Spousal Insurance and the Amplification of Business Cycles

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Abstract

I document that spousal labor supply substantially mitigates the impact of cyclical labor income risk on married households. Motivated by this evidence, I present a macroeconomic model with incomplete markets in which households are heterogeneous by gender and marital status. Couples can smooth their consumption over the business cycle better than singles because (i) spouses rarely lose their jobs at the same time; and (ii) secondary earners can increase their labor supply on the extensive margin in response to a job loss of the primary earner. According to my estimated model, joint decision-making by married men and women mitigate the volatility of aggregate consumption by about 40%. Spousal insurance acts as a powerful automatic stabilizer because it weakens the general-equilibrium feedback between unemployment risk and economic activity.

1 Introduction

Households face large income uncertainty that varies systematically with the business cycle. This idiosyncratic risk is not fully insurable. Blundell, Pistaferri and Saporta-Eksten (2016) highlight three channels of partial insurance: (i) progressive taxes and transfers; (ii) accumulating assets; and (iii) risk sharing within the family. According to their estimates, the family channel is by far the most important form of insurance. In terms of consumption smoothing, it contributes more than the other two channels combined. Yet, macroeconomists have focused their efforts on the first two channels[1], whereas the business cycle implications of intra-family insurance have remained largely unexplored.

In this paper, I argue that spousal insurance acts as an automatic stabilizer that dampens aggregate fluctuations. Recessions are amplified by countercyclical unemployment risk that encour-

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[1]Examples for (i) include Oh and Reis (2012) and McKay and Reis (2016) who study the roles of targeted transfers and automatic fiscal stabilizers. Examples for (ii) include Bayer, Lütticke, Pham-Dao and Tjaden (2019) and Kaplan, Moll and Violante (2018) who focus on precautionary savings in liquid and illiquid assets.

ages precautionary saving and depresses aggregate demand.[2] Spousal insurance dampens the propagation of unemployment risk in two ways. First, idiosyncratic risk is diversified within the family, which makes goods demand less responsive to unemployment. Second, secondary earners respond to the heightened risk of job loss to primary earners by increasing their labor supply. This precautionary labor supply—in sharp contrast to precautionary saving—reduces the cyclical volatility of unemployment and output. This implies that single household also benefit from spousal insurance in general equilibrium.

First, I discuss the empirical evidence. Pruitt and Turner (2020) provide direct evidence of spousal insurance from the joint tax returns of married couples. The administrative data show that household income is less volatile than individual income, and is less likely to fall by large amounts in recessions. They also confirm the observation that married women have less procyclical earnings than married men (Doepke and Tertilt 2016).

Using data from the Current Population Survey (CPS), I argue that differential patterns in the extensive margin of male and female employment can account for these facts. Three key features emerge from my empirical analysis. First, the probability of joint job loss by spouses is very low. Second, the probability of job loss is about twice as countercyclical for married men than married women. Third, labor force participation is procyclical for married men but mildly countercyclical for married women.

Second, I build a dynamic stochastic general equilibrium (DSGE) model that is consistent with these facts and use it to characterize their implications for aggregate business cycles. The model has two key features. First, unemployment is determined in equilibrium in the presence of search frictions. Second, the extensive margin of spousal labor supply is a source of insurance against unemployment. In its other aspects, it is a standard incomplete markets model in the tradition of Krusell and Smith (1998).

The model economy is populated by three types of households: single men, single women, and married couples. I abstract from the dynamics of marriage and divorce and model these types as permanent. People of a particular type are ex-ante identical and face uninsurable labor income risk from two sources, idiosyncratic productivity shocks and job losses.

In each period, some jobs disappear exogenously. Workers who do not have a job decide whether to engage in costly job search or leave the labor force. Some workers who search do not receive an offer and are unemployed. Depending on their history, these people may or may not be eligible for unemployment benefits. People who leave the labor force continue to receive job offers, but at a lower rate than unemployed people.

Spousal insurance operates in the model via both a passive and an active channel. The passive channel reflects income pooling between employed spouses. The strength of this channel depends on the correlation of separation shocks between spouses. The active channel arises from family labor supply decisions on the extensive margin.

[2] See Ravn and Sterk (2017) and Challe, Matheron, Ragot and Rubio-Ramirez (2017) for recent expositions of this argument that goes back to Keynes (1936).

According to the model, married households make joint labor supply choices that dampen the cyclical volatility of their labor income. The key here is that the labor force participation rate of secondary earners is countercyclical. In contrast, the labor force participation rate of single people is procyclical. These model-based outcomes are consistent with the evidence.

The intuition is the following. Secondary earners always have an incentive to enter the labor force when the primary earner is without a job. In a recession, more primary earners lose their jobs and are likely to be unemployed for a longer time. As a result, non-employed secondary earners are more likely to enter the labor force during a recession. In contrast, non-employed singles are more likely to leave the labor force during a recession. The reason is that the job-finding probability is low. If they have enough savings, it is optimal for them to leave the labor force and re-enter when they receive an offer or when job-finding rates are back to normal.

Third, I use the quantitative model to isolate the role of spousal insurance in the propagation of aggregate shocks. I do so by considering a counterfactual economy in which married people do not provide insurance to each other. I subject both economies to the same aggregate demand shocks[3] and compare the aggregate fluctuations they generate.

Spousal insurance implies less procyclical demand for goods and less procyclical supply of labor. The net result is a 42% decrease in the cyclical volatility of output. This effect is large for two reasons. First, married households account for a large share of aggregate consumption and labor supply. Second, there is a multiplier-like effect because unemployment risk is a function of output in the model. This is the reason why spousal insurance affects singles as well in general equilibrium.

The strength of the dampening effect depends critically on the cyclical volatility of job loss and job-finding rates. I estimate these to match the cyclical worker flows between labor market states using an exactly-identified Simulated Method of Moments (SMM). This is a challenging problem, because it requires simulating aggregate fluctuations in a complex heterogeneous-agent DSGE model. I develop a novel and efficient way of implementing SMM estimation in this setting. The key idea is that impulse response functions are sufficient to construct business cycle moments without the need for costly simulation of artificial data.

Fourth, I use the model to carry out counterfactual experiments that reveal how the strength of spousal insurance can vary across time and space. First, the marriage rate among the working-age population determines the availability of spousal insurance. The decline in marriage observed in the United States since the 1960s, all else equal, has increased aggregate volatility. Second, the gender wage gap and the level of female labor force participation affect married women's ability to provide spousal insurance. In my model, a rise in the labor force participation of married women has opposing effects on passive and active insurance. As a result, I find that aggregate volatility is not sensitive to female labor force participation.

Finally, I analyze the effectiveness of spousal insurance during the ongoing COVID-19 reces-

[3] I model these as shocks to the discount factor of households. Hall (2017) uses the same strategy to generate business cycles in a real model with labor search frictions.

sion. In most recessions, fewer women lose their jobs than men. By contrast, as Alon, Doepke, Olmstead-Rumsey and Tertilt (2020a) show, in the COVID-19 recession more women lost their jobs than men. This unusual pattern also holds for married men and women. Moreover, the probability of both earners losing their jobs has been also unusually high during this recession. According to my model, this aspect of the COVID-19 shock rendered spousal insurance less effective than usual.

More generally, the example of the COVID-19 recession shows that the nature, and not just the size, of an economic shock matters for its impact on households. Aggregate shocks that originate in sectors with a high employment share of just one gender (such as construction) are better insured than shocks that affect women and men equally and are more likely to affect two spouses at the same time.

Literature. This paper relates and contributes to a diverse body of research on idiosyncratic income risk and its ramifications for households and the macroeconomy.

Improved computational power and access to administrative earnings data have facilitated the discovery of new facts about income inequality and risk (Guvenen, Karahan, Ozkan and Song 2015). The model I develop accommodates two recent findings and enables me to study their implications. First, Hoffmann and Malacrino (2019) document that large income shocks are associated with non-employment spells, which therefore drive the procyclical skewness of income growth first described by Guvenen, Ozkan and Song (2014). Second, Pruitt and Turner (2020) show that the joint income of married couples displays significantly less procyclical skewness than individual income, which points to the importance of family labor supply in mitigating cyclical income risk.[4]

Another line of research studies the various ways in which households insure themselves against income shocks (Blundell, Pistaferri and Preston 2008, Guler, Guvenen and Violante 2012, Ortigueira and Siassi 2013, Heathcote, Storesletten and Violante 2014). Blundell et al. (2016) develop a structural econometric framework in which family labor supply, assets, and the tax system all have a role in accommodating income shocks. According to their estimates, family labor supply contributes more to consumption smoothing than the other two channels combined. My work is motivated by these household-level analyses. It complements them by arguing that family labor supply shapes aggregate business cycles, too.

The focus on aggregate consequences of spousal insurance is shared by a few recent papers. The most closely related is Mankart and Oikonomou (2017), who argue that countercyclical labor supply of secondary earners can explain the acyclicality of the aggregate labor force participation rate. At the household level, I model spousal insurance similarly. The crucial difference is that, in my model, search frictions are determined endogenously, which creates a feedback be-

[4]Busch, Domeij, Guvenen and Madera (2020) report that "within-household smoothing does not seem effective at mitigating skewness fluctuations". My conjecture is that they reach this conclusion because they exclude individuals with earnings below a minimum threshold. This selection criterion removes long unemployment spells and some movements on the participation margin. Pruitt and Turner (2020) keep individuals with zero earnings. My own analysis of the CPS data suggests that countercyclical labor force participation of secondary earners is an important channel of spousal insurance.

tween spousal insurance and unemployment risk. Moreover, I account for the profound gender differences in unemployment risk, rather than modeling individuals as ex-ante identical. Also emphasizing gender differences in labor market dynamics is Ellieroth (2019). She presents a partial equilibrium model with precautionary labor supply to rationalize married women's countercyclical labor market flows. Last but not least, Birinci (2019) studies how alternative government transfers interact with spousal insurance over the business cycle.

In its objective and methodology, my paper belongs to the rapidly growing literature that studies how microeconomic heterogeneity affects the transmission of macroeconomic shocks (McKay and Reis 2016, Guerrieri and Lorenzoni 2017, Kaplan et al. 2018, Bayer et al. 2019, Auclert, Rognlie and Straub 2018, De Ferra, Mitman and Romei 2020). This "HANK" literature is almost unified in its focus on income and wealth inequality between households.[5] My results demonstrate that gender and marital status are key dimensions of household heterogeneity because they correlate with exposure to cyclical income risk. By modeling spousal insurance explicitly, I also take a step toward endogenizing the dynamics of income inequality.[6] In terms of methodology, I extend a state-of-the-art solution method (Auclert, Bardóczy, Rognlie and Straub 2019) to the case of discrete-continuous choices, and work out a tractable way of estimating HANK models via Simulated Method of Moments. I hope these tools will be useful for other researchers in the field.

A key element of spousal insurance in my model is that secondary earners are more likely to enter the labor force when the primary earner loses their job. In labor economics, this is called the "added worker effect", following the seminal work of Lundberg (1985). Mankart and Oikonomou (2016, 2017) document that the added worker effect has increased over time in the United States, and has been about 8% in the last two decades.[7] Although the magnitude may seem low at first sight (Gorbachev 2016, Ellieroth 2019), it is quite powerful through the lens of a dynamic model in which households are heterogeneous with respect to wealth. In my calibrated model, the added worker effect is just 5%, but entrants are selected from poor households who need extra income the most. Moreover, there is excess entry for months after the primary earner's job loss, from households that run down their savings.

My work contributes to the literature on how long-term changes in women's employment affect business cycle fluctuations (Doepke and Tertilt 2016, Fukui, Nakamura and Steinsson 2018). Albanesi (2019) estimates that women's rising share of aggregate hours and countercyclical labor supply played a crucial role in jobless recoveries, the productivity slowdown and the Great

[5]A notable exception is Patterson (2018), who argues that business cycles are amplified by their unequal incidence with respect to demographic characteristics (gender, race, and age). She does not consider marital status or spousal labor supply.

[6]Although the distribution of income shocks plays a central role in this class of models, it is typically let to be determined by an exogenous Markov chain. Models with search and matching frictions (Gornemann, Kuester and Nakajima 2016, Den Haan, Rendahl and Riegler 2017, Kekre 2019, Graves 2019) depart from this benchmark by endogenizing some aspect of unemployment (typically the job-finding rate). The richest model in this vein is Alves (2019)'s, which features on-the-job search and wage setting by firms who Bertrand compete for workers. State-dependent unemployment risk is a key feature of my model as well, where it is a main driver of spousal labor supply.

[7]A married woman whose husband loses his job in month t is 8 percentage points more likely to enter the labor force in month t than a woman whose husband remained employed.

Moderation. My model accounts for the lower cyclicality of women's employment, partly as a result of an spousal insurance channel. It shows that higher female labor force participation does not necessarily reduce aggregate volatility, because it has opposing effects on passive and active insurance.

Finally, my paper makes contact with the literature on the macroeconomic consequences of the COVID-19 pandemic. I document that the epidemic led to job losses that were three times more highly correlated among spouses than usual. Together with the fact that women's employment was hit especially hard, this implies that spousal insurance was weaker than in regular recessions. Here, my results complement Alon, Doepke, Olmstead-Rumsey and Tertilt (2020b), who emphasize that family labor supply was disrupted by the dramatic increase in childcare needs due to the widespread closure of schools and daycares.

