions, i.e. to work or not to work, and extensive search decisions, i.e. to search or not to search. Husbands, on the other hand, are fully exogenous. They are either employed or unemployed and households take as given the

[8]For the remaining part I will suppress the subscript $i$ for households for ease of notation if it is clear that the variable refers to a household. Furthermore, the model features only married households and therefore, I use the terms men and women in the context of the model synonymously to married men and married women or husband and wife.

movement between employment and unemployment. Married men in the model work until they become unemployed as a result of an exogenous job destruction shock. Once without a job, they are unemployed and remain unemployed until they receive a job offer, which they have to accept and become employed.

Preferences are as follows

$$\log(c_t) - \alpha(\varepsilon_2)e_{2,t} - \kappa_t s_{2,t} \tag{1}$$

The household can choose $e_{2,t} \in \{0, 1\}$ for the wife if she has a job or job offer. If the wife chooses to not work $e_{2,t} = 0$ or does not have a job offer, she can choose between active search $s_{2,t} = 1$ or passive search $s_{2,t} = 0$. In order to map the model to the data and explicitly distinguish between unemployment and not in the labor force, the wife is considered unemployed when she actively searches, and not in the labor force otherwise.

The parameters $\alpha$ and $\kappa_t$ are the disutilities resulting from working and searching for the wife, respectively. The disutility $\alpha$ depends on the woman's (shadow) wage and the search disutility $\kappa_t$ is stochastic to match the flows between unemployment and not in the labor force.

Although I deNUNify the data, there remains a substantial number of transitions between unemployment and not in the labor force (U-to-N), and from not in the labor force to unemployment (N-to-U), which cannot be explained by shocks to labor supply, productivity or frictions. Thus, I follow Krusell et al. (2017), who point out the same problem, and model the search disutility $\kappa_t$ as distributed according to a three point distribution with mean $\bar{\kappa}$ and support $\{\bar{\kappa} - \varepsilon_\kappa, \bar{\kappa}, \bar{\kappa} + \varepsilon_\kappa\}$.

Flows between employment and not in the labor force (E-to-N) in the model are a result of shocks to employment, the value of (non) employment, or spouses' productivity. In order to have enough married women close to the non-participation margin in the model, I model their disutility from working $\alpha(\varepsilon_2)$ as a function of their wage or if without job in terms of their shadow wage, where

$$\alpha(\varepsilon) = \delta\varepsilon \qquad 0 > \delta > 1 \tag{2}$$

Assumption (2) entails that highly productive women in the market face a higher utility cost to not working, which implies they are also highly productive at home and it is more costly for them to work. This is a reasonable assumption given that in the data we see the reduction of E-to-N transitions during recessions across all income groups for married women.

Both, men and women, have stochastic productivity which follows a gender-specific AR(1) process

$$\log \varepsilon_{i,t} = \rho_j \varepsilon_{i,t-1} + \sigma_{\varepsilon,j} \nu_{i,t}$$

Productivity shocks between spouses are uncorrelated and household productivity is denoted by $\mathcal{E}$ which is simply the vector of productivity states for both spouses. Therefore, both spouses have exogenous labor income $w_{j,t}\varepsilon_{i,t}$ for $i \in \{1, 2\}$.

Furthermore, households have access to a risk-free asset $a$, which pays an exogenous real interest rate $r$. Households can save, but they cannot borrow, i.e. $a_{t+1} \geq 0$. Therefore, both wages for husband and wife and the real interest rate are exogenous.

Both members of the household face labor market frictions, a job finding probability $\lambda_j(s, y)$ and a job loss probability $\chi_j(y)$. The job finding probability and the job loss probability depend on $j$, i.e. men and women face different labor market frictions. The business cycle in the model is indicated by $y$ and determines the level of frictions in recessionary and normal times. Recessions in this economy ($y = 1$) are periods of low job finding and high job loss probabilities and normal times ($y = 0$) are characterized by high job finding and low job loss probabilities, i.e. $\chi_j(1) > \chi_j(0)$ and $\lambda_j(s, 1) < \lambda_j(0, y)$.

The wife's job finding probability $\lambda_2(s, y)$ additionally depends on whether she actively searches or not. Active search increases the probability of finding a job relative to passive search, and therefore, $\lambda_2(1, y) > \lambda_2(0, y)$ for $y = 0, 1$.

Job loss shocks are correlated within households. For an Employed-Employed household, this leads to the following joint household job loss probabilities:

$$\pi_{L^m} \left[ (1-\varphi)\pi_{L^f} + \varphi 1\{L^m = L^f\} \right] \tag{3}$$

where $L^i \ \forall i = m, f$ is the job loss outcome for both spouses and equals 1 in case of job loss and zero otherwise. The parameter $\varphi$ measures the degree of correlation of job loss between the spouses. If $\varphi = 1$, then the job loss shocks are perfectly correlated, whereas $\varphi = 0$ is the other extreme and in this case, the spouses' job destruction shocks are completely unrelated.[9]

### 3.1 Household Problem

The states for each household are their assets $a$, the productivity shock for each spouse $\varepsilon_i$, wife's search disutility $\kappa$, the current labor market state for the wife $S_2 \in \{E, U, N\}$, and the current labor market state for the husband $S_1 \in \{E, U\}$. The aggregate state is $y \in \{0, 1\}$ indicating the state of the economy.

In order to simplify notation, the following shows the recursive formulation of the household problem once both the idiosyncratic and aggregate shocks are realized. Households are distinguished by the job status of their spouses: Each spouse starts a period either as jobless ($L$) or with a job offer ($J$). Thus, at the beginning of the period, the households face either of the four value functions (the first superscript identifies the husband and the second superscript identifies the wife): $W^{EJ}(a, \mathcal{E}, \kappa, y)$ if both spouses have a job offer, $W^{UL}(a, \mathcal{E}, \kappa, y)$ if both spouses are jobless, and $W^{EL}(a, \mathcal{E}, \kappa, y)$ or $W^{UJ}(a, \mathcal{E}, \kappa, y)$ if one of the spouses has a job offer and the other is jobless.

If the husband has a job offer, he will always be employed ($E$). If the wife has a job offer, the household can choose for her between employment ($E$), unemployment ($U$), and not in the labor force ($N$). If the husband is jobless, he will always be unemployed ($U$), whereas the household can choose between unemployment ($U$) and not in the labor force ($N$) if the wife is jobless.

Thus, if both spouses have a job or job offer at the beginning of the period, the household decides whether the wife works or leaves employment into unemployment or not in the labor force as well as how much to consume and how much to save. The value for a household in which both members have a job or job offer ($W^{JE}$) is the maximum of the three options

[9] See the appendix for further details and derivations.

based on the household's individual states and state of the economy:

$$W^{EJ}(a,\varepsilon,\kappa,y) = \max\{V^{EE}(a,\varepsilon,\kappa,y), V^{EU}(a,\varepsilon,\kappa,y), V^{EN}(a,\varepsilon,\kappa,y)\}$$

If the husband has a job offer and the wife if jobless, the husband is employed ($E$) and the household can choose between unemployment ($U$) and not in the labor force ($N$) for the wife and consumption and savings. The value for a household with a jobless wife and a husband with a job offer is the maximum of the value when the wife is unemployed $V^{EU}$ or not in the labor force $V^{EN}$

$$W^{EL}(a,\varepsilon,\kappa,y) = \max\{V^{EU}(a,\varepsilon,\kappa,y), V^{EN}(a,\varepsilon,\kappa,y)\}$$

The values for households in which the husband is unemployed and the wife is either jobless or has a job are analogous:

$$W^{UJ}(a,\varepsilon,\kappa,y) = \max\{V^{UE}(a,\varepsilon,\kappa,y), V^{UU}(a,\varepsilon,\kappa,y), V^{UN}(a,\varepsilon,\kappa,y)\}$$

$$W^{UL}(a,\mathcal{E},\kappa,y) = \max\{V^{UU}(a,\mathcal{E},\kappa,y), V^{UN}(a,\mathcal{E},\kappa,y)\}$$

In the following I am going to illustrate the problem for one type of household, in which both members are employed, and the remaining types can be found in the appendix.

### 3.1.1 Employed-Employed (EE) household

A household which has both spouses employed chooses joint consumption and savings and has to pay the disutility cost $\alpha(\varepsilon_2)$ since the wife is working. The household receives labor income from both spouses as well as savings from the previous period. $\beta$ is the household's discount factor. The value function for a household which has both spouses employed is

$$
\begin{aligned}
V^{EE}(a,\mathcal{E},\kappa,y) = & \max_{c,a'} \log(c) - \alpha(\varepsilon_2) \\
& +\beta\mathbb{E}[(1-\chi_1(y))\left[(1-\varphi)(1-\chi_2(y))+\varphi\right]W^{EJ}(a',\mathcal{E}',\kappa',y')+ \\
& \quad \chi_1(y)(1-\varphi)(1-\chi_2(y))W^{UJ}(a',\mathcal{E}',\kappa',y')+ \\
& \quad (1-\chi_1(y))(1-\varphi)\chi_2(y)W^{EL}(a',\mathcal{E}',\kappa',y')+ \\
& \quad \chi_1(y)\left[(1-\varphi)\chi_2(y)+\varphi\right]W^{UL}(a',\mathcal{E}',\kappa,'y')] \\
& \text{s.to} \quad c+a' = (1+r)a + w_1\varepsilon_1 + w_2\varepsilon_2
\end{aligned}
$$

The household faces four mutually exclusive situations tomorrow: (1) With probability $(1-\chi_1(y))(1-\chi_2(y))$ both spouses keep their job and start tomorrow with a job offer $W^{EJ}(a,\mathcal{E},\kappa,y)$; or (2) with probability $(1-\chi_1(y))\chi_2$ the husband remains employed and the wife receives an exogenous job destruction shock so that tomorrow the husband will have a job offer but the wife will start as jobless $W^{EL}(a,\mathcal{E},\kappa,y)$; (3) the household will start tomorrow with the wife having a job offer and the husband jobless $W^{UJ}(a,\mathcal{E},\kappa,y)$ if he loses his job with probability $\chi_1(y)$ and the wife keeps hers with probability $(1-\chi_2(y))$; (4) lastly, with probability $\chi_1(y)\chi_2(y)$ they will start as a household in which both spouses do not have a job offer $W^{UL}(a,\mathcal{E},\kappa,y)$.

This value function illustrates nicely how expectations matter for the employment decision of the wife. The aggregate state of the economy $y$ enters into the households expectations for the continuation value. If the economy is currently in normal times and the household expects to stay in normal times in the next period, depending on the asset accumulation, they might find it optimal to choose non-employment for the wife. If the economy continues in normal times, the job loss probability for the husband is low and the job finding probability for the wife is high. Therefore, if they have accumulated enough assets the wife might decide to leave the labor force since the probability that her husband loses his job is relatively low and even if he does, it is relatively easy for her to rejoin the labor force. However, if the economy is entering into a recession, a period of high job loss and low job finding probabilities, the wife might be less likely to leave, even if the household has the same level of assets. Now it is relatively more likely that the husband will lose his job and if that happens it is relatively harder for the wife to rejoin the labor force. So she will stay employed to insure against the possible job loss of the primary earner and the income loss associated with the job loss. This attachment to employment of the wife in response to a possible job loss by the husband due to a recession is a form of precautionary labor supply.

