Spousal Labor Supply Response to Job Displacement and Implications for Optimal Transfers*

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Abstract

I document a small spousal earnings response to the job displacement of the family head. The response is even smaller in recessions when earnings losses are larger and additional insurance is most valuable. I investigate whether the small response is an outcome of crowding-out effects of existing government transfers. To accomplish this, I use an incomplete asset markets model with family labor supply and aggregate fluctuations whose predicted spousal labor supply elasticities with respect to transfers are in line with microeconomic estimates both in aggregate and across subpopulations. In this model, counterfactual experiments indeed show that generous transfers in recessions discourage spousal labor supply significantly after the head's job displacement. Given the large incentive costs of transfers, I solve for optimal means-tested transfers paid to poor families and employment-tested transfers paid to the unemployed. Unlike the current policy that maintains generous transfers of both types in recessions, I find that the optimal policy features procyclical means-tested and countercyclical employment-tested transfers.

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1 Introduction

Job displacement has large negative and long-lasting effects on individual labor earnings. These effects are more pronounced when the displacement happens in recessions. The impact of earnings losses on family consumption is mitigated through both public insurance and private insurance. Government transfers in the United States are more generous in recessions. At the same time, households also have access to self-insurance mechanisms, a crucial component of which is spousal labor supply adjustments in response to severe earnings loss within the household.[1] Importantly, the magnitude of spousal labor supply response to unexpected earnings fluctuations depends on the generosity of government transfers made available to these households. Thus, while generous transfers in recessions are thought to alleviate earnings losses in the event of a head's job loss, they may crowd out private insurance in the form of spousal labor supply and, in effect, leave households worse off because of a higher tax burden. Given the interaction of public and private insurance, I ask the following questions: how much do government transfers affect the magnitude of the spousal labor supply response to the family head's job displacement over the business cycle? What is the optimal design of transfers over the business cycle when spousal labor supply is endogenous to policy?

To answer these questions, I first measure the impact of a family head's job displacement in both recessions and expansions on family labor earnings and spousal labor earnings, using data from the Panel Study of Income Dynamics (PSID).[2] Little is known about the change in family and spousal earnings upon the head's job displacement across recessions and expansions, but it has an important role in quantifying the magnitude of private insurance available to families over the business cycle under current public insurance programs. I address this gap by documenting two novel results. First, families enjoy some insurance from the presence of a second earner who was simultaneously employed with the head prior to his displacement. In particular, the decline in family labor earnings is around two-thirds of the decline in the head's labor earnings one year after the job displacement in recessions and expansions. Second, the change in spousal earnings in response to the head's displacement is small, especially after displacements that occur in recessions. Over 10 years after

[1]For example, Blundell, Pistaferri, and Saporta-Eksten (2016) show that family labor supply provides sizeable consumption insurance against wage shocks within the family.

[2]Family labor earnings is defined as the sum of the head's and spouse's labor earnings.

the head's displacement, the average change in spousal earnings relative to the spousal earnings of non-displaced head is only -0.8 percent in recessions and 8 percent in expansions. This result is particularly interesting because one might expect a stronger spousal earnings response during times when the head experiences larger earnings losses. Hence, this finding motivates an investigation of the potential reasons behind the small change in spousal earnings upon the head's displacement in recessions.

I argue that the small spousal earnings response in recessions is an outcome of crowding-out effects of existing government transfers, which feature more generous transfers in recessions relative to expansions (i.e., countercyclical). To investigate this, I use an incomplete asset markets model with family labor supply and aggregate fluctuations. In the model, employed individuals are subject to idiosyncratic job displacement risk, while unemployed individuals face the risk of a long duration without a job because of frictions in the labor market that prevent the formation of matches. Negative and persistent effects of unemployment on individual earnings are captured by human capital depreciation, as in Ljungqvist and Sargent (1998). The strength of the labor market frictions varies over the business cycle: job displacement rate increases, while job finding rates endogenously decrease in recessions since firms decrease vacancy posting when labor productivity is lower. Individuals can partially self-insure against idiosyncratic and aggregate risk through their spouse's labor market earnings, savings of their family in an incomplete asset market, and means-tested and employment-tested government transfers.[3]

The key contribution of this framework is to endogenize the labor supply decisions of both members of the household to changes in government transfer generosity over the business cycle. I show that when the model is calibrated to match the level and cyclicality of i) the head's earnings loss upon job displacement, ii) job finding rates, and iii) government transfers, it generates small changes in spousal earnings upon the head's displacement as I have documented in the data.

I quantify the crowding-out effects of existing government transfers on spousal earnings responses to the head's job displacement over the business cycle in a counterfactual experiment. When government transfers are designed to be less generous in recessions and more generous

[3]The Supplemental Nutrition Assistance Program (SNAP), Earned Income Tax Credit (EITC), and Temporary Assistance for Needy Families (TANF), and Medicaid are examples of means-tested transfers, while Unemployment Insurance (UI) is an example of employment-tested transfers. These types of government transfers are typically available to families with frequently displaced members.

in expansions (i.e., procyclical), I find that spousal earnings increase significantly following the head's displacement in recessions but remain small in expansions. The procyclical policy leaves the marginal utility of consumption high after job loss in recessions and induces spouses to supplement family earnings by working. In expansions, earnings losses are relatively smaller and the marginal value of increasing spousal earnings is lower. Hence, during these times, spousal response to the head's displacement is small and inelastic to government transfer generosity. To ensure that the role of crowding-out effects of transfers in explaining the small spousal earnings response is not overstated in the model, I show that the model implied female labor supply elasticities are in line with empirical estimates. In particular, female participation elasticity with respect to net wages is 0.31 in the model and between $0.15 - 0.43$ in the data. Female earnings elasticity with respect to transfers is 0.37 in the model and 0.44 in the data. Furthermore, the female participation elasticity with respect to net wages in the model is decreasing in household income as in the data. This corroborates why spousal labor supply is more elastic to transfers in recessions when the head's earnings loss is larger.

The results of this counterfactual experiment show that the incentive costs of transfers in the form of reduced spousal labor supply are larger in recessions and smaller in expansions. Since existing transfers are more generous in recessions, there may be potential welfare gains from changing the generosity of government transfers over the business cycle. Motivated by this observation, I study the optimal design of means-tested and employment-tested transfers over the business cycle. In my main optimal policy analysis, I restrict policy instruments to take the form of the means-tested transfer amount and the employment-tested transfer amount as linear functions of current aggregate labor productivity and a constant income tax used to balance the government's budget for any proposed government program.[4]

I find that the optimal policy features procyclical means-tested and countercyclical employment-tested transfers. Overall, however, total government transfers under the optimal policy are procyclical which is in contrast to the current policy that maintains generous transfers in recessions. Means-tested transfers are procyclical because lower transfers in recessions induce a large increase

[4] When solving for the optimal mix of means-tested and employment-tested transfers, I follow a large literature that uses calibrated models to study the optimal policy for a restricted class of policy instruments. See Hansen and Imrohoroğlu (1992), Acemoglu and Shimer (2000), Abdulkadiroğlu, Kuruşçu, and Şahin (2002), Wang and Williamson (2002), Krusell, Mukoyama, and Şahin (2010), and Koehne and Kuhn (2015).

in spousal entry into the labor force upon a head's displacement. This is a direct implication of the high incentive costs of transfers during recessions. Employment-tested transfers are more generous in recessions because these benefits are smaller and short-term, and thus have relatively lower incentive costs on spousal labor supply. As a result, the provision of insurance is better accomplished through more generous employment-tested transfers in recessions when unemployment is higher.

In an economy in which the optimal policy is implemented, female labor force participation is 5 percentage points higher compared to an economy in which the current policy is implemented. Higher employment reduces the income tax required to finance a similar average level of government transfers.[5] Moreover, the economy under the optimal policy is wealthier and has a lower fraction of families with non-positive liquid wealth. These differences in the macroeconomy result in a higher average consumption level and a slightly lower average consumption volatility. Overall, the optimal policy yields an ex-ante welfare gain of around 0.6 percent additional lifetime consumption compared with the current policy. Most of the welfare gains are enjoyed by wealth-poor families with an unskilled male who is married to a skilled female. It is precisely for this family that a spouse's participation in the labor force can bring higher levels of income to the family especially when a displacement of the head occurs.

To understand why accounting for the response of spouses in the presence of transfers is critical in determining the optimal policy, I modify the model such that spousal labor supply is exogenous to government policy. In particular, I keep female labor supply decisions unchanged even when government policy is varied. Abstracting from the incentive costs of transfers on spousal labor supply results in an optimal policy that is more generous on average than the optimal policy in the model with endogenous spousal labor supply. Furthermore, the optimal policy now features slightly countercyclical means-tested and employment-tested transfers because the optimal cyclicality of government transfers is driven largely by the cyclicality of insurance benefits, which is larger in recessions. This exercise shows that endogenizing the spousal labor supply response to changes in government policy is critical in determining both the optimal level and cyclicality of government transfers. As a result, policy makers should recognize that married households have an important source of self-insurance through adjustments in spousal labor supply, and generous payments to these households make them worse-off due to large crowd-out.

[5] I will show in Section 5 that the optimal policy has similar levels of average transfers to the current policy.

Related Literature This paper contributes to the literature that explores the role of female labor supply as an insurance mechanism against idiosyncratic earnings risk within the family. Importantly, Blundell, Pistaferri, and Saporta-Eksten (2016) find that female labor supply provides sizeable consumption insurance against wage shocks faced by the husband. Wu and Krueger (2018) show that a calibrated life-cycle two-earner household model with endogenous labor supply can match well these empirically estimated labor supply and consumption responses to wage shocks within the family.[6] In this paper, I condition the change in spousal earnings and hours in response to the head's job displacement to the aggregate state of the economy, rather than looking at an average spousal response. Empirically, I find small changes in spousal earnings and hours upon the head's job displacement in recessions. In expansions, spousal responses are positive and statistically significant, but only a few years after the head's displacement. I then explore the effects of more generous government transfers on the small changes in spousal earnings upon the head's displacement in recessions and study the optimal design of these transfers over the business cycle.

Another strand of literature studies the optimal design of transfer programs. It is possible to divide this large literature into two groups based on their modeling choices and welfare analysis. The first is a group of papers that study the optimal design of transfers using models with endogenous family labor supply but without aggregate fluctuations (Ortigueira and Siassi 2013, Haan and Prowse 2017, Mankart and Oikonomou 2017).[7] The second is a group of papers that study the optimal design of taxes or transfers in a model with aggregate fluctuations but without endogenous family labor supply as a private insurance mechanism (Mitman and Rabinovich 2015, Birinci and See 2017, McKay and Reis 2017, Bhandari, Evans, Golosov, and Sargent 2018, Kekre 2018, Landais, Michaillat, and Saez 2018).[8] This paper combines these two groups of studies because it analyzes the optimal level and cyclicality of means-tested and employment-tested transfers using a model

[6]Previously, Attanasio, Low, and Sánchez-Marcos (2005) also quantify the role of female labor supply response to earnings risk within the family. They also find that female participation rates increase when risk is larger. Guler, Guvenen, and Violante (2012) study joint search problem of household and show that higher wage offers received by spouses allow the family head to look for better employment opportunities. Furthermore, Rendon and Garcia-Perez (2018) study the change in job search decisions due to the employment risk of the other member and their wealth.

[7]Mankart and Oikonomou (2017) incorporate aggregate fluctuations into their baseline model to explain the acyclicality of labor force participation, which is their main focus. However, when they study the optimal design of UI program, they reduce the model into a stationary environment.

[8]Among these papers, my paper is closest to Birinci and See (2017). There, we emphasize the importance of incorporating endogenous changes in precautionary saving motives in response to changes in UI generosity over the business cycle using a directed search model with aggregate fluctuations and incomplete asset markets. Here, I extend our previous work by analyzing the role of endogenous spousal labor supply response to idiosyncratic and aggregate risk on the optimal mix of means-tested and employment-tested transfers over the business cycle.

with endogeneous family labor supply and aggregate fluctuations. I overcome the computational difficulties encountered in models of this nature through an application of segmented search across skill requirements of jobs, achieved by an extension of block recursivity (Menzio and Shi, 2010, 2011).[9] Relative to the first group of papers, I study the optimal cyclicality of transfers using a model with aggregate fluctuations and find that more than half of the welfare gains from the optimal policy are attributable to its cyclicality since insurance benefits net of incentive costs vary substantially over the cycle. Relative to the second group of papers, I show that endogenizing spousal labor supply changes the optimal level and cyclicality of means-tested transfers.

Finally, this paper contributes to two empirical literatures. The first literature studies the impact of job displacement on individual earnings (Jacobson, LaLonde, and Sullivan 1993, Ruhm 1991, Stevens 1997). More recently, Davis and Von Wachter (2011) estimate the earnings loss upon job displacement separately for recessions and expansions. In addition to individual earnings, I estimate the impact of a head's job displacement in recessions and expansions on family earnings and on spousal earnings and hours. This helps me to quantify the available spousal insurance to displaced individuals in recessions and expansions.[10] The second literature actually estimates the contemporaneous change in spousal earnings upon her husband's unemployment, otherwise known as the "added worker effect", without conditioning on the time of his unemployment (Heckman and MaCurdy 1980, 1982, Lundberg 1985, Cullen and Gruber 2000, Stephens 2002, Hendren 2017). Pruitt and Turner (2018) measure spousal earnings responses to earnings fluctuations of the household head in both recessions and expansions using Social Security Administration data but do not focus on measuring these responses to job displacements. Job displacement events are particularly relevant because their effects are large and long-lasting compared with temporary earnings fluctuations. My paper focuses on measuring the dynamic response of spousal earnings specifically in response to a head's job displacement and how this response varies over the business cycle. I then use these empirical findings in a structural model to understand the effects of government transfers on spousal earnings response to the head's displacement, and then study the optimal design of

[9]To the best of my knowledge, this paper is the first to extend the concept of a block recursive equilibrium in an endogeneous family labor supply model with aggregate fluctuations.

[10]Davis and Von Wachter (2011) also show that standard search and matching models fail to generate such large negative and long-lasting effects of job displacement on labor earnings. More recently, Jarosch (2015), Huckfeldt (2016), Krolikowski (2017), and Jung and Kuhn (2018) develop variants of such models that can endogenously generate these persistent effects of job displacement.

these transfers over the business cycle.[11]

This paper is organized as follows. Section 2 presents the model. Section 3 documents the empirical findings about the impact of the head's displacement on family and spousal earnings, and explains the calibration strategy and the model's validation against untargeted data moments. Section 4 discusses the effects of transfer policies on spousal labor supply response to the head's displacement. Section 5 studies the optimal design of government transfers. In Section 6, I provide a list of extensions and robustness checks on the optimal policy analysis. Finally, Section 7 concludes.

2 Model

In this section, I develop a tractable job search model of families with incomplete asset markets and aggregate fluctuations. The key contribution of this framework is to endogenize labor supply decisions of both members of the household to changes in government transfers.

2.1 Environment

2.1.1 Setting

Time t is discrete and runs forever. The economy is populated by a large number of ex-ante identical households, and each household j consists of a male m and a female f individual i, i.e. $i \in \{m, f\}$ $\forall j$.[12] At any point in time, a household can be in the labor force or retired. I model retirement as an exogenous event. In every period, both members of the household retire with probability ζ_R. Retired households die with probability ζ_D and they are replaced by new households entering into the labor force. Households discount future at rate β.

Households are heterogeneous in terms of their asset holdings a, human capital level of each member h_i, and employment status of each member l_i. An individual can be classified into one of the

[11] A separate literature studies the effects of income taxation on i) the observed time series of married female labor force participation (Kaygusuz 2010), ii) participation of married women over their life cycle (Borella, De Nardi, and Yang 2018), and iii) international differences in married women's hours worked (Bick and Fuchs-Schundeln 2017). These papers conclude that reducing marginal tax rates for married households incude a sizeable increase on the labor supply of married women. Gayle and Shephard (2018) show that the optimal tax system for married couples is characterized by negative jointness, i.e. reducing marginal tax rates on the wife when the husband makes more money. My paper complements them as I show that a decline in the implicit tax rate of work during recessions encourage spousal labor supply upon a large permanent decline in household income.