2 Empirical Evidence

In this section, I present empirical evidence to show that spousal labor supply mitigates the labor income risk faced by married individuals. First, I review the latest evidence from administrative data on tax returns (Pruitt and Turner 2020). This data shows that (i) household income is less volatile than individual income; (ii) household income is less likely to fall by large amounts in recessions than individual income; (iii) married women have much less procyclical earnings than married men. Second, I use monthly worker flows to show that the extensive margin of employment can account for these facts. Specifically, I find that (a) women are systematically less likely to lose their job in typical downturns than men; (b) joint job loss by dual-earner couples is very rare; and (c) married women are less likely to leave the labor force during recessions. Collectively, these findings suggest that spousal insurance is effective against cyclical unemployment risk.

2.1 Earnings data

The best direct evidence for spousal insurance of labor income risk comes from the joint tax returns of married couples. My analysis is based on the aggregated dataset made available by Pruitt and Turner (2020).

Let y_{it} denote the gross labor earnings of individual i in year t, expressed in 2014 dollars. The variable I focus on is annual labor income growth, which is commonly used as an indicator of transitory labor income risk. This is computed as $x_{it} \equiv \log y_{it} - \log y_{it-1}$, where \$0 earnings are replaced with \$1. This measure is ideal for my purposes as it keeps individuals with occasionally zero earnings in the sample without leading to infinite growth rates. As we will see, movements on the extensive margin are important for both income risk and spousal insurance.

The two rows of figure 1 show two moments of income growth x_{it}: its standard deviation and

Kelley skewness[8]. The first two columns show these moments for the earnings of married men and women separately. The third column shows the moments for household income, which is simply the sum of the spouses' earnings. Each figure plots a given moment against the position of the household in the income distribution based on its average earnings in the full sample of 2000–2014. Finally, I report the statistics separately for recession years (2001–2002, 2008–2010) and expansion years (2003–2007, 2011–2014).

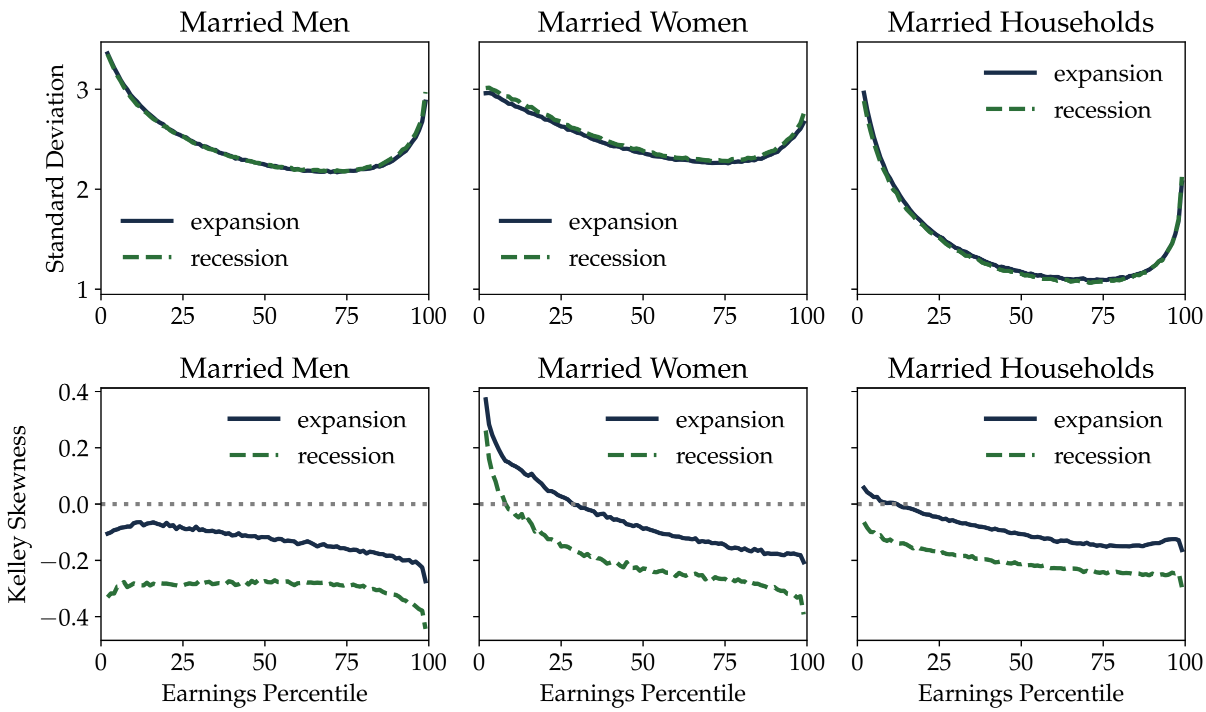

Figure 1: Distribution of One-Year Labor Income Growth for Individuals and Households

By comparing the graphs in the first line, we see that individuals face much more dispersion in their income growth than households. The standard deviation of a household's income growth is lower than that of its individual members across the income distribution, though the difference is largest for middle-income households. Furthermore, the standard deviation of income growth is remarkably acyclical.

This does not mean, however, that income risk itself is acyclical. Turning to skewness in the second line, we see that it is lower in recessions. To put it simply, during recessions, large income losses become more likely and large gains become less likely. That is, cyclical income risk materializes in the probability of large shocks. This echoes the findings of Guvenen et al. (2014), who

[8] Let p_n denote the n^{th} percentile of a random variable. Kelley skewness is defined as

$$\frac{(p_{90} - p_{50}) - (p_{50} - p_{10})}{p_{90} - p_{10}}.$$

This measure takes values in $[-1, 1]$ and is less sensitive to potential outliers than the fourth moment.

focused on men above a certain income threshold.

However, men and women are not affected equally in typical recessions. Skewness of men's income growth is more negative and falls more in recessions than women's. In low-income households, women's income growth actually displays positive skewness. These observations suggest that women are either less exposed to large income losses than men or make less procyclical labor supply choices. In the next section, I verify that both of these channels are in play by analyzing monthly worker flows in the Current Population Survey (CPS).[9]

2.2 Worker flows

Tax data paint an accurate picture of household income, but they do have some limitations. Most importantly, they provide little guidance to distinguish income shocks from labor supply choices. This is partly because the annual frequency of tax data is low relative to the frequency of income shocks and households' ability to respond to them. Take the example of job loss. In the United States, many employees can be dismissed at will or at most with one month's notice. In turn, the average unemployed person who is actively searching for a job can expect to find one in less than three months. Annual income is thus impacted by a series of shocks and labor supply choices.

To address this challenge, I turn to the Current Population Survey (CPS). The CPS is a monthly labor force survey of about 60,000 households that is designed to be representative at the national level. Households are in the survey for 4 consecutive months, which allows me to construct monthly transition probabilities between employment (E), unemployment (U), and non-participation (N) disaggregated by gender and marital status. These worker flows provide additional insights into the incidence of cyclical income risk and the ways in which spousal insurance works. As such, they are also valuable to discipline the quantitative model I develop in section 3.

Figure 2 shows all six transition probabilities for 1976–2019, the longest span for which CPS micro data are publicly available. One of the the most prominent features of these time series is the decline in the EN transitions by married women that lasted until the mid 1990s. Since my primary interest is business cycle fluctuations, I choose the 1995–2019 period as my baseline sample. By this time female labor force participation has plateaued. Although most of my observations apply to the entire sample, separating recent cycles from long-term trends makes the exercise cleaner.

Next, I condense the information in the time series of worker flows into just two numbers: their long-run average and cyclicality. Motivated by Doepke and Tertilt (2016), I measure the latter as the unconditional elasticity with respect to detrended GDP. To be precise, I report β from the linear regression $\log p_t = \alpha + \beta \log Y_t + u_t$ where p_t is a quarterly average of a monthly transition rate, and Y_t is quarterly real GDP HP-filtered with a smoothing parameter of 1600.

[9] Hoffmann and Malacrino (2019) provide a strong reason for tracing these patterns to the extensive margin of employment. Using Italian social security data, they find that non-employment spells drive the fat tails of the earnings growth distribution for prime-age men, including essentially all of its procyclical skewness. I found the same for both men and women in the German employment history data (SIAB).

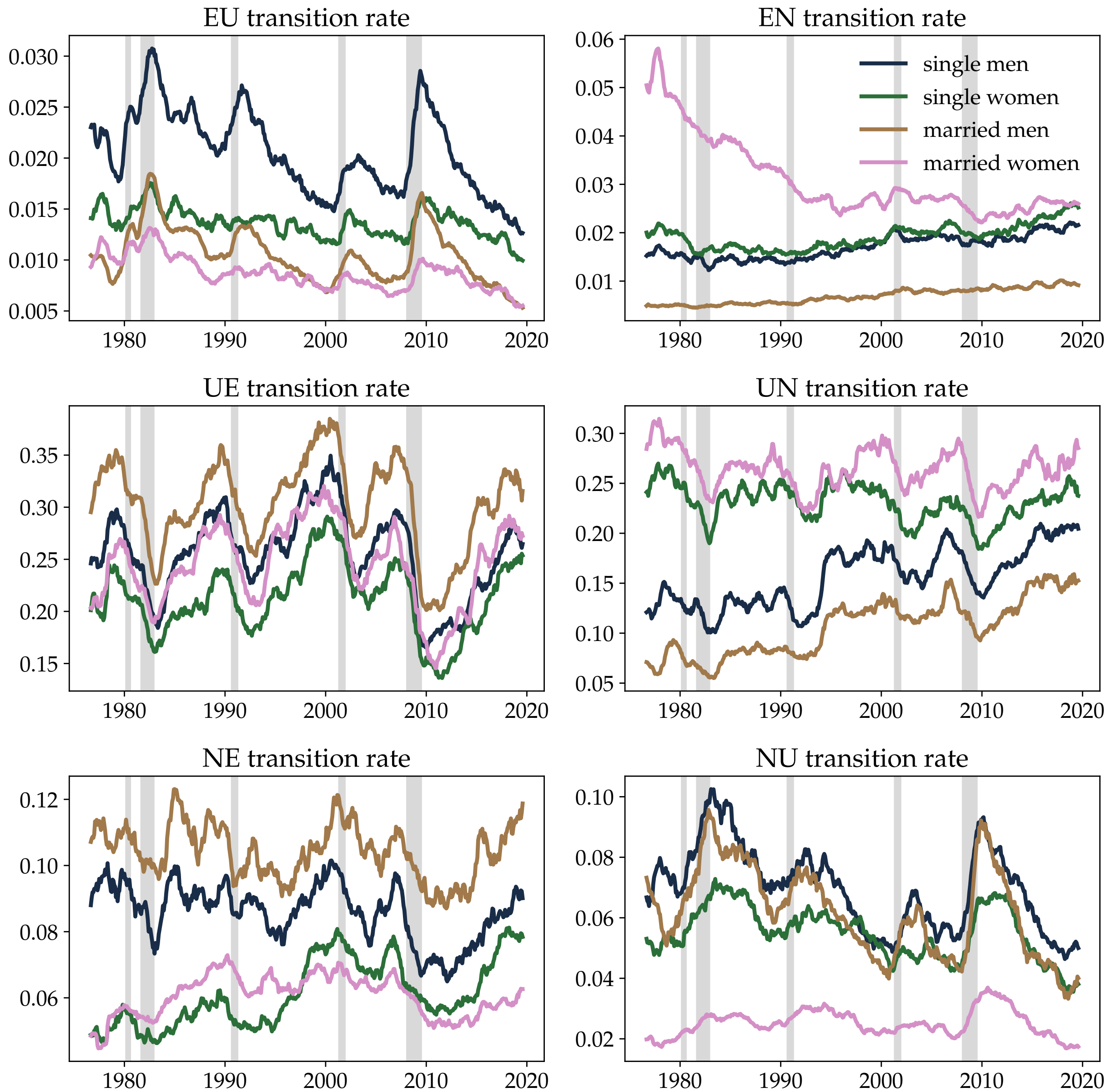

Figure 2: Worker flows by gender and marital status

Source: CPS monthly files. Sample is restricted to civilian population aged 25-54. Plotting 12-month centered moving averages of monthly transition probabilities.

Table 1: Outflows from Employment by Gender and Marital Status

		single men	single women	married men	married women
Average	EU	1.82%	1.29%	0.92%	0.77%
	EN	1.89%	2.06%	0.81%	2.59%
Cyclical	EU	-10.12***	-5.68***	-13.60***	-7.87***
		(1.53)	(0.87)	(1.92)	(0.99)
	EN	0.90	1.28	-0.61	2.40**
		(0.69)	(0.84)	(0.89)	(0.74)

Source: Current Population Survey, monthly files for 1995–2019.
Sample: Civilian population aged 25–54.
Average: average of monthly transition rates.
Cyclical: elasticity to real GDP. HAC standard errors in parentheses. ***: p-value < 0.01, **: p-value < 0.05.

Table 1 shows information on the outflows from employment: EU and EN. The upper panel shows the average transition probabilities between 1995 and 2019. First, the magnitude of EU and EN flows are similar, which shows that they are both relevant. Second, the differences between the four groups are large: the average EU rate is more than twice as large for single men than for married women; and the average EN rate of married women is more than three times as large as that of married men.