## 4 Calibration

### 4.1 Externally set parameters

Table 2 summarizes the 13 externally set parameters and their values, targets, and sources.[10] A time period in the model is one month. The parameters for the exogenous

| Targeted Parameters | | | |
|---|---|---|---|
| Parameter | | Value | Source |
| Persistence of productivity MM | $\rho_1$ | 0.98 | Chang and Kim (2006) |
| Std. deviation of productivity MM | $\sigma_1$ | 0.13 | Chang and Kim (2006) |
| Persistence of productivity MW | $\rho_2$ | 0.973 | Chang and Kim (2006) |
| Std. deviation of productivity MW | $\sigma_2$ | 0.15 | Chang and Kim (2006) |
| Prob. of recession | $\rho$ | 0.986 | cycle lasts 6 years |
| Wage husband | $w_1$ | 1 | normalized |
| Wage wife | $w_2$ | 0.8 | wage gap CPS 1995-2017 |
| Separation shock MM | $\chi_1$ | 0.008 | E-to-U transition rate MM |
| Job offer (U) MM | $\lambda_1$ | 0.287 | U-to-E transition rate MM |
| Job offer (U) MW | $\lambda_2(1)$ | 0.2408 | U-to-E transition rate MW |
| Shock to separation MM | $\varepsilon_{\chi_1}$ | 0.0025 | Std. deviation E-to-U MM |
| Shock to job offer MM | $\varepsilon_{\lambda_1(1)}$ | 0.0765 | Std. deviation U-to-E MM |
| Shock to job offer MW | $\varepsilon_{\lambda_2(1)}$ | 0.0686 | Std. deviation U-to-E MW |

Table 2: Externally set parameters

productivity process, the persistence of productivity $\rho$ and the standard deviation of productivity $\sigma_\rho$ are gender-specific and taken from Chang and Kim (2006). The authors in that paper estimate the AR(1) productivity process separately for men and women using PSID data and controlling for self-selection. Since the estimates are gender-specific but do not distinguish by marital status, I assume that single and married women and single and

[10]MM in the table indicates Married Men, and MW indicates married women.

married men are characterized by similar productivity processes. Since the estimates by Chang and Kim (2006) are obtained for annual data, I use the methodology by Mankart and Oikonomou (2016*a*) and Chang and Kim (2006) to convert the estimates into monthly values. I set the probability of a recession occurring $\rho$ to be equal to 0.986, which implies that a business cycle lasts on average six years in this model with a period being defined as a month. The wages for both spouses are relative to each other and are calculated from the CPS outgoing rotation group basic monthly files between 1995 and 2017. I normalize the husband's wage to 1 and the wife's wage is set to 0.8 to match the wage gap among married households in the United States. The parameters governing the labor market frictions for the husband are also taken from the CPS basic monthly files. Since husbands are modelled as exogenous, their separation probability $\chi_1$ and job offer probability from unemployment[11] $\lambda_1$ are equal to the average E-to-U transition rate and average U-to-E transition rate for married men, respectively, in the data. The parameters governing the shocks to both labor market frictions for married are as explained in the previous section and set equal to the standard deviation of the E-to-U and U-to-E transition rates in the data. Similarly, I also take married women's job offer probability from unemployment $\lambda_2(1)$ from the data and set it equal to the average U-to-E transition rate for married women in the data. While married women in the model have can choose whether to accept a job offer when they actively search, there is no reason for them to not accept the job offer and therefore, I take it directly from the data. The shock to married women's job finding probability determining good and bad economic times again is set equal to the standard deviation of the U-to-E transition rate in the data as explained in the previous section.

## 4.2 Labor market frictions

The key parameters in the model and in the quantitative analysis are the job separation and job destruction rate and in particular the differences between normal times and recessions. Labor market frictions for the husband are set exogenously, while I estimate the labor market frictions for with wife within the model.

I use the method proposed by Krusell et al. (2017) to calibrate both spouses' labor

[11]Reminder: Married men can only be unemployed if they are without a job but not leave the labor force.

market frictions over the business cycle as follows:

$$\chi_j^N = \chi_j - \varepsilon_{\chi_j} \quad \text{and} \quad \chi_j^R = \chi_j + \varepsilon_{\chi_j} \tag{4}$$

$$\lambda_j^N(1) = \lambda_j(1) + \varepsilon_{\lambda_j(1)} \quad \text{and} \quad \lambda_j^R(1) = \lambda_j(1) - \varepsilon_{\lambda_j(1)} \tag{5}$$

where $\chi_j$ and $\lambda_j(1)$ are the job destruction shock and job finding probabilities estimated from the stationary model without any aggregate fluctuations. This implies that in recessionary times, the exogenous job loss probability $\chi_j^R$ for both spouses, $j = 1, 2$, is $\varepsilon_{\chi_j}$ higher than the average exogenous job loss probability in the stationary case, and the job offer probability from unemployment $\lambda_j^R(1)$ for both spouses is $\varepsilon_{\lambda_j(s)}$ lower than compared to the stationary case. The opposite is true during normal times. Furthermore, I assume that the job finding probability from not in the labor force for the wife, $\lambda_2(0)$, in normal times and recessions are such that it maintains a constant ratio relative to the job finding probability from unemployment for the wife $\lambda_2(1)$.

I estimate the two shocks to market frictions governing normal and recessionary periods $\varepsilon_{\chi_j}$ and $\varepsilon_{\lambda_j(s)}$ such that the standard deviation of the E-to-U, U-to-E, and N-to-E transition rates in the model match the standard deviations of their data counterparts. Note that both the probabilities in the stationary model as well as the shocks are gender-specific.

Since married men are assumed to make exogenous transitions, I use the average of their E-to-U and U-to-E transition rates from the data as their separation and offer probability, respectively. Similarly, the shocks to the two rates are set such that the model rates display the same standard deviation as the data rates.

The parameters for married women, however, are estimated within the model. In the data, an individual who leaves employment can choose to become unemployed or leave the labor force. If not all transitions from employment to not in the labor force are voluntary but some occur due to an exogenous destruction shock, the observed E-to-U transition rate in the data potentially understates the true job loss probability. Therefore, I estimate the separation shock within the model and match the model E-to-U transition rate with the data E-to-U transition rate. As can be seen in table 3, the estimated job destruction shock for married women is 0.0125 and is greater than the observed average E-to-U transition rate computed from CPS data.

Similarly, I also estimate married women's job finding probability from not in the labor force, $\lambda_2(0)$, within the model. In the data I only observe when an non-employed individual accepts a job offer and becomes employed but I cannot observe the non-employed individuals who receive a job offer but choose to not accept it and therefore, remain non-employed. Thus, the observed average N-to-E transition rate potentially understates the true job finding probability for a non-employed individuals. I estimate the job offer probability from not in the labor force for married women in the model such that the average N-to-E transition rates in the model matches the one in the data. Table 3 shows that while the average N-to-E transition rate for married women in the data is 4.9%, the estimated job arrival probability in the model is 12.04%.

Second, once I obtain the stationary values for the frictions, I estimate the parameters which govern the job offer probability and job loss probability in recessionary and normal times.

### 4.3 Jointly estimated parameters

After externally setting the above parameters, there are 9 parameters left to estimate; the disutility of searching and working parameters $\bar{\kappa}$, $\varepsilon_{\kappa}$, $\delta$, the labor market friction parameters for the wife $\chi_2$, $\lambda_2(0)$ , $\varepsilon_{\chi_2}$, $\varepsilon_{\lambda_2(0)}$, the discount factor $\beta$, and the correlation of job loss shocks among spouses within a household $\varphi$. Table 3 displays the estimated parameters, their values, targets, and source. While I specify one target for each parameter, I estimate the parameters jointly using a Simulated Method of Moments approach in which I minimize the sum of squared differences between the model and data moments.

| Internally calibrated parameters | | | | | | |
|---|---|---|---|---|---|---|
| Description | Parameter | Value | Moment | Target | Model | Source |
| Cost of search | $\bar{\kappa}$ | 0.1460 | Unemp.rate MW | 0.0366 | 0.0366 | CPS |
| Search shock | $\varepsilon_{\kappa}$ | 0.0756 | U-to-N rate MW | 0.1233 | 0.1237 | CPS |
| Disutility of work | $\delta$ | 0.4019 | Emp.-Pop. ratio MW | 0.7164 | 0.7180 | CPS |
| Discount factor | $\beta$ | 0.994 | Avg. Asset to Inc. Ratio Married | 5.90 | 5.88 | Kuhn et al. 2013 |
| Separation shock MW | $\chi_2$ | 0.0125 | E-to-U transition rate MW | 0.0070 | 0.0063 | CPS |
| Job offer (N) MW | $\lambda_2(0)$ | 0.1204 | N-to-E transition rate MW | 0.0490 | 0.0507 | CPS |
| Corr. separation shock | $\varphi$ | 0.0465 | Correlation job loss | 0.0289 | 0.0282 | CPS |
| Shock to separation MW | $\varepsilon_{\chi_2}$ | 0.0018 | Std. deviation E-to-U MW | 0.0018 | 0.0017 | CPS |
| Shock to job offer (N) MW | $\varepsilon_{\lambda_2(0)}$ | 0.0125 | Std. deviation N-to-E MW | 0.0080 | 0.0086 | CPS |

Table 3: Estimated parameters from CPS

The disutility parameters of searching $\bar{\kappa}$ and working $\delta$ directly affect the stocks of married women in different labor market states in the economy. In particular, the average utility cost of searching $\bar{\kappa}$ determines the average unemployment rate for married women in the economy. The higher the utility cost of searching, the less likely the wife will be to actively search and be unemployed, which lowers the unemployment rate for married women. Similarly, if there was no cost to actively searching for a job, all non-employed married women would choose to search, which in turn would increase the unemployment rate for married women. Thus, the disutility derived from searching and the unemployment rate for married women in the model economy are inversely related. A similar relationship is true for the disutility of working parameter $\delta$. As a reminder, I model the disutility of working as a function of the woman's (shadow) wage, i.e. $\alpha(\varepsilon) = \delta\varepsilon$. The parameter governs the disutility of working for married women, the higher $\delta$, the higher the disutility from working. Since it multiplies the (shadow) wage for married women, it furthermore implies that the disutility of working is even higher for married women who are highly productive in the market. The disutility to the household of the wife working, therefore, directly impacts the employment-population ratio in the economy. The disutility of working parameter $\delta$ can be interpreted as a reduced form way of modelling the different factors that impact a married woman's decision to work or stay out of the labor force.

The shock to the disutility cost of searching parameter $\varepsilon_{\kappa}$ is estimated so that the average U-to-N transition rate in the model matches the average U-to-N transition rate in the data.

Households in this model can use precautionary savings in addition to labor supply responses to insure themselves against income shocks over the business cycle. Savings in the model depend on the discount factor $\beta$. In order to ensure that households in the model do not accumulate too few or too much savings, I estimate the parameter $\beta$ to match the average assets-to-income ratio for married households in the United States. The data is taken from a project by Kuhn and Rios-Rull (2015) who compile data on U.S. earnings, income, and wealth for different groups using the Survey of Consumer Finances from 1989 to 2013. I use their collected data on average income and average assets for married households for the years 1995 until 2013 and compute the average assets-to-income ratio.

The parameter $\varphi$ governs the correlation of job loss among spouses within a household, i.e. it affects the probability of a household that both spouses lose their jobs within the same period. The higher $\varphi$, the higher is the correlation among spouses, and the higher is the probability that both spouses lose their job in the same period. The correlation of job loss shocks among spouses crucially affects a household's ability to self-insure and share risks. In the extreme case of perfect correlation of the spouses' job loss shocks, households would not able to share risks and smooth any income shocks. I estimate the correlation of joint loss in the CPS data as the correlation among spouses to make an employment to unemployment (E-to-U) transition in the same month. In the monthly CPS data, the correlation or probability of joint job loss is about 3 percent.[12]

## 5 Results from Quantitative Analysis

### 5.1 Stationary Results

Table 4 shows the transition rates generated in the stationary model and for the U.S. economy between 1995 and 2017. I targeted four rates in my model estimation, the E-to-U transition rates, the U-to-E transition rate, the N-to-E transition rate, and the U-to-N

[12] For comparison, Shore and Sinai (2010) as well estimate the correlation of couples' unemployment events and find that couples have a 5% probability of losing their job in the same year if the spouses are employed in different occupations, and a 16.3% probability of joint loss if spouses are employed in the same occupation.

transition rate. I explained in the previous section that despite deNUNifying the data, about

| | Data | | | Model | | |
|---|---|---|---|---|---|---|
| | E ($t$) | U ($t$) | N ($t$) | E ($t$) | U ($t$) | N ($t$) |
| E ($t-1$) | 0.9738 | 0.0070 | 0.0192 | 0.9728 | 0.0063 | 0.0208 |
| U ($t-1$) | 0.2408 | 0.6329 | 0.1241 | 0.2404 | 0.6362 | 0.1237 |
| N ($t-1$) | 0.0483 | 0.0120 | 0.9397 | 0.0507 | 0.0213 | 0.9280 |

Table 4: Model and data levels of transition rates for married women

12 percent of unemployed individuals every month flow from unemployment into not in the labor force. The stochastic disutility of searching for married women helps matching the number and table 4 shows that the model does a good job in matching the average U-to-N transition rate. Furthermore, I estimated the outflow of employment due to an exogenous separation shock (E-to-U transition rate) and inflow into employment from unemployment and not in the labor force (U-to-E and N-to-E transition rate) and the model matches them both well. All remaining transition rates are not targeted, but the model does a good job in matching their data counterparts. In particular, the stationary model generates average E-to-N transition rates that are close to the average E-to-N transition rate of married women in the data. This implies that the model does a good job in matching the number of married women crossing the participation margin from employment each month and it captures married women's idiosyncratic shocks well. Table 5 shows the targeted employment-

| Stock | Data | Model |
|---|---|---|
| Employment-Population Ratio | 71.64% | 71.80% |
| Unemployment rate | 3.66% | 3.66% |
| Labor force participation rate | 74.17% | 74.53% |

Table 5: Model and data labor market stocks for married women

population ratio, unemployment rate, and labor force participation rate for married women in the model and data and shows that the model matches them well as well. The stochastic disutility of working and searching does a good job in matching the number of women crossing the participation margin as well as the number of employed and unemployed married women.