[12] Throughout the paper, I suppress the index j when it is clear that a variable is a household variable. Instead, I use the index i for individual variables to differentiate them from household variables.

following employment statuses: employed E, unemployed individual who is eligible for employment-tested UI benefits U_b, unemployed individual who is ineligible for such benefits U_n, or retired R.

Households have access to incomplete asset markets where they can save or borrow up to a limit at an exogenous interest rate r. They make joint choices of savings and labor supply of the non-employed members. Preferences of a household are given by

$$U\left(c,\, l_m,\, l_f,\, s_m,\, s_f\right) = u\left(c\right) + \sum_i \eta_i \times \underbrace{\mathbf{1}\left(l_i \neq E,\ \text{and}\ s_i = 0\right)}_{\text{out of labor force}}$$

where $u\left(\cdot\right)$ is a strictly increasing and strictly concave utility function over household consumption level c that satisfies Inada conditions, $s_i \in \{0, 1\}$ is labor supply decision of individual i at the extensive margin, and η_i is the value of leisure.[13] Thus, the above functional form assumes that individuals only enjoy value of leisure if they do not look for jobs when unemployed.[14]

The aggregate state variables of the economy are summarized by $\mu = (z,\, \Gamma)$, where z is aggregate labor productivity, and Γ is the distribution of households across individual states.

2.1.2 Labor market

The labor market is segmented in human capital h, i.e. jobs are characterized by their human capital requirement level h. Vacant firms post job openings in specific human capital submarkets after paying a fixed cost κ of posting a vacancy. On the other side of the labor market, when unemployed individuals decide to participate into the labor market by exerting positive job search effort s_i, they look for jobs that are compatible with their own human capital level.

The labor market tightness of submarket h is defined as the ratio of vacancies v posted in the submarket to the number of unemployed individuals searching for a job within that submarket. It is denoted as $\theta\left(h;\, \mu\right) = \frac{v(h;\mu)}{u(h;\mu)}$. Let $M\left(v, u\right)$ be a constant returns to scale matching function that determines the number of matches in a submarket with number of unemployed u and number of vacancies v. Then, $p\left(h;\, \mu\right) = \frac{M(v(h;\mu),u(h;\mu))}{u(h;\mu)}$ is the job finding rate and $q\left(h;\, \mu\right) = \frac{M(v(h;\mu),u(h;\mu))}{v(h;\mu)}$ is the vacancy filling rate in submarket h when aggregate state is μ. The constant returns to scale

[13] The only parameter that defines gender in this model is η_i. This implies that utility cost of work or search is different between male and female to capture the employment differences between them.

[14] In Section 6, I also analyze the effect of a utility function with non-separable consumption and leisure on my main results, following Blundell, Browning, and Meghir (1994) and Attanasio and Weber (1995).

assumption on the matching function guarantees that the equilibrium object θ suffices to determine job finding and vacancy filling rates since $p(\theta) = \frac{M(v,u)}{u} = M(\theta, 1)$ while $q(\theta) = \frac{M(v,u)}{v} = M\left(1, \frac{1}{\theta}\right)$.

Once matched, the firm-worker pair operates a constant returns to scale technology that converts one indivisible unit of labor into final consumption goods. The amount of production output is given by $g(h, z)$, where $g(\cdot)$ is strictly increasing function of both worker's human capital level h, and aggregate productivity z. Firm pays a wage $w(h, z)$ to the worker. I assume that the period output is shared between the firm and the worker. In particular, worker receives α share of the period output as wage, which implies that $w(h, z) = \alpha g(h, z)$.[15]

The firm-worker pair continues to operate until the match exogenously dissolves with probability $\delta(h, z)$ or the worker retires with probability ζ_R. $\delta(\cdot)$ is a decreasing function of both h and z.

2.1.3 Human capital dynamics

Human capital of an individual h lies in an equispaced grid $\mathcal{H} \equiv \{h_L, ..., h_H\}$. All newborn individuals begin with the lowest skill level. Employed and unemployed individuals experience stochastic accumulation or depreciation of skills as in Ljungqvist and Sargent (1998). For an unemployed individual with human capital level h, human capital evolves as follows:

$$h' = \begin{cases} h & \text{with probability} \quad 1 - \pi^U \\ h - \Delta^U(z) & \text{with probability} \quad \pi^U. \end{cases}$$

Similarly, for an employed individual with human capital level h, human capital evolves as follows:

$$h' = \begin{cases} h + \Delta^E & \text{with probability} \quad \pi^E \\ h & \text{with probability} \quad 1 - \pi^E. \end{cases}$$

The only extra assumption in this process when compared to the one in Ljungqvist and Sargent

[15] This assumption is similar to Herkenhoff, Phillips, and Cohen-Cole (2017) and it serves for two purposes. First, when I analyze the role of government transfers in explaining the small changes in spousal earnings upon head's displacements in recessions, this assumption implies that varying the government policy does not affect equilibrium wages and thus firm vacancy posting decisions, leaving the labor demand same across policies. This allows me to better isolate the effect of transfers on labor supply. Second reason is tractability. This is because if unemployed also choose the wage submarket when looking for jobs, I would then need to keep track of wage levels of employed members of the household as additional state variables. I refrain doing this in the baseline model, but, in Section 6, I extend the baseline model to endogenize wage choices of the unemployed into a directed search model, and analyze the effects of this assumption on my main results.

(1998) is that I allow Δ^U to vary over the business cycle z. This assumption helps the model to generate cyclical difference in the magnitude of individual earnings drop upon job displacement, as documented by Davis and von Wachter (2011).[16]

2.1.4 Government transfers

Government runs three transfer programs: means-tested transfers, employment-tested transfers, and retirement transfers. Employment-tested and means-tested transfers are paid to only eligible households in the labor force, while only retired households receive retirement transfers. The time-invariant amount of retirement transfers paid to the retired households is given by b_R.

Eligibility for the means-tested transfers is determined at the household level. A household is eligible for the means-tested transfers if the amount of household assets a is lower than an asset threshold $\underline{a}$, and the amount of household labor income y (which is the summation of the labor income of male and female) is lower than an income threshold $\underline{y}$. Both $\underline{a}$ and $\underline{y}$ are policy instruments of the government. Eligibility for means-tested transfers never expires as long as the income and assets tests are satisfied. The amount of means-tested transfers may also vary over the business cycle, and it is given as follows:[17]

$$\phi(z; a, y) = \begin{cases} \phi(z) & \text{if} \quad y < \underline{y},\, a < \underline{a} \\ 0 & \text{otherwise.} \end{cases}$$

Eligibility for the employment-tested transfers is determined at the individual level. An individual may be eligible U_b or ineligible U_n for employment-tested transfers upon job displacement, and the eligible individual only starts receiving these transfers if he/she actively searches for a job, i.e. $s_i > 0$.[18] Employment-tested transfers stochastically expire at rate e, as in Fredriksson and

[16] In principle, the model generates larger earnings losses upon displacements in recessions relative to displacements in expansions due to endogenously lower job finding rates in recessions. However, this alone is insufficient to generate the observed difference in magnitude. Hence, the extra assumption on larger human capital loss when unemployed in recessions is needed. Moreover, this assumption is in fact reasonable, given that most of the human capital is indeed occupation specific (Kambourov and Manovskii 2009), and finding a job within the same occupation is much more difficult in recessions (Huckfeldt 2016).

[17] I restrict the policy instruments to depend on the aggregate state of the economy μ only through the current aggregate productivity z and not through the distribution of individuals across states Γ. This restriction allows my model to retain the block recursitivity, which I will explain in Section 2.4.

[18] Here, I assume that government can observe the search behavior of the unemployed. In the U.S., UI offices may verify job search activities of UI recipients by asking them to fill a form about name, location, and contact information of the employer that recipients have recently contacted. In Section 6, I remove the assumption that search effort is

Holmlund (2001), Albrecht and Vroman (2005), Faig and Zhang (2012), and Mitman and Rabinovich (2015). This assumption simplifies the solution of the model because I do not need to carry the unemployment duration as another state variable for the eligible unemployed. The generosity of employment-tested transfers b and the expiration rate e may vary over the business cycle. Hence, the amount of employment-tested transfers is given as follows:

$$b\left(z;\, l_i,\, s_i\right) = \begin{cases} b\left(z\right) & \text{if} \quad l_i = U_b,\, s_i > 0 \\ 0 & \text{otherwise.} \end{cases}$$

To finance these programs, government levies a flat income tax τ applied to labor income, employment-tested transfers, and retirement transfers.[19] The government balances the following budget constaint in expectation:[20]

$$\sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^{t}\times\Big[\sum_{i}\mathbf{1}_{\{l_{it}=E\}}w_{it}\tau-\sum_{i}\mathbf{1}_{\{l_{it}=U_b,\, s_{it}>0\}}b_t\left(1-\tau\right)-\sum_{j}\mathbf{1}_{\left\{y_{jt}<\underline{y},\, a_{jt}<\underline{a}\right\}}\phi_t-\sum_{j}\mathbf{1}_{\{l_{jt}=R\}}b_R\left(1-\tau\right)\Big]=0 \tag{1}$$

where the terms in the bracket respectively are total income tax revenues generated from employed individuals, net employment-tested transfers paid to eligible unemployed individuals with positive search effort, total means-tested transfers paid to eligible households, and net retirement transfers paid to retired households.

2.1.5 Timing

Every single period t is divided into three stages. In the first stage, ζ_R fraction of households in the labor force retires, and ζ_D fraction of retired households dies and they are replaced with new households entering into the labor force. Then, aggregate productivity z realizes. The period productivity level z completely determines i) the government policy of generosity of employment-tested transfers $b\left(z\right)$, its expiration rate $e\left(z\right)\in[0,1]$, and the generosity of means-tested transfers

observable to the government and check the implications on my main results.

[19] According to the U.S. tax policy, social security and UI benefits are subject to income tax, while means-tested transfers are mostly non-taxable. Moreover, in Section 6, I also analyze the effects of progressive taxation on the main results.

[20] This assumption is motivated by the fact that according to the current transfer system in the United States, states are allowed to borrow from a federal fund. For example, states may borrow from federal UI trust fund when they meet certain federal requirements, and thus they are allowed to run budget deficits during some periods.

$\phi(z)$, ii) the exogenous job separation rate $\delta(h, z) \in [0,1]$ in each submarket h. This implies that $\delta(h, z)$ fraction of those who were employed in $t-1$ in each submarket h loses their jobs and must spend at least one period being unemployed. Among those who lose their job, $e(z)$ fraction become ineligible for employment-tested transfers.

Search and matching in the labor market occurs in the second stage. Vacant firms decide the human capital submarket in which to post a vacancy, while the unemployed individuals look for a job in a submarket that is compatible their own human capital level. Then, $p(h, z)$ fraction of unemployed individuals searching for a job in submarket h finds a job. Human capital stochastically evolves based on labor market outcomes. Finally, the third stage is the production and consumption stage. Each firm-worker pair produces $g(h, z)$ units of consumption goods. Wages are paid to workers, employment-tested transfers are paid to eligible unemployed individuals, means-tested transfers are paid to eligible households, and retirement income is paid to retired households. Each household then makes their joint saving/borrowing decision. Prior to time $t+1$, households in the labor force jointly decide whether its unemployed members will supply labor in the labor market stage of time $t+1$ where the forgone utility of leisure for the member with positive labor supply is incurred at time t.

2.2 Household Problem

A household's state vector consists of the net asset level $a \in \mathcal{A} \equiv [a_L, a_H] \subseteq \mathbb{R}$, the current employment status of each member $l_i \in \{E, U_b, U_n, R\}$, and the current human capital level of each member $h_i \in \mathcal{H} \equiv \{h_L, ..., h_H\}$.

The aggregate state is denoted by $\mu = (z, \Gamma)$, where $z \in \mathcal{Z} \subseteq \mathbb{R}_+$ denotes the current aggregate productivity and $\Gamma : \{E, U_b, U_n, R\} \times \{E, U_b, U_n, R\} \times \mathcal{A} \times \mathcal{H} \times \mathcal{H} \to [0, 1]$ denotes the distribution of agents across employment statuses, asset level, and human capital levels. The law of motion for the aggregate states is given by $\Gamma' = \Lambda(\mu, z')$ and $z' \sim \Phi(z' \mid z)$.

Among the households in the labor force, there are nine distinct types of households in terms of the employment statuses of their members, given that individual employment status for the individuals in the labor force can take three different values, i.e. $l_i \in \{E, U_b, U_n\}$. Thus, there are nine different value functions for such households. In the main text, I will lay out the recursive problem of three types of households: i) one member is employed, the other is eligible unemployed,

ii) both members are eligible unemployed, and iii) both members are employed. I will then discuss the changes for the problems of other types of households. Finally, I will show the recursive problem of the retired households.

Let $V^{l_m l_f}$ denote the value function of household with male's employment status of l_m and female's employment status of l_f after search and matching has occurred, i.e. the value at the start of third stage of a period. Let $\mathbf{h} \equiv (h_m,\, h_f)$ and $\mathbf{l} \equiv (l_m,\, l_f)$ be the human capital and employment state vectors of the household. To simplify the notation further in the recursive formulations below, let $\delta_i \equiv \delta\,(h_i,\, z)$ and $p_i \equiv p\,(h_i,\, z)$ be the job displacement rate and job finding rate of individual $i \in \{m,\, f\}$, and δ_i' and p_i' denote the respective probabilities in the next period. Finally, let $\lambda_b = 1 - e\,(z)$ be the probability that eligibility for employment-tested benefits does not expire, and $\lambda_n = e\,(z)$ be the expiration probability. Similarly, λ_b' and λ_n' denote the respective probabilities in the next period.

2.2.1 Employed - unemployed household

First, consider a household in which the male is employed and the female is eligible unemployed. The recursive problem of this household is given as follows:[21]

$$
\begin{aligned}
V^{EU_b}\,(a,\, \mathbf{h};\, \mu) \quad &= \quad \max_{a' \geq a_L,\, s_f \in \{0,1\}} \quad u\,(c) + \eta_f\,(1 - s_f) \\
&+ \quad \beta\Big[(1-\zeta_R)\,\mathbb{E}_{\mathbf{l}',\mathbf{h}',\mu'}\left[V^{l'}\,(a',\, \mathbf{h}';\, \mu')\,\Big|\, s_f, \mathbf{l}, \mathbf{h}, \mu\right] + \zeta_R V^R\,(a')\Big] \qquad (2)
\end{aligned}
$$

subject to

$$
\begin{aligned}
& c + a' \leq (1+r)\,a + y + \phi\,(z;\, a,\, y) + b\,(z;\, U_b,\, s_f)\,(1-\tau) \\
& y = w\,(h_m,\, z)\,(1-\tau) \\
& \Gamma' = \Lambda\,(\mu,\, z') \quad \text{and} \quad z' \sim \Phi\,(z' \,|\, z)\,.
\end{aligned}
$$

In the current period, the household decides savings and female labor force participation, given that she is the non-employed member of the household. If the household stays in the labor force with probability $1-\zeta_R$, the household takes expectation over the transition of employment statuses, human capital levels of both members, and the aggregate states, conditional on current employment

[21] The problem of the symmetric household is identical to this household's problem with the change of indices for m and f.

statuses, human capital levels of both members, and the job search decision for the female. If the household retires with probability ζ_R, then the only relevant state variable is assets a. The household receives employment-tested transfers only if eligible female searches for a job in the current period. Given that male is only employed member of the household, total labor income of the household y is equal to his net wage.

For the household in which male is employed but female is ineligible unemployed, the above problem is the same except that she does not receive employment-tested transfers even if she searchers for a job. This captures the fact that according to current UI policy in the United States, the unemployed receive UI benefits only for a certain number of weeks - which varies over the business cycle - and once that threshold is reached, the unemployed cannot continue to collect UI benefits.