The bottom panel of Table 1 shows that the EU rate is strongly countercyclical for all groups, with an almost twofold difference between men and women.[10] In contrast, the EN rate is acyclical for singles and married men, and mildly procyclical for married women. This reflects a fundamental difference between the two outflows of employment. EU flows are mostly involuntary: resulting from layoffs, firings, and expiration of temporary contracts. Such events become more common in recessions. EN flows reflect a mix of choices (to not search actively) and acyclical shocks (e.g. to health). Notably, the estimated EN elasticity is highest and significant for married women. This indicates that delaying quitting in bad times is an active insurance channel that spouses provide.

Correlation of job loss within the family. If married women lost their job every time their husbands did, spousal insurance would be quite weak. Empirically, this is not the case. In the monthly CPS, I find that the correlation of EU transitions among dual-earner couples is just 0.042. Such a low value is consistent with the family economics literature. For example, exploiting the longer panel in the Survey of Income and Program Participation (SIPP), Shore and Sinai (2010) report that that the probability that a married couple has overlapping unemployment spells in a year is 1.4% on average.[11] This shows that dual-earner couples who pool their income enjoy passive insurance against job loss simply because these shocks are largely uncorrelated within the

[10] Albanesi and Şahin (2018) estimate that gender difference in industry composition accounts for most of the difference in payroll employment changes during recessions.

[11] See their table 3, column (4). They emphasize that the probability of joint unemployment is larger for couples who have the same occupation, but such couples are only 3% of their sample.

family.

Table 2: Inflows to Employment by Gender and Marital Status

		single men	single women	married men	married women
Average	UE	25%	22%	30%	25%
	NE	8%	7%	10%	6%
Cyclical	UE	10.71***	8.72***	10.36***	8.40***
		(1.32)	(1.55)	(1.17)	(1.55)
	NE	4.74***	3.74***	2.78**	2.30*
		(1.06)	(1.00)	(0.91)	(0.75)

Source: Current Population Survey, monthly files for 1995–2019.
Sample: Civilian population aged 25–54.
Average: average of monthly transition rates.
Cyclical: elasticity to real GDP. HAC standard errors in parentheses. ***: p-value < 0.01, **: p-value < 0.05.

Table 2 shows an analogous summary of employment inflows: UE and NE. The upper panel shows two well-known facts about US labor markets. First, monthly UE flows are high, which translates into short unemployment durations. Second, NE rates are far from negligible. Given that there are many more non-participants than unemployed, the number of people who transition into employment from out of the labor force is actually higher than the number who transition from unemployment. This observation reinforces the importance of the participation margin for the determination of household income.

Turning to cyclicality, we see that UE flows are strongly procyclical for all groups, and more similar than EU flows. Men have somewhat more procyclical job-finding rates than women, but the difference is not too large. NE rates are also procyclical, albeit to a much lesser degree. This makes sense. NE transitions require finding a job, which is harder in recessions. However, a large share of non-participants don't want a job, which mitigates the effect of the underlying job-finding rate to NE flows. In terms of spousal insurance, notice that married non-participants have significantly less procyclical NE rates, which is consistent with an added worker effect subject to countercyclical job-finding frictions (Lundberg 1985).

Table 3: Flows on the Participation Margin

		single men	single women	married men	married women
Average	UN	18%	23%	13%	26%
	NU	6%	5%	5%	2%
Cyclical	UN	5.91***	4.09***	6.64***	5.43***
		(1.00)	(0.81)	(1.22)	(0.64)
	NU	-10.06***	-6.55***	-13.98***	-8.73***
		(1.34)	(1.23)	(1.47)	(1.23)

Source: Current Population Survey, monthly files for 1995–2019.
Sample: Civilian population aged 25–54.
Average: average of monthly transition rates.
Cyclical: elasticity to real GDP. HAC standard errors in parentheses. ***: p-value < 0.01, **: p-value < 0.05.

Finally, table 3 shows the flows between unemployment and non-participation. Note that these flows are somewhat less reliable than the flows on the employment margin, because the CPS is prone to classification error between U and N (Abowd and Zellner 1985). With this caveat in mind, the UN flows are procyclical across the board, though slightly more so for the married than singles. Elsby, Hobijn and Şahin (2015) attribute this to a composition effect. In recessions, a large number of workers who lose their jobs have high attachment to the labor market and thus are less likely to leave the labor force.

NU flows in turn are countercyclical and significantly more so for married people. Again, this difference is consistent with the added worker effect: non-working spouses enter in bad times when the primary earner faces more risk. The conventional wisdom is that the added worker effect should be stronger for women, who are more likely to be secondary earners. This is not what we see in aggregate NU flows: they are more cyclical for married men than women and substantial for singles as well. This is sometimes interpreted as evidence that the added worker effect is weak (Elsby et al. 2015). This is certainly true in the sense that the added worker effect cannot be the dominant driver of aggregate NU flows. However, it does not mean that the added worker effect is weak at the household level. In the aggregate, it may be masked by the fact that, among non-participants, the average married woman is less attached to the labor force than the average married man. In section 4, I show that my calibrated model is consistent with the added worker effect at the household level, estimated by Mankart and Oikonomou (2017).

Takeaway. In recessions, job loss becomes more common and new jobs become harder to find which leads to longer unemployment durations. Countercyclical unemployment accounts for the procyclical skewness of annual earnings growth. Exposure to cyclical unemployment risk is not uniform: men are more exposed than women, and single people are more exposed than married people. Flows on the participation margin, which are more likely to reflect labor supply choices than shocks, are consistent with spousal insurance provision.

3 A business cycle model with spousal insurance

In this section, I introduce a macroeconomic model with spousal insurance. The model builds the 3-state search models of Krusell, Mukoyama, Rogerson and Şahin (2017) and Mankart and Oikonomou (2017). Its key features are the following. First, financial markets are incomplete and individuals are exposed to idiosyncratic risk. Second, idiosyncratic risk includes unemployment, which is determined in equilibrium and varies by gender and marital status. Third, married couples pool their income and wealth and maximize joint utility.

The economy consists of a household sector, a firm sector and public sector. Households consume, supply labor to firms, and save in government bonds. There is a representative final good producer who uses labor to produce a homogeneous final good. The fiscal authority collects labor income tax and issues one-period real bonds to finance its expenditures on the final good, lump-sum transfers and unemployment benefits. Time is discrete and one period corresponds to a month.

3.1 Households

There is a unit mass of infinitely-lived households of three types: single men, single women, and married couples. Married households are made up of two individuals, who maximize their joint utility. For simplicity, I assume that gender and marital status are permanent types. Motivated by the evidence in section 2, the most important difference between the four types of individuals is the labor income risk they face.

Households have time-separable preferences over consumption and leisure. In every period, households choose consumption c, assets a, and labor market status s that can take four values for each member of the household: full-time employment (E), unemployment with benefits (U_b), unemployment without benefits (U_{nb}), and non-participation (N). I distinguish two types of unemployment in order to capture the public transfer channel of consumption insurance.

Labor supply choice is constrained by type-dependent search frictions. Non-employed agents have to meet a firm to be able to work. Unemployed agents have job-finding probability f_t that is higher than the job-finding probability of non-participant agents f_t^*. Employed agents experience involuntary separation with probability s_t. Newly separated workers are eligible for unemployment benefits which expire every period with probability ξ.[12] Workers who quit are not eligible to collect benefits. Non-employed agents whose benefits have expired have to cycle through a new employment spell to qualify again.

These search frictions call for a state variable that determines the set of feasible labor supply choices. There are three relevant states: matched with a firm (M), UI eligible (B), and neither (L). Matched workers can choose $s \in \{E, U_{nb}, N\}$, UI eligible workers may choose $s \in \{U_b, U_{nb}, N\}$, and ineligible workers may choose $s \in \{U_{nb}, N\}$. Let $x \in \{M, B, L\}$ denote this state and $\Gamma(x)$ the feasible set associated with x.

[12] This is a parsimonious way to capture the limited duration of unemployment benefits.

The remaining state variables are standard. Assets that are subject to a tight borrowing constraint $a \geq \underline{a}$. And idiosyncratic labor productivity z that follows a finite-state Markov chain. These are necessary to generate sufficient inequality in income, wealth, and realistically high marginal propensities to consume (i.e. exposure to income shocks).

The decision problem of singles. For single men and women, the Bellman equation may be written as

$$\begin{aligned} \mathcal{V}_t(x, z, a_-) = \max_{c,a,s} & \left\{ u(s, c) + \beta \mathbb{E}_t \left[\mathcal{V}_{t+1}(x', z', a) \right] \right\} \\ \text{s.t. } & c + a = y_t(s, z) + (1 + r_t)a_- \\ & s \in \Gamma(x) \\ & a \geq \underline{a} \end{aligned} \tag{1}$$

where $u(s, c)$ denotes flow utility, and $y_t(s, z)$ denotes non-financial income. I assume that flow utility is additively separable in consumption and leisure (or home production)

$$u(s, c) = \begin{cases} \log(c) - \varphi & \text{for } s = E \\ \log(c) - \chi & \text{for } s = U_b, U_{nb} \\ \log(c) & \text{for } s = N \end{cases} \tag{2}$$

where $\varphi > \chi > 0$ are the utility costs of formal employment and active job search, respectively. Non-financial income depends on the real wage per efficiency units w_t, the labor tax τ_t, lump-sum transfers T_t, and a UI benefit schedule parameterized by a constant replacement rate b and a cap $\bar{b}$.

$$y_t(s, z) = \begin{cases} (1 - \tau_t) w_t z + T_t & \text{for } s = E \\ (1 - \tau_t) w_t \min\{bz, \bar{b}\} + T_t & \text{for } s = U_b \\ T_t & \text{for } s = U_{nb}, N \end{cases} \tag{3}$$

The decision problem of couples. By assumption, couples pool their income and assets to maximize their joint utility. The flow utility of married men and women are analogous to those of singles given by (2) and (3). Therefore, their decision problem is analogous to (1), just with a larger state space to account for all combinations of individual labor market outcomes.

To be specific, at the household level, employment shock can take 9 values $x \in \{M, B, L\}^2$ and labor market status can take 16 values $s \in \{E, U_b, U_{nb}, N\}^2$. Since flow utility is concave in consumption, couples always choose the same consumption for both spouses.

3.2 Firms

My priority is to capture the observed magnitude of cyclical unemployment risk. This requires endogenizing separation rates (frequency of unemployment spells) as well as job-finding rates (duration of unemployment spells). As we saw in section 2.2, both margins are strongly cyclical and heterogeneous by gender and marital status. Therefore, I opt for a simple and flexible setup that allows me to specify these moments almost directly.

Final good firm. The final good market is competitive. A representative firm produces a homogeneous final good using a linear technology

$$Y_t = \Theta_t L_t. \tag{4}$$

The firm hires workers subject to search frictions, which it takes as given. The identity of the workers is irrelevant for the firm, who pays each worker their marginal product ($w_t = \Theta_t$, so essentially exogenous) and makes zero profits.

Search frictions. Let hatted variables denote log deviations from steady state. The job-finding and involuntary separation probabilities $\{f_t, f_t^*, s_t\}$ are specified directly as a function of contemporaneous output fluctuations with type-specific elasticities $\epsilon(\bullet)$:

$$\hat{f}_t = \epsilon(f) \cdot \hat{Y}_t, \qquad \hat{f}_t^* = \epsilon(f^*) \cdot \hat{Y}_t, \qquad \hat{s}_t = \epsilon(s) \cdot \hat{Y}_t. \tag{5}$$

Although I offer no microfoundation for these equations, it is worth noting that any specification that generates the same, empirically realistic, transition probabilities would have the same distributional effect on households and prompt equivalent precautionary responses.[13]

3.3 Government

The fiscal authority issues one-period bonds B_t and levies a proportional labor tax τ_t on employed workers to finance its expenditures. These include lump-sum transfers T_t, unemployment benefits, and public consumption of the final good G_t. The government budget is thus given by

$$\tau_t w_t \int_E z_{it} \, \mathrm{d}i + B_t = (1 + r_t) B_t + G_t + T_t(1 + \omega_{mc}) + \underbrace{(1 - \tau_t) w_t \int_{U_b} \min\{b z_{it}, \bar{b}\} \, \mathrm{d}i}_{\text{total UI claims}}, \tag{6}$$

where ω_{mc} is the share of married couples. There is a unit mass of households, but every couple has two members and hence the total measure of individuals is $1 + \omega_{mc}$.

I treat G_t and T_t as exogenous, and assume that the government adjusts the proportional tax τ_t according to the rule

$$\tau_t - \tau_{ss} = \phi \frac{B_{t-1} - B_{ss}}{Y_{ss}}. \tag{7}$$

That is, taxes are increased whenever debt is above its steady state level, and the parameter $\phi > 0$ determines the speed of fiscal adjustment. Assuming smooth fiscal policy is useful in non-Ricardian models such as this to avoid the unreasonably large income effects that would result from balancing the budget period by period.

[13] Standard microfoundations of the Diamond-Mortensen-Pissarides literature such as vacancy posting with free entry are feasible to implement conceptually as well as computationally. However, they tend to fall short of generating sufficient volatility quantitatively.