## 5.2 Cyclicality of Stocks

The next step is to evaluate the cyclicality of the labor market stocks in my model compared to the data. Much of the implications of my model depend on the definition of labor market risk in recessions compared to normal times. Table 6 shows the standard deviations of the unemployment rate, employment-population ratio, and the labor force participation rate in the model and data. These three moments are untargeted[13] but provide a good benchmark for evaluating the cyclical properties of my model and the definition of risk in recessions and normal times. We can see that the model matches the standard deviations of the three stocks

| Stock | Data | Model |
|---|---|---|
| Standard deviations | | |
| Unemployment rate MW | 0.0091 | 0.0182 |
| Employment-Population ratio MW | 0.0091 | 0.0197 |
| Labor force participation rate MW | 0.0082 | 0.0114 |

Table 6: Cyclicality of labor market stocks

fairly well. The model slightly overstates the standard deviation of the unemployment rate. This is because the model also slightly overstates the cyclicality of the N-to-U transition rate and therefore, more married women are flowing into unemployment in recessions than in the model. Furthermore, the model also slightly overstates the employment-population ratio and the labor force participation rate. Again this is a result of the model slightly overstating the cyclicality of the N-to-U and also the N-to-E transition rate.

## 5.3 Cyclicality of transition rates

This section presents my first main result and analyzes how much of the procyclical E-to-N transition rate for married women in the data can be explained by aggregate risk in the form of cyclical labor market frictions and precautionary labor supply. I compute the cyclicality of transition rates both in the data and in the model by regressing the log

[13] I only target the standard deviation of the flow rate from non-employment (unemployment and nilf) to employment and from employment to unemployment but the behavior of the stocks depends on all transition rates.

transition rate on the log unemployment rate and the reported cyclicality measure is the regression coefficient from this regression.

| Married women | | |
|---|---|---|
| Transition rate | Data | Model |
| E-to-N | -0.2514 | -0.1578 |

Table 7: E-to-N transition rate

Table 7 shows that the estimated regression coefficient is negative both in the data and in my model, and furthermore, the cyclicality of the E-to-N transition rate in the model is about 62% of the cyclicality of the E-to-N transition rate. This result shows that the E-to-N transition rate for married women is procyclical in the model as in the data. This finding suggests that a portion of the cyclicality of employment and hours displayed by married women stems from the precautionary labor supply behavior in response to an increase in her non-labor income risk due to her husband's higher job loss probabilities. In particular, married women are relatively less likely to leave the labor force in recessions and are more likely to be attached to employment as a result of higher income risk during recessions faced by their spouse.

### 5.4 Precautionary Labor Supply vs. Job Hoarding

Married women face two additional risks in recessions compared to normal times; First, married men, the primary earner of the household, faces a significantly higher risk of losing their job, which relates directly to the precautionary labor supply hypothesis. However, as a second risk, married women also face a significantly lower job finding probability in recessions than in normal times. This implies that leaving employment is more risky in recessions for a married woman since her probability of finding a job if she would like to return to employment is now lower than in normal times. Thus, part of married women's reduction in E-to-N transitions could be due to her lower job finding probability in recessions, which is known as "job hoarding". In the following I compute counterfactuals to analyze how much of married women's procyclical E-to-N transition rate is due to the cyclicality of their husbands' labor market risk (precautionary labor supply) and how much is due to the cyclicality of their own labor market risk (job hoarding).

I compare the baseline results (Table 8 column 1) to two counterfactuals: (1) I shut down married men's risk and set their job loss and job finding probability equal to the average E-to-U and U-to-E transition rate for married men in the data; and (2) I shut down married women's cyclicality of risk and set their job loss and job finding probabilities equal to the values derived in the stationary model.

| | Baseline | No cyclical risk men | No cyclical risk women |
|---|---|---|---|
| Cyclicality | -0.1578 | -0.1200 | -0.3885 |

Table 8: Counterfactual analysis

Table 8 column 3 shows that in the absence of married women's own cyclical risk the cyclicality of the E-to-N transition would more than double (in absolute terms). This implies that married women would be able to provide substantially more spousal insurance. Hence, married women's own cyclical job loss risk does not seem to explain their precautionary labor supply behavior but rather prohibits them from providing more. On the other hand, column 2 shows that in the absence of cyclical risk for married men, the cyclicality of married women's E-to-N transition rate decreases by 20% indicating that a substantial part of the procyclical E-to-N transition rate is due to the cyclical risk of the husband.

### 5.5 Contribution of Risks: Shapley-Owen Decomposition

In this section I evaluate the contribution of different sources of risk for married women to the degree of precautionary labor supply. In particular, this section quantifies the importance of (i) gender-specific labor market frictions, (ii) gender-specific productivity process, and (ii) correlated job loss risk to married women's ability to provide spousal insurance.

In order to calculate the contribution of the different sources of risk I decompose the contribution of each form of risk and compute the differential impact of each source of risk on precautionary labor supply. I decompose my findings from the baseline model into the contribution of the following three shocks: (i) gender-specific differences in level and cyclicality of job loss probabilities, (ii) gender-specific differences in the productivity process, and (iii) correlation of job loss probabilities for spouses within the same household. For the first set of shocks, gender-specific differences in level and cyclicality of job loss probabilities, I assign married women the level and cyclicality of married men's job loss probabilities. For the second set, gender-specific differences in the productivity process, I assign married men's productivity process parameters to married women. Lastly, for the correlation of job loss probabilities for spouses within the same household, I set the correlation equal to zero.

I compute a Shapley-Owen decomposition, which is commonly used in the applied micro literature and derives from a game-theoretic concept.[14] The idea is that the order of shutting down risks matters since the risks interact with each other. Therefore, I compute counterfactual simulations for all possible permutations of shutting down risks and then compute the marginal contribution for each risk including the risk or shutting it down. The contribution of each risk then is the average of all marginal contributions.

Table 9 shows the contribution of each risk to the procyclical E-to-N transition computed in the baseline model and the implied impact on spousal insurance. The first column shows

| Counterfactual | Contribution | Impact spousal insurance |
|---|---|---|
| Married men's labor market frictions | 146% ↑ | Less |
| Men's productivity process | 3.5% ↓ | More |
| Uncorrelated shocks | 1.3% ↓ | More |

Table 9: Decomposition of procyclical E-to-N transition rate

the contribution of each set of risks to the procyclicality of the E-to-N transition rate. In the baseline model, the degree of cylicality was measured by regressing the log E-to-N transition rate on the log unemployment rate and the resulting coefficient of -0.1578 is a measure of cyclicality.

We can see that gender-specific labor market frictions is the most important contributor to married women's ability to provide spousal insurance.

In the first row, if married women had married men's job loss probabilities the coefficient from the baseline model would be 146% higher. In fact, this means that the coefficent changes signs and if married women had married men's job loss probabilities, their E-to-N transition rate would be countercyclical and increase during recessions when the unemployment rate

[14]This type of decomposition as part of a structural macro model was first used by Michaud and Wiczer (2018).

increases.

Both differences in the productivity process between men and women as well as the correlation in job loss between men and women only has a small impact on spousal insurance provided by married women. If married women were to have the same productivity process as married men, they would be able to provide more spousal insurance. If shocks were uncorrelated, then households are able to insure themselves better, and therefore, married women could provide more spousal insurance.

## 6 Consumption volatility

In this section I am going to quantify how much spousal insurance married women provide over the business cycle by computing the reduction in consumption volatility. In particular, I compute consumption volatility in the baseline model and compare it to consumption volatility in a single-earner married household. This is a married household, in which only the husband works and the wife never works. Thus, married men are modelled as in the main model, but married women do not.

I follow Blundell, Pistaferri and Preston (2008) and compute consumption volatility as the cross-sectional variance of consumption growth ($\text{Var}(\Delta c)$) and income volatility as the cross-sectional variance of income growth ($\text{Var}(\Delta y)$). Then consumption volatility is defined as the ratio of consumption volatility over income volatility $\frac{\Delta c}{\Delta y}$.

I find that in the baseline model consumption volatility is 32.47% of the consumption volatility in the single-earner model. This implies that spousal insurance provided by married women reduces consumption volatility by about 67 percent or two-thirds compared to a model in which married women do not work.

While the counterfactual makes a stark assumption by considering a single-earner household, it provides an upper bound to the reduction in consumption volatility that married households can enjoy by being able to use both spouses' labor supply.

## 7 Extension: Education groups

In the following I will further test the precautionary labor supply hypothesis and analyze four household types based on the education level of their household members: (i) both husband and wife are college educated (some college and more); (ii) both husband and wife are high school educated (high school diploma at most); (iii) and (iv) one spouse is college educated and the other is high school educated.

The level of education in the United States is closely related to the type of occupation and income, but most importantly for this paper, it is closely correlated to both the levels of job loss and job finding probabilities as well as the volatility of these over the business cycle.

| | Married men | | Married women | |
|---|---|---|---|---|
| | High school | College | High school | College |
| | Average | | | |
| Job loss probability | 0.0129 | 0.0054 | 0.0093 | 0.0057 |
| Job finding probability | 0.2891 | 0.2705 | 0.2223 | 0.2522 |
| | Cyclicality | | | |
| Job loss probability | 0.7426*** | 0.6704*** | 0.4102*** | 0.4137*** |
| | (0.0617) | (0.0934) | (0.0888) | (0.0609) |
| Job finding probability | -0.7456*** | -0.7745*** | -0.8271*** | -0.8509*** |
| | (0.0553) | (0.0697) | (0.0830) | (0.0747) |

Table 10: Level and cyclicality of labor market frictions by education

For example, married men who have at most a high school diploma have a job loss probability of 1.29% which is more than twice as high as for married men who have at least some college education. The same holds true for married women.

The important distinction for this exercise however is, that high school educated men not only have a higher job loss probability on average but also experience a larger increase in their job loss risk during recessions than college educated men.

Table 10 shows the average job loss and job finding probability for married men and women by education level as well as the correlation of the job loss and job finding probability with the unemployment rate ("cyclicality"). Splitting married households into these four groups based on whether each of their household members is highly or low educated allows to test whether women who are married to a husband with a high cyclicality of job loss risk are more likely to display precautionary labor supply than married women who are married to a husband with low cylicality of job loss risk.

I re-estimate the model but I update the targeted moments to fit the four different household types[15]. Then I compute the model-generated correlation between married women's E-to-N transition rate and the unemployment rate for each of the four household types to assess the degree of precautionary labor supply for each household type.