It is also insightful to discuss the expectation over the transition of employment statuses of this household, which I lay out below:[22]

$$\begin{aligned}
\mathbb{E}_{\mathbf{l}',\mathbf{h}',\mu'}\left[V^{l'}\left(a',\mathbf{h}';\mu'\right)\middle|s_f,\mathbf{l},\mathbf{h},\mu\right] = \mathbb{E}_{\mathbf{h}',\mu'}\Bigg[& s_f\left(1-\delta'_m\right)\left(p'_f V^{EE}\left(a',\mathbf{h}';\mu'\right)+\left(1-p'_f\right)\sum_{k\in\{b,n\}}\lambda'_k V^{EU_k}\left(a',\mathbf{h}';\mu'\right)\right) \\
& + s_f\delta'_m\left(p'_f\sum_k \lambda'_k V^{U_kE}\left(a',\mathbf{h}';\mu'\right)+\left(1-p'_f\right)\sum_{k,d\in\{b,n\}}\lambda'_k\lambda'_d V^{U_kU_d}\left(a',\mathbf{h}';\mu'\right)\right) \\
& + \left(1-s_f\right)\left(1-\delta'_m\right)\sum_k \lambda'_k V^{EU_k}\left(a',\mathbf{h}';\mu'\right) \\
& + \left(1-s_f\right)\delta'_m\sum_{k,d\in\{b,n\}}\lambda'_k\lambda'_d V^{U_kU_d}\left(a',\mathbf{h}';\mu'\right)\Bigg)\Bigg|\mathbf{h},\mu\Bigg].
\end{aligned}$$

The first line in the right hand side is the case when she searches for a job in the current period and he keeps his current job. In this case, if she finds the job, the household will be an employed - employed household, otherwise the household will continue to be an employed - unemployed household but she may retain or lose eligibility for employment-tested transfers. The second line describes the case when she searches for a job and he loses his current employment. Then, if she finds a job, the household will be an unemployed - employed household where the male may or may not be eligible for employment-tested transfers.[23] If she cannot find a job, then both members

[22]Expectations over human capital levels and aggregate states are relatively simpler and are already discussed in the previous sections.

[23]According to the current UI policy in the United States, not all workers transitioning into unemployment qualify for UI benefits. In particular, individuals do not qualify for benefits if they voluntarily quit their job or if they do

of the household will be unemployed, and they will both face eligibility risk for the employment-tested transfers. The third line is the case when she does not search for a job and continue to be unemployed with or without eligibility, and he keeps his current job. Finally, the last line shows the case when she does not search for a job and he loses his job. In this case, again, both members of the household will be unemployed, and they will both face eligibility risk for the employment-tested transfers.

For the household in which male is employed but female is ineligible unemployed, the above expectation is the same except that she stays ineligible for employment-tested transfers if she does not find a job.[24]

2.2.2 Unemployed - unemployed household

Second, consider a household in which both male and female are eligible unemployed. The recursive problem of this household is given as follows:

$$
\begin{aligned}
V^{U_b U_b}\left(a, \mathbf{h}; \mu\right) \quad = & \quad \max_{a' \geq a_L,\, s_m, s_f \in \{0,1\}} u\left(c\right) + \sum_{i \in \{m, f\}} \eta_i \left(1 - s_i\right) \\
+ & \quad \beta \Big[\left(1 - \zeta_R\right) \mathbb{E}_{\mathbf{l}', \mathbf{h}', \mu'} \left[V^{l'}\left(a', \mathbf{h}'; \mu'\right) \Big| s_m, s_f, \mathbf{l}, \mathbf{h}, \mu \right] + \zeta_R V^R\left(a'\right) \Big]
\end{aligned} \tag{3}
$$

subject to

$$
\begin{aligned}
& c + a' \leq \left(1 + r\right) a + \phi\left(z;\, a,\, 0\right) + \Big[b\left(z;\, U_b,\, s_m\right) + b\left(z;\, U_b,\, s_f\right) \Big] \left(1 - \tau\right) \\
& \Gamma' = \Lambda\left(\mu,\, z'\right) \quad \text{and} \quad z' \sim \Phi\left(z' \,|\, z\right).
\end{aligned}
$$

Given that both members of the household are now unemployed, the household chooses labor supply of both members. Moreover, both members enjoy leisure if they do not look for a job, in which case they do not receive employment-tested transfers even if they are both eligible. In the current period, the household does not have any labor income.

Similarly, for the household in which any unemployed member is ineligible unemployed, the above problem is the same except that this member does not receive employment-tested transfers

not meet requirements for wages earned or time worked during an established period of time referred to as the base period.

[24] This captures the fact that according to current UI policy in the United States, the unemployed individuals receive UI benefits only for a certain number of weeks - which varies over the business cycle - and once that threshold is reached, the unemployed cannot continue to collect UI benefits.

even if he/she searchers for a job.

The expectation term in the right hand side of Equation (3) is similar to the one I discussed in Equation (2) except that employment statuses of both members in the next period are determined by their labor supply decisions and job finding rates. In Appendix A, I lay out and discuss the expectation over the transition of employment statuses of this household.

2.2.3 Employed - employed household

Next, consider a household in which both male and female are employed. The recursive problem of this household is given as follows:

$$\begin{aligned} V^{EE}(a,\, \mathbf{h};\, \mu) \quad &= \quad \max_{a' \geq a_L} \quad u(c) + \beta \Big[(1-\zeta_R)\, \mathbb{E}_{\mathbf{l}',\mathbf{h}',\mu'} \Big[V^{l'}(a',\, \mathbf{h}';\, \mu') \,\Big|\, \mathbf{l}, \mathbf{h}, \mu \Big] + \zeta_R V^R(a') \Big] \\ &\text{subject to} \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (4) \\ &\qquad c + a' \leq (1+r)\, a + y + \phi(z;\, a,\, y) \\ &\qquad y = \Big[w(h_m,\, z) + w(h_f,\, z) \Big] (1-\tau) \\ &\qquad \Gamma' = \Lambda(\mu,\, z') \quad \text{and} \quad z' \sim \Phi(z' \,|\, z)\,. \end{aligned}$$

The employed - employed household chooses only consumption vs savings given that there is no on-the-job-search in the baseline model. Individuals of this household are not eligible for employment-tested transfers. Total labor earnings of the household is equal to the sum of net wages of male and female.

The expectation term in the right hand side of Equation (4) is similar to the one I discussed in Equation (2) except that employment statuses of both members in the next period are determined only by their job separation rates. In Appendix A, I lay out and discuss the expectation over the transition of employment statuses of this household.

2.2.4 Retired household

Finally, I discuss the problem of retired households. Here, I assume that both members of the households retire at the same time and the household receives a time-invariant retirement transfers b_R upon retirement. In every period, retired households die with probability ζ_D and they are replaced with new households entering into the labor force. I also assume that retired members of the households do not enjoy leisure. Given that the retired household is not allowed to re-enter into the labor market and that the retirement households receive time-invariant transfers, the state variables of such households reduce to only their asset holdings a.[25]

Let V^R be the value of a retired household. The recursive problem of this household is given as follows:

$$\begin{aligned} V^R(a) &= \max_{a' \geq a_L} \quad u(c) + \beta(1-\zeta_D) V^R(a') \\ \text{subject to} & \\ & c + a' \leq (1+r) a + b_R \end{aligned} \tag{5}$$

2.3 Firm Problem

First, consider a firm that is matched with a worker in submarket h when the aggregate state is μ. The pair operates under a constant returns to scale technology and produces $g(h, z)$ units of output, and the worker is paid a wage of $w(h, z)$. With some probability $\delta(h, z)$ the match dissolves, and the worker retires with probability ζ_R. Let $J(h; \mu)$ be the value of a matched firm in submarket h when the aggregate state is μ. The recursive problem of this firm is given as follows:

$$J(h; \mu) = g(h, z) - w(h, z) + \frac{1}{1+r}(1-\zeta_R)\mathbb{E}_{h',\mu'}\left[(1-\delta(h', z')) J(h'; \mu') \Big| h, \mu\right] \tag{6}$$

subject to

$$\Gamma' = \Lambda(\mu, z') \quad \text{and} \quad z' \sim \Phi(z' \mid z).$$

Meanwhile, the value of a vacant firm that posts a vacancy in submarket h under aggregate state μ is given by

$$V(h; \mu) = -\kappa + q(\theta(h; \mu)) J(h; \mu) \tag{7}$$

where κ is a fixed cost of posting a vacancy that is financed by risk-neutral foreign entrepreneurs who own the firms.

When vacant firms decide the submarket in which to post a vacancy to maximize profits, they

[25] Relaxing the assumptions about leisure or transfer payments to retired households has only small quantitative effects on the baseline calibration of the model.

face the trade-off between the probability of filling a vacancy and the level of surplus from a possible match. This is because if a firm posts a vacancy in a high human capital submarket, then the firm's surplus from the match in that submarket will be higher given that the period output net of wages is increasing in h and job displacement rate $\delta(\cdot)$ is decreasing in h. However, the probability of filling the vacancy is lower in high human capital submarkets given that few unemployed individuals are able to visit such submarket to search for a job.

The free entry condition implies that profits are just enough to cover the cost of filling a vacancy in expectation. As a result, the owner of the firm makes zero profits in expectation. Thus, $V(h;\, \mu) = 0$ for any submarket h such that $\theta(h;\, \mu) > 0$. Then, imposing the free entry condition to Equation (7) yields the equilibrium market tightness:

$$\theta(h;\, \mu) = \begin{cases} q^{-1}\left(\frac{\kappa}{J(h;\, \mu)}\right) & \text{if} \quad h \in \mathcal{H}(\mu) \\ 0 & \text{otherwise.} \end{cases} \tag{8}$$

The equilibrium market tightness contains all the relevant information needed by households to evaluate the job finding probabilities at each submarket.

2.4 Equilibrium

Definition of the Recursive Equilibrium: Given government policies $\left\{b(z), e(z), \phi(z), \underline{a}, \underline{y}, b_R, \tau\right\}_{z\in\mathcal{Z}}$, a recursive equilibrium is a list of household policy functions for assets $\left\{a'^{l_m l_f}(a,\, \mathbf{h},\, \mu)\right\}_{l_m, l_f \in \{E, U_b, U_n, R\}}$ and labor supply of unemployed members of the household $\left\{s_i(a,\, \mathbf{h},\, \mu)\right\}_{i\in\{m,\, f\}}$, a labor market tightness function $\theta(h;\, \mu)$, and an aggregate law of motion $\mu' = (z',\, \Gamma')$ such that

1. Given government policy, shock processes, and the aggregate law of motion, the household's policy functions solve their respective dynamic programming problems (2), (3), (4), and similar problems for other types of households.
2. The labor market tightness is consistent with the free entry condition (8).
3. The government budget constraint (1) is satisfied.
4. The law of motion of the aggregate state is consistent with household policy functions.

Notice that in order to solve the recursive equilibrium defined above, one must keep track of an infinite dimensional object Γ in the state space, making the solution of the model infeasible. To address this issue, I utilize the structure of the model and use the notion of block recursive equilibrium (BRE) developed by Menzio and Shi (2010, 2011).

Definition of the Block Recursive Equilibrium (BRE): A BRE for this economy is an equilibrium in which the value functions, policy functions, and labor market tightness depend on the aggregate state of the economy μ, only through the aggregate productivity z, and not through the aggregate distribution of agents across states Γ.

The model presented here is block recursive. Notice that the only payoff relevant individual state variable of the unemployed for the firm is the human capital level h of the unemployed because h determines the level of output, wage, and separation risk of the match. Thus, given that the segmented labor market allows unemployed to self-select into a specific submarket in searching for a job that is compatible with their own human capital level, once the firm is inside this submarket, it does not need to know the entire distribution of unemployed across the domain of the state space. Moreover, firms are indifferent across human capital submarkets when they are posting a job opening because of the trade-off between vacancy filling rate and their surplus from a match, and the free entry condition for firms guarantees the entry of firms until the profits are run down to zero. Finally, the constant returns to scale feature of the matching function implies that the relative ratio of vacancies to number of unemployed visiting each submarket, i.e. the market tightness, matters for agents when they make their own decisions. These features, together with the assumption that government policy instruments are functions of aggregate productivity z, allows the model to admit block recursivity. In Appendix D, I provide a proof for the existence of BRE for an extended version of the baseline model with endogeneous wages, which also shows that the baseline model is also block recursive. Appendix E provides a computational algorithm for solving BRE.

The block recursivity of the model is very useful because it allows me to solve the model numerically without keeping track of the aggregate distribution of agents across states Γ. This becomes especially important when I solve for the optimal government transfers, which requires solving the equilibrium and finding the tax rate that balances the government budget over a long simulation period for each set of policy instruments.

3 Calibration and Validation

I calibrate the stochastic steady state of the model to match key labor market moments pre-Great Recession. Besides these, I also calibrate the model to match three particularly important moments: the level and cyclicality of i) head's earnings drop upon job loss, ii) government transfers, and iii) job finding rates. It is important to match the depth and cyclicality of heads' earnings losses because it determines how critical the role of both public and private insurance when a displacement in the family occurs. Likewise, matching the average generosity of government transfers and how it varies over the business cycle allows me to correctly quantify the insurance benefits of increasing or decreasing transfers as well as its incentive costs on family labor supply. Finally, the model must also match well how job finding rates vary over the cycle since this directly affects the strength of private insurance mechanisms through family employment. Since job finding rates are low in recessions, spouses may find it difficult to find a job and may thus not be able to provide adequate insurance to the family.

Next, I validate the calibrated model against the change in family earnings and spousal earnings upon head's job displacements in recessions and in expansions, consumption drop upon job displacement, marginal propensity to consume (MPC) level and cyclicality, asset-to-income distribution, and correlation between head and spouse displacements.

Among these data moments, I emphasize the effect of head's job displacement on head's own earnings, family earnings, and spousal earnings, as these turn out to be key in understanding the effects of transfers on spousal labor supply as well as in correctly quantifying the insurance benefits and incentive costs of these transfers. Thus, I will now measure these moments from the data. The magnitude of head's own earnings loss upon displacements will be a calibration input, while the effects of head's displacement on family and spouse earnings will be validation inputs.

3.1 Earnings loss upon job displacement over the business cycle

3.1.1 Data and methodology

In this section, I use data from Panel Study of Income Dynamics (PSID) between 1968-2015 to study the changes in head earnings and hours, spouse earnings and hours, and family earnings upon a family head's job displacement over the business cycle. For this analysis, I restrict the sample to families in which both the husband and the wife are between ages of 20 and 60 who are not in the Latino sample. I drop families with only one year of observation and those above the 99th percentile of family labor income distribution.[26] I create variables for involuntary job displacement using a question that asks the reason for losing the previous job to individuals who are either without a job or have been employed in their current job for less than a year. Following the literature, I define an involuntary job loss as a separation due to firm closure, layoff or firing.[27] This way, I only consider unexpected separations so that I can eliminate cases in which family were informed about the separation and spouses were already searching for a job. The resulting unbalanced sample of families contains $86,541$ observations on $9,383$ families with $1,204$ of them experiencing at least one displacement in a recession, and $2,269$ of them experiencing at least one displacement in an expansion. The family head of 674 families have at least one displacement event both in recessions and expansions. In this sample, there are $1,573$ displacements in recessions, and $3,517$ displacements in expansions. Appendix B provides more details about the data and sample selection.

Table 1 compares the characteristics of families in which the head is never displaced whenever family is surveyed with characteristics of families in which the head of the family is displaced at least once. Couples of the families in which the head experiences a job displacement are slightly younger and less educated than families in which the head is never displaced. On average, displaced heads and their spouses work relatively lower hours than never displaced heads and their spouses even in the year prior to displacement.

To study the effects of head's job displacement on his individual earnings and hours, spousal earnings and hours, and family earnings, I adopt the regression specification in Jacobson, LaLonde, and Sullivan (1993) and Stevens (1997) given as follows:[28]

$$y_{it} = \beta X_{it} + \sum_{k\geq -2}^{10} \psi_k D_{it}^k + \alpha_i + \gamma_t + \epsilon_{it} \tag{9}$$

[26]Table A.1 and Table A.2 in Appendix B show that main results of this section are robust to alternative sample selections.

[27]The latter category includes workers who report that they have been fired, which is typically not considered as an exogenous job displacement event. However, Boisjoly, Duncan, and Smeeding (1994) report that only 16% of the workers in the layoff or fired category have indeed been fired.

[28]Based on the definition of the head in the PSID, family head is almost always male. In my sample, only 49 observations have female head among $86,541$ observations.