3.4 Market clearing

Labor, asset, and goods market clearing are given by

$$L_t = \int_E z_{it}\,\mathrm{d}i, \tag{8}$$

$$B_t = \int a_{it}\,\mathrm{d}i, \tag{9}$$

$$Y_t = C_t + G_t. \tag{10}$$

Note that my choice of government debt instead of capital as the source of liquidity in the economy is deliberate. Consider what would happen if the only asset that households could save in was productive capital. Precautionary saving in the presence of unemployment risk would lead to countercyclical investment that stabilizes business cycles. I think this would be highly unrealistic.

3.5 Numerical solution

As with any heterogeneous agents model, equilibrium depends on the time-varying, high-dimensional distribution of households over their state variables. My goal is estimate the model with aggregate shocks, which requires a fast and stable solution method.

This presents the following challenge. Existing solution methods that achieve sufficient speed and stability rely on linearization with respect to aggregate variables.[14] But linearization can give extremely misleading results for models with discrete-continuous choices. For example, if the problem is discretized on a grid, then the first-order response of the discrete choice to an aggregate shock is either zero or singular. More generally, discrete choices lead to jumps in the policy functions of continuous choices. The locations of jumps are endogenous and respond to (small) aggregate shocks, which makes linearization very delicate if not ill-defined.

Therefore, I follow Iskhakov, Jørgensen, Rust and Schjerning (2017) and introduce independent and identically distributed taste shocks into the household problems. This approach follows a long tradition in discrete choice modeling, dating back to the seminal work of McFadden (1973). In structural microeconometrics, assuming continuously distributed taste shocks is necessary to avoid statistically non-degenerate predictions. Here, they facilitate linearization with respect to aggregates by smoothing out discontinuities in the policy functions. In particular, taste shocks allow me to apply the "fake news algorithm" of Auclert, Bardóczy, Rognlie and Straub (2021) to rapidly compute linearized general-equilibrium impulse responses.

I explain details in computational appendix D. Sections D.1 D.2 show how to solve the household problem with an endogenous gridpoint method. Section D.3 explains how to estimate the elasticities in (5).

[14] Including Ahn, Kaplan, Moll, Winberry and Wolf (2018), Winberry (2018), Bayer and Luetticke (2020), Papp and Reiter (2020).

4 Quantifying the model

The quantitative model is meant to capture the extent of cyclical unemployment risk and households' exposure to it by gender and marital status in the United States. Therefore, in addition to standard calibration from the literature, I target the level and cyclical volatility of labor market flows in the CPS for the period between 1995-M1 and 2019-M12. In line with the flows data, I set the model frequency to one month.

I quantify the model in three steps via a mix of calibration and estimation. First, I fix some parameters to typical values from the literature. Second, I internally calibrate household type-specific parameters to hit steady-state targets. The structure of the model allows me to perform this step separately for single men, single women, and married couples. Third, I estimate the elasticities of search frictions in (5) to match the co-movement between gross worker flows and output. This is a complicated case of GMM, because the moments depend on how heterogeneous agents respond to idiosyncratic and aggregate shocks in general equilibrium. I take a novel approach to implementing the estimation efficiently.

4.1 Fixed parameters

The first set of parameters are calibrated externally to typical values from the literature. Table 4 summarizes my choices.

Panel A. The labor productivity process depends on gender but not marital status, because there are no recent estimates at that level of disaggregation. I normalize the average productivity of men to 1, and set the average for women to be 0.8 which is the gender wage gap observed in the CPS for 1995–2019. I set the monthly autocorrelation to be $\rho_z^m = 0.98$ for men and $\rho_z^f = 0.973$ for women, based on the estimates of Chang and Kim (2006). The standard deviation is informed by Song, Price, Guvenen, Bloom and Von Wachter (2019), who report that the cross-sectional standard deviation of pre-tax income, in logs, is 0.943 for men, and 0.86 for women. I scale these values down by 0.82 to account for progressive taxation as estimated by Heathcote, Storesletten and Violante (2017).

Panel B. I set the real interest rate to $r = 1.92\%$ annually, and assume that households cannot borrow $\underline{a} = 0$. The correlation of separation shocks for dual-earner couples is $\rho = 0.042$, the average value in the CPS between 1995 and 2019. During the same period, 59% of individuals aged 25–54 lived in a same household with their spouse. This implies that married households account for $0.59/(2-0.59) = 42\%$ of all households. The remaining mass is split equally between single men and women. I only count legally married couples who live in the same household, because data limitations prevent me from taking into account cohabitation, even though it most probably involves a degree of spousal insurance. Thus, the calibration is conservative given that my goal is to demonstrate that spousal insurance matters for aggregate outcomes.

I set the scale of taste shocks to $\sigma_\varepsilon(x) = 0.01$ for $x \in \{M, B\}$, and $\sigma_\varepsilon(L) = 0.04$. These are small values that induce a mild smoothing of the policy functions. Assigning larger taste shocks to UI

Table 4: Fixed parameters

Parameter		Value
A. Labor productivity		
Average (M, W)[1]	$\bar{z}$	1, 0.8
Persistence (M, W)	ρ_z	0.98, 0.973
Cross-sectional standard deviation of log (M, W)	σ_z	0.7733, 0.7052
B. Households		
Real rate, annualized	r	1.92%
Borrowing constraint	$\underline{a}$	0
Correlation of spousal job loss	ρ	0.042
Population shares (SM, SW, MC)[2]	ω	29%, 29%, 42%
Scale of taste shocks (M, B, L)[3]	σ_ε	0.01, 0.01, 0.04
C. Government		
Labor tax	τ	0.3
Lump-sum transfer	T	0.001
UI replacement rate	b	0.5
UI cap	$\bar{b}$	0.66
UI expiry rate	ξ	1/6

[1] (M, W) stand for men, women.
[2] (SM, SW, MC) stand for single men, single women, married couples.
[3] (M, B, L) stand for matched, UI eligible, neither.

ineligible households increase flows between unemployment and non-participation which would otherwise be minuscule in equilibrium.[15] In appendix XXX, I show that the choice of taste shock scale has very small effect on aggregate outcomes.

Panel C. The marginal labor tax is $\tau = 0.3$ and lump-sum transfers are negligible at $T = 0.001$. Positive transfers ensure that households can maintain a positive consumption at all times, but the precise value is not important given that I calibrate the MPCs internally. Government bonds B will be pinned down by asset demand from households. Government spending G is determined residually from the budget constraint. Unemployment benefits offer a replacement rate $b = 50\%$ up to a limit of $\bar{b} = 66\%$ of the average wage. Together with an expiration rate of $\xi = 1/6$ per month, this provides a reasonably good description of the US system in normal times.

[15] In principle, one could raise taste shocks of UI ineligible households until the model matches observed NU or UN flows. However, I found that this requires very large shocks. Since these flows are subject to large measurement error, I prefer not to explicitly target them and keep taste shocks smaller.

4.2 Internally calibrated steady-state parameters

The second set of parameters are those that affect the steady state and need to be calibrated within the model. These are the type-specific utility parameters $\{\beta, \varphi, \chi\}$ and search frictions $\{f, f^*, s\}$. Given the fixed parameters, these may be calibrated separately for single men, single women, and married couples. Table 5 summarizes the results.

Identification. Although the parameters are calibrated jointly, each is identified by a particular moment in the data. I pin down the discount factor by targeting the average marginal propensity to consume (MPC). Impatient households accumulate fewer assets, which leaves them more exposed to labor income shocks. The disutility of work φ and of search χ are chosen to match labor market stocks: the mass of employed and unemployed workers. Finally, each search friction is pinned down by the transition rate it affects most directly. The job-finding rate of unemployed workers f is identified by the average UE flow, the job-finding rate of non-participants f^* by the average NE flow, and the involuntary separation rate s by the average EU flow.

Interpretation. The MPC target is 25% quarterly for all groups. Kaplan and Violante (2014) report this as the headline estimate of average MPC from a large empirical literature. The available evidence suggests that average MPC does not vary with gender and marital status. See appendix B.3 fore details. Note that matching the uniform MPC target requires couples to be more patient than singles. This is because spousal insurance lowers couples' need for precautionary savings. If they were as impatient as singles, they would save very little at the equilibrium interest rate, and hit the borrowing constraint often.

The labor market targets are averages from the CPS for the civilian population aged 25–54. As we saw in section 2, labor market outcomes vary strongly by gender and marital status. Notice that flows are matched almost perfectly, while the unemployment to population ratio is a little low for married workers. There is some tension between matching stocks and flows, and I put a higher weight on flows because my primary concern is labor income risk.

The importance of search frictions vary between the different flows. UE flows are essentially equal to the job-finding rate f, because workers who do not want a job are not searching in the first place. In contrast, the finding rate f^* has to higher than the observed NE flows, because a large share of non-participants have no desire to work and reject job offers. The involuntary separation rate s is also higher than the observed EU flows. There are households whose preferences are $E \succ N \succ U$. They don't quit on their own, but exit the labor force as soon as they lose their job.

4.3 Estimated parameters

It remains to specify the elasticities of search frictions with respect to output that make unemployment risk state-dependent. I estimate these jointly by targeting an equal number of business cycle moments via Simulated Method of Moments (SMM).

First, I have to take a stance on the nature of aggregate shocks that drive business cycle in the model. Although the SMM estimation itself extends trivially to multiple shocks, for simplicity I

Table 5: Internally Calibrated Steady-State Parameters

Parameter		Value	Moment	Data	Model
Single Men					
Discount factor	β	0.9659	Quarterly MPC	25%	24.99%
Disutility of work	φ	1.4352	Employment to Population	78.26%	78.29%
Disutility of search	χ	0.9029	Unemployment to Population	6.33%	6.47%
Job offer rate, U	f	0.2506	UE transition probability	25%	25.02%
Job offer rate, N	f^*	0.1208	NE transition probability	8%	8.01%
Exog separation rate	s	0.0209	EU transition probability	1.82%	1.82%
Single Women					
Discount factor	β	0.9688	Quarterly MPC	25%	24.98%
Disutility of work	φ	1.5685	Employment to Population	74.19%	74.47%
Disutility of search	χ	0.9997	Unemployment to Population	5.20%	5.57%
Job offer rate, U	f	0.2206	UE transition probability	22%	22.03%
Job offer rate, N	f^*	0.0983	NE transition probability	7%	6.89%
Exog separation rate	s	0.0150	EU transition probability	1.29%	1.29%
Married Couples					
Discount factor	β	0.9889	Quarterly MPC	25%	25.00%
Disutility of work (men)	φ	0.2157	Employment to Population	90.70%	90.73%
Disutility of search (men)	χ	0.2688	Unemployment to Population	3.04%	2.52%
Job offer rate, U (men)	f	0.2999	UE transition probability	30%	29.97%
Job offer rate, N (men)	f^*	0.1920	NE transition probability	10%	9.95%
Exog separation rate (men)	s	0.0105	EU transition probability	0.92%	0.92%
Disutility of work (women)	φ	0.3087	Employment to Population	70.38%	70.48%
Disutility of search (women)	χ	0.6602	Unemployment to Population	2.60%	1.70%
Job offer rate, U (women)	f	0.2498	UE transition probability	25%	24.97%
Job offer rate, N (women)	f^*	0.1332	NE transition probability	6%	5.76%
Exog separation rate (women)	s	0.0154	EU transition probability	0.77%	0.77%

focus on a single shock that perturbs the discount factor of households. I assume that the shock follows and AR(1) process with a monthly autocorrelation of 0.95, a conventional value in light of DSGE models estimated via full information maximum likelihood methods (Justiniano, Primiceri and Tambalotti 2010, Auclert, Rognlie and Straub 2020). With a single aggregate shock process, the standard deviation of innovations is irrelevant, because I linearize the model with respect to aggregate shocks.

Conditional on the stochastic process for aggregate shocks, I can estimate the elasticities of search frictions to match the elasticities of UE, EU, and NE flows with respect to output. I choose these moments as targets because they identify the frictions most closely, and thus capture cyclical unemployment risk. As table A2 shows, the model can match all 12 moments perfectly. To the best of my knowledge, mine is the first heterogeneous-agent DSGE model that captures the cyclical volatility of unemployment this well.

4.4 Non-targeted moments

Table 6 shows that the model does a goods job of matching moments that were not explicitly targeted in the calibration but matter for spousal insurance. The EN transition probabilities are close to the data for all types. This means that the model captures well the composition of separations (EU vs EN), since EU transition rates were targeted and hit very closely (Table 5).

The added worker effect is defined as the increase in the probability that a married woman enters the labor force when her husband becomes unemployed. In the model, married women whose husband remains employed enter the labor force with 6% probability. This probability is almost doubles, to about 11%, if the husband loses his job in the same month. That is, the added worker effect in my model is about $11\% - 6\% = 5\%$, somewhat lower than the 8% in the data. This shows that my results are not due to exaggerating this common form of active spousal insurance.

Note that "adding a worker" is an optimal choice on behalf of single-earner households. Therefore, the households that choose to do so are those that need the extra income the most. Figure A1 in the appendix visualizes this selection with respect to MPCs. Households that respond to job loss by adding the second worker have an average MPC that is more than 40% larger than the average MPC of those that decide to keep the secondary earner out of the labor force.