Table 11 shows the cyclicality of married women's E-to-N transition rate for each of the four household types. The first two rows compare college educated women married to either a high school husband or college educated husband. We see that indeed women married to a husband with higher cyclicality of job loss risk provide spousal insurance (Cyclicality E-to-N: -0.0572) from precautionary labor supply whereas women married to college educated men do not. While this is true for college-educated women we cannot observe the same for high school women. Both groups exhibit a positive cyclicality of their E-to-N transition rate, albeit it's less positive for the women married to high school educated men. This extension

| Hh type | Cyclicality E-to-N |
|---|---|
| High school - College | -0.0572 |
| College - College | 0.2439 |
| High school - High school | 0.1727 |
| College - High school | 0.2808 |

Table 11: Cyclicality of transition rate for each household type

confirms the finding that women who are married to a husband with a higher cyclicality of job loss risk are more likely to display precautionary labor supply than women who are married to a husband with a lower cyclicality of job loss risk. Furthermore, the extension shows that married women's characteristics matter as well for the degree of precautionary labor supply. In particular, these findings support the earlier job hoarding finding, i.e. college educated married women are more likely to exhibit precautionary labor supply since they face lower

[15]See appendix for model moments and fit.

risk in recessions than their high school educated counterpart (conditional on being married to the same husband type).

## 8 Conclusion

In this paper I document that married women have a lower cyclicality in hours and employment than married men and single individuals. I find empirically that married women are more attached to employment and less likely to leave the labor force in recessions relative to both normal times and married men and single individuals, which leads to procyclical E-to-N transition rates for married women. In light of the procyclical E-to-N transition rates for married women, I propose a novel mechanism of spousal insurance: precautionary labor supply. While a married woman might quit from employment to not in the labor force in normal times due to a positive shock to her value of non-employment or a positive shock to her husband's employment, she might choose to remain employed and not quit in recessions. In recessions, her non-labor income risk increases due to her husband's higher job loss probability and therefore, she increases her labor supply and remains employed.

I build a quantitative model to analyze married women's labor supply decisions over the business cycle and to derive implications for spousal insurance and the cyclicality of employment. The model features incomplete assets markets, aggregate risk in the form of high job loss and low job finding probabilities in recessions, and endogenous movements between employment, unemployment, and not in the labor force for married women.

I find that the cyclicality of risk and the channel of precautionary labor supply account for about 62% of the procyclical E-to-N transition rate in the data. Since spousal insurance is potentially an important mechanism to smooth consumption for married households over the business cycle, I compute the reduction in consumption volatility due to spousal insurance provided by married women. In find that consumption volatility is about 67 percent lower in the model with married households compared a single earner married household.

These findings are potentially important to evaluate the risk households face over the business cycle and to derive implications for the interaction of formal and informal insurance. Optimal unemployment insurance, e.g. depends on the importance of spousal insurance to the household and to what degree spousal insurance might be crowded out by formal insurance. This paper offers new insights into how households insure themselves over the business cycle and how much of the risks they are able to insure themselves.

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# 9 Appendix

## 9.1 Empirics

### 9.1.1 Cyclicality of aggregate hours

The following describes the estimation of the cyclicality of aggregate hours in the United States by gender and marital status and provides more details to figure 1 in the introduction of the article.

I estimate the following linear regression for married women, married men, single women, and single men separately, where $g = m, f$ indicates whether the observation is male of female, and $r = m, s$ indicates married or single, and both hours and the unemployment rate are of annual frequency and detrended using a HP filter with smoothing parameter 1600.

$$\text{hours}_t^{g,r} = \beta_0 + \beta_1 \text{unemployment rate}_t + \varepsilon_t \tag{6}$$

Since this paper argues that wives adjust their labor supply in response to the cyclicality of labor market risk faced by their husbands, and therefore, respond directly to the changing conditions of the labor market, I use the unemployment rate as the business cycle indicator rather than GDP per capita as used by Jaimovich, Siu and Pruitt (2013) and Doepke and Tertilt (2016). The labor market has been lagging significantly in the recent recessions in the United States and, thus, the unemployment rate is a better measure of business cycles with regards to the cyclicality of job loss and job finding probabilities.

Table 12 starts by showing the estimation results from the regression equation in (6) for married women and men as well as single women and men. The results are in line

| | Aggregate detrended hous | | | |
|---|---|---|---|---|
| | Married women | Married men | Single women | Single men |
| Unemployment rate | -0.0197<br>(0.0591) | -0.1616*<br>(0.0873) | -0.1586<br>(0.0964) | -0.3535**<br>(0.1652) |

Table 12: Regression results

with figure 1. Aggregate hours for married women respond significantly less to fluctuations in the unemployment rate than aggregate hours for the other groups. Married women's aggregate hours' response to an increase in the unemployment rate is not statistically significant whereas the response for men, both married and single, is substantially bigger and statistically signficant, Single women's response is larger as well, however, not statistically significant.

Figure 1 in the introduction showed that married women have a significantly lower cyclicality in the aggregate hours worked than the other three groups. This aggregate volatility in hours worked can further be decomposed into volatility that is due to business cycle fluctuations (Cyclical volatility) and volatility due to other factors, such as personal reasons, household formation, etc. Following Jaimovich, Siu and Pruitt (2013) and Doepke and Tertilt (2016), I estimate the aggregate hours worked cyclicality due to business cycle fluctuations for each group by first regressing the detrended hours worked series for each group on a (detrended) business cycle indicator. Second, I compute cyclical volatility as the percentage deviation of the predicted hours from trend.

Table 13 shows the decomposition into total volatility and cyclical volatility and we can observe that married women experience the lowest cyclical volatility both considering the intensive margin only and all married women.

| | Married | | Single | |
|---|---|---|---|---|
| | Men | Women | Men | Women |
| | Intensive and extensive margin | | | |
| Total Volatility | 0.5607 | 0.5513 | 1.1630 | 0.9599 |
| Cyclical Volatility | 0.2563 | 0.0478 | 0.6627 | 0.3381 |
| $R^2$ | 21.62 | 0.73 | 32.47 | 12.41 |
| Share | 0.45 | 0.09 | 0.57 | 0.35 |
| | Intensive margin | | | |
| Total Volatility | 0.2854 | 0.3413 | 0.3796 | 0.3696 |
| Cyclical Volatility | 0.2209 | 0.1059 | 0.2020 | 0.2074 |
| $R^2$ | 50.12 | 10.85 | 40.25 | 37.71 |
| Share | 0.77 | 0.31 | 0.53 | 0.56 |

Table 13: Married women have the lowest cyclical volatility

Aggregate hours worked for individuals can vary due to two reasons: individuals moving between employment and non-employment and changes in hours by employed individuals. Following Jaimovich, Siu and Pruitt (2013), I decompose the hours cyclical volatility for married women into two components: volatility due to movements between employment and non-employment and volatility due to pure hours adjustments of working married women.

This simple variance decomposition shows that for married women variation on the extensive margin, i.e. transitions between employment and non-employment, accounts for the majority of the cyclical volatility. Table 14 shows that about 78% of the hours volatility

| | Extensive margin | Intensive margin |
|---|---|---|
| Cyclical volatility | 78% | 22% |

Table 14: Decomposition of cyclical volatility into the extensive and intensive margin

stems from the extensive margin only 22% are due to pure hour fluctuations. Since movements between labor market states account for the majority of the aggregate hours worked cyclicality for married women the rest of my empirical section as well as the model will only consider the extensive margin.

### 9.1.2 Implications of Short-term unemployment for job-to-job transitions

This section shows robustness checks regarding the transition rates. In particular, it is well known that some short spells of unemployment are due to job-to-job transitions and individuals looking for better jobs. Therefore, in the following I exclude individuals with short spells of unemployment from the analysis and show that the cyclical results regarding the transitions of individuals between different labor market states still hold. I identify individuals who are unemployed for one month and were employed before and become employed afterwards, thus, individual with the following transition: E-U-E. I exclude them from the analysis which leaves me with the following transition rates: As can be seen in the table, the responsiveness of the E-to-E and E-to-N transition rates to fluctuations in the (log) unemployment rate is almost unchanged, only the estimated coefficient on the E-to-U transition rates increased, which implies more procyclical E-to-U transition rates.

| Transition rate | Estimated coefficient | | | |
|---|---|---|---|---|
| | Married women | Married men | Single women | Single men |
| E-to-E | 0.0025*** | -0.0055*** | -0.0035*** | -0.0081*** |
| | (0.0008) | (0.0005) | (0.0010) | (0.0012) |
| E-to-U | 0.5577*** | 0.9228*** | 0.4088*** | 0.7630*** |
| | (0.0665) | (0.0730) | (0.0802) | (0.0850) |
| E-to-N | -0.2517*** | 0.1884*** | 0.0699 | 0.0636 |
| | (0.0366) | (0.0637) | (0.0606) | (0.0575) |

#### 9.1.3 Implications of Short-term non-employment for job-to-job transitions

Similarly, I can control for whether short spells of non-employment are driving my results. Therefore, I exclude individuals from my analysis who experience one month spells of non-employment after and followed by employment. This implies individuals with an E-N-E transition rate. The following table shows that these individuals are few and excluding them does not change my initial findings. Hence, the procyclicality of married women's E-to-

| Transition rate | Estimated coefficient | | | |
|---|---|---|---|---|
| | Married women | Married men | Single women | Single men |
| E-to-E | 0.0006 | -0.0069*** | -0.0029*** | -0.0093*** |
| | (0.0008) | (0.0006) | (0.0009) | (0.0012) |
| E-to-U | 0.3478*** | 0.6803*** | 0.2315*** | 0.4456*** |
| | (0.0572) | (0.0587) | (0.0661) | (0.0567) |
| E-to-N | -0.2491*** | 0.2841*** | 0.0883*** | 0.2033** |
| | (0.0482) | (0.0828) | (0.0267) | (0.0847) |

N transition rate and acyclicality of the E-to-E transition rate is not affected by short-term spells of non-employment (both unemployment and not in the labor force) as a result of, for example, frequent job-to-job transitions.

#### 9.1.4 Other Hypotheses

While this paper argues that spousal insurance and expectations about aggregate economic conditions and therefore labor market risk contributes to the observed low cyclicality of aggregate hours for married women, there are certainly other reasons one might suspect can (at least partially) explain the low hours cyclicality. Furthermore, there is substantial heterogeneity among married women and different demographic groups might have a different impact on aggregate labor market outcomes. In the following, I will discuss other potential hypotheses explaining the observed low aggregate hours cyclicality of married women and show that it holds for different subgroups.

### 9.1.5 Industry and Occupation

The most common reason cited in the literature to explain differences in labor market outcomes between men and women, for example differences in the cyclicality of the unemployment rate, is the different occupation and industry composition for men and women. In particular, men in the United States are more likely to work in industries or choose occupations which are more affected by economic downturns and therefore, are characterized by signficantly higher job loss rates. In the recent recession, unemployment rates for men were significantly higher than for women. However, I will argue in the following that the difference in industry/occupation composition cannot explain why *married* women's aggregate hours are significantly less cyclical than for the other groups.

First, in the appendix I show that *married* and *single* women have a similar distribution across the different industry and occupation categories, which implies if this was the main driver we would expect single women to be characterized by a similar low hours cyclicality.

Second, and more importantly I show that married women still have the lowest aggregate hours cyclicality even if controlling for different types of industries. I repeat the decomposition into total volatility and volatility directly related to business cycle fluctuations in the previous section for married men, married women, single men, and single women for two types of industries: manufacturing and services (See appendix for my classification). Since I aggregate the annual data by gender, marital status, and industry classification, I do not have enough data to show the hours volatility for finer industry groups. Some categories will have very few observations and there is too much noise leading to very imprecise results. Nevertheless, the broader classifications shows that while there may be differences between particular industries, employment in the service sector vs employment in the manufacturing sector alone cannot explain the observed differences in hours volatility for married women and the other groups.

Tables 15 display the estimation results from regressing the detrended aggregate hours series for each gender-marital status-industry group on the unemployment rate. These results show how much each hours series fluctuates in respond to fluctuations in the unemployment rate and thus, replicates the methodology on cyclical volatility in section 3.1.1. First, for both the service and manufacturing industry groups, the estimated coefficient for married women is the lowest indicating that their hours decline the least (or do not decline since the estimated coefficient is not statistically significant) when the unemployment rate increases, i.e. in recessions. Thus, their hours seem to fluctuate less over the business cycle within both industry groups compared to married men and single individuals.