Table 1: Summary Statistics for Families with and without Job Displacement

	Never Displaced*	Displaced°
Head's age	36.49	32.90
Spouse's age	34.38	30.99
Head's education	15.49	13.19
Spouse's education	15.02	13.07
White (%)	67.96	57.03
Number of children	1.30	1.52
Number of young children	0.51	0.65
Head's annual hours	2,154	1,851
Spouse's annual hours	1,288	1,142
Head's industry - Manufacturing (%)	18.38	19.76
Number of families	6,584	2,799

Note: This table shows unweighted averages of selected characteristics for never displaced families (i.e. families in which the head of the family is never displaced during all times the family is observed in the survey), and displaced families (i.e. families in which the head of the family is displaced at least once). Data is obtained from PSID 1968-2015 surveys for families in which both the husband and the wife are between the ages of 20 and 60 and are not in the Latino sample.
* Averages are obtained using all observations for families with never-displaced head.
° Averages are obtained from the survey year prior to the displacement year of the head.

The outcome variable y_{it} include the real annual labor earnings of the head, spouse, and the family (defined as the sum of head and spouse labor earnings), as well as the head's and spouse's annual working hours.[29] The variable X_{it} is a vector of time-varying family characteristics, including a quadratic term of the head's experience, a quadratic term of spouse's experience, the number of children, and the number of young children with age less than 6. α_i captures time invariant unobserved error component associated with family i, and γ_t is an error component common to all families in the sample at year t. The vector of dummy variables D^k_{it} indicate a job displacement of the head in a future, current, or previous year. For example, $D^3_{it} = 1$ if the individual i is displaced at time $t-3$, and zero otherwise. I estimate the impact a head's job displacement on individual and spousal earnings and hours as well as family earnings in the two years preceding job loss ($k = -2, -1$), in the year of job loss ($k = 0$), and in every year until 10 years after job loss ($k = 1, 2, ..., 10$). Thus, ψ_k captures the effect of job displacement on outcome variables in families whose head were displaced k years prior/after (treatment group) relative to families whose

[29]Labor earnings include wages and salaries, bonuses, overtime, tips, commissions, professional practice or trade, market gardening, miscellaneous labor income, and extra job income.

head has never been displaced (control group). Thus, individuals in the control group would have $D_{it}^k = 0$ for all years t. In all of the results below, the relative change of an outcome variable means the change in the outcome variable of the treatment group relative to the change in the outcome variable of the control group.[30]

In order to measure the differential effects of job displacements in recessions and in expansions on outcome variables, I group displacements into those that occurred in recessions and those that occured in expansions using NBER business cycle definitions. This means that when a displacement occurs in a recession year t, the individual is considered to be part of the treatment group that is displaced in recessions. I then estimate the regression Equation (9) for i) a treatment group where the head is displaced only in recessions and a control group where the head is never displaced, and ii) a treatment group where the head is displaced only in expansions and a control group where the head is never displaced. The regressions are estimated with fixed effects and robust standard errors clustered at the family level. In the following figures I report estimated ψ_k as a percent of the pre-displacement mean value of the outcome variable.

3.1.2 Head earnings

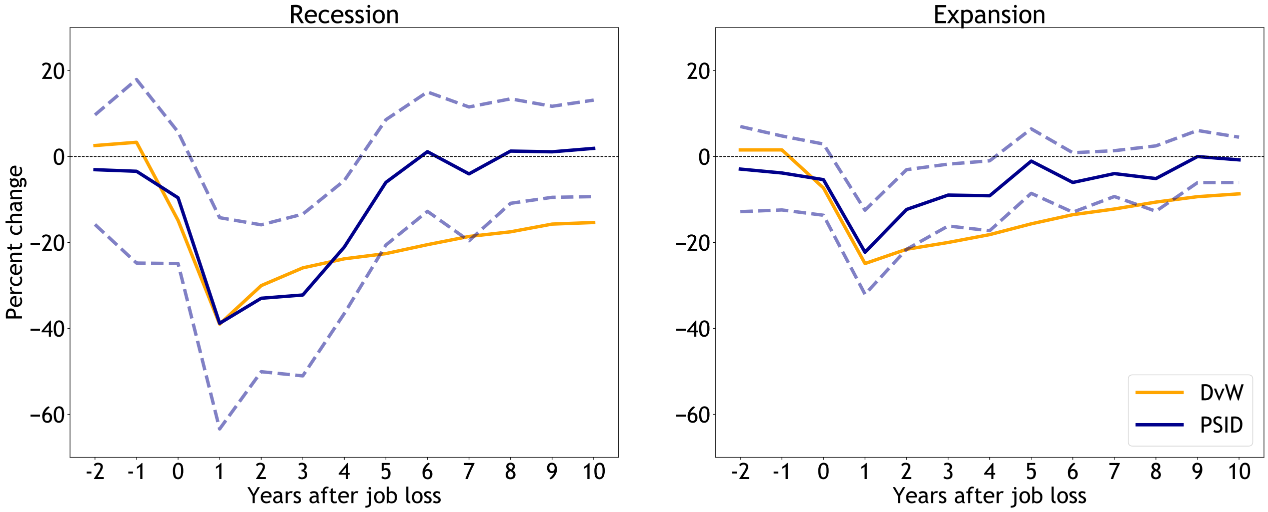
Figure 1 shows the change in relative labor earnings of the family head upon job displacement in recessions and expansions. The solid blue line shows the estimated coefficeints $\{\psi_k\}_{k=-2}^{10}$ as a percent of pre-displacement mean labor earnings of displaced heads, and the dashed light blue line shows the 90 percent confidence interval. I compare these results that I obtain from the PSID to the estimates of Davis and von Wachter (2011) who use Social Security Administration (SSA) data between 1974-2008.[31] I find that the magnitude of the average drop in head's relative labor earnings is larger when the head is displaced in recessions. In the year following the job displacement, the relative earnings drop by 39 percent in recessions and only 22 percent in expansions.[32] These

[30] Individuals who experience an unemployment spell because of reasons other than displacement (such as quits) are part of the control group.

[31] My econometric model is slightly different than the model that Davis and von Wachter (2011) use. In their analysis, they regress equation (9) for every year, obtain δ_k for each of these years, and then report the average values of δ_k across these years. Given that my sample size is smaller in PSID, I follow the baseline specification applied by Jacobson, LaLonde, and Sullivan (1993) and Stevens (1997) who also use PSID. However, I still compare my results to Davis and von Wachter (2011) results because they provide the only empirical baseline for cyclicality of the magnitude of earnings drop upon job displacement.

[32] This finding is similar to results in the previous literature that estimates the earnings loss upon job displacement without conditioning the timing of displacement. Jacobson, LaLonde, and Sullivan (1993) find 25 percent, Stevens (1997) finds 30 percent, Stephens (2002) finds 30 percent, and Huckfeldt (2016) finds 32.5 percent drop in individual

Figure 1: Relative Labor Earnings of Family Head upon Job Displacement



Note: This figure plots the changes in relative labor earnings of the family head upon his job displacement in recessions (left panel) and expansions (right panel). I estimate the changes in relative labor earnings from a distributed lag-recession model using PSID. The solid blue line shows the point estimates and the dashed light blue line shows the 90 percent confidence interval. I compare these results to the estimates of Davis and von Wachter (2011) given by the orange line.

results are consistent with the findings of Davis and von Wachter (2011) as they also document larger earnings losses upon displacements that occur in recessions (39 percent) than in expansions (25 percent). Furthermore, I find that these earnings losses upon job displacement over the business cycle are persistent. Labor earnings of the head recover after 5 years upon displacements in recessions and expansions. A notable difference between my results and Davis and von Wachter (2011) is that, according to my results, the persistence of earnings losses is not as prolonged as their findings wherein individual earnings do not recover even 10 after years following displacements in recessions and expansions. This difference is partly because my sample is restricted to married or cohabiting households. The labor earnings of married men is typically larger than single men, given that they have higher education levels on average.

Figure A.1 in Appendix B measures the effect of a head's job displacement over the business cycle on his annual hours. I find that hours recover relatively quickly. Moreover, results suggest that both the cyclical gap in earnings loss upon displacements over the business cycle and the persistence of earnings losses are largely explained by a drop in wages rather than a drop in hours.

---

earnings upon displacement using annual data from PSID (until 1997 survey). Moreover, Saporta-Eksten (2014) shows that relative hourly wages of laid-off workers drops by around 30 percent in the year following job loss.

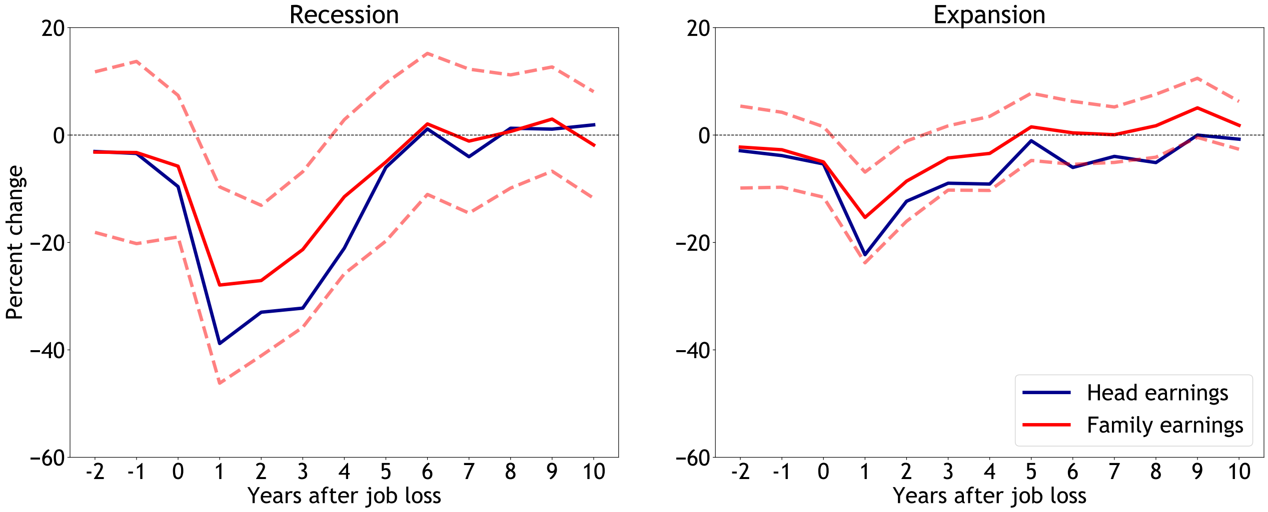
3.1.3 Family earnings and spousal earnings

The main focus of this section of the paper is to measure the effects of a head's job displacement in recessions and expansions on family earnings (defined as the sum of head and spouse labor earnings), and spousal earnings and hours. Figure 2 shows the change in relative labor earnings of the family upon job displacement of the family head in recessions and expansions, and compares it to the changes in relative head earnings as obtained above. I will highlight three results. First, I find that family earnings drop by 28 percent when the head's displacement occurs in recessions and by 15 percent when it occurs in expansions in the year following displacement. This implies that families enjoy some insurance from the presence of a second earner who was simultaneously employed with the head prior to his displacement. Having the spouse retain employment results in family earnings dropping by one-third less than individual earnings.[33] Second, the initial cyclical gap of family earnings loss upon head's job displacement between recessions and expansions ($28 - 15 = 13$ pp) is not very different from the initial cyclical gap of heads earnings loss ($39 - 22 = 17$ pp). Finally, the statistical significance of the coefficients based on the 90th percent confidence intervals plotted as blue dashed-lines in Figure 2 suggests that family earnings recovers 4 years after displacements in recessions (1 year earlier than head's earnings recovery), and 3 years after displacements in expansions (2 year earlier than head's earnings recovery). However, it is important to notice from the figure that the slopes of the recovery of head's earnings and family earnings look similar to each other. This hints us that earlier recoveries of family earnings are mostly due to a smaller initial drop coming from already working spouses rather than behavioral responses of, say, non-employed spouses who may enter the labor force to increase earnings.

The small behavioral response of spouses is confirmed by Figure 3 which shows the change in relative spousal earnings upon the head's displacement in recessions and in expansions. I find that the relative spousal earnings upon the head's displacement in recessions fluctuates around 0 and that these behavioral responses are always insignificant across years after the head's displacement in recessions. Moreover, the mean of the post displacement coefficients is only -0.8 percent for displacements in recessions. Hence, the insignificance of the post displacement coefficients is not only explained by larger error bands around the point estimates in the recession regression due

[33] The presence of a second-earner reduces the initial earnings loss by $100 \times ((39-28)/39) = 28$ percent in recessions and $100 \times ((22-15)/22) = 32$ percent in expansions.

Figure 2: Relative Labor Earnings of the Head and Family upon Job Displacement



Note: This figure plots the changes in relative labor earnings of the head (blue line) and relative labor earnings of the family (red line) - defined as the sum of head and spouse labor earnings - upon head's job displacement in recessions (left panel) and expansions (right panel). The dashed light blue line shows the 90 percent confidence interval for family earnings. I estimate the changes in relative labor earnings of the head and the family from a distributed lag-recession model using PSID.

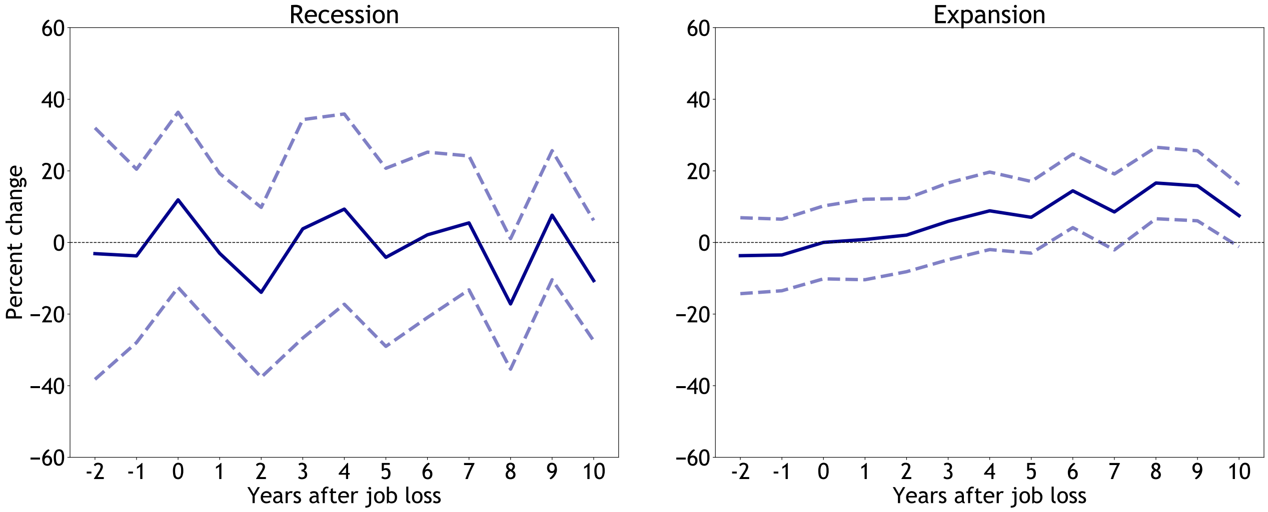
to a comparably smaller sample size, but also because of the small average behavioral spousal response to head's displacement in recessions. On the other hand, in expansions, there is a slight positive trend in spousal earnings upon head's displacement, but coefficients are also insignificant until year 6. Similarly, the mean of the post displacement coefficients is 8 percent in expansions. Furthermore, the p-values of a statistical test on joint significance of post displacement coefficients allow us to reject the hypothesis that they are jointly significant ($p = 0.35$ in recession and $p = 0.11$ in expansion).[34]

Figure A.2 in Appendix B measures the effect of the head's job displacement over the business cycle on annual spouse hours. I also find that the change in spousal hours upon the head's displacement in recessions is very small in recessions, with a mean post displacement coefficient of only -0.1 percent. On the other hand, spousal hours in expansions becomes significantly positive 3 years after the head's displacement and later increases by up to 15 percent. The mean of post displacement coefficients in expansions is 10.1 percent and the p-value of joint significance test is $p = 0.02$.

As a result, I find no evidence for significantly positive spousal earnings and hours response to

[34]Small initial response of relative hours both in recessions and expansions is consistent with previous "added worker effect" literature that studies the contemporaneous change in spousal hours upon husband's unemployment (Heckman and MaCurdy 1980, 1982, Cullen and Gruber 2000).