Table 6: Non-Targeted Moments

	Data	Model
EN transition probabilities		
Single men	1.89%	1.81%
Single women	2.06%	2.20%
Married men	0.81%	0.65%
Married women	2.59%	2.11%
Added worker effect*	7.73%	4.72%
Joint distribution of employment in married households		
(E, E)	67.19%	62.36%
(E, U)	2.01%	1.36%
(E, N)	22.29%	27.00%
(U, E)	1.90%	1.65%
(U, U)	0.26%	0.14%
(U, N)	0.66%	0.73%
(N, E)	3.47%	6.46%
(N, U)	0.18%	0.20%
(N, N)	2.14%	0.09%

Source: CPS, monthly files for 1995–2019. Sample: Civilian population aged 25–54.
* The added worker effect in the data is from Mankart and Oikonomou (2017) Table 5. They estimate a linear probability model on CPS data spanning the years 1994–2014 on the sample of the civilian population aged 25–55. Their sample is almost identical to what I use in this paper.

The model captures the joint distribution of employment states in married households fairly well. It predicts too many single-earner households and thus undershoots the share of two-earner and zero-earner couples.

5 Macroeconomic consequences of spousal insurance

Having calibrated the steady state and estimated cyclical unemployment risk, I now use the model to isolate the role of spousal insurance in the amplification of typical business cycles with the help of a counterfactual experiment.

5.1 Household labor supply in response to idiosyncratic risk

I provide a brief overview of household labor supply in the stationary equilibrium in which there is idiosyncratic risk but no aggregate risk. This sets the stage for the discussion of spousal insurance over the business cycle in the next section.

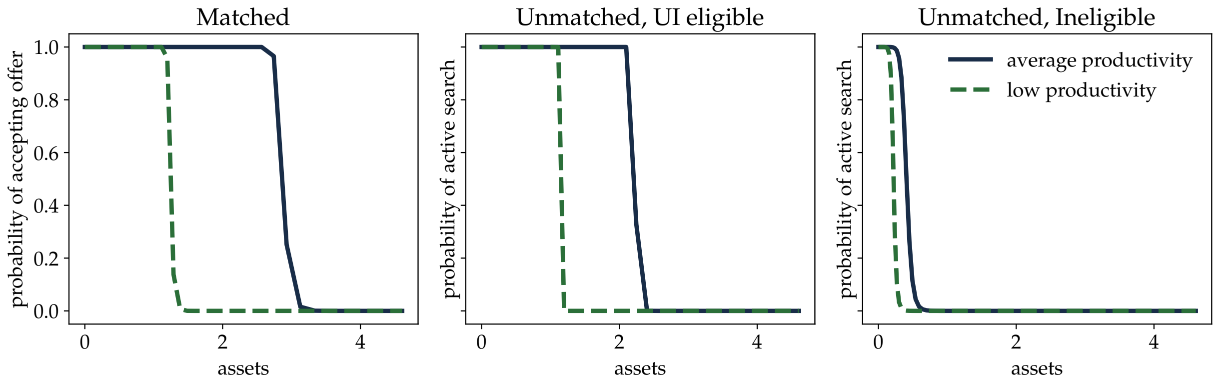

Figure 3: Selected Labor Supply Choices of Singles

Figure 3 illustrates how singles make labor supply choices. For a matched worker, labor supply choice comes down to accepting or rejecting the offer. The left panel shows that the probability of acceptance is increasing in productivity and decreasing in assets. This is because working has a fixed utility cost while the wage is proportional to productivity. An unmatched worker can increase her labor supply by choosing unemployment over non-participation. The two panels on the right show that this decision is governed by the same logic as the acceptance of offers: poor households with high productivity are more likely to search actively. Note that the choice probability is a logistic function of assets because of the taste shocks. Otherwise, there would be a single threshold $a(z_{it})$ at which the probability jumps from 1 to 0.

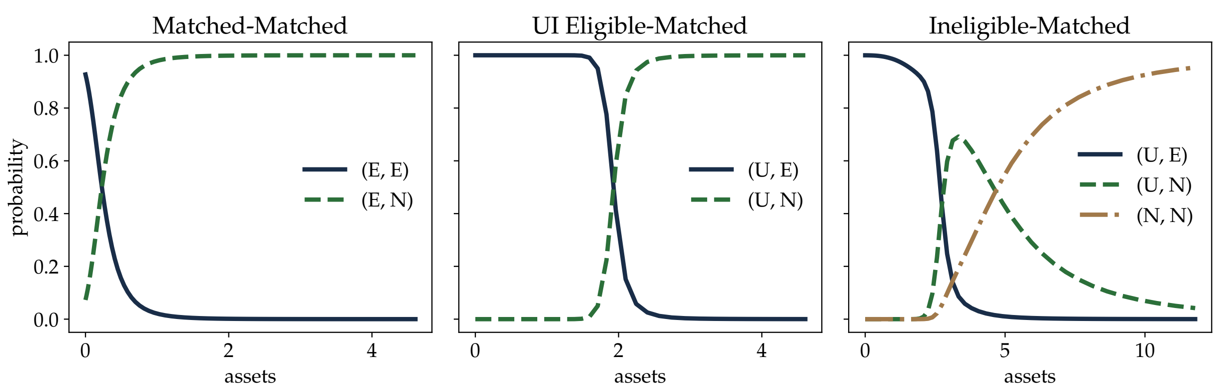

Figure 4: Selected Labor Supply Choices of Couples

Figure 4 illustrates the labor supply of a typical one-earner family. For concreteness, let the husband have average productivity and the wife have slightly below average productivity. When both spouses have offers, they prefer that only the husband works, unless they are very poor. When the husband loses his job (but still collects UI), the wife's acceptance threshold increases. For assets below 2, she prefers to work until her husband finds a new job. The choices are a bit more complicated when the husband's benefits expired already. If the family is rich, they both stay out of the labor force and wait for the husband to find a job. As they are running down their assets, they become increasingly likely to send the husband to search for a job. Eventually, the wife will be willing to accept a job while the husband searches.

5.2 Household labor supply and the transmission of aggregate shocks

First, I explain why my model can generate aggregate demand-driven recessions despite having no nominal rigidities. Second, I discuss how spousal insurance affects the transmission of unemployment risk to consumption and labor supply.

Figure 5 shows the dynamic effect of a contractionary aggregate demand shock on the equilibrium interest rate and consumption by household type. The left panel shows the shock itself, a persistent rise in the discount factor of all households, which prompts them to consume less, save more, and increase their labor supply. Therefore, the ex-post interest rate has to rise on impact and then fall persistently to clear the market via income and intertemporal substitution effects. Relative to a neoclassical model, search frictions prevent supply from rising sufficiently to offset the direct effect of the shock on demand, which allows output to fall in equilibrium.[16] The recession is then amplified by the ensuing increase in unemployment which depresses both demand and supply further.

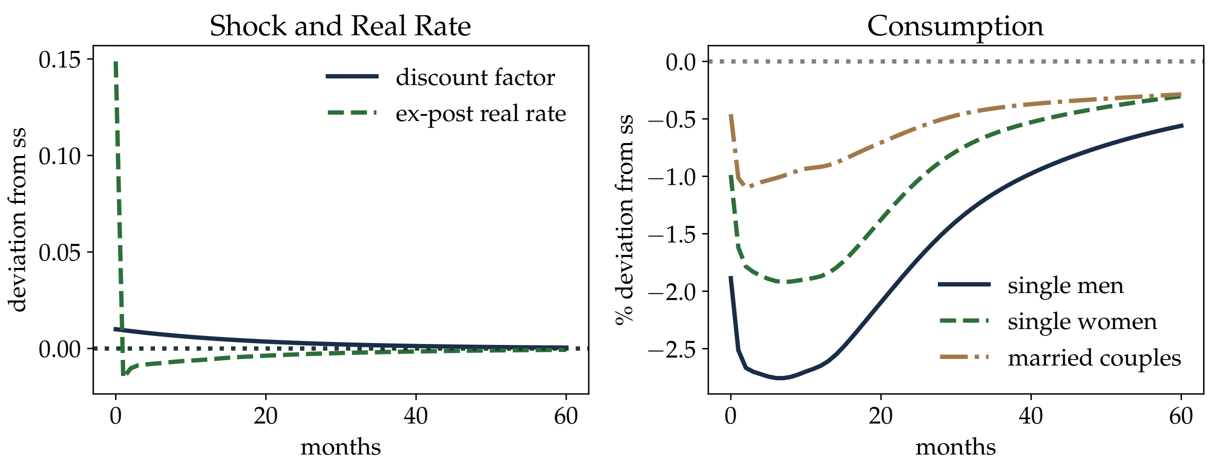

Figure 5: Impulse Responses to a Contractionary Aggregate Demand Shock

The right panel of Figure 5 shows the consumption responses broken down by household type. The large increase in financial income in period 0 mitigates but does not prevent an immediate fall in consumption, which gets worse as more workers lose their jobs and takes a long time to recover. The three types of households are affected very differently. On average, the consumption of married couples falls about half as much as the consumption of single women, and little more than third as much as the consumption of single men. Since each group has the same MPC in the

[16] If labor supply was a static, frictionless hours choice, households would want to raise it so much that the interest rate would have to fall enough to completely offset the effect of the discount factor shock.

stationary equilibrium, most of the difference is driven by what happens to income. Labor income is subject to both employment and wage shocks, but only the employment shocks vary with the cycle. Therefore, I turn to labor market responses next.

Figure 6: Labor Market Responses to a Contractionary Aggregate Demand Shock

Figure 6 shows how the mass of employed, unemployed, and non-participating agents evolves in response to the shock. As expected from the estimated differences in job stability, employment falls most among single men and least among married women. However, married women's employment actually increases as more women decide to enter the labor force. The same holds for married men, albeit to a lesser extent. I argue that this is because secondary earners provide active spousal insurance by entering the labor force to compensate for job loss by the primary earner.

The steady-state labor supply policies we saw on Figures 3 and 4 are already sufficient to see why singles are more likely to drop out of the labor force in a recession, while married women (and men) may increase their labor supply. Let us start with singles. Comparing the first two panels of Figure 3 show that single men with average productivity and assets between 2.3 and 3.0 engage in job hoarding (Garibaldi and Wasmer 2005). These workers don't quit their job on their own, but will not be willing to search actively if they lose it, even if that means giving up unemployment benefits. More quit as soon as their benefits expire. In the recession, more singles lose their jobs, and the hoarders among them quit the labor force.

Figure 7 shows that the labor supply behavior of singles changes relatively little when they learn about the recession in month 0. Matched workers become marginally more likely to accept the job and less likely to refuse unemployment benefits. This is driven by intertemporal substitution: jobs are more valuable as an asset when they are harder to find. However, the same reasoning implies that ineligible singles are less likely to stay in the labor force. In sum, singles not only have more cyclical employment shocks than married men and women, but also make procyclical labor force participation decisions. This means that their income falls more in the downturn, forcing them to cut consumption more than married households.

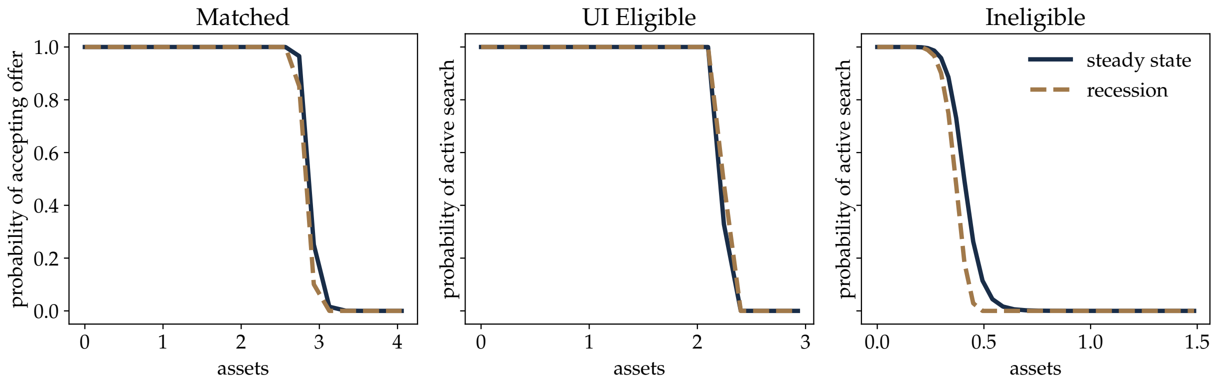

Figure 7: Response of Singles' Labor Supply on Impact

Couples are different in that they each have a primary and a secondary earner, dictated by comparative advantage.[17] Poor couples prefer to keep both of their members in the labor force, while richer couples find it optimal to keep the secondary earner out of the labor force. As Figure 4 shows, a job loss by the primary earner can induce the secondary earner to accept a job, at least temporarily. In that example, this happens for a rather large range of assets between 0.25 and 2. This explains why employment of married women can rise when more men lose their job.