Second, these results show that indeed aggregate hours fluctuations associated with business cycle fluctuations in the unemployment rate are lower for the services industry, but for all groups and in particular for men, both single and married. While the estimated coefficient did not change in magnitude between the manufacturing and service group for married women, it slightly declined for single women, and it is 25 percent lower for married men and 50 percent lower for single men. However, the "ordering" of the groups with regards to their cyclical volatility among each industry category is unaffected.

| | Manufacturing | | | |
|---|---|---|---|---|
| | Married women | Married men | Single women | Single men |
| Unemployment rate | -0.0481 | -0.1618** | -0.1056 | -0.2617*** |
| | (0.0535) | (0.0610) | (0.0793) | (0.0842) |
| | Services | | | |
| | Married women | Married men | Single women | Single men |
| Unemployment rate | -0.0396 | -0.1231*** | -0.0921** | -0.1354* |
| | (0.0291) | (0.0354) | (0.0357) | (0.0709) |

Table 15: Regression Results: Manufacturing and Service Industries

Table 16 displays the cyclical volatility for each gender-marital status-industry group, i.e. the volatility in aggregate hours related to (business cycle) fluctuations in the unemployment rate, and emphasizes the findings. Married women's aggregate hours are significantly less cyclical in both the manufacturing as well as the service industries and similar in magnitude between the two industry categories. Therefore, differences in the industry of

| | Married women | Married men | Single women | Single men |
|---|---|---|---|---|
| | Manufacturing | | | |
| Cyclical volatility | 0.0829 | 0.2482 | 0.1732 | 0.4180 |
| | Services | | | |
| Cyclical volatility | 0.0734 | 0.1851 | 0.1577 | 0.2195 |

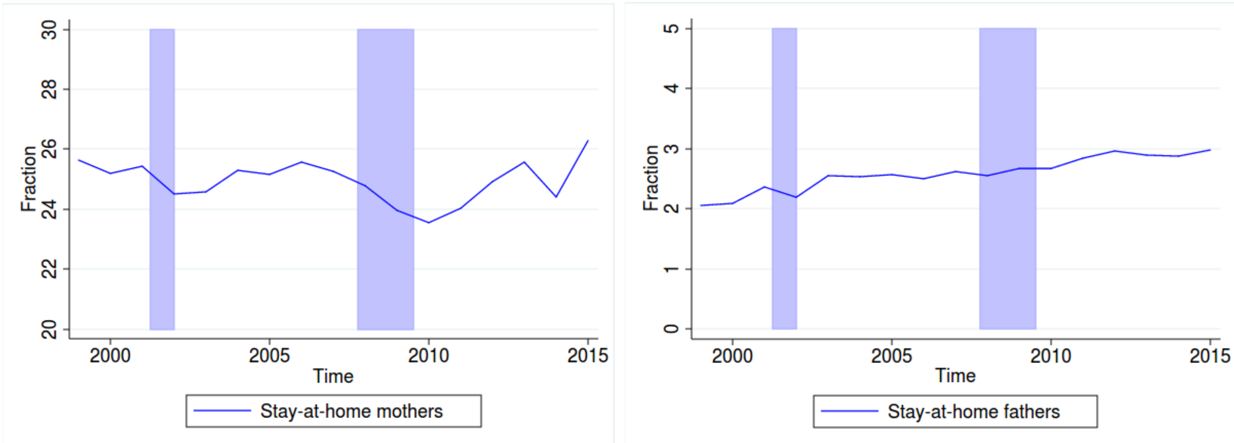
Table 16: Cyclical volatility: Manufacturing and Service Industries

employment explain part of the cyclicality in aggregate hours, however, married women's cyclical hours volatility is lowest regardless of the industry.

#### 9.1.6 Children

When (married) women choose whether to work or not to work one of the more important factors to consider is the presence of children as well as the number of children and age of children. Mothers with young children or many children are less likely work than childless married women or mothers with few or older children. I will show in the following that the presence of children certainly matters in the aggregate to which married women work, with regards to cyclicality in the aggregate children do not seem to cause big differences between mothers and childless married women.

Figures 3a and 3b show the fraction of stay-at-home married mothers and fathers in the United States between 1998 and 2015, covering two recessions. From figure 3a it is clear that the choice to participate in the labor market and work or stay at home for married mothers is not acyclical, but very much procyclical. The fraction of married mothers who stay at home drops with the beginning of both recessions and recovers a couple years after the recession to its pre-recession value. For comparison, in the same time period the fraction of stay-at-home fathers is completely acyclical and we might detect a slight upward trend. But it does not appear that there is a switch between parents in who is raising children, but rather married mothers respond to business cycle fluctuations. Therefore, we even see a response to business cycle fluctuations and aggregate risk among mothers. In the recent recession the fraction of stay-at-home married mothers is about 2 to 3 percentage points lower than during normal times which implies some mothers choose to work despite having




(a) Married mothers (b) Married fathers

Figure 3: Stay-at-home married mothers and fathers in the United States 1998 until 2015

children. While this figure does not yield any evidence whether these are married mothers who join the labor force during recessions or married mothers choose to remain employed during recessions when they would not during normal times, it indicates that on average in the aggregate having children does not prevent mothers from insuring their family.

These findings are in line with the literature studying the cyclicality of fertility and the response of fertility to changes in the aggregate economic conditions. The consensus among these studies is that fertility is procyclical, meaning households delay fertility in recessions until the economy is back in normal times.[16]

### 9.1.7 Occupation and Industry distribution for married and single women

First, if the composition was the main driver of the low hours cyclicality for married women, we would expect to see a similar cyclicality for single women, since their shares among different industries is very similar to the ones of married women as shown in table 17.[17].

[16]See the related literature section on a more detailed summary of findings regarding the cyclicality of fertility.

[17]The classification is following the IPUMS classification by Flood et al. (2018) and provides consistent industrial and occupational codes by following the 1990 Census Bureau classification system. The recoding by IPUMS allows for comparing industries and occupations over time since the raw data experiences a break in 1994 due to a change in the classification

| Industry | Married | Single | Statistically different |
|---|---|---|---|
| Agriculture, Forestry, and Fisheries | 1.57% | 1.02% | *** |
| Mining | 0.21% | 0.20% | * |
| Construction | 1.60% | 1.32% | *** |
| Manufacturing | 9.30% | 10.30% | *** |
| Transportation, Communications, & other Public Utilities | 4.01% | 4.96% | *** |
| Wholesale Trade | 2.20% | 2.11% | *** |
| Retail Trade | 14.30% | 17.21% | *** |
| Finance, Insurance, and Real Estate | 8.56% | 7.69% | *** |
| Business and Repair Services | 5.17% | 6.19% | *** |
| Personal Services | 4.49% | 5.70% | *** |
| Entertainment and Recreation Services | 1.45% | 1.79% | *** |
| Professional and Related Services | 42.59% | 36.06% | *** |
| Public Administration | 4.54% | 5.47% | *** |

Table 17: Share of married and single women among different industries

## 9.2 Model

### 9.2.1 Household Problem: Additional household types

**Unemployed-Employed (UE) household**

An $UE$ household consists of an unemployed husband, who remains unemployed until a job offer arrives, and an employed wife who can choose between employment, active search, and passive search. Furthermore, the household decides how much to consume and how much to save. The household has to pay $\alpha_2(w_2\varepsilon)$ in participation cost for the wife. The household receives income from savings and labor income from the employed wife. The value function for this type of household is

$$
\begin{aligned}
V^{UE}(a,\mathcal{E},\kappa,y) = \max_{c,a'} \log(c) - \alpha(\varepsilon_2) + \beta\mathbb{E}[&\lambda_1(y)(1-\tilde{\chi}_2(y))W^{EJ}(a',\mathcal{E}',\kappa',y')+\\
&(1-\lambda_1(y))(1-\tilde{\chi}_2(y))W^{UJ}(a',\mathcal{E}',\kappa',y')+\\
&\lambda_1(y)\tilde{\chi}_2(y)W^{EL}(a',\mathcal{E}',\kappa',y')+\\
&(1-\lambda_1(y))\tilde{\chi}_2(y)W^{UL}(a',\mathcal{E}',\kappa',y')\\
\text{s.to}\ \ c+a' = (1+r)a + w_2\varepsilon&
\end{aligned}
$$

Both husband and wife will have an offer tomorrow and start as a $W^{EJ}$ household if the husband receives a job offer with probability $\lambda_1(y)$ and the wife keeps her job with probability

$(1-\tilde{\chi}_2(y))$. The husband will be unemployed and the wife employed $W^{UJ}$ with probability $(1-\lambda_1(y))\tilde{\chi}_2(y)$. The husband will be employed next period with probability $\lambda_1(y)$ and the wife will lose her job with probability $\tilde{\chi}_2(y)$ and they will be continuation value $W^{EL}$. Lastly, with probability $(1-\lambda_1(y))\tilde{\chi}_2(y)$ both husband and wife are jobless next period $W^{UL}$.

Again, this value function highlights the role of expectations in the wife's decision between employment and non-employment. Similarly to the previous case, the wife's decision is affected by her expectation of the state of the economy in the next period. Since her husband is jobless, she is less likely to leave the labor force than in the case where her husband has a job. However, if the household has a large amount of assets accumulated and the wife expects the economy to remain in good times, she might consider leaving the labor force, since the probability of her husband finding a job is high and if he does not her probability of rejoning employment is high. However, if she expects a recessions, she is very unlikely to leave since it became less likely that her husband gets a job offer.

**Employed-Jobless (EL) household**

A household in which the husband is employed and the wife is jobless chooses joint consumption, savings, and whether the wife searches or not. If they choose $s_2 = 1$, then the wife is unemployed and the household has to pay the stochastic disutility cost of searching $\kappa$. If they choose $s_2 = 0$, the wife does not actively search and the household does not face any disutility from searching. In this case the wife is considered not in the labor force. The household only receives labor income from the husband and from savings from the previous period. The value function for this type of household is

$$\begin{aligned} V^{EL}(a,\mathcal{E},\kappa,y) = \max_{c,a',s_2} \log(c) - \kappa + \beta\mathbb{E}[&(1-\chi_1(y))\lambda_2(s,y)W^{EJ}(a',\mathcal{E}',\kappa',y') + \\ &\chi_1(y)(1-\lambda_2(s,y))W^{UJ}(a',\mathcal{E}',\kappa',y') + \\ &(1-\chi_1(y))(1-\lambda_2(s,y))W^{EL}(a',\mathcal{E}',\kappa',y') + \\ &\chi_1(y)(1-\lambda_2(s,y))W^{UL}(a',\mathcal{E}',\kappa',y') \\ \text{s.to}\ \ c + a' = (1+r)a + w_1\varepsilon \end{aligned}$$

Both spouses will have a job offer tomorrow $W^{EJ}(a',\mathcal{E}',\kappa',y')$ if the husband keeps his job with probability $(1-\chi_1(y))$ and the wife receives a job offer with probability $\lambda_2(s,y)$. They will be a $LJ$ household $W^{UJ}(a',\mathcal{E}',\kappa',y')$ if the husband becomes unemployed with probability $\chi_1(y)$ and the wife finds a job with probability $\lambda_2(s,y)$. Similarly, the husband has a job offer next period and the wife does not $W^{EL}(a',\mathcal{E}',\kappa',y')$ if the husband remains employed with probability $(1-\chi_1(y))$ and the wife remains jobless with probability $(1-\lambda_2(s,y))$. They will be a jobless household $W^{UL}(a',\mathcal{E}',\kappa',y')$ if the husband loses his job with probability $\chi_1(y)$ and the wife does not receive a job offer with probability $(1-\lambda_2(s,y))$.