Figure 3: Relative Labor Earnings of the Spouse upon Job Displacement



Note: This figure plots the changes in relative labor earnings of the spouse upon family head's job displacement in recessions (left panel) and expansions. I estimate the changes in relative spousal labor earnings from a distributed lag-recession model using PSID. The solid blue line shows the point estimates and the dashed light blue line shows the 90 percent confidence interval.

head's displacements in recessions, during when the drop in head's earnings is much larger. On the other hand, spousal earnings and hours response to a head's displacement in expansions are small during the early years following displacement, and if anything, they become significantly positive at least 3 years after the displacement with a later increase by as much as 15 percent.

Table A.1 and A.2 in Appendix B show that these results are robust to many different sample selections, including using combinations of alternative PSID samples (SRC, SEO, Immigrant, Latino), using alternative age limits, incorporating singles, keeping outliers of the labor income distribution, or keeping families when the head is displaced both in recessions and expansions in the treatment group.

3.1.4 Summary of empirical results

It is useful to summarize important empirical findings of this section, all of which except the first one are novel contributions to the literature. First, I find that there are large negative and persistent effects of head's displacement on his own labor earnings and that the magnitude of the earnings loss is larger when the displacement occurs in recessions, as in Davis and von Wachter (2011). Second, the mere presence of a second earner already mitigates close to one-third of the head's earnings losses upon job displacements both in recessions and in expansions. Third, there is no evidence for significantly positive spousal earnings and hours response to head's displacements in recessions, during when the drop in head's earnings is much larger. On the other hand, spousal earnings and hours response to head's displacement in expansions becomes significantly positive at least 3 years after the displacement with a later increase by as much as 15 percent.

The last empirical result is particularly interesting because one could expect a stronger spousal earnings and hours response during times when the head experiences larger earnings losses. Hence, it motivates an investigation of potential reasons behind the small change in spousal earnings upon head's displacement in recessions. In the next section, I am going to calibrate the model to match the first empirical result above. Then, I am going to use the second and the third empirical findings to validate my model against. Next, using the model, I will investigate the role of countercyclical generosity of current government transfers on small labor earnings response to head's displacement in recessions.

3.2 Calibration

3.2.1 Functional forms

The model period is set to be a quarter. Utility function over consumption is $u\left(c_t\right) = \frac{c_t^{1-\sigma}}{1-\sigma}$ with risk aversion parameter σ. The labor market matching function is $M\left(v,\, u\right) = \frac{uv}{\left[u^{\gamma}+v^{\gamma}\right]^{1/\gamma}}$ as in den Haan, Ramey, and Watson (2000). This functional form implies that job finding rate $p\left(\theta\right) = \theta\left(1+\theta^{\gamma}\right)^{-1/\gamma}$ and vacancy filling rate $q\left(\theta\right) = \left(1+\theta^{\gamma}\right)^{-1/\gamma}$ are between 0 and 1.

As in Shimer (2005), I use a process for the job displacement rate that depends on labor productivity, which is extended to incorporate that displacement rates across jobs with various skill levels may be different: $\delta\left(h,\, z\right) = \bar{\delta} \times \exp\left(\omega_z^{\delta} \times \left(z-\bar{z}\right)\right) \times \exp\left(\omega_h^{\delta} \times \left(h-\bar{h}\right)\right)$, where $\bar{\delta}$ is mean of the displacement rate over time, ω_z^{δ} captures the volatility of job displacement rate over time, and ω_h^{δ} captures the variation of job displacement rate across skills, and $\bar{z}$ and $\bar{h}$ are average labor productivity and human capital levels respectively. In general, these separation shocks can be interpreted as idiosyncratic match quality shocks that drive down the productivity of a match to a low enough level so that the match endogenously finds it optimal to dissolve, as in Lise and Robin (2017). Finally, production function is set to be $g\left(h,\, z\right) = hz$.

The generosity of means-tested transfers ϕ and employment-tested transfers b vary with aggregate state. I set $\phi(z) = \bar{\phi} - \omega_\phi (z - \bar{z})$ and $b(z) = \bar{b} - \omega_b (z - \bar{z})$. This implies that if, for example, $\omega_\phi > 0$, then means-tested policy is countercyclical.

The logarithm of the aggregate labor productivity z_t follows an AR(1) process:

$$\ln z_{t+1} = \rho \ln z_t + \sigma_\epsilon \epsilon_{t+1}$$

where $0 \leq \rho < 1$, $\sigma_\epsilon > 0$, and ϵ are independent and identically distributed standard normal random variables. I take z_t as the average seasonally adjusted quarterly real output per person in the non-farm business sector, which is constructed by the Bureau of Labor Statistics (BLS). The data for the time period 1948:I-2007:IV is logged and HP filtered to obtain deviations from trend.[35] In the model, I use five grid points for the process and set $\bar{z} = 1$. Estimation of this process yields $\rho = 0.7612$ and $\sigma_\epsilon = 0.0086$.

3.2.2 External calibration

Having specified functional forms and the law of motion of the productivity process, I now calibrate several parameters outside of the model. Table 2 summarizes these parameters and their values.

I choose a coefficient of relative risk aversion $\sigma = 2$. I set the value of leisure for male to be 0, implying that males are always searching for the job. Hence, changes in government transfers do not affect the search behavior of the household's primary earner in the model. [36]

Next, I set $r = 0.005$, which generates an annual return on assets of around 2 percent. I set ζ_R to 0.00625, which implies 40 years of average working lifetime, and ζ_D to 0.01666, which implies 15 years of retirement.

I use data from National Income and Product Account (NIPA) tables and calculate the ratio of total wages and salaries to GDP between 1948-2007. I find that the average ratio across these years is 0.477. I then set worker's share of output α to this value.

I use 20 equally-spaced grid points for human capital, $h \in \{h_L, ..., h_H\}$. I set $h_L = 0.2$ and $h_H = 1.8$. I assume that the human capital increases by one step with probability π^E when

[35] I choose to exclude Great Recession period from this data due to the increase in the value of this measure of productivity, since the reconciliation of this is beyond the scope of my paper. Standard deviations of quarterly time series are computed as log deviations from an HP-trend with parameter 1600. For standard deviations of annual times series, I use the same object with parameter 100.

[36] The average labor force participation rate of married men is 92 percent, implying that η_m would be small if any. Moreover, this assumption allows me to focus on the effects of government transfers on spousal labor supply.

employed. This implies $\Delta^E = 0.084$. Moreover, I set the probability of human capital depreciation when unemployed π^U to be 0.75.[37]

I also calibrate the asset and income thresholds $\underline{a}$ and $\underline{y}$ for means-tested transfers as well as the benefit expiration rate $e(\cdot)$ for employment-tested transfers outside of the model. In the baseline calibration, I consider three means-tested transfers: Supplemental Nutrition Assistance Program (SNAP), Earned Income Tax Credit (EITC), and Temporary Assistance for Needy Families (TANF).[38]

Asset threshold of eligibility for SNAP has been \$2000 between 1997 and 2007 according to the program reports published by U.S. Department of Agriculture.[39] Asset threshold of eligibility for EITC was \$2350 in 1995 and \$2900 in 2007 according to the program reports published by U.S. Internal Revenue Service (IRS).[40] Finally, in 2007, while the asset limit for TANF eligibility varied across different states, most of states applied \$2000 as the asset limit according to the program report published by U.S. Department of Health and Human Services.[41] In order to convert these values into model units, I calculate the ratio of the weighted-average of these asset limit values in the data to quarterly minimum labor earnings.[42] I find that this is around 0.73 in the data. Then, I set $\underline{a}$ in the model so that the ratio of asset limit $\underline{a}$ to quarterly minimum labor earnings, $\alpha h_L z_L$, in the model is the same as its counterpart in the data.[43] As a result, I set $\underline{a}$ to be 0.068.

Using the same program reports, I first calculate the weighted-average of income limits for these three programs in 2007. I find that the average gross quarterly income limit is around \$7000. Similarly, I calculate the ratio this value to the same quarterly minimum labor earnings in the data,

[37]Ljungqvist and Sargent (1998) set $\pi^U = 0.2$ in the calibration of their model, where the model period is taken to be 2 weeks. For a quarterly calibration (i.e. around 6 period long unemployment spell), this implies that the probability of experiencing human capital loss is around 0.75.

[38]Another quantitatively large means-tested transfer paid to households in the working age population is Medicaid. However, I do not incorporate insurance provided by Medicaid transfers into the calibration of the means-tested transfer policy instruments given that the baseline model does not incorporate extra eligibility risk such as health status or presence of a young children rules. In Section 6, I incorporate Medicare to the calibration of total-means tested transfers in an extension of baseline model with these eligibility risks, and study the effects of it on the main conclusions of this paper.

[39]These reports are titled "Characteristics of Supplemental Nutrition Assistance Program Households" and published for every fiscal year since 1997. Reports are available at https://www.fns.usda.gov/ops/supplemental-nutrition-assistance-program-snap-research.

[40]These reports are available at https://www.irs.gov/pub/irs-prior.

[41]This report is available at https://www.acf.hhs.gov/sites/default/files/opre/wel_rules07.pdf

[42]Between 2000 and 2006, the federal minimum hourly wage was \$5.15, and in 2007, it was \$5.85. For these years, I calculate the total quarterly minimum labor earnings as min hourly wage $\times$ 40 hours/week $\times$ 13 weeks/quarter. Next, I divide the average of asset limit to the average of quarterly minimum labor earnings in the data.

[43]Notice that the quarterly minimum labor earnings in the model is invariant to policy changes. This allows me to calibrate both $\underline{a}$ and $\underline{y}$ outside of the model.

Table 2: Externally calibrated parameters

Parameter	Explanation	Value
ρ	Autocorrelation of productivity process	0.7612
σ_ϵ	Standard deviation of productivity process	0.0086
σ	Risk aversion	2
η_m	Value of leisure for male	0
r	Interest rate	0.005
ζ_R	Retirement probability	0.00625
ζ_D	Death probability	0.01666
α	Worker's share of output	0.477
h_L	Lowest human capital	0.2
h_H	Highest human capital	1.8
Δ^E	Human capital increase when employed	0.084
π^U	Prob. of human capital depreciation when unemployed	0.75
$\underline{a}$	Asset threshold of means-tested transfers	0.068
$\underline{y}$	Income threshold of means-tested transfers	0.240
e	Mean expiration rate of employment-tested transfers	0.5

Note: This table summarizes the parameters that are calibrated outside of the model. Please refer to the main text for the interpretation of the values.

and find that this ratio is around 2.58. Then, I set $\underline{y}$ in the model so that the ratio of income limit $\underline{y}$ to quarterly minimum labor earnings in the model is the same as its counterpart in the data. As a result, I set $\underline{y}$ to be 0.24.

Finally, the average duration of UI payments is around 26 weeks (i.e. 2 quarters), while this duration is typically extended during recessions. For example, during the Great Recession, UI payment duration was extended up to 99 weeks (i.e. 7.6 quarters). Hence, I set expiration rate of employment-tested transfers to be 0.5 (i.e. 1/2) when the labor productivity is greater or equal to its mean, and set it to be 0.13 (i.e. 1/7.6) when the labor productivity is at its lowest level.[44]

[44] Specifically, the grid for e is set to be $[1/(99/13), 1/(75/13), 1/(26/13), 1/(26/13), 1/(26/13)]$, where 75 weeks reflect the intermediary extensions of UI transfers.

3.2.3 Internal calibration

I jointly estimate the remaining fifteen parameters using the model to match the moments of the U.S. economy. Table 3 summarizes the results of this estimation.

I choose two paremeters, the discount factor β and borrowing limit a_L, to match two data moments of the asset-to-income distribution from Survey of Consumer Finances (SCF) 2007: the fraction of households with non-positive liquid wealth, and the median ratio of credit limit to quarterly labor income. Section 3.3 and Appendix B provide the details of calculating these moments from the data.

Utility value of leisure for female η_f controls the level of opportunity cost of searching for a job for female. I choose η_f to match the female labor force participation rate (LFPR) relative to male LFPR in the data. I use monthly data from Current Population Survey (CPS) 2000-2007 to compute the average LFPR of males and females separately for a sample of married or cohabiting couples of ages between 20 and 60, i.e. a similar sample to the PSID sample used in Section 3.1. I find that the average LFPR is 71 percent for female and 92 for male, which implies a relative female LFPR of 77 percent.

The next five parameters are calibrated to discipline five labor market moments of the model. I obtain the average unemployment rate from quarterly data provided by the BLS between 1948 and 2007, and choose the cost of posting a vacancy κ to match the same level in the model.[45] Next, I target the volatility of job finding rate in the data by choosing the elasticity of matching function γ. I use quarterly data from CPS between 1948 - 2007 and compute standard deviation as log deviations from an HP-trend with parameter 1600.[46] Finally, I use three parameters $\bar{\delta}$, ω_z^δ, and ω_h^δ of the job displacement process in the model to match three moments in the data: the average job displacement rate, its volatility over time, and its variation across the earnings distribution.[47] According to the Job Openings and Labor Turnover Survey (JOLTS) data between 2008 and 2018, average quarterly total separation rate is around 9 percent of total employment, and that an average

[45] I use the data provided by FRED - Federal Reserve Economic Data from the Federal Reserve Bank of St. Louis, which is constructed from the BLS data.

[46] Job finding rate data was constructed by Robert Shimer. For additional details, please see Shimer (2012). The data from June 1967 and December 1975 were tabulated by Joe Ritter and made available by Hoyt Bleakley.

[47] The model-implied Beveridge curve, which plots the relationship between unemployment and vacancies, exhibits a negative slope as in the data. This is because when labor productivity declines, firms cut back on vacancies, which translates to lower job finding rates and higher unemployment. Moreover, the rise in separation shocks further amplifies the increase in unemployment. As a result, unemployment and vacancies move in the opposite direction.

of 38 percent of all separations are due to layoff or discharge. This implies a quarterly average job displacement rate of 3.4 percent.[48] I find a standard deviation of job displacement rate as 0.06. Finally, I calculate the ratio of median predisplacement labor earnings of displaced household heads (i.e. labor earnings one year prior to displacement) to median labor earnings of never displaced heads using the PSID data under the sample created in Section 3.1. I find that this ratio in the data is 76 percent, which implies that displacement risk is relatively higher for the lower paying jobs. In the model, ω_h^δ controls the heterogeneity in job displacement risk across jobs with different human capital, and as a result different wages given that skill level directly affects wages in the model. Hence, I choose ω_h^δ to match the same earnings ratio in the model.

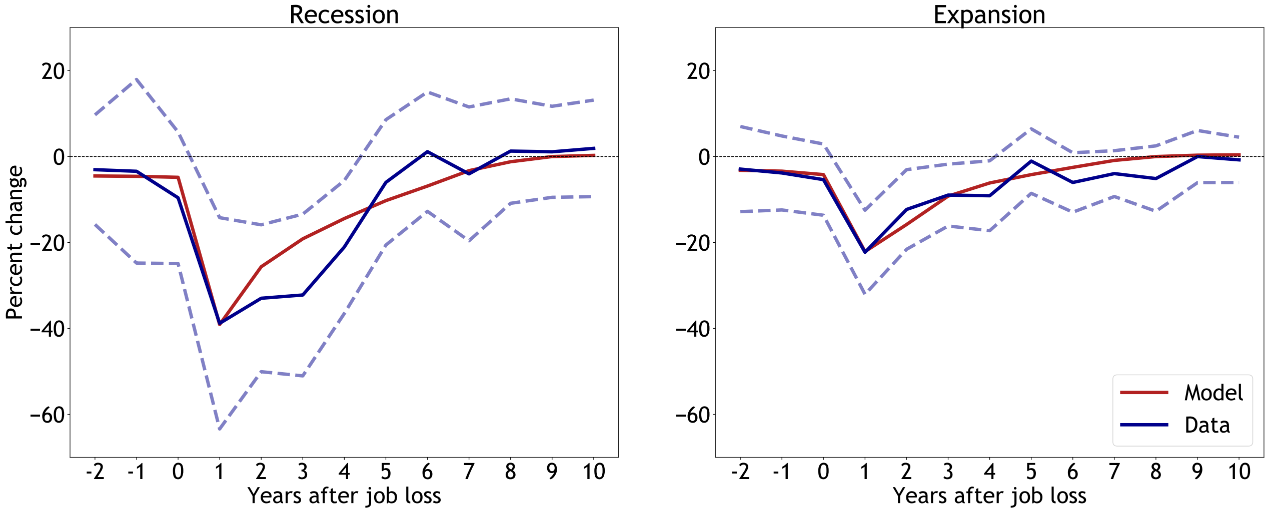
I choose two parameters of the human capital process to discipline the cyclicality of the initial drop in head earnings upon job loss, and the labor earnings distribution across employed individuals. Recall that, in the model, the magnitude of the decline in human capital Δ^U varies across displacements that occur in recessions and expansions, so that the model is constructed to generate the cyclicality of the initial drop in head earnings upon job loss. I set $\Delta^U = 0.59$ for relaziations of z that are lower than its mean value $\bar{z}$, and $\Delta^U = 0.34$ for realizations of z that are greater than or equal to $\bar{z}$.[49] Figure 4 compares head's earnings loss upon his job displacement in recessions and in expansions between the model and the data, where the latter was obtained in Section 3.1. While the model generates the same magnitude of earnings losses one year after displacements in recessions and expansions, as they are targeted in calibration, the recovery of head's earnings loss is slightly later in the model than in the data.