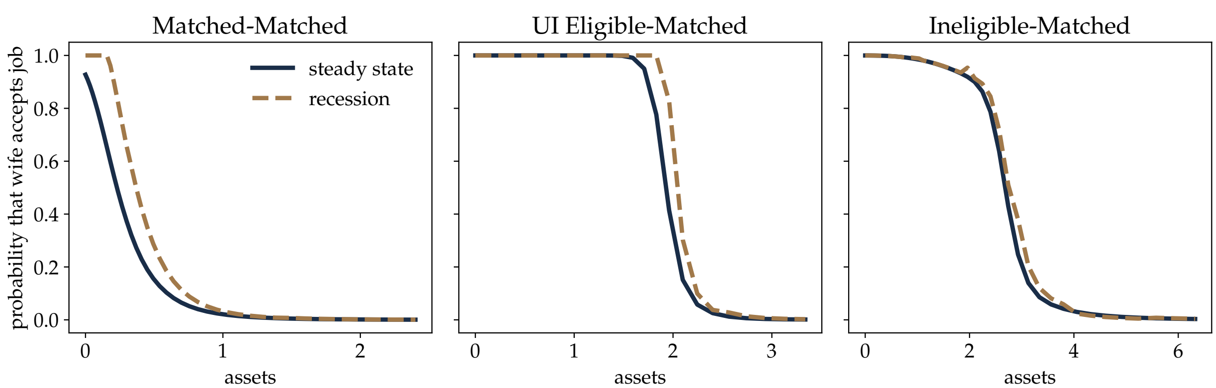

Figure 8: Response of Couples' Labor Supply on Impact

Moreover, secondary earners tend to adjust their labor supply policies in a countercyclical fashion. Figure 8 shows that when a secondary earner (in that example, the wife) gets matched in the first month of the recession, she is substantially more likely to accept regardless of the status of the primary earner. On top of the intertemporal substitution effect that I already described for singles, married households have a precautionary motive to offset the heightened risk to the primary earner.

In conclusion, married household are much less exposed to unemployment risk than singles. Spousal insurance is partly mechanical: joint income is less volatile than individual income

[17] Comparative advantage depends on the labor productivity, utility cost of work, and search frictions of the spouses.

when shocks are imperfectly correlated.[18] I call this channel passive insurance, and explains why employed-employed couples (the majority of married households) are better insured than singles. However, we saw that households provide active insurance as well: secondary earners increase their labor supply to make up for realized (and anticipated) income shocks to the primary earner.

5.3 Business cycles with and without spousal insurance

We saw that the spousal insurance motive meaningfully changes the consumption and labor supply of married households relative to singles. But how much does this matter for aggregate outcomes? In this section, I answer this question with the help of a counterfactual experiments.

No spousal insurance. To isolate the role of spousal insurance in the contemporary US economy, I consider a counterfactual economy where all married households have split up. The formerly married men and women have the same income risk and MPC as before, which maximizes comparability to the benchmark model. The only parameters I recalibrate are the discount factor β, disutility of work φ, and disutility of search χ. These are necessary for the separated men and women to have the same MPC, employment rate, and unemployment rate as before. That is, the counterfactual economy is as close as possible at both the individual and macro levels, but differs in terms of household formation.

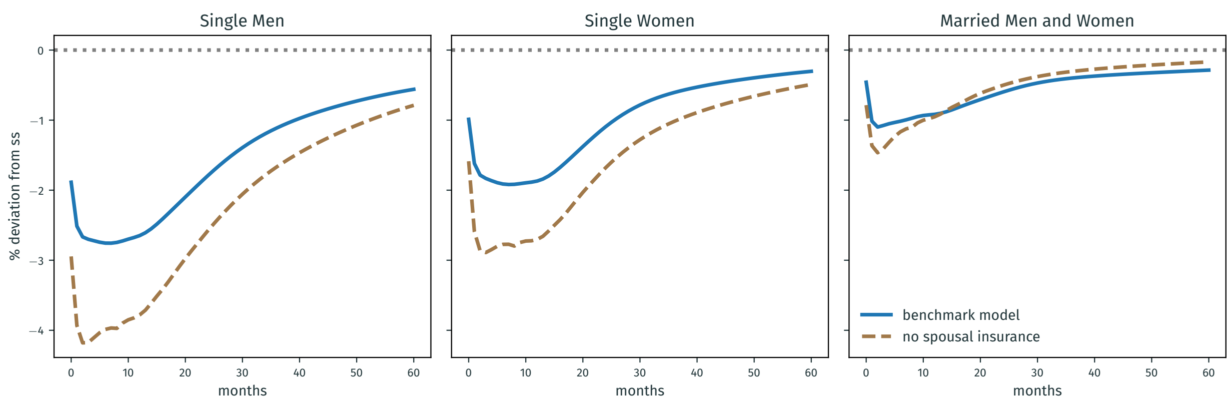

Figure 9: Consumption Responses to the Same Aggregate Shock

Figure 9 plots the consumption responses to the same aggregate demand shock in the counterfactual model without spousal insurance against the benchmark model. Starting with the right panel, the consumption of married men and women fall much more without spousal insurance, with a peak response that is almost 3 times as large in percentage terms as in the benchmark case. Unsurprisingly, taking away an insurance mechanism from these households leaves them more exposed to the recession. However, single men and women also suffer larger drops in consumption in the economy without spousal insurance. The reason is that when demand from married men and women falls, it aggravates unemployment for every other household in the economy.

[18]If both wage and employment shocks were perfectly correlated across spouses, a married household would simply be a scaled-up version of a single household.

My model captures this spillover accurately via the estimated gender and marital status-specific search frictions. Spousal insurance weakens the feedback between unemployment and aggregate demand, and thereby stabilizes the macroeconomy more broadly.

6 Spousal insurance across time

The stabilizing potential of spousal insurance can vary substantially over time. In this section, I use my model to characterize the effect of three scenarios on spousal insurance. The first two are long-run trends: the decline in marriage rate, and the rise in female labor force participation. The third is the incidence of job losses during the early months of the COVID-19 recession.

6.1 Marriage rate

Household formation determines how widespread the access to spousal insurance is. The left panel of Figure 10 shows that the share of married households in the United States has fallen from about 70% in the 1960s to less than 40% in 2019. This is a dramatic change in the composition of households.

Interpreting the decline in marriage rate is subject to the caveat that it overstates the decline in spousal insurance because of the secular rise in cohabitation, i.e. the number of unmarried people living together. Unfortunately, cohabitation has been measured consistently in the CPS since 1994 only. Between 1994 and 2018, the share of cohabiting adults aged 25–54 increased from 3.6% to 9.3%, which is not nearly enough to offset the decline in marriage, especially compared to its high level in 1960s.

To quantify the impact on macroeconomic volatility, I change the household composition in the model to represent 1960s. The shaded areas represent the basis for the benchmark calibration (blue) and counterfactual calibration (green). Then, I subject the model to the same aggregate demand shock as before. The right panel of Figure 10 shows that a larger share of married households, all else equal, leads to a much smaller and less persistent fall in aggregate consumption.

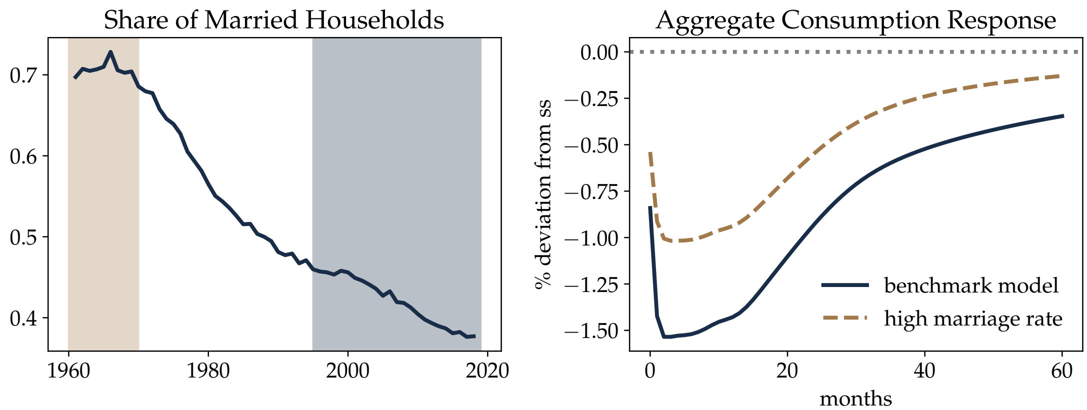

Figure 10: Marriage Rate and Aggregate Volatility

Share of married households is from the CPS ASEC. Sample is restricted to civilian population aged 25-54.

Note that this experiment not only extends the availability of spousal insurance but lowers the amount of individual unemployment risk in the economy as well. This is because married couples have lower probability of job loss than singles. My modeling choice is justified by the time series of EU and UE flows which have not diverged between married and single workers despite the steep and steady increase in the share of single households (Figure 2). But it is also a conservative choice, since giving spousal insurance would be even more valuable to people with higher individual risk.

6.2 Female Labor Force Participation

The left panel of Figure 11 shows that the labor force participation rate of married women in the United States increased from less than 40% in 1960 to more than 70% by 1995, where it has plateaued. This is a profound structural change that has a subtle impact on spousal insurance.

On the one hand, women have had more stable jobs and more countercyclical labor supply than men throughout this period. Therefore, one may expect that aggregate volatility will decrease as more for them decide to work. Albanesi (2019) makes this argument for why women's employment contributed to the Great Moderation. On the other hand, when more married women are already in the labor force, the room for countercyclical entry diminishes. The idea that dual-earner families may be more vulnerable than single-earner families is emphasized by Warren and Warren Tyagi (2004). My model accommodates both of these considerations, and therefore can provide a nuanced answer to this question.

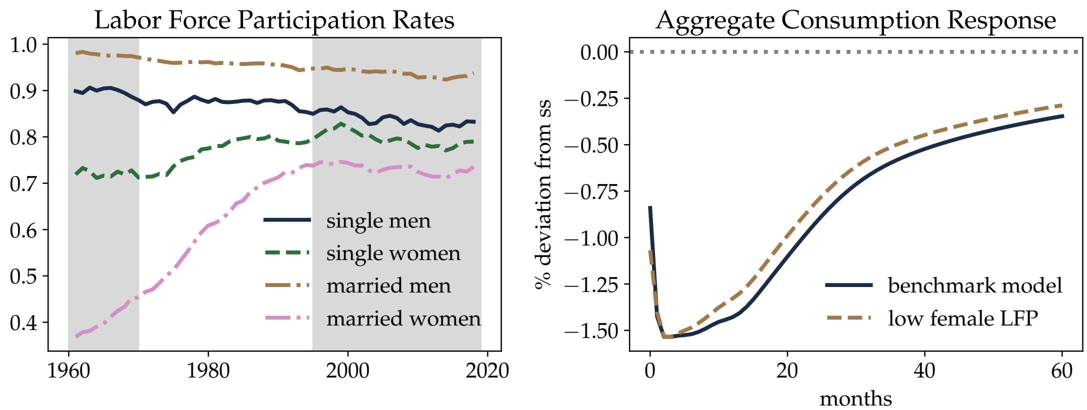

Figure 11: Female Labor Force Participation and Aggregate Volatility

Labor force participation rates are from the CPS ASEC. Sample is restricted to civilian population aged 25-54.

I calibrate the economy to the 1960s level of female labor force participation with a combination of lower wages and higher disutility of work for women. The gender wage gap is an observed moment. Doepke and Tertilt (2016) report that the gap in the median wage was 45% in 1960. I find that targeting this higher gender wage gap in the model explains about half the rise in married women's participation. I use the disutility of employment to make up for the rest.[19] Finally, I recalibrate the discount factor to keep the quarterly MPC at 25% and the disutility of search to target an unemployment rate of 3.5% for married women.

The right panel of Figure 11 shows that low female labor force participation (FLFP) has an ambiguous effect on the volatility of aggregate consumption. In the first three months, consumption falls less in the benchmark model, which means that high FLFP does mitigate the immediate impact of the shock. However, the subsequent recovery is lower in the benchmark economy. This pattern reflects the offsetting effects of FLFP on the passive and active channels of spousal insurance. Passive insurance acts without delay and benefits only dual earner couples. There are more of them in the benchmark economy. Active insurance is more relevant for single-earner families, whose secondary earner is out of the labor force. Her entry is slowed down by the search frictions, but only for a few months. In sum, the model implies that high female labor force participation boosts passive insurance at the cost of weakening active insurance, and ultimately has a small impact on aggregate volatility.

Takeaway. My model accounts for the fact that women have less procyclical employment than men. The difference is partly targeted (estimated elasticities of separation) and partly microfounded (active spousal insurance). The experiment demonstrates that these differences are not sufficient to conclude that high FLFP dampens business cycle fluctuations.

My model highlights a key moment that drives the net effect of FLFP on macroeconomic

[19]Disutility of work may be thought of as capturing various factors behind the rise of female labor force participation during this period such as the increased availability of oral contraception (Goldin and Katz 2002) and household appliances (Greenwood, Seshadri and Yorukoglu 2005) as well as cultural change (Fernández 2013).

volatility. It is is how easy it is for married women out of the labor force to find a job when they want one. If it was impossible, FLFP would be synonymous with spousal insurance, because one-earner couples would behave as singles. If labor supply was frictionless, FLFP would be irrelevant for spousal insurance, since a non-participant spouse could earn income at will. My model is between these two extremes. In particular, I keep search frictions constant at a moderate level. This fits well the evolution of gross flows which shows that declining NE transitions are the dominant driver of rising participation of married women (Figure 2).