**Unemployed-Jobless (UL) household**

If the husband is jobless, he has to be unemployed and the household has to pay the search cost $\kappa$. The wife, however, can choose between unemployment and not in the labor force. In the case in which both husband and wife are jobless the household has a consumption, savings, and search choice for the wife. If the wife decides to search the household has to pay the stochastic search cost $\kappa$ for her. Otherwise, she is not in the labor force and no search cost needs to be paid. Then the value function for a jobless household is

$$\begin{aligned}
V^{UL}(a,\mathcal{E},\kappa,y) = \max_{c,a',s_2} \log(c) - \kappa + \beta\mathbb{E}[&\lambda_1(y)\lambda_2(s,y)W^{EJ}(a',\mathcal{E}',\kappa',y')+ \\
&(1-\lambda_1(y))\lambda_2(s,y)W^{UJ}(a',\mathcal{E}',\kappa',y')+ \\
&\lambda_1(y)(1-\lambda_2(s,y))W^{EL}(a',\mathcal{E}',\kappa',y')+ \\
&(1-\lambda_1(y))(1-\lambda_2(s,y))W^{UL}(a',\mathcal{E}',\kappa',y') \\
\text{s.to}\quad c + a' = (1+r)a&
\end{aligned}$$

With probability $\lambda_1(y)\lambda_2(s,y)$ both spouses will have a job offer tomorrow and the continuation value is $W^{JJ}(a',\mathcal{E}',\kappa',y')$, whereas both spouses are jobless next period $W^{LL}(a',\mathcal{E}',\kappa',y')$ with probability $(1-\lambda_1(y))(1-\lambda_2(s,y))$. The household will have a spouse with a job offer and one without if either the husband finds a job with probability $\lambda_1(y)$ or the wife receives a job offer with probability $\lambda_2(s,y)$.

### 9.2.2 Correlated job loss shocks

For both spouses the probability of losing and keeping the job has to add up to one, such that

$$\pi_{L^m=1}(y) = \chi_1(y) \quad \text{and} \quad \pi_{L^m=0}(y) = 1 - \chi_1(y) \tag{7}$$

$$\pi_{L^f=1}(y) = \chi_2(y) \quad \text{and} \quad \pi_{L^f=0}(y) = 1 - \chi_2(y) \tag{8}$$

The correlation of shocks implies that the wife's displacement shock depends on her husband's displacement shock but is independent of her husband's current labor market state. This means that on average the probability of job loss for the wife is the same regardless of whether her husband is employed or unemployed in the current period.

If the household is currently EE, i.e. both spouses are employed, then the wife's probability of job loss is the sum of her losing the job and the husband loses his job and her losing the job and the husband keeps his job:

$$(1-\chi_1)(1-\varphi)\chi_2 + \chi_1\left[(1-\varphi)\chi_2 + \varphi\right] \tag{9}$$

$$=(1-\varphi)\chi_2 + \varphi\chi_1 \tag{10}$$

$$=\tilde{\chi}_2 \tag{11}$$

### 9.2.3 Illustration of precautionary labor supply in the model

Before analyzing the quantitative results from the model and its cyclical implications, this section illustrates the spousal insurance mechanism, precautionary labor supply, as generated in the model. Furthermore, in the appendix I illustrate how this model also features an added-worker effect. In order to highlight precautionary labor supply in response to a change in aggregate conditions, I fix the productivity level for both spouses and the search shock for the wife, i.e. the following figures show precautionary labor supply for a household where only aggregate risk varies.

Figure 4 illustrates the joint labor market states policy functions for three types of households in non-recessionary times as a function of household's assets. Normal times are characterized by high job finding and low job loss probabilities for both spouses. The top line shows the policy function for a household in which both spouses have a job offer (JJ), for the middle line only the husband has a job offer and the wife is jobless (JL), and lastly in the bottom case both spouses are jobless (LL). The thresholds between different labor market states are a result of the wealth effect. For example, considering the JJ household, if the household is asset-poor, they will choose employment for the wife, whereas if they are asset-rich, the household finds it optimal to not incur the utility cost of working for the wife and chooses not in the labor force for her. If the wife is without a job offer, as it is the case for the JL and LL household, she will actively search (unemployment) if the household is asset-poor and passively search (not in the labor force) if the household has more assets. By construction of the model, the husband will be always employed if he has a job offer as illustrated for the JJ and JL household where he is employed across the whole assets range. Similarly, if the husband is without a job offer, he is unemployed across the whole assets range.

Figure 4 shows that it is never optimal for the household to choose unemployment for the wife if she has a job offer. In the top panel, a wife with a job offer is either employed if the household is asset-poor or not in the labor force if the household becomes richer in terms of their assets, but never chooses unemployment. This is due to the job hoarding behavior by married women in this model. Job hoarding occurs in models of labor supply decisions which feature labor market frictions, such as exogenous job loss and/or job finding probabilities. Similar to Mankart and Oikonomou (2016*a*) this model features job hoarding for the wife. In general, job hoarding implies that agents in a dynamic model choose to be employed for higher asset levels than it would be statically optimal[18]. If employed agents are deciding whether to remain employed or quit in the current period, they also take into consideration that once they quit, they cannot re-enter into employment right away since there is a probability that they do not receive a job offer. Thus, they remain employed either until they lose their job exogenously or until they accumulated enough assets and then leave the labor force altogether. But they would not choose to quit into unemployment, since then they are incurring the utility cost of searching. Unemployment in this model can be

[18]This behavior occurs in both single and dual earner households

interpreted as workers who are available and want to work but cannot because of frictions, i.e. it is an indicator of desired labor supply limited by frictions. Therefore, individuals who actively search indicate their willingness to work and their desire to be employed which is only limited by the frictions in the model. Thus, an individual who receives a job offer, will always take the job offer and never reject it.

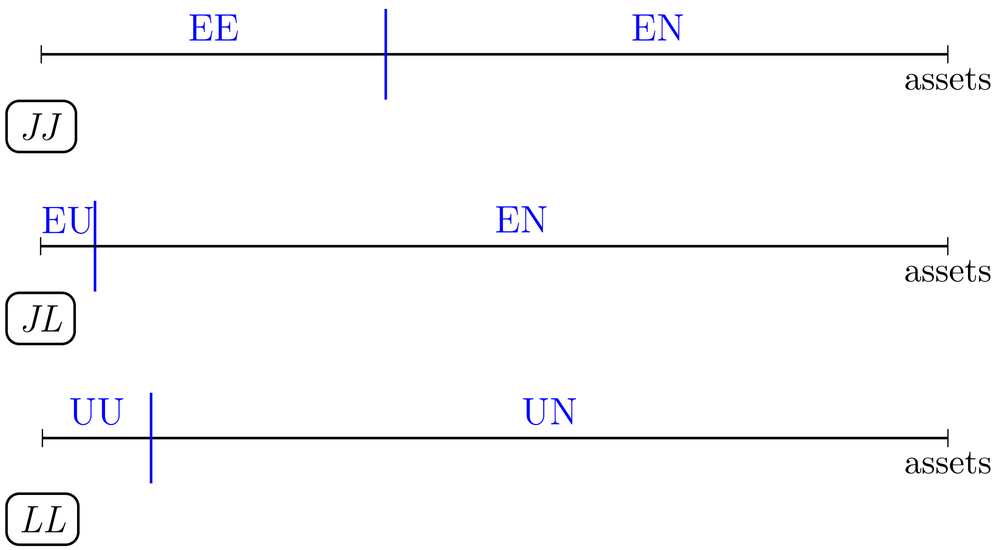



Figure 4: Precautionary labor supply

Figure 5 illustrates how a change in aggregate, higher job loss probabilities and lower job finding probabilities, translates into a precautionary labor supply response for the wife. As a result of a change in the aggregate state of the economy, the thresholds shift to the right. Now married women will quit from employment or unemployment into not in the labor force for higher asset levels than in non-recessionary times, since the risk of job loss for the husband increases and her probability of finding a job when non-employed decreases. This means for JJ households that hold assets between the old and new threshold, it will now be optimal for the wife to be employed rather than leave the labor force. Thus, the wife chooses to remain employed due to higher uncertainty. Similarly, if the wife does not have a job offer (JL or LL households), she chooses to remain unemployed and keep actively searching as a precaution in the event of job loss of her husband.

The size of the aggregate precautionary labor suppy response depends crucially on the number of households that have married women at the margin of employment and

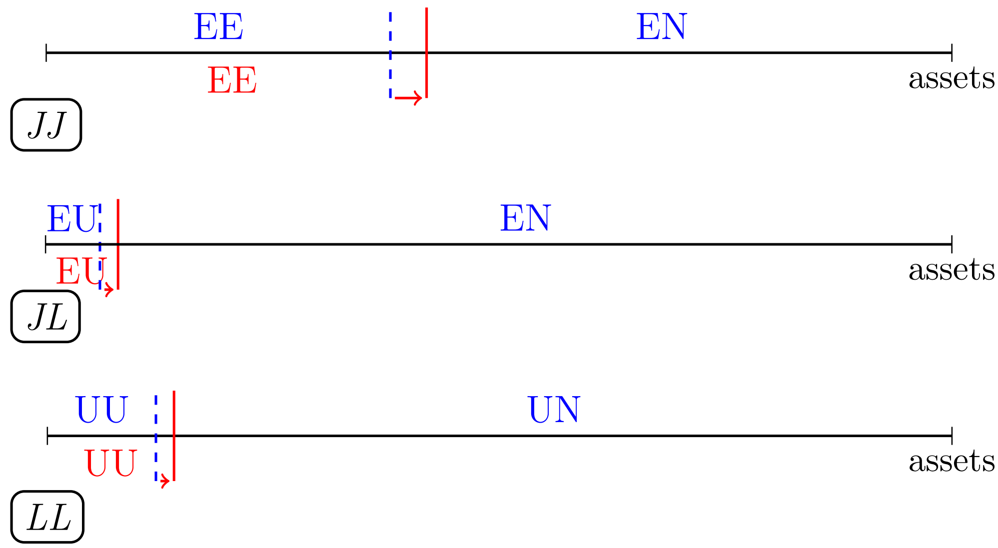



Figure 5: Precautionary labor supply

non-participation. In the next section, I will show that this is a non-negligible fraction of households.

However, there is a trade-off in the model between lower E-to-N transitions due to precautionary labor supply and more E-to-N transitions due to the increase in exogenous job separations during recessions. Consider figure 6 as an illustration of the latter part of the trade-off. Figure 6 shows the joint labor market states policy functions for a different household. Its productivity level and search cost is fixed, but the wife's productivity is lower and her search cost is higher compared to the previous household. When the economy

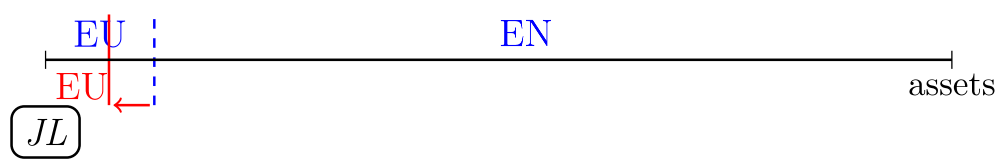



Figure 6: More E-to-N transitions due to higher separation rates

switches from good to bad times, this household's threshold shifts to the left and the wife chooses not in the labor force for assets levels she would have chosen unemployment in normal times. Since she has a relatively low productivity and incurs a high utility cost from searching she leaves the labor force in recessions since searching is costly, her job finding probability decreased, and she has low productivity. Thus, if this married woman was formerly employed and loses her job, she leaves the labor force directly rather than remain unemployed. In recessions, separation rates are higher, so more married women lose their job, but some of them are also more likely to leave the labor force.

Therefore, we have this trade-off in the model between lower E-to-N transition rates because of married women providing precautionary labor supply and higher E-to-N transition rates due to higher job loss rates.

### 9.2.4 Illustration of added-worker effect in the model

First, the added-worker effect describes the situation in which the secondary spouse, in the model the wife, joins the labor force into either employment or unemployment following job loss by the primary earner, in the model the husband. Thus, it captures the change in labor market state by the wife in response to the husband's movement from employment to unemployment. The added-worker effect is present regardless whether the economy is in a recession or not. There are just more households affected during recessions since more husbands are going to lose their jobs.