Next, the probability of human capital accumulation π^E controls the skill distribution, and thus labor earnings distribution in the model. For example, if π^E is very large, then workers would

[48] This value is larger than estimates based on annual data. Davis and von Wachter (2011) report annual job displacement rate of around 4 percent using SSA data, which is accordance with job displacement rates reported by Stevens (1997) using the PSID data and Farber (1997) using the Displaced Worker Supplement. However, these estimates are likely to be underestimated of the true dusplacement probabilities because of recall bias (Topel 1991).

[49] Notice that these values of Δ^U are quite large. Given that the human capital levels are in between 0.2 and 1.8, a drop of 0.59 implies that when a worker with a mean human capital level of $\bar{h} = 1$ loses his job in a recession, he would lose 60 percent of his skill with probability π^U in the quarter following displacement. However, it is well known in this literature that generating large and persistent earnings losses upon job displacement with a more reasonable calibration of the human capital process is quite unsuccessful. Hence, for example, Huckfeldt (2016) use a model of two different types of occupations (skill-intensive and skill-neutral) with a more reasonable parametrization of the human capital process to explain the cyclicality of earnings loss. In this paper, I do not aim to endogenously generate the cyclicality of earnings loss, but rather take this as a calibration target and anaylze its effects on spousal behavior. Moreover, one could interpret a relatively larger loss of human capital in recessions as "occupational displacement" similar to Huckfeldt (2016).

Figure 4: Relative Labor Earnings of the Head upon Job Displacement: Model vs Data



Note: This figure plots the changes in relative labor earnings of the family head upon his job displacement in recessions (left panel) and expansions (right panel) both in the model and in the data. I estimate the changes in relative labor earnings from a distributed lag-recession model using PSID. The solid blue line shows the point estimates and the dashed light blue line shows the 90 percent confidence interval. I compare these results to the estimates obtained from the same regression using the model simulated data, which is aggregated up to yearly period. Earnings drop one year after displacements both in recessions and expansions are targeted in the model calibration.

quickly accumulate their human capital, and resulting dispersion of labor earnings would be small. I calculate the ratio of 90th to 10th value of labor earnings distribution of employed individuals from the PSID 2007 survey as 7.6. I choose π^E to match the same ratio in the model.

Finally, I choose remaining five parameters of the model related to government transfers. I measure the average generosity of means-tested transfers by the ratio of total quarterly means-tested transfers per recipient individual to the minimum quarterly labor earnings using data from NIPA 1976 - 2007 and program reports.[50] The average ratio across these years in the data is 0.74. I choose the average level of means-tested transfers $\bar{\phi}$ so that this statistic in the model is the same as its data counterpart. Similarly, I calculate the average ratio of total quarterly UI transfers per unemployed individual to the minimum quarterly labor earnings using data on UI transfer amount from NIPA and data on total number of unemployed from BLS between 1948 - 2007, and find 0.36. Again, I choose the average level of employment-tested transfers $\bar{b}$ so that this statistic in the

[50]For each program, the program reports published by the government agencies provide information on the number of recipient individuals for each year. Using this data together with data from NIPA, I calculate the total transfer amount per recipient for each program at a given year and then sum these amounts to obtain the total means-tested transfer amount per recipient for that year. 1976 is the year that we observe positive transfer amounts paid under each of the three programs in NIPA. I divide annual amounts of total means-tested transfers per recipient by 4 to obtain the quarterly amounts. Then, I divide this amount by the minimum quarterly labor income to obtain the ratio of total quarterly means-tested transfers per recipient to minimum labor earnings in the data.

model is the same as its data counterpart. Using micro data from SIPP between 1996 and 2014, I find that, on average, around 35 percent of all means-tested transfers and 60 percent of total UI transfers are paid to married households. Also, married households constitute around 33 percent of all means-tested transfer recipients and 58 percent of all UI recipients. Finally, around 60 percent of all transfers received by the married households are means-tested transfers. I present detailed results in Appendix B.

Next, I measure the cyclicality of means-tested transfers by the standard deviation of total means-tested transfers per recipient individual. The standard deviation of this value across years in the data is 0.06. In the model, I choose ω_ϕ to generate the same value for the standard deviation of means-tested transfers per recipient individual.[51] Similarly, I measure the cyclicality of employment-tested transfers by the standard deviation of total UI transfers per unemployed individual. In the data, this value is 0.15, implying that UI transfers are much more cyclical than means-tested transfers. In the model, I set ω_b to match the same value for this statistic. Last, I choose retirement transfers b_R to match the average ratio of total social security payments to GDP between 1976 - 2007 in NIPA.[52]

3.3 Validation

In this section, I will compare model outcomes with a list of important untargeted data moments. I will emphasize that the model endogenously generates reasonable changes in family earnings and spousal earnings upon head's displacement over the business cycle. This is important for two reasons. First, it later allows me to quantify the crowding-out effects of government transfers (incentive costs) on spousal earnings response to displacement by comparing the change in spousal earnings under counterfactual government policies. Second, it helps the model to correctly quantify the magnitude and cyclicality of available spousal insurance, which in turn determines the insurance benefits of government transfers over the business cycle. The other untargeted moments presented below are also related to either insurance benefits or incentive costs of government transfers, and thus relevant for optimal policy analysis.

[51] Standard deviation of this annual time series is computed as log deviations from an HP-trend with parameter 100.

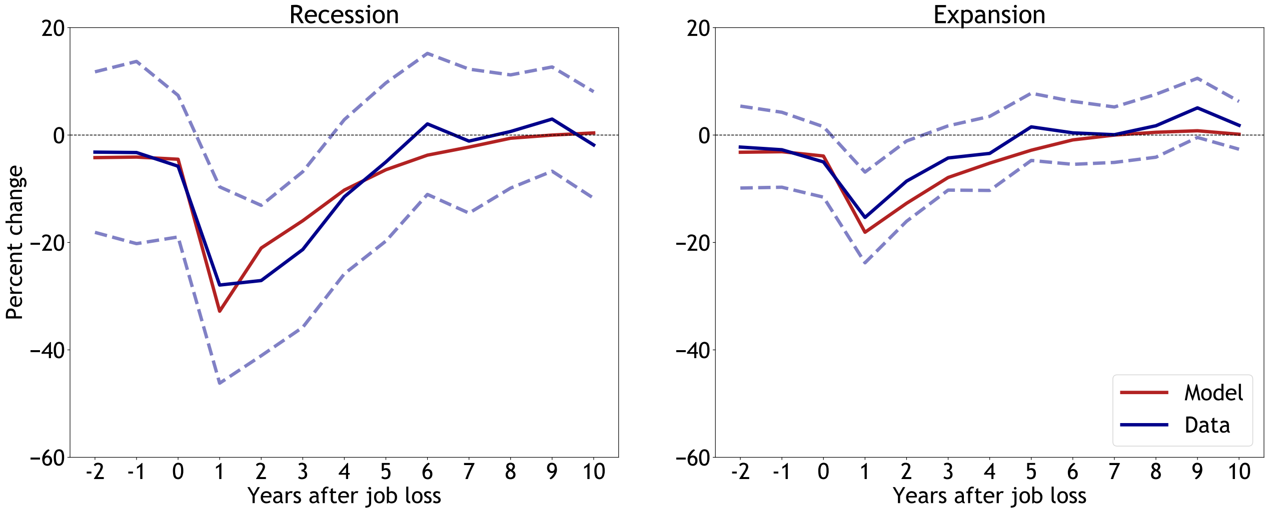
[52] There is a large increase in social security transfers between 1948 - 1975, but this increase mostly disappeared since then. Given that I do not model any trend in social security transfers, I calculate the social security to GDP ratio starting from 1976 in the data.

Table 3: Internally calibrated parameters

Parameter	Explanation	Value	Target	Source	Data	Model
β	Discount factor	0.983	Frac. of households with non-positive liquid wealth	SCF 2007	0.097	0.13
a_L	Borrowing limit	-0.67	Median ratio of credit limit to quarterly labor income	SCF 2007	0.64	0.65
η_f	Leisure value (female)	0.51	Relative female LFPR	CPS 2000-2007	0.77	0.77
			Labor Market			
κ	Vacancy posting cost	2.9	Unemployment rate	BLS 1948-2007	0.056	0.051
γ	Matching function	1.43	Std. dev of job finding rate	CPS 1948-2007	0.08	0.08
$\bar{\delta}$	Average job disp. rate	0.053	Job displacement rate	JOLTS 2000-2018	0.034	0.034
ω_z^δ	Displacement rate vol.	-5.8	Std. dev. of job disp. rate	JOLTS 2000-2018	0.06	0.06
ω_h^δ	Displacement rate across h	-0.52	Ratio of median earnings displaced to nondisplaced	PSID 1968-2015	0.76	0.77
			Human Capital Process			
Δ^U	Human capital decrease (unemp.)	$[0.59, 0.34]$	Cyclicality of head's initial earnings loss upon disp.	PSID 1968-2015	$[0.39, 0.22]$	$[0.39, 0.22]$
π^E	Prob. of human capital increase (emp.)	0.04	Labor earnings p90/p10	PSID 2007	7.60	6.20
			Government Transfers			
$\bar{\phi}$	Average means-tested transfers	0.15	Ratio of total means-tested trans. per rec. to min. wage	NIPA 1976-2007	0.74	0.76
$\bar{b}$	Average emp.-tested transfers	0.08	Ratio of total UI trans. per unemployed to min. wage	NIPA 1948-2007	0.36	0.37
ω_ϕ	Cyclicality of means-tested transfers	0.96	Std. dev of means-tested transfers per recipient	NIPA 1976-2007	0.06	0.08
ω_b	Cyclicality of emp.-tested transfers	0.64	Std. dev of total UI per unemployed	NIPA 1948-2007	0.15	0.14
b_R	Retirement transfers	0.36	Ratio of social security transfers to GDP	NIPA 1976-2007	0.041	0.04

Note: This table summarizes internally calibrated parameters. Please refer to the main text for the interpretation of the values.

Figure 5: Relative Labor Earnings of the Family upon Job Displacement: Model vs Data



Note: This figure plots the changes in relative labor earnings of the family upon head's job displacement in recessions (left panel) and expansions (right panel) both in the model and in the data. I estimate the changes in relative family earnings from a distributed lag-recession model using PSID. The solid blue line shows the point estimates and the dashed light blue line shows the 90 percent confidence interval. I compare these results to the estimates obtained from the same regression using the model simulated data, which is aggregated up to yearly period.

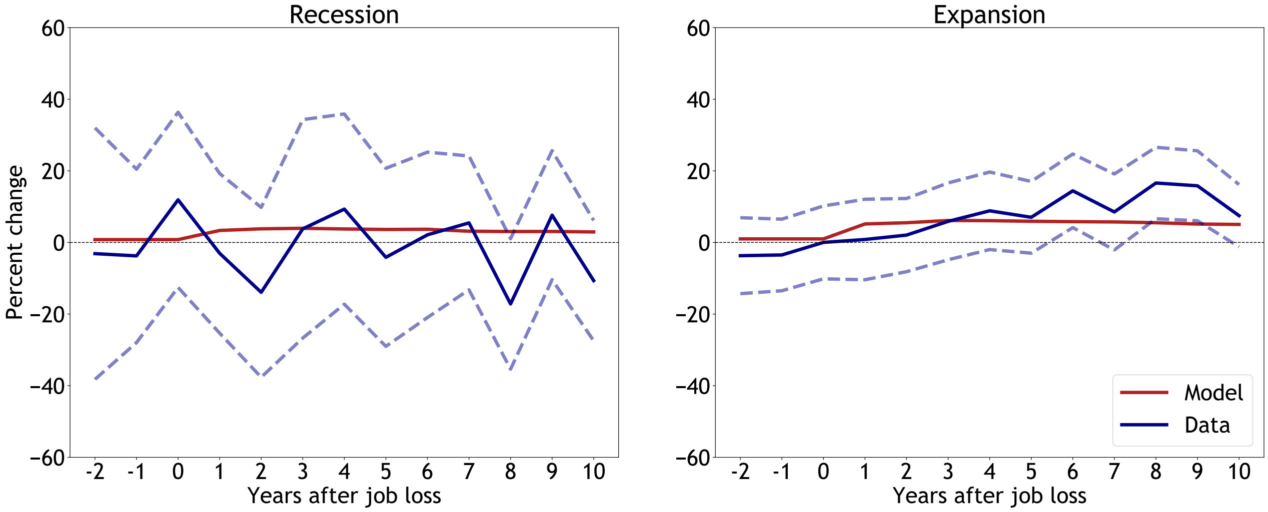
3.3.1 Family and spouse earnings upon head's job displacement over the business cycle

Figure 5 compares the change in family earnings upon head's job displacement in recessions and in expansions between the model and the data. In the model, the magnitudes of drops in family earnings one year after head's displacements both in recessions and in expansions are slightly larger than their respective counterparts in the data. Moreover, family earnings in the model fully recover around 2 years later than full recovery of family earnings in the data both in recessions and in expansions.

Next, Figure 6 compares the change in spouse earnings upon head's job displacement in recessions and in expansions between the model and the data. In the model, changes in spousal earnings upon head's displacements both in recessions and expansions are limited as in the data. However, the model fails to capture the slight positive trend in the change in spousal earnings in expansions that we observe in the data. In recessions (expansions), the mean of the post displacement coefficients is 3.2 (5.2) percent in the model compared to -0.8 (8) percent in the data.

This comparison shows that when the model is calibrated to match level and cyclicality of i) head's earnings drop upon job loss, ii) government transfers, and iii) job finding rates and job

Figure 6: Relative Labor Earnings of the Spouse upon Job Displacement: Model vs Data



Note: This figure plots the changes in relative labor earnings of the spouse upon head's job displacement in recessions (left panel) and expansions (right panel) both in the model and in the data. I estimate the changes in relative spouse earnings from a distributed lag-recession model using PSID. The solid blue line shows the point estimates and the dashed light blue line shows the 90 percent confidence interval. I compare these results to the estimates obtained from the same regression using the model simulated data, which is aggregated up to yearly period.

separation rates, it is able to generate small change in spousal earnings upon head's displacement especially in recessions, as I have documented in the data.

3.3.2 Consumption upon job loss

I now compare the average drop in family consumption in the year following head's job displacement in the model and in the data. This is another way to assess the insurance benefits of transfers in the model. For example, if the magnitude of consumption drop is very low in the model, then the insurance benefits would be understated in the model.