This experiment, however, is not a conclusive proof that the rise in FLFP did not have a dampening effect. A caveat to my analysis is that married women today may have a much higher earnings capacity even when they are out of the labor force, as a result from extra work experience they accumulate before quitting the labor force. Although my model does have the property that people with low productivity select to stay out of the labor force, it does not include explicit skill depreciation.

6.3 COVID-19 recession

Spousal insurance is particularly powerful against unemployment because of two regularities of cyclical job loss. First, the correlation of job loss between spouses is essentially zero. Second, the probability of job loss is much less cyclical for women than men.

Figure 12 shows that job losses during the early months of COVID-19 pandemic did not follow the usual pattern.[20] First, married women were much more likely to lose their job than married men. Second, the correlation of spousal job loss was unusually high during this period. In fact, both EU flows and the correlation of spousal job loss reached their all time high in April 2020, at least in the four decades covered by the CPS sample.

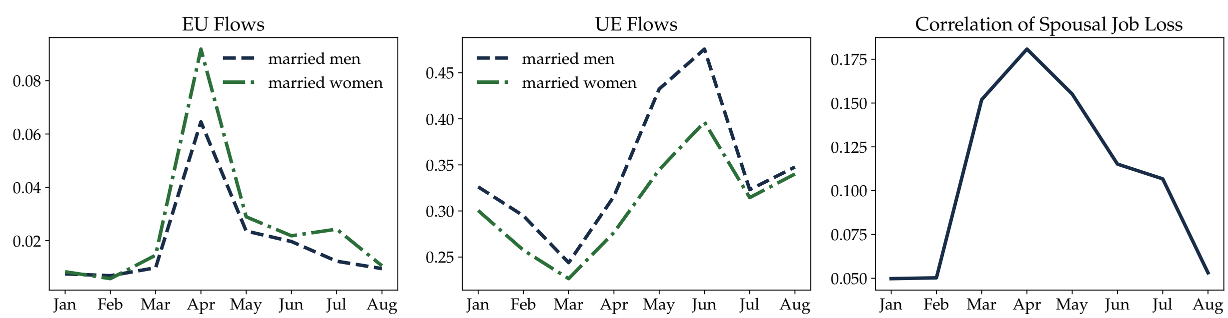

Figure 12: Unemployment Risk of Married Households in 2020

Source: CPS monthly files. Sample is restricted to civilian population aged 25-54.

To assess the effect of this large and sudden shock on household consumption, I pursue a different strategy than before. Instead of generating a recession via a reduced-form discount factor shock, I feed the observed paths of EU flows, UE flows, and correlation directly into the decision

[20] Alon et al. (2020a) were the first to point out that COVID-19 recession hit women particularly hard.

problem of married households. Specifically, I assume that the economy starts from its stationary equilibrium in February 2020. In March, households are surprised by the low job-finding rates and high separation rates, but believe that these are temporary deviations and April will be normal. In April, they are surprised again. The same process continues until August 2020.

Figure 13 shows the average consumption response (red line). To put this response in context, I construct a "regular recession" as follows. Married men face the same transition probabilities as before. However, the probability of married women's job loss follows the usual pattern, and rises just $7.87/13.6 = 58\%$ as much as married men's. In addition, the correlation of joint job loss remains constant at 0.042. Although this counterfactual recession is still very severe, household consumption falls less than three-quarters as much than in the COVID-19 recession.

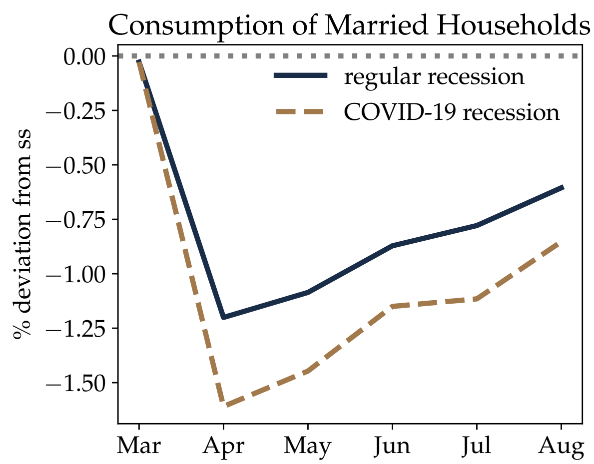

Figure 13: Consumption Response to Labor Market Risk

Takeaway. The example of the COVID-19 recession shows that the nature, and not just the size, of an economic shock matters for its impact on households. Aggregate shocks that originate in sectors with a high employment share of just one gender (such as construction) are better insured than shocks that affect women and men equally and are more likely to affect two spouses at the same time.

7 Conclusion

This paper was motivated by the observation that married households rely heavily on spousal labor supply to absorb idiosyncratic income shocks. I built a general equilibrium model with incomplete markets in which households have access to this important channel of partial insurance. I estimated the model on US data, so that it reproduced the volatility of cyclical unemployment risk and labor force participation patterns by gender and marital status. Then, I used the model to argue that spousal insurance dampens aggregate fluctuations substantially via both demand and supply channels.

An immediate consequence of this result is that business cycle analysis ought to be broader in scope. Any feature of the economy that boosts spousal labor supply can be expected to dampen business cycles. Conversely, anything that hinders spousal insurance has the potential to amplify business cycles. I called attention to long-term trends as well as aggregate shocks that have this property.

Future research could expand this project in two directions. First, a case could be made for rethinking social policies that provide more insurance to married households than singles. Married couples have more choices than singles to maintain health insurance coverage, to collect social security benefits, and to optimize saving for retirement. Thus, the tax and transfer system reinforces the insurance advantage that married couples already have from spousal labor supply. The design of these policies may be rooted in the old model of single earner families, or chosen with long-term goals in mind, such as promoting marriage. My results suggest that business cycle stabilization calls for using the tax and transfer system to provide extra insurance to single households instead.

Second, my model of the household is stylized in many dimensions. The family economics literature has emphasized that assortative mating with respect to education (long-term earnings potential) is an important driver of inequality (Fernandez, Guner and Knowles 2005). Assortative mating is likely to play a role in the business cycle context as well. Here, the relevant notion is assortative mating with respect to job stability and short-run earnings potential, i.e. the determinants of spousal insurance. In addition, I modeled households as permanent units that make decisions jointly. But limits of cooperative behavior could have first-order effects on family labor supply and consumption smoothing, and hence on the macroeconomy as well. I leave the development of richer models along these lines for future research.

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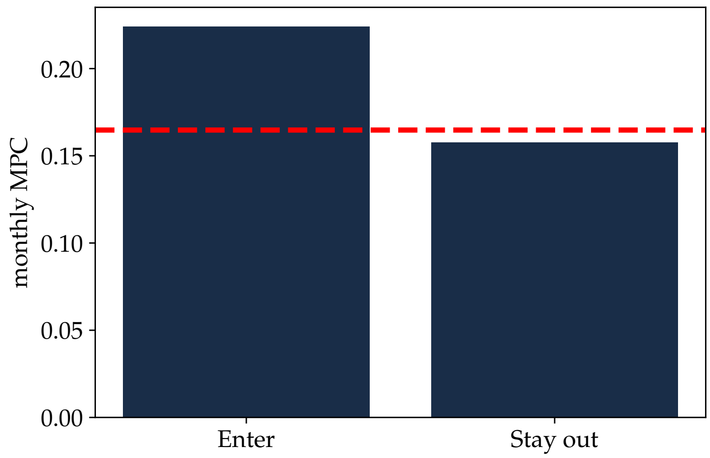
A Additional figures and tables

Figure A.1: Selection of Added Workers in the Model



Notes. This figure shows that the added worker effect is driven by single-earner couples with high MPCs, that is the households that need extra income the most. The red dashed line shows the average MPC of single earner households that have just experienced a job loss of the primary earner. Within this group, the “Enter” column shows the average MPC of those where the secondary earner entered the labor force. The “Stay out” column shows the average MPC of those households where the secondary earner stayed out of the labor force.

Table A1: Cyclicality of Labor Market Stocks

		single men	single women	married men	married women
Average	E	78.43%	74.31%	90.68%	70.37%
	U	6.28%	5.18%	3.04%	2.60%
	N	15.28%	20.52%	6.28%	27.04%
Cyclical	E	1.44***	0.82***	0.84**	0.39***
		(0.22)	(0.18)	(0.12)	(0.09)
	U	-1.18***	-0.66***	-0.75***	-0.40***
		(0.17)	(0.09)	(0.11)	(0.05)
	N	-0.27	-0.16	-0.10	0.00
		(0.09)	(0.12)	(0.45)	(0.08)

Source: Current Population Survey, monthly files for 1995–2019.
Sample: Civilian population aged 25–54.
Cyclical: semi-elasticity to cyclical component of real GDP. HAC standard errors in parentheses.
***: p-value < 0.01, **: p-value < 0.05.

Notes. This table summarizes the cyclical behavior of employment, unemployment, and non-participation, disaggregated by gender and marital status. Notably, non-participation is less pro-cyclical for married people than single people (also for women than for men). The model rationalizes this outcome as a result countercyclical entry by secondary earners.

Table A2: Estimated Elasticities of Transition Probabilities

Parameter		Value	Moment	Data	Model
Single Men					
Job offer rate, U	$\varepsilon(f)$	10.69	UE flow	10.71	10.71
Job offer rate, N	$\varepsilon(f^*)$	5.57	NE flow	4.74	4.74
Separation rate	$\varepsilon(s)$	-11.17	EU flow	-10.12	-10.12
Single Women					
Job offer rate, U	$\varepsilon(f)$	8.72	UE flow	8.72	8.72
Job offer rate, N	$\varepsilon(f^*)$	3.55	NE flow	3.74	3.74
Separation rate	$\varepsilon(s)$	-6.55	EU flow	-5.68	-5.68
Married Men					
Job offer rate, U	$\varepsilon(f)$	10.37	UE flow	10.36	10.36
Job offer rate, N	$\varepsilon(f^*)$	9.74	NE flow	2.78	2.78
Separation rate	$\varepsilon(s)$	-13.35	EU flow	-13.60	-13.60
Married Women					
Job offer rate, U	$\varepsilon(f)$	8.40	UE flow	8.40	8.40
Job offer rate, N	$\varepsilon(f^*)$	10.72	NE flow	2.30	2.30
Separation rate	$\varepsilon(s)$	-3.71	EU flow	-7.87	-7.87

Notes. This table summarizes the estimated elasticities of job-finding and separation rates to output. The elasticities are estimated jointly in an exactly-identified Simulated Method of Moments, and are matched perfectly. Business cycle fluctuations in the model originate in discount factor shocks.

B Data

In this appendix, I describe the three datasets I rely on in the paper. The tax records of married couples (section B.1), the Current Population Survey (section B.2), and the Italian Survey of Household Income and Wealth (section B.3).

B.1 Administrative earnings data

These data were published by Pruitt and Turner (2020) and can be downloaded from the AEA's website[21]. The authors start from population-level data on earnings and marriage from the Internal Revenue Service (IRS) combined with demographic information from the Social Security Administration (SSA). The gross earnings data is from the W-2 forms that include wage and salary

[21] https://www.aeaweb.org/articles?id=10.1257/aeri.20190096

earnings. The earnings reported on these forms are verified by employers and are not top-coded. Missing data are likely to represent true $0 earnings.

To construct their sample, they draw a 1-in-5 random sample of males aged between 25 and 60. They pull the W-2s of these males and their spouses for the years 1999–2014. Then, they impose the following restrictions.

1. When an individual dies in the sample period, drop observations from the last two years of life. (remove large health-induced earnings shocks)

2. Remove individuals who receive Social Security disability payments. (focus on labor market earnings, not transfers)

3. Remove individuals with nonzero self-employment income (self-employment income is not third-party verified).

4. Require spouses to file jointly in all years used to measure earnings growth. (eliminate the effect of divorce)

This procedure leaves about 90% of joint tax returns, and more than 235 million person-year observations. Nominal earnings are converted to 2014 dollars using the CPI.

In section 2, I present selected moments of annual labor earnings growth. These can be found in file `DELTA1.xlsx`. Let y_{it} denote the gross labor earnings of individual i in year t, where $0 earnings are replaced by $1. Annual labor earnings growth is then defined as $x_{it} \equiv \log y_{it} - \log y_{it-1}$. Household-level earnings growth is given by $x_{ht} = \log(y^m_{ht} + y^f_{ht}) - \log(y^m_{ht-1} + y^f_{ht-1})$, where y^m_{ht} and y^f_{ht} are the earnings of the male and the female spouse within the household.[22]

B.2 Current Population Survey

The harmonized CPS micro data files can be downloaded from IPUMS[23]. The CPS is the primary source of labor force statistics for the population of the United States. It is conducted at the household level, and provides information about all household members. I use the basic monthly files for the years 1976–2020 and the Annual Social and Economic Supplement (ASEC) for the years 1962–2019. The monthly files are the source of worker flows. The ASEC provides a longer time-series of labor force participation rates and wages. In all cases, I restrict the sample to the civilian population aged 25–54.