Figure 7 illustrates a situation in which the added-worker effect occurs, in particular a case in which the wife joins the labor force into employment. Figure 7 shows the household's policy functions for the joint labor market states for both spouses as functions of the household's assets. The top line shows the joint labor market states policy function in which both spouses have a job offer (JJ). The bottom line illustrates a household, in which the husband has a job offer and the wife is jobless (JL). We start by considering the top line. The husband is employed at all asset levels because he has a job offer and due to the definition of his optimization problem. The wife also has a job offer, but the household can choose the optimal labor market state for her given their asset level, the spouses' productivity levels, and the husband's labor market state. Figure 7 shows that the household finds it optimal to have the wife employed if they are asset-poor and choose her to be not in the labor force if they have more assets. This is the result of a standard wealth effect.

Now suppose the husband loses his job due to an exogenous job destruction shock and unexpectedly moves from employment to unemployment. This constitutes a change in the type of household from JJ to LJ. Now for a certain range of assets levels (identified here as the red bracket), the household will find it optimal to have the wife employed rather than not in the labor force since the job loss of the husband means lower household wealth. So for households close enough to the wife's threshold between non-employment and employment, job loss for the household results into the wife joining the labor force, i.e. into the added-worker effect.

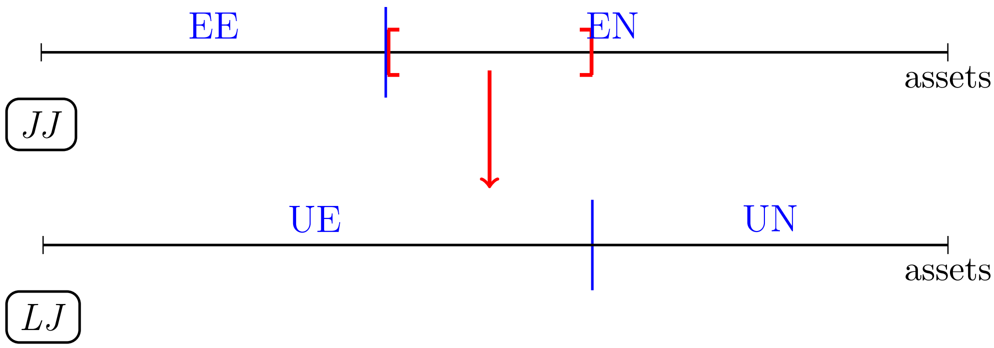



Figure 7: Added-worker effect into unemployment

Figure 8 similarly illustrates the added-worker effect, however, now the wife does not have a job offer and therefore, she joins the labor force into unemployment.

The top line illustrates the joint labor market states policy function for a household in which the husband has a job offer and the wife is jobless (JL). The bottom line shows a household in which both spouses are jobless (LL). Start by considering the top line. The husband is employed for all asset levels if he has a job offer by definition of his optimization problem. The wife does not have a job offer and therefore is non-employed. She will be unemployed if the household is asset-poor and not in the labor force once the household has enough wealth.

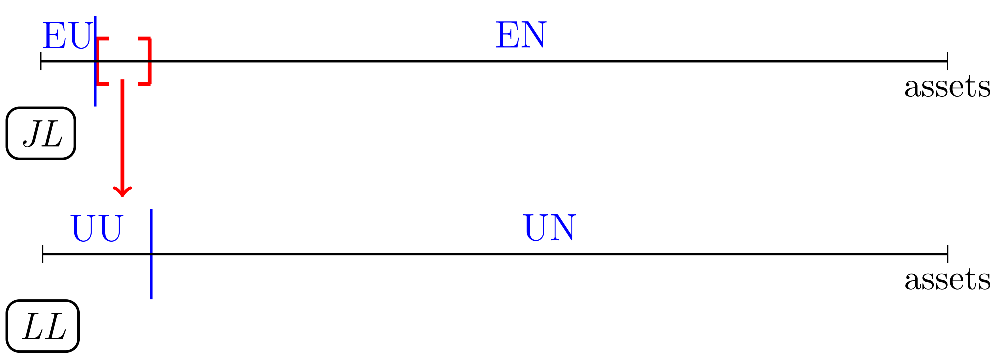



Figure 8: Added-worker effect into unemployment

Now consider the husband loses his job through an exogenous job destruction shock, which constitutes an unexpected movement from employment to unemployment. In figure 8, this can be seen from moving to the top line to the bottom line, i.e. the household went from being a JL household to being a LL household. Now for household in the asset range indicated by red brackets it will be optimal to choose active search for the wife and therefore, she will be considered unemployed. Similar to the added-worker effect into employment, for households close enough to the wife's threshold between unemployment and not in the labor force, job loss for the husband is associated with the wife joining the labor force into unemployment, and therefore, an added-worker effect.

Both added-worker effects shown are for a fixed productivity level for both spouses and a fixed aggregate state of the economy. The size of the added-worker effect in the model will crucially depend on the number of households which are close to the wife's thresholds between employment and not in the labor force and between unemployment and not in the labor force as well as on the size of the husband's job loss probability. One would expect that during recessions, times in which husbands experience a higher job loss probability, would feature more wives making the aforementioned transitions conditional on being close to the threshold since more husbands are being laid off.

## 10 Additional Quantitative Model Results

#### 10.0.1 Cyclicality of E-to-E and E-to-U

| Married women | | |
|---|---|---|
| Transition rate | Data | Model |
| E-to-E | 0.0024 | -0.0001 |
| E-to-U | 0.3648 | 0.5193 |

Table 18: E-to-E and E-to-U transition rate

Table 18 shows the cyclicality of the E-to-E and E-to-U transition rates for married women. While the E-to-E transition rate is acyclical to mildly countercyclical in the data, my model produces an acyclical to mildly procyclical E-to-E transition rate. The reason for that becomes clear when we analyze both flow rates from employment to non-employment.

While my model generates a countercyclical E-to-U transition rate that is slightly more cyclical than its data counterpart, the E-to-N transition rate is only about 62% of its data counterpart. Thus, my model features a similar outflow from employment to unemployment in recessions, but it does not generate the same reduction in flows from employment to not in the labor force. Therefore, the E-to-E transition rate in the model is slightly procyclical, since the reduction in E-to-N does not make up for the increase in E-to-U flows in recessions.

#### 10.0.2 Joint distribution over labor market states

Table 20 shows that the model, moreover, does a good job in also matching households' joint distribution over the different labor market states.[19]

| Joint household labor market state | Data | Model |
|---|---|---|
| EE | 71.01% | 68.37% |
| EU | 2.13% | 2.27% |
| EN | 23.71% | 25.36% |
| UE | 2.12% | 2.62% |
| UU | 0.28% | 0.30% |
| UN | 0.75% | 0.61% |

Table 19: Joint distribution of husband and wife over labor market states

Table 20 shows that the model also matches the cyclicality of the joint labor market states of both spouses well. It only understates the cyclicality of EN households which is because the model also understates the cyclicality of the E-to-N transition rate for married women and less women remain employed and not leave out of the labor force than in the data. Therefore, the model also overstates the cyclicality of EE and EU households.

#### 10.0.3 Cyclicality of all transition rates for married women

Table 21 shows the cyclicality of all transition rates for married women. In each case, cyclicality is computed as the regression of the log transition rate on the log unemployment rate. While the model does overall well in capturing the cyclicality of each transition rate, it fails to capture the procyclicality of the U-to-N transition rate. While in the data, married

[19]The first letter indicates the husband's labor market state, and the second the wife's, so for example, EU indicates that the husband is employed and the wife is unemployed.

| Joint household labor market state | Data | Model |
|---|---|---|
| EE | -0.8549 | -0.9094 |
| EU | 0.9159 | 0.9939 |
| EN | -0.3153 | -0.1931 |
| UE | 0.9240 | 0.9448 |
| UU | 0.9365 | 0.9029 |
| UN | 0.8713 | 0.8917 |

Table 20: Cyclicality of joint labor market states

women are less likely to leave the labor force from unemployment when the unemployment rate is high, in the model they are more likely to leave the labor force from unemployment. Otherwise, the model does a good job in matching the direction of cyclicality.

| Married women | | |
|---|---|---|
| Transition rate | Data | Model |
| E-to-E | 0.0024 | -0.0001 |
| E-to-U | 0.3648 | 0.5193 |
| E-to-N | -0.2616 | -0.1578 |
| U-to-E | -0.8193 | -0.5960 |
| U-to-U | 0.3431 | 0.1705 |
| U-to-N | -0.2418 | 0.2944 |
| N-to-E | -0.2863 | -0.4142 |
| N-to-U | 0.4309 | 0.8776 |
| N-to-N | 0.0090 | 0.0020 |

Table 21: Cyclicality of married women's transition rates

## 10.1 Extension: Education Groups

### 10.1.1 Calibration

In the following I only list the parameters which I update or re-estimate based on the education level of each husband and wife pair household type. Tables 22, 23, 24, and 25 list the externally set parameters for each household type. I update the wage gap for each household type since the wage gap determines the importance of each spouse for household income and the stocks of employment and labor force participation for married women. Moreover, I update the level of and shocks to the labor market frictions for married women and men to account for the fact that people with different education levels experience different risks in the labor market.

| Targeted Parameters: High school/High school | | | |
|---|---|---|---|
| Parameter | | Value | Source |
| Wage husband | $w_1$ | 1 | normalized |
| Wage wife | $w_2$ | 0.72 | wage gap CPS 1995-2017 |
| Separation shock MM | $\chi_1$ | 0.0125 | E-to-U transition rate MM |
| Job offer (U) MM | $\lambda_1$ | 0.2829 | U-to-E transition rate MM |
| Job offer (U) MW | $\lambda_2(1)$ | 0.2194 | U-to-E transition rate MW |
| Shock to separation MM | $\varepsilon_{\chi_1}$ | 0.0044 | Std. deviation E-to-U MM |
| Shock to job offer MM | $\varepsilon_{\lambda_1(1)}$ | 0.0853 | Std. deviation U-to-E MM |
| Shock to job offer MW | $\varepsilon_{\lambda_2(1)}$ | | Std. deviation U-to-E MW |

Table 22: High school husband and high school wife: Externally set parameters

| Targeted Parameters: High school/College | | | |
|---|---|---|---|
| Parameter | | Value | Source |
| Wage husband | $w_1$ | 1 | normalized |
| Wage wife | $w_2$ | 1.04 | wage gap CPS 1995-2017 |
| Separation shock MM | $\chi_1$ | 0.0125 | E-to-U transition rate MM |
| Job offer (U) MM | $\lambda_1$ | 0.2829 | U-to-E transition rate MM |
| Job offer (U) MW | $\lambda_2(1)$ | 0.2509 | U-to-E transition rate MW |
| Shock to separation MM | $\varepsilon_{\chi_1}$ | 0.0044 | Std. deviation E-to-U MM |
| Shock to job offer MM | $\varepsilon_{\lambda_1(1)}$ | 0.0853 | Std. deviation U-to-E MM |
| Shock to job offer MW | $\varepsilon_{\lambda_2(1)}$ | 0.0793 | Std. deviation U-to-E MW |

Table 23: High school husband and college wife: Externally set parameters

Tables 26, 27, 28, and 29 display the targets, moments, and values of parameters I re-estimated for each household type. I use the same average asset to income ratio for married couples and the same estimated correlation of job loss as a target for the estimation for all household types.