Several papers in the literature estimated the average consumption drop upon job loss from various data sources. Gruber (1997) estimates a decline in food expenditure of 6.8 percent using the PSID for the period up to 1987. Saporta-Eksten (2014) uses cross-sectional variation in the PSID and measures an 8 percent decline in consumption expenditure in the year during which a job loss happens.[53] Stephens (2004) estimates the average decline in food expenditure upon job loss in the Health and Retirement Survey (HRS) and the PSID and finds that the decline is between 12 percent (PSID) and 15 percent (HRS). Browning and Crossley (2001) report a 14

[53] However, this estimate does not condition on the fraction of the year spent as unemployed. When we assume an average unemployment duration of 17 weeks, this would imply a decline in consumption of around 24 percent.

percent decline using Canadian Out of Employment Panel (COEP) survey data. Chodorow-Reich and Karabarbounis (2016) conduct an analysis of the effects of job loss on consumption both in the PSID and the Consumer Expenditure Survey (CE) and find that the decline in total food expenditure is between 14 percent (PSID) and 21 percent (CE). Finally, Aguiar and Hurst (2005) measure a 19 percent decline in food expenditure among the unemployed using scanner data.

I estimate the consumption drop upon job displacement in the model using Equation (9). I find that family consumption drops on average by 14 percent in the year following head's displacement, which is in line with available empirical estimates discussed above.

3.3.3 Marginal propensity to consume: average, cyclicality, and heterogeneity

Insurance benefits of transfers can directly be measured by the fraction of an unexpected transfer that families spend on consumption.

The empirical literature documents two aggregate marginal propensity to consume (MPC) data moments that I can use to validate the model. First, Parker, Souleles, Johnson, and McClelland (2013) measure that households, under different specifications, spend between 12 and 30 percent of unexpected tax rebates in the quarter that they are received. Second, Gross, Notowidigdo, and Wang (2016) measure the cyclicality of the MPC by exploiting the unexpected changes in credit card borrowing limits of previously bankrupt individuals and find that the MPC is countercyclical over the Great Recession. In particular, they show that the average semiannual MPC difference of borrowing-constrained individuals between 2008 and 2011 is 8 percent.

In the model, I compute the MPC of a family by calculating the fraction of an unexpected transfer, scaled such that it is equivalent to \$500, that the family spends on consumption. This transfer can be interpreted as a one time unexpected deposit to family's bank account. As in Kaplan and Violante (2014), I implement a \$500 rebate in order to ensure consistency with the above available empirical estimates.

Table 4 compares the average economy-wide quarterly MPC and the magnitude of MPC increase for borrowing-constrained families in recessions in the model to available empirical estimates discussed above.[54] The results show that the model generated average quarterly MPC lies in the

[54] I group families with non-positive wealth as borrowing-constrained families. Then, I report the difference in average semiannual MPC for such families between when labor productivity is strictly below the mean and it is equal to or above the mean.

Table 4: Average MPCs: Model vs Data

	Model	Data
Average economy-wide quarterly MPC	0.22	$0.12 - 0.30$
Semiannual MPC increase for borrowing-constrained in recessions	0.10	0.08

Note: This table shows the average quarterly economy-wide MPC, and the average increase in semiannual MPC of borrowing-constrained individuals in a recession implied by the model's simulation. I group families with non-positive wealth as borrowing-constrained families. MPC of each family type are calculated by computing the fraction consumed out of an unexpected \$500 worth transfer. These model-generated average values are then compared to available empirical estimates in the literature.

Table 5: MPCs across Heteregeneous Families in the Model

Family employment: Only head employed

		Head skill	
		$\leq p50$	$> p50$
Asset	$\leq p50$	0.58	0.07
	$> p50$	0.02	0.02

Family employment: Both unemployed

		Head skill	
		$\leq p50$	$> p50$
Asset	$\leq p50$	0.67	0.17
	$> p50$	0.02	0.02

Note: This table shows the average quarterly MPCs across families grouped by their employment status, assets holdings, and skill level of the head. Cutoffs for the asset and skill groups are obtained from the respective distributions under the stationary distribution of the economy. MPC of each family type are calculated by computing the fraction consumed out of an unexpected \$500 worth transfer.

middle of range of estimates provided by Parker, Souleles, Johnson, and McClelland (2013). However, the cyclicality of MPC for borrowing-constrained individuals is slightly larger in the model than in the data. This means that the insurance benefits in recessions would probably be slightly overestimated in the model.[55]

In order to quantitatively understand how MPCs differ across heterogeneous families in the economy, Table 5 presents the average quarterly MPC of different employment, wealth, and skill level of the head groups based on the stationary distribution of the economy. Noticeably, wealth-poor families with unskilled head exhibit highest MPC given the absence of self-insurance through savings and low labor earnings of the head. On the other hand, wealth-rich families spend only 2 percent of the tax rebate on consumption regardless of the head's skill and employment status of their members.

[55] Nevertheless, the optimal policy is less generous in recessions, implying that even if insurance benefits would be overestimated in recessions, incentive costs still exceed the insurance benefits in recessions.

3.3.4 Asset-to-income distribution

Wealth distribution of the economy is also relevant for both insurance benefits and incentive costs of transfers. Both insurance benefits and incentive costs are larger for wealth-poor families, implying that the model would overstate benefits and costs of transfers if the fraction of such families is much larger in the model than its data counterpart. For this reason, fraction of families with non-positive liquid wealth is taken as a calibration target in Table 3, while the percentiles of the distribution presented below are not targeted in the calibration.

To normalize wealth and better capture the level of self-insurance available to families, I compute asset-to-income ratio by dividing net liquid assets to quarterly family labor income both in the PSID 2015 and SCF 2007.[56] I use net liquid asset holdings as the primary measure of wealth because of its immediate availability as a means to smooth consumption in the event of job loss. The net liquid asset holdings of a family are calculated by adding transaction accounts (checking, saving, money market accounts) and tradable assets (mutual funds, certificates of deposits, stocks, bonds), and then deducting unsecured debt. Furthermore, countable assets for asset eligibility threshold of means-tested transfers often include vehicles across many states in the United States. For this reason, I incorporate vehicle equity to the liquid assets calculation. Appendix B provides more details on the calculation of the liquid asset to quarterly labor income distributions from the PSID and SCF.

I compute the same distribution using the model simulated data and compare it to empirical estimates, as shown in Table 6. In the model, the median family holds net liquid wealth equivalent to 1.1 quarter of family labor earnings, while it is 1.2 quarter of family labor earnings both in the PSID and the SCF. However, the model misses both the amount of wealth owned by richest and the dispersion of wealth among the rich families, given that 75th and 90th percentiles are much closer in the model than in the data.

[56]PSID collects information for the amount of credit card debt starting from 2011 survey. Since this information is needed to calculate net liquid wealth, we can only calculate the asset-to-income distribution after 2011. Here, I choose to present data from the latest survey.

Table 6: Distribution of Liquid Asset Holdings relative to Quarterly Family Labor Earnings

	Percentiles					Fraction of population
	10th	25th	50th	75th	90th	with non-positive wealth
PSID 2015	0.05	0.48	1.20	2.88	14.38	0.091
SCF 2007	0.02	0.48	1.20	2.71	6.45	0.097
Model	−0.18	0.37	1.10	4.23	4.86	0.13

Note: This table shows the liquid asset to quarterly family labor earnings distribution in both the model and in the data. The empirical distributions are separately calculated from the PSID 2015 and the SCF 2007. The main text provides the details of these calculations.

3.3.5 Correlated spells of family members

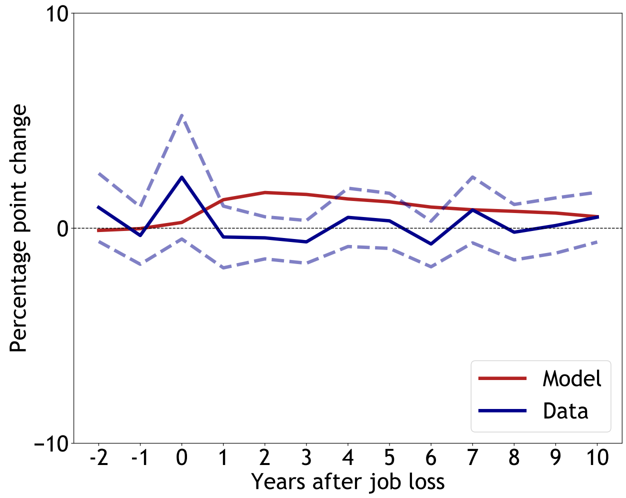
Finally, imagine that there are two types of families in which the head is displaced: i) the spouses are also displaced around the year of their husband's displacement and they also experience earnings losses, and ii) the spouses start working and contributing significantly to the family income. If this is the case, then these two opposite changes in spousal earnings among families with displaced heads may cancel out each other, and we would see small changes in spousal earnings on average. Moreover, if this is the case, the government policy should be targeted toward the former type of families.

In order to test whether this is the case, I estimate the same regression given in Equation (9) in which the outcome variable is now a dummy variable that takes a value of 1 if the spouse is also displaced, and 0 otherwise. Figure 7 compares the percentage point change in spousal displacement probability upon head's displacement both in the model and in the data. It shows that there is at most 2 percentage point increase in spousal displacement probability upon head's displacement in the data. The model successfully generates a similar pattern given that there is no such correlation of unemployment spells across family members present in it.

4 Effects of Transfers on Spousal Earnings Response

In this section, I will present two main results. First, I will implement a counterfactual experiment to discuss the role of more generous government transfers during recessions in explaining the small

Figure 7: Change in Spousal Displacement Probability upon Head's Displacement: Model vs Data



Note: This figure plots the changes relative displacement probability of spouses upon head's job displacement both in the model and in the data. I estimate the percentage point change in relative spousal displacement probability in the data from a distributed lag-recession model using PSID. The solid blue line shows the point estimates and the dashed light blue line shows the 90 percent confidence interval. I compare these results to the estimates obtained from the same regression using the model simulated data, which is aggregated up to yearly period.

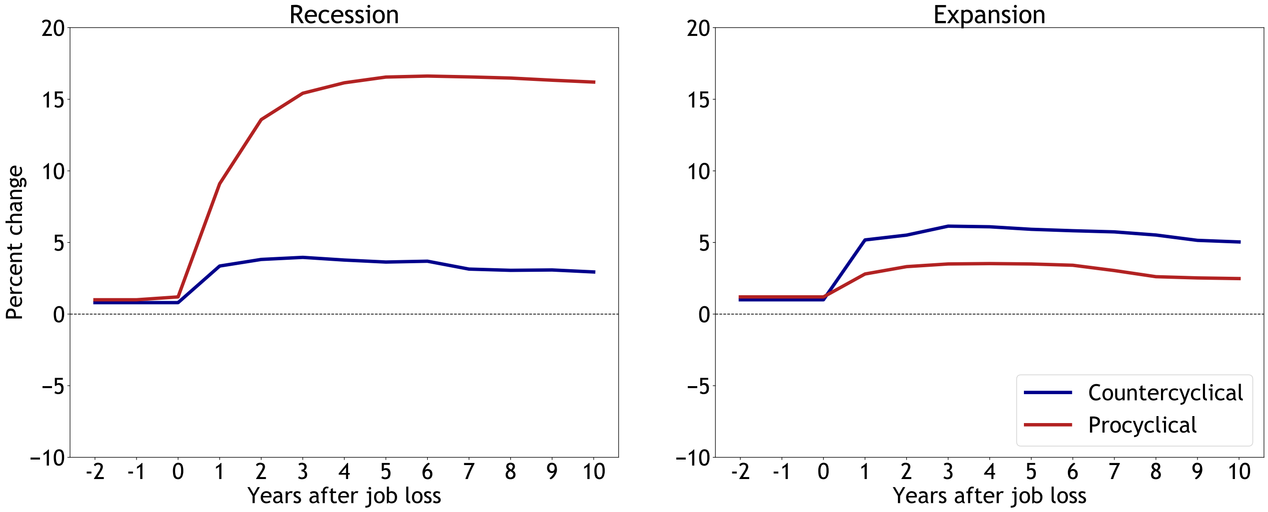
change of spousal earnings upon the head's displacement in recessions. Second, I will compare the model implied spousal labor supply elasticities to existing microeconomic estimates to provide external validation for the model's predictions from the counterfactual experiment.

4.1 Counterfactual experiment

When the model is calibrated to match the level and cyclicality of i) head's earnings drop upon job loss, ii) government transfers, and iii) job finding rates and job separation rates, it is able to generate small changes in spousal earnings upon the head's displacement especially in recessions, as I have documented in the data.

I will now analyze the change in spousal earnings in response to head's displacement over the business cycle under alternative government policies. The calibrated model is designed to isolate the effect of varying transfers on spousal earnings. I do this in two steps. First, I normalize the value of leisure for male η_m as 0 to make male workers inelastic to changes in government policy. Second, I assume that the wage paid in each human capital submarket is a fraction of the period aggregate labor productivity. This implies that wages and firm vacancy posting decisions are invariant to

Figure 8: Relative Labor Earnings of the Spouse upon Job Displacement under Different Policies



Note: This figure plots the changes in relative labor earnings of the spouse upon head's job displacement in recessions (left panel) and expansions (right panel) in the model under the countercyclical baseline policy and a procyclical policy, which later will be shown as the optimal policy. I estimate the changes in relative spouse earnings from a distributed lag-recession model using model simulated data, which is aggregated up to yearly period.

government policy in the baseline model.[57] These two features of the model allow me to focus on changes in spousal earnings response to displacements under different government policies.

Figure 8 compares the change in spousal earnings upon the head's job displacement in recessions and in expansions in the model under the countercyclical baseline policy and a procyclical policy, which later will turn out to be the optimal policy. It shows that under the procyclical policy, relative spousal earnings increase by up to 15 percent in recessions, but remains below 5 percent in expansions. In particular, I find that the mean of the post-displacement coefficients in recessions is 14 percent under the procyclical policy as opposed to 3.2 percent under the current policy. For expansions, it is 2.9 percent under the procyclical policy and 5.2 percent under the current policy.

This result is driven by the fact that in recessions, the large earnings losses incurred by the head of the family are mitigated by generous transfers from government in the current policy. This lowers the marginal utility of consumption of the family and thus lowers spousal incentives to increase earnings during recessions. When transfers are less generous in recessions, a high marginal utility of consumption induces spouses to increase earnings to raise family consumption. In contrast, expansions are periods when earnings losses are small and the marginal utility of consumption is

[57]In Section 6, I explore the implications of allowing for endogenous wage choices by households to capture the effects of transfers on labor demand.

Table 7: Magnitudes of Female Labor Supply Elasticities: Data vs Model

	All households	Low income households	High income households
	Female participation elasticity with respect to net wages		
Data	0.15 – 0.43	0.27 – 0.43	0.15
Model	0.31	0.38	0.21
	Female labor earnings elasticity with respect to transfers		
Data	0.44		
Model $\bar{\phi}$	0.36	0.47	0.23
Model $\bar{b}$	0.01	0.03	0.002

Note: This table compares female participation elasticity with respect to net wages and female labor earnings elasticity with respect to transfers both in the data and in the model. Comparisons are made for all females, females in low income households, and females in high income households. Empirical estimates of participation elasticities are summarized by Chetty, Guren, Manoli, and Weber (2012), and the empirical estimate of earnings elasticity is obtained by the author from the PSID. Participation elasticity is calculated as the change in log female employment rates divided by the change in log net-of-tax wage rates, while earnings elasticity is calculated as the change in log female labor earnings divided by the change in log transfer amounts.

low regardless of the generosity of transfers. As such, spousal response is small and inelastic to government transfer generosity.

4.2 Spousal labor supply elasticities: Data vs Model

I now implement an external validation exercise to test whether the model implied spousal labor supply response to changes in government policies is reasonable. This is important because, for example, if the magnitude of this elasticity is much larger in the model than in the data, then the crowding-out effects of transfers would be overestimated in recessions, during when transfer generosity increases. As a result, the model would overstate the role of government transfers in explaining the small change of spousal earnings in response to the head's displacement in recessions. Furthermore, in the optimal policy analysis, the model would also overestimate the incentive costs of transfers, which would bias results toward less generous transfers.

The first panel of Table 7 compares female participation elasticity with respect to net wages in the data and in the model. Chetty, Guren, Manoli, and Weber (2012) summarize the magnitude of female participation elasticity estimates identified from permanent wage changes resulting from tax reforms across seven different studies.[58] They report female participation elasticity as the change in log employment rates divided by the change in log net-of-tax wages. Employment rate is typically defined as positive work hours in a year. The magnitude of these empirical estimates on the female participation elasticity with respect to net earnings lie between 0.15 and 0.43.