The basic monthly files have a rotating panel structure. Households are interviewed for four months, have eight months off, then are interviewed again for four months. Therefore, in principle, 75% of households are observed in two consecutive months. I link individuals based on their unique identifier. I validate matches using gender, age, and marital status. Keeping matches

[22]Same-sex marriage has been legal in all 50 states since 2015. The sample predates this year, hence does not include same-sex couples.

[23]https://cps.ipums.org/cps/

where marital status remains constant is in line with my theoretical model, in which it is a permanent type.

Given the linked sample, the transition probability between, say, employment and unemployment in month t can be computed as follows. Count people who report being employed in $t-1$ and unemployed in t, then divide by the number of all people who report being employed in $t-1$. By construction, the number is between 0 and 1. To make the flows representative of the intended population (single men etc.), I weight by the time-t sample weights.

When estimating the elasticities to GDP, I take quarterly averages of the monthly flows, and seasonally adjust them using the X-13ARIMA-SEATS program from the Census Bureau (using the default parameters).

B.3 Survey of Household Income and Wealth

The SHIW is an annual household survey conducted by the Bank of Italy. Its structure and size is similar to the Survey of Consumer Finances in the US, but has the important advantage that it directly measures household-level MPCs. Following Auclert (2019), I work with the 2010 wave, which can be downloaded from ICPSR.[24]

I restrict the sample to households with a head aged 25–60, and compute the sample-weighted average MPC (self-reported) for single men, single women, and married couples, respectively. Table A3 shows that the average MPCs are remarkable close foe these groups, despite substantial dispersion in cash on hand, which is well-known to be a good predictor of the MPC (Jappelli and Pistaferri 2014, Kaplan, Violante and Weidner 2014). This observation leads me to target equal average MPC in the calibration.

Table A3: Uniformity of MPCs in SHIW

	single men	single women	married couples
Annual MPC	47.7	51.0	48.6
Cash on hand per adult	34,557	27,717	26,201
Number of observations	519	768	2969

[24] https://www.openicpsr.org/openicpsr/project/113120/version/V1/view

C Derivations

C.1 Parameterizing job loss for married couples

Let X and Y be two Bernoulli random variables given by

$$\Pr(X = 1, Y = 1) = a \tag{11}$$
$$\Pr(X = 1, Y = 0) = b \tag{12}$$
$$\Pr(X = 0, Y = 1) = c \tag{13}$$
$$\Pr(X = 0, Y = 0) = d \tag{14}$$

The total probability that either event happens is

$$\Pr(X = 1) = a + b \equiv p \tag{15}$$
$$\Pr(Y = 1) = a + c \equiv q \tag{16}$$

and their correlation is

$$\text{Corr}(X, Y) = \frac{a - pq}{\sqrt{p(1-q)q(1-p)}}. \tag{17}$$

This means that the transitions of an employed-employed couple can be constructed from the separation rate of married men (s_m), the separation rate of married women (s_f), and the correlation of job loss between spouses (ρ) as follows:

$$\Pr(\overrightarrow{EB}_m, \overrightarrow{EB}_f) = s_m s_f + \rho\sqrt{s_m s_f(1-s_m)(1-s_f)} \tag{18}$$
$$\Pr(\overrightarrow{EB}_m, \overrightarrow{EM}_f) = s_m(1-s_f) - \rho\sqrt{s_m s_f(1-s_m)(1-s_f)} \tag{19}$$
$$\Pr(\overrightarrow{EM}_m, \overrightarrow{EB}_f) = (1-s_m)s_f - \rho\sqrt{s_m s_f(1-s_m)(1-s_f)} \tag{20}$$
$$\Pr(\overrightarrow{EM}_m, \overrightarrow{EM}_f) = (1-s_m)(1-s_f) + \rho\sqrt{s_m s_f(1-s_m)(1-s_f)} \tag{21}$$

D Computation

D.1 Multi-stage formulation of the household problem

The first step to solve the dynamic problem (1) is to break it up into a sequence of simpler stages.

- **Stage 0.** Agent enters a new period with state variables inherited from last period (s_-, z_-, a_-). Unanticipated aggregate shocks, if any, are realized.
- **Stage 1.** Productivity z is drawn from probability mass function $\pi_z(z_-)$.
- **Stage 2.** Employment shock x is drawn from probability mass function $\pi_s(s_-)$.

- **Stage 3.** Taste shocks $\varepsilon(s)$ are realized for each $s \in \Gamma(x)$. Agent makes labor supply decision

$$\mathcal{V}_t(x, z, a_-) = \max_{s \in \Gamma(x)} \left\{ V_t(s, z, a_-) + \varepsilon(s) \right\} \tag{22}$$

where $V_t(s, z, a_-)$ denotes an interim value function conditional on the discrete choice. The solution of this stage is a set of choice probabilities. Assuming that taste shocks are iid extreme value type I with scale $\sigma_\varepsilon \geq 0$, the choice probabilities have logit form.

$$P_t(s|x, z, a_-) = \exp\left(\frac{V_t(s, z, a_-)}{\sigma_\varepsilon}\right) \Bigg/ \sum_{s \in \Gamma(x)} \exp\left(\frac{V_t(s, z, a_-)}{\sigma_\varepsilon}\right) \tag{23}$$

- **Stage 4.** Agent makes consumption-saving decision.

$$\begin{aligned} V_t(s, z, a_-) = \max_{c,a} & \left\{ u(s, c) + \varepsilon(s) + \beta \mathbb{E}_t \left[\mathcal{V}_{t+1}(x', z', a) \right] \right\} \\ \text{s.t. } & c + a = y_t(s, z) + (1 + r_t) a_- \\ & a \geq \underline{a} \end{aligned} \tag{24}$$

With the maintained assumption on taste shocks, the continuation value has logsum form

$$\mathbb{E}_t \left[\mathcal{V}_{t+1}(x', z', a) \right] = \mathbb{E}_t \left\{ \sigma_\varepsilon \ln \left[\sum_{s' \in \Gamma(x')} \exp\left(\frac{V_{t+1}(s', z', a)}{\sigma_\varepsilon}\right) \right] \right\} \tag{25}$$

This stage can be solved efficiently by the endogenous gridpoint method. The caveat is, as Iskhakov et al. (2017) point out, that small taste shocks smooth out discontinuities but do not fully convexify the problem. Thus, first order conditions are necessary but not sufficient and the original endogenous gridpoint method of Carroll (2006) has to be extended with an upper envelope step as in Fella (2014).

D.2 EGM with an upper envelope

The first order conditions of the consumption-saving decision (24) are

$$u_c(s, c) \geq \beta \mathbb{E}_t \partial_a V_{t+1}(s', z', a) \tag{26}$$

$$\partial_a V_t(s, z, a_-) = (1 + r_t) u_c(s, c) \tag{27}$$

$$c + a = y_t(s, z) + (1 + r_t) a_- \tag{28}$$

where the Euler equation holds with equality when $a > \underline{a}$.

Algorithm. To set up the algorithm, choose an increasing grid for end-of-period assets $\mathcal{G}_a = \{a_i\}_{i=0}^{n_a - 1}$ and provide an initial guess of next period's interim value function $V_{t+1}(s', z', a)$ and its partial $\partial_a V_{t+1}(s', z', a)$ on $\mathcal{G}_a$. We're going to iterate backward on these two functions until convergence.[25]

1. **Expectations.** Compute post-decision value function $W_t(s,z,a) = \beta \mathbb{E}_t V_{t+1}(s',z',a)$ and its partial $\partial_a W_t(s,z,a) = \beta \mathbb{E}_t \partial_a V_{t+1}(s',z',a)$.

   (a) $\underline{s' \to x'}$: Expectation with respect to next period's taste shocks and discrete choice. For the value function, we have to use the logsum formula (25). For the partial, we have to compute the logit choice probabilities (23) and use them to compute the expectation as a weighted average

   $$\partial_a W_{t+1}(s',z',a) = \sum_{x'} P_{t+1}(s'|x',z',a) \partial_a V_{t+1}(s',z',a) \tag{29}$$

   (b) $\underline{x' \to s}$: Expectation with respect to next period's employment shock. We compute this as a weighted average using the transition matrix

   $$\Pi_{t+1}(x'|s) = \begin{bmatrix} 1-s_{t+1} & s_{t+1} & 0 \\ f_{t+1} & (1-\xi)(1-f_{t+1}) & \xi(1-f_{t+1}) \\ f_{t+1} & 0 & 1-f_{t+1} \\ f^*_{t+1} & 0 & 1-f^*_{t+1} \end{bmatrix} \tag{30}$$

   The rows corresponds to $s \in \{E, U_b, U_{nb}, N\}$, the columns corresponds to $x' \in \{M, B, L\}$.

   (c) $\underline{z' \to z}$: Expectation with respect to next period's productivity shock. We compute this as a weighted average using the exogenous transition matrix $\Pi(z'|z)$.

2. **Standard EGM.** Invert the Euler equation (26) to obtain post-decision consumption function $c_t(s,z,a)$ and then substitute it into the budget constraint (28) to obtain the "endogenous grid" $\mathcal{G}_a^{endo} = \{a_-(s,z,a)\}$.

3. **Upper envelope.** Obtain the consumption function $c_t(s,z,a_-)$ and value function $V_t(s,z,a_-)$ on the exogenous grid $\mathcal{G}_a$ by linear interpolation against $\mathcal{G}_a^{endo}$.

   There are two complications. First, the Euler equation is necessary but not sufficient, so the post-decision consumption function $c_t(s,z,a)$ may contain suboptimal points. Second, the endogenous grid $\mathcal{G}_a^{endo}$ is not increasing.

   A simple, robust implementation (along the lines of Druedahl 2020) follows.

   Fix (s,z) and loop over $a^i \in \mathcal{G}_a$:

   (a) **if** $a^i \leq a_-(s,z,\underline{a})$ the borrowing constraint binds and we set

   $$c_t(s,z,a^i) = (1+r_t)a^i + y_t(s,z) \tag{31}$$
   $$V_t(s,z,a^i) = u\big(c_t(s,z,a^i),s\big) + W_t(s,z,\underline{a}) \tag{32}$$

[25] Iterating explicitly on the partial $\partial_a V_t(s,z,a)$ leads to a much more accurate solution than iterating only on the value function $V_t(s,z,a)$ and computing the partial by numerical differentiation.

(b) **else** find all segments $\{a_-^j, a_-^{j+1}\} \in \mathcal{G}_a^{endo}(s,z)$ that bracket a^i; for each segment j, compute $c_t^j(s,z,a^i)$ and $W_t^j(s,z,a^i)$ by linear interpolation; compute the implied $V_t^j(s,z,a^i)$; keep the maximum.

4. **Updating.** Compute $\partial_a V_t(s,z,a_-) = (1+r_t)u_c\big(s, c_t(s,z,a_-)\big)$.

The main bottleneck is finding the bracketing intervals in step 3/b. Two insights can help to economize this search, which were explored by Fella (2014) and apply to my model as well. First, one can partition the post-decision state space (s,z,a) into a concave and a non-concave region. This is a cheap operation. In the concave region, $\mathcal{G}_a^{endo}$ is increasing, and there's a single bracketing interval for each a^i. Second, standard results from monotone comparative statics (Edlin and Shannon 1998) imply that the discrete choice-specific policy function $a(s,z,a_-)$ is increasing in a_-. This is another advantage of breaking up the problem to stages, since $a(x,z,a_-)$ is not increasing in general.

D.3 SMM estimation in sequence space

As discussed in section 4.3, I estimate the elasticities in (5) to match the cyclical volatility of flows between employment and unemployment. In this section, I explain how to construct these moments in the model with aggregate shocks without resorting to simulation.

Let $\mathrm{d}X_t$ denote the percentage point deviation of a generic variable X_t from its deterministic steady state. Let $\mathcal{Z}$ be the set of exogenous shocks that drive fluctuations in the model, and let z be their index. Therefore, any variable $\mathrm{d}X_t$ can be written in MA(∞) form as

$$\mathrm{d}X_t = \sum_{z\in\mathcal{Z}} \sum_{s=0}^{\infty} \underbrace{\left(\frac{\mathrm{d}X_t}{\mathrm{d}\varepsilon_{t-s}^z}\right)}_{m_s^{X,z}} \varepsilon_{t-s}^z, \tag{33}$$

where ε_{t-s}^z are the past realizations of shock z, and $m_s^{X,z}$ is the horizon-s impulse response of X to a unit shock z.

The elasticity of any transition probability p_t with respect to output Y_t is, by definition,

$$\varepsilon(p) = \frac{\mathrm{Cov}(\mathrm{d}p_t, \mathrm{d}Y_t)}{\mathrm{Var}(\mathrm{d}Y_t)} \tag{34}$$

So, all we need is the covariance function. These can be computed from the MA(∞) representation (33) as

$$\mathrm{Cov}(\mathrm{d}p_t, \mathrm{d}Y_t) = \sum_{z\in\mathcal{Z}} \sigma_z^2 \sum_{s=0}^{\infty} m_s^{p,\beta} m_s^{Y,z}, \qquad \text{and} \qquad \mathrm{Var}(\mathrm{d}Y_t) = \sum_{z\in\mathcal{Z}} \sigma_z^2 \sum_{s=0}^{\infty} (m_s^{Y,z})^2. \tag{35}$$