However, I update both the stock and transition rates targets from the data for each household type since it is crucial to estimate these correctly for each household type.

| Targeted Parameters: College/High school | | | |
|---|---|---|---|
| Parameter | | Value | Source |
| Wage husband | $w_1$ | 1 | normalized |
| Wage wife | $w_2$ | 0.62 | wage gap CPS 1995-2017 |
| Separation shock MM | $\chi_1$ | 0.0053 | E-to-U transition rate MM |
| Job offer (U) MM | $\lambda_1$ | 0.2660 | U-to-E transition rate MM |
| Job offer (U) MW | $\lambda_2(1)$ | 0.2194 | U-to-E transition rate MW |
| Shock to separation MM | $\varepsilon_{\chi_1}$ | 0.0021 | Std. deviation E-to-U MM |
| Shock to job offer MM | $\varepsilon_{\lambda_1(1)}$ | 0.0890 | Std. deviation U-to-E MM |
| Shock to job offer MW | $\varepsilon_{\lambda_2(1)}$ | 0.0793 | Std. deviation U-to-E MW |

Table 24: College husband and high school wife: Externally set parameters

| Targeted Parameters: College/College | | | |
|---|---|---|---|
| Parameter | | Value | Source |
| Wage husband | $w_1$ | 1 | normalized |
| Wage wife | $w_2$ | 0.89 | wage gap CPS 1995-2017 |
| Separation shock MM | $\chi_1$ | 0.0053 | E-to-U transition rate MM |
| Job offer (U) MM | $\lambda_1$ | 0.2660 | U-to-E transition rate MM |
| Job offer (U) MW | $\lambda_2(1)$ | 0.2509 | U-to-E transition rate MW |
| Shock to separation MM | $\varepsilon_{\chi_1}$ | 0.0021 | Std. deviation E-to-U MM |
| Shock to job offer MM | $\varepsilon_{\lambda_1(1)}$ | 0.0890 | Std. deviation U-to-E MM |
| Shock to job offer MW | $\varepsilon_{\lambda_2(1)}$ | 0.0855 | Std. deviation U-to-E MW |

Table 25: College husband and high school wife: Externally set parameters

| Internally calibrated parameters: High school/High School | | | | | | |
|---|---|---|---|---|---|---|
| Description | Parameter | Value | Moment | Target | Model | Source |
| Cost of search | $\bar{\kappa}$ | | Urate MW | 0.0486 | | CPS |
| Search shock | $\varepsilon_\kappa$ | | U-to-N rate MW | 0.1398 | | CPS |
| Disutility of work | $\delta$ | | Emp.-Pop. ratio MW | 0.6045 | | CPS |
| Discount factor | $\beta$ | | Avg. a/y Married | 5.90 | | Kuhn et al. 2013 |
| Separation shock MW | $\chi_2$ | | E-to-U transition rate MW | 0.0097 | | CPS |
| Job offer (N) MW | $\lambda_2(0)$ | | N-to-E transition rate MW | 0.0444 | | CPS |
| Corr. separation shock | $\varphi$ | | Correlation job loss | 0.0289 | | CPS |
| Shock to separation MW | $\varepsilon_{\chi_2}$ | | Std. deviation E-to-U MW | | | CPS |

Table 26: Estimated parameters: High School/High School

| Internally calibrated parameters: High school/College | | | | | | |
|---|---|---|---|---|---|---|
| Description | Parameter | Value | Moment | Target | Model | Source |
| Cost of search | $\bar{\kappa}$ | | Urate MW | 0.0297 | | CPS |
| Search shock | $\varepsilon_\kappa$ | | U-to-N rate MW | 0.1129 | | CPS |
| Disutility of work | $\delta$ | | Emp.-Pop. ratio MW | 0.7070 | | CPS |
| Discount factor | $\beta$ | | Avg. a/y Married | 5.90 | | Kuhn et al. 2013 |
| Separation shock MW | $\chi_2$ | | E-to-U transition rate MW | 0.0056 | | CPS |
| Job offer (N) MW | $\lambda_2(0)$ | | N-to-E transition rate MW | 0.0533 | | CPS |
| Corr. separation shock | $\varphi$ | | Correlation job loss | 0.0289 | | CPS |
| Shock to separation MW | $\varepsilon_{\chi_2}$ | | Std. deviation E-to-U MW | | | CPS |

Table 27: Estimated parameters: High School/College

| Internally calibrated parameters: College/High School | | | | | | |
|---|---|---|---|---|---|---|
| Description | Parameter | Value | Moment | Target | Model | Source |
| Cost of search | $\bar{\kappa}$ | | Urate MW | 0.0486 | | CPS |
| Search shock | $\varepsilon_\kappa$ | | U-to-N rate MW | 0.1398 | | CPS |
| Disutility of work | $\delta$ | | Emp.-Pop. ratio MW | 0.6045 | | CPS |
| Discount factor | $\beta$ | | Avg. a/y Married | 5.90 | | Kuhn et al. 2013 |
| Separation shock MW | $\chi_2$ | | E-to-U transition rate MW | 0.0097 | | CPS |
| Job offer (N) MW | $\lambda_2(0)$ | | N-to-E transition rate MW | 0.0444 | | CPS |
| Corr. separation shock | $\varphi$ | | Correlation job loss | 0.0289 | | CPS |
| Shock to separation MW | $\varepsilon_{\chi_2}$ | | Std. deviation E-to-U MW | | | CPS |

Table 28: Estimated parameters: College/High School

| Internally calibrated parameters: College/College | | | | | | |
|---|---|---|---|---|---|---|
| Description | Parameter | Value | Moment | Target | Model | Source |
| Cost of search | $\bar{\kappa}$ | | Urate MW | 0.0297 | | CPS |
| Search shock | $\varepsilon_\kappa$ | | U-to-N rate MW | 0.1129 | | CPS |
| Disutility of work | $\delta$ | | Emp.-Pop. ratio MW | 0.7070 | | CPS |
| Discount factor | $\beta$ | | Avg. a/y Married | 5.90 | | Kuhn et al. 2013 |
| Separation shock MW | $\chi_2$ | | E-to-U transition rate MW | 0.0056 | | CPS |
| Job offer (N) MW | $\lambda_2(0)$ | | N-to-E transition rate MW | 0.0533 | | CPS |
| Corr. separation shock | $\varphi$ | | Correlation job loss | 0.0289 | | CPS |
| Shock to separation MW | $\varepsilon_{\chi_2}$ | | Std. deviation E-to-U MW | | | CPS |

Table 29: Estimated parameters: College/College

**For Online Publication**

## 11 Data

### 11.1 Description Current Population Survey (CPS)

I use data from the Current Population Survey for the years 1995 until 2017 and I use both the basic monthly files as well as the Annual Social and Economic (ASEC)[20] supplement.

The CPS is the largest household survey in the United States and the primary source of monthly labor force statistics. It contains information about employment, earnings as well as individual and household socio-economic characteristics of about 50,000 to 60,000 households each month representing the non-institutional population of the United States. The ASEC additionally provides annual data of about 75,000 household covering in detail social and economic characteristic, such as work experience, income, and hours per week for worked. The reference time period for the ASEC is the previous calendar year and the information is released every March. The basic CPS files, on the other hand, survey households every month and the reference period is the calendar week which includes the 12th day of the month[21].

A great advantage of the CPS is that it provides information not only about the household head but all household members, in my case it is important that I have detailed information about both the husband, who is the household head in most cases but also about the wife. Since the CPS allows to link spouses residing in the same dwellings unit, I can get intensive information about married couples' characteristics, and spouses' behavior and choices. Furthermore, the monthly availability of data and the possibility of linking households and individuals across months[22] makes the CPS well-suited to study questions at business cycle frequency.

In the following I will only use data covering the years 1995 and 2017. Labor force participation and employment for women grew strongly until the mid-1990s, by choosing 1995 as my start date, I pick a time period, where the growth slowed down and there is no

[20]Before 2003 known as the Annual Demographic File (ADF), also known as the "March" supplement
[21]Except for months with major holidays
[22]See later section on transition rates about more details .

strong trend present for married women in many labor force statistics. I face the trade-off that I abstract from the trend but this time period also only covers two recessions.[23]

Futhermore, I only consider individuals that are between 25 and 55 years old and are not members of the Armed Forces. I choose the age bounds in order to abstract from any effects due to education or retirement. Married couples are defined as legally married couples where both spouses are present live at the same physical address. Since the CPS requires spouses to live at the same physical address and be married to link them, I do not consider couples where the spouse is not present and furthermore, I also cannot consider cohabitating couples. Signle men and women are defined by being "not married", i.e. it includes never married, divorced, and widowed men and women.

### 11.1.1 Linking Households in the CPS and Computing Transition Rates

I will start by briefly reviewing the feature of the CPS that allows for the short panel of individuals and household. The CPS surveys households in a rotation pattern[24], which means households are interviewed for 4 consecutive months, rotated out for 8 months, and then interviewed again for 4 consecutive months. Therefore, not accounting for attrition, about 75 percent of households in a given month can be linked across two consecutive months, and about 50 percent can me linked across three consecutive months.

(i) I start by linking households and individual household members across subsequent months. Since the unique household and personal identifiers in the CPS correspond to the physical location of the household, we can only identify and link individuals who have not moved between the two observation periods. Furthermore, following Madrian and Lefgren (1999), I use type of household, as well as sex and age of household members as indicators to check match quality.[25] Additionally, I use marital status as a measure to rejecting a match, since I am particularly interested in features by sex and marital status. The second issue that arises when linking individuals across months is that it is not possible to link the months May 1995 until September 1995. I will address this again once I describe how I compute

[23]For robustness, I consider an extended time period in the appendix, 1990-2017, such that my time period includes an additional recessions but also a short period of an upward trend in women's participation.

[24]Commonly referred to as the 4-8-4 pattern

[25]Type of household, sex, and age are characteristics that should not change between months if we are still observing the same household/individual.

transition probabilities, but I will linearly interpolate the values for the missing months.

(ii) I use the linked data to compute gross worker flows for each month, i.e. the number of individuals transitioning between different labor market states each month, as illustrated in table 30. The table iilustrates the flows between employment (E), unemployment (U), and not in the labor force (N). Each worker flow $IJ$, for $I = E, U, N$ and $J = E, U, N$ is computed by counting the number of individuals that were in labor state $I$ in the previous month and in labor state $J$ in the current month. The problem that arises with this practice

| | *Current month* | | |
|---|---|---|---|
| *Previous month* | Employed | Unemployed | Not in Labor Force |
| Employed | E-to-E | E-to-U | E-to-N |
| Unemployed | U-to-E | U-to-U | U-to-N |
| Not in Labor Force | N-to-E | N-to-U | N-to-N |

Table 30: Gross worker flows

and which has been addressed by Shimer (2012) and Elsby, Hobijn and Şahin (2015) among others, is that in general it is difficult to distinguish between an unemployed and not-in-the-labor force individual which leads to classification errors and as result we get spurious transitions between unemployment (U) and not-in-the-labor force (N).[26] In general, there are two different approaches of addressing this issue, the first one is the Abowd and Zellner (1985) correction and the second one is a method known as deNUNification. I will follow the deNUNification method as described in Elsby, Hobijn and Şahin (2015). The Abowd and Zellner (1985) correction method relies on re-interviews of CPS survey participants which have last been conducted in the mid-1990s. Thus, this method relies implicitly on the assumption that the classification error is both time invariant and has not changed over time. Due to these shortcomings I will use deNUNification instead. Elsby, Hobijn and Şahin (2015) check for comparison and robustness of the two different methods and show that there are slight differences in levels but the cyclical properties of the different worker flows remain unaffected.

The main idea of the deNUNification method is to identify misclassification by frequent reversals between unemployment (U) and not in the labor force (N). Therefore, if an indi-

[26] See for example Abowd and Zellner (1985), Poterba and Summers (1986), and Elsby, Hobijn and Şahin (2015) for a more detailed discussion.

vidual's transitions between three consecutive months is NUN or UNU, these are classified as frequent reversals and recoded to NNN and UUU, respectively. Therefore, I apply this method and deNUNify my data to compute gross worker flows and transition rates based on the deNUNified data.

(iii) I use the deNUNified data and gross worker flows to compute transition probabilities between employment, unemployment as the number of individuals with labor force status $I$ in the previous month and labor force status $J$ in the current month relative to all individuals with labor force status $I$ in the previous month.

(iv) Lastly, since my matched data displays high seasonality, I use the X-13ARIMA-SEATS seasonal adjustment program from the Census Bureau to seasonally-adjust the transition rates for married women, married men, single men, and single women.

(v) Due to the monthly frequency of the data, the transition rates display a high level of noise, in order to reduce some of the noise, I apply a 12-month moving average to the transition rates in the following (See the appendix for the raw transition rates).