In order to calculate magnitude of the female participation elasticity with respect to net-of-tax wages in the model, I implement an unexpected and permanent decline in τ so that the average net wages of the employed in the model, i.e. $(1-\tau)\,\bar{w}$ where $\bar{w}$ is the average wage in the model prior to change in tax rate, increases by 10 percent. This way, the model generates permanent changes in wages resulting from an income tax reform, which is similar to the identification used in the microeconomic studies. I then calculate the model implied female participation elasticity with respect to net wages as the ratio of the change in log female employment rates to the change in log average wages of the employed. I find that the magnitude of female participation elasticity with respect to net wages is 0.31 in the model, which lies in between the range of values found in the literature.

Moreover, it is possible to divide a subset of these empirical estimates summarized by Chetty, Guren, Manoli, and Weber (2012) into two groups based on the demographics and characteristics of their sample. On one hand, we can group estimates by Eissa and Liebman (1996), Meyer and Rosenbaum (2001), and Eissa and Hoynes (2004) as participation elasticities of female who are living in low income households. This is because these three studies focus on either married women living in low income households or single women receiving government transfers, both of which can be interpreted as spouses in low income households from the lens of my model. In these papers, the magnitude of female participation elasticities with respect to net-of-tax wages are 0.30, 0.43, and 0.27 respectively. On the other hand, Liebman and Saez (2006) estimate the participation elasticity of women who are married to high income men as 0.15. As a result, the participation elasticity is much larger for females living in low income households than in high income households.

This allows me to compare the heterogeneity of female participation elasticity across families with different income levels in the model with that of the data. I compute the magnitude of female participation elasticity with respect to net wages separately for women in low income households

[58] Chetty, Guren, Manoli, and Weber (2012) summarize results from nine different papers in total. However, two of these papers focus on men in their sample. Hence, I consider the remaining seven papers as my comparable benchmark.

and high income households using the same calculations as before.[59] I find that the magnitudes of participation elasticities are 0.38 for spouses living in low income households and 0.21 for spouses living in high income households. Hence, the model also generates a quantitatively reasonable difference between the participation elasticities of females across different household income groups. However, the model overestimates the magnitude of the female participation elasticity for high income households. This is because as shown in Section 3, the model does not fully capture households in the right tail of the asset and income distribution for whom these elasticities are very low.

The second panel of Table 7 compares female labor earnings elasticity with respect to transfers in the data and in the model. The goal here is to provide external evidence for the effect of transfer generosity on spousal labor supply response to the head's job displacement. In order to do so, I will compare the change in spousal earnings upon the head's job displacement for households living in either U.S. states providing the most generous transfer payments or states providing the least generous transfer payments. Using the PSID, I group the sample of households into these two groups and run the regression Equation (9) separately for spousal earnings and transfer receipts as dependent variables, also controlling for state fixed effects and state level employment rates to account for labor market differences.[60] As a result, I obtain post-displacement dollar amount changes of spousal earnings and transfer receipts of households upon the head's job displacement relative to non-displaced households separately for these two samples. Then, I calculate the ratio of the difference in log spousal earnings to the difference in log transfer receipts of displaced households between the sample in the most generous states and in the least generous states. I find that this

[59]Eissa and Hoynes (2004) report the gross hourly wage of husband and wife as \$12.09 and \$7.56 in 1995 dollars respectively for their entire sample. This implies that the ratio of total gross hourly wage of the household (\$19.65) to the hourly minimum wage in 1995 (\$4.25) is equal to 4.62 in their sample. To discipline the model sample of low income households, I consider households whose total gross labor earnings are less than or equal to 4.62 times of the model's minimum wage as low income households. On the other hand, the data sample in Liebman and Saez (2006) that is used to calculate elasticities for high income families include heads whose earnings are above 75th percentile of earnings. Hence, in the model, I group households as high income households in the model if the head's gross wage is greater than or equal to 75th percentile of the wage distribution of the employed prior to the policy change.

[60]U.S. states with most generous safety net programs are taken as Vermont, District of Columbia, North Dakota, Massachusetts, and Minnesota. U.S. states with the least generous safety net programs are taken as Alabama, South Carolina, Florida, Nevada, and Georgia. I have 421 displacements in the former sample and 647 displacements in the latter sample. Given this small sample size, it is unfortunately not possible to further divide these samples into displacements in recessions and in expansions, or displacements that occur in low income or high income families. One valid concern in this estimation is selection of households with frequently displaced heads into states with more generous transfers. I acknowledge this concern and view the estimates in this exercise as suggestive correlational evidence.

ratio is 0.44, and I take this as the magnitude female labor earnings elasticity with respect to transfers in the data.[61]

I perform a similar exercise in the model by separately implementing a permanent 10 percent decline in i) average generosity of means-tested transfers $\bar{\phi}$, and ii) average generosity of employment-tested transfers $\bar{b}$. I find that female labor earnings elasticity with respect to $\bar{\phi}$ is 0.36 and with respect to $\bar{b}$ is 0.01. The combined elasticity of these transfers is close but lower than the elasticity of 0.44 in the data. Interestingly, in the model, most of the response is driven by changes in means-tested transfers while female earnings are inelastic to the generosity of employment-tested transfers. This is because eligibility for employment-tested transfers require job search and such transfers pay only low amounts for a short duration.

Finally, I calculate female labor earnings elasticity with respect to these two types of transfers separately for low income and high income households in the model. In particular, I find that the earnings elasticity with respect to $\bar{\phi}$ is 0.47 for females in low income households and 0.23 for females in high income households. In recessions, the head's job displacement causes a larger drop in the household income. For this reason, spousal labor supply is more responsive to changes in government transfers in recessions. Hence, reducing the generosity of transfers in recessions increases spousal earnings response to the head's displacement in recessions significantly, as shown in Figure 8.

5 Optimal Policy

The results in the previous section show that the incentive costs of transfers on spousal labor supply are larger in recessions and smaller in expansions. Since the existing transfers are more generous in recessions, it implies that there may be potential welfare gains from changing the generosity of government transfers over the business cycle. Motivated by this observation, in this section, I will study the optimal design of means-tested and employment-tested transfers over the business cycle.

[61] This result implies a higher spousal labor supply response when government transfers are less generous. Similarly, Bredtmann, Otten, and Rulff (2017) use data from 28 European countries between 2004 and 2013, and document that spousal labor supply to their husband's unemployment is strongest in less generous welfare states (i.e. the Mediterranean, Central, and Eastern European countries), while it is weakest in more generous welfare states (i.e. the Continental European and Nordic countries).

5.1 Welfare calculation

The ex-ante welfare gains or losses of any proposed government policy is measured by answering the following question: how much additional lifetime consumption must be endowed to all families in an economy where the baseline countercyclical policy is being implemented so that average welfare will be equal to an economy where the proposed policy is implemented? This criterion evaluates whether an alternate policy will be welfare improving when compared the baseline countercyclical policy.

Let o denote the baseline (old) policy and n denote the new/proposed policy. Using a utilitarian social welfare function, I compute the additional percent lifetime consumption $\bar{x}$ that makes the average ex-ante welfare equal across these two economies using the following equation:

$$\int_j \left[E_0 \sum_{t=0}^{\infty} \beta^t U\left(c^o_{jt}\left(1+\bar{x}\right),\, l^o_{m,jt},\, l^o_{f,jt},\, s^o_{m,jt},\, s^o_{f,jt} \right) \right] d\Gamma_{ss}\left(j\right) = \int_j \left[E_0 \sum_{t=0}^{\infty} \beta^t U\left(c^n_{jt},\, l^n_{m,jt},\, l^n_{f,jt},\, s^n_{m,jt},\, s^n_{f,jt} \right) \right] d\Gamma_{ss}\left(j\right) \tag{10}$$

subject to the government budget constraint given in Equation (1). Here, c^k_{jt}, $l^k_{i,jt}$, and $s^k_{i,jt}$ denote household consumption, employment status, and participation decision of individual $i \in \{m,\, f\}$ of family j at time t under government policy $k \in \{o,\, n\}$, and Γ_{ss} is the stationary distribution at the stochastic steady state of the economy.

The welfare exercise in Equation (10) can be interpreted as follows. Consider two countries populated by people with the same type-distribution under transfer policy o. The only difference between both countries is that the government of the first country continues to implement policy o, while the second introduces policy n unexpectedly and permanently.[62] The welfare effects of a proposed policy is measured by how much additional lifetime consumption $\bar{x}$ should the first government compensate a family who is behind the veil of ignorance (i.e., does not know initial type in the stationary distribution) in order to make the family indifferent between being part of one of these two countries? Thus, the best policy n that the second government can implement is the one that makes the first government pay the highest compensation $\bar{x}_{\max}$ to weakly attract this prospective citizen. This policy will be the optimal transfer policy.

In my main optimal policy analysis in this section, I restrict policy instruments to take the form

[62] Hence, the economy of the second country will transition to its new steady state under policy n. Thus, the welfare exercise already incorporates the welfare gains or losses from the transitional dynamics.

Table 8: Current Policy vs Optimal Policy in the Baseline Model

Labor Productivity	Means-tested	Employment-tested	Total
	Current Policy		
Average	1.61	0.86	2.48
Recession	1.90	1.04	2.94
	Optimal Policy		
Average	1.40	1.18	2.58
Recession	0.40	1.34	1.74

Note: This table compares per recipient transfer amount as a multiple of minimum wage in the model paid under the means-tested and employment-tested transfers in the current policy and the optimal policy. Separate comparisons are presented for when the aggregate labor productivity z is at its average level $\bar{z}$, and its minimum level, i.e. deep recession. Minimum wage in the model is exogeneous to changes in policy and thus reporting transfer amounts as a multiple of minimum wage presents a useful interpretation.

of the means-tested transfer amount and employment-tested transfer amount as linear functions of current aggregate labor productivity. I set $\phi(z) = \bar{\phi} - \omega_\phi(z - \bar{z})$ and $b(z) = \bar{b} - \omega_b(z - \bar{z})$, where $\bar{z}$ is the average level of labor productivity z. This implies that if, for example, $\omega_\phi > 0$, then means-tested policy is countercyclical. Under this restriction of policy instruments, I search over five policy parameters $\left(\bar{\phi}, \omega_\phi, \bar{b}, \omega_b, \tau\right)$ to solve for the optimal transfer policy.[63]

5.2 Optimal policy in the baseline model

Table 8 compares per recipient transfer amount as a multiple of minimum wage in the model paid under the means-tested and employment-tested transfers in the current policy and the optimal policy. Separate comparisons are presented for when the aggregate labor productivity z is at its average level $\bar{z}$, and its minimum level, i.e. deep recession. Minimum wage in the model is exogeneous to changes in policy as discussed previously in Section 3. Thus, reporting transfer amounts as a multiple of minimum wage presents a useful interpretation.

The optimal level of transfers on average is determined by the tradeoff between insurance

[63]This means that for any values of $\left(\bar{\phi^n}, \omega_\phi^n, \bar{b}^n, \omega_b^n\right)$, I first solve for the income tax rate τ^n that balances the government budget in the long-run. Then, using these policy parameters, I numerically compute the welfare gains/losses relative to the baseline values of $\left(\bar{\phi^b}, \omega_\phi^b, \bar{b}^b, \omega_b^b, \tau^b\right)$, i.e. the baseline countercyclical policy, using Equation (10). Given any guess of $\bar{x}$, I can compute for both sides of this equation over the stationary distribution for any values of $\left(\bar{\phi^n}, \omega_\phi^n, \bar{b}^n, \omega_b^n, \tau^n\right)$. I then solve for the $\bar{x}$ that equates both sides of Equation (10). Finally, I select the policy that yields the highest welfare gain $\bar{x}_{max}$ as the optimal transfer policy.

benefits vis-à-vis incentive costs. When labor productivity is at its average level, the optimal policy features a lower level of means-tested transfers and higher level of employment-tested transfers when compared to the current policy under the average labor productivity. This way, the optimal policy induces larger spousal labor force participation. Nevertheless, total transfers under the optimal policy is 2.58 times the minimum wage which is close to 2.48 under the current policy. This is because, given that the model well accounts for important sources of private insurance channels (e.g. assets and spousal earnings), there is little redistributive role of government transfers.

The optimal cyclicality is determined by how insurance benefits net of incentive costs vary over the business cycle. The most striking difference between the optimal policy and current policy is that optimal means-tested transfers provides less generous transfers in recessions (procyclical) while the current policy expands benefits (countercyclical). In recessions, optimal means-tested transfers reduce the amount paid per recipient household from 1.40 to 0.40 times the minimum wage, whereas current policy increases it from 1.61 to 1.90. Less generous transfers in recessions alleviates large incentive costs of public insurance on the labor supply of spouses and induce female participation as a response to a head's displacement due to a larger increase in marginal utility of consumption as a result of head's larger earnings losses upon his displacements in recessions. On the other hand, optimal employment-tested transfers is more generous in recessions (countercyclical) and is of comparable cyclicality with the current policy. In particular, the amount paid per eligible individual increases from 1.18 to 1.34 times the minimum wage under the optimal policy, while it increases from 0.86 to 1.04 under the current policy. The provision of insurance benefits in recessions is better accomplished through employment-tested transfers because these are small payments and more importantly, limited in duration. This dampens its crowding-out effects on the labor supply of family members. This is corroborated by results of Section 4.2, where I show that the magnitude of the elasticity of female labor supply elasticity with respect to changes in $\bar{b}$ is small. Overall, total government transfers under the optimal policy is procyclical, while it is countercyclical under the current policy.

The optimal policy yields welfare gains equivalent to 0.61 percent additional lifetime consumption compared to the current policy. Roughly half of this welfare gains is attributable to optimizing over the average level of transfers, and the other half is attributable to optimizing over the cyclicality of transfers.[64]

5.2.1 Understanding the reasons behind the optimality

In order to better understand the reasons behind the optimality of this policy, I will compare family outcomes and macroeconomic outcomes under the optimal and current policies.

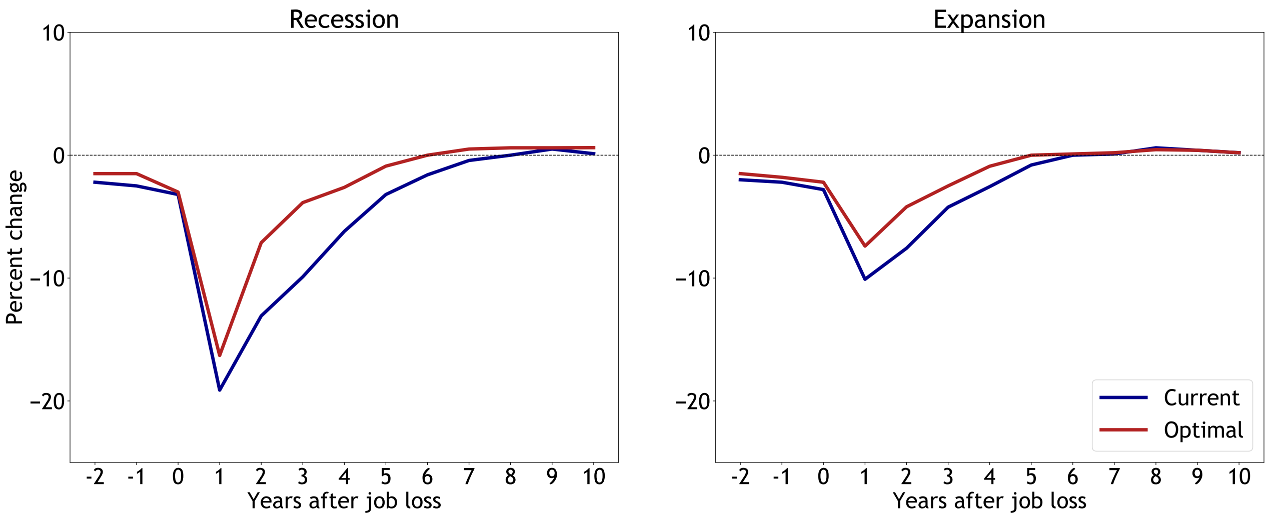
Effects of optimal policy on family outcomes upon displacement As mentioned earlier in Section 4.2, Figure 8 compares the change in spousal earnings upon the head's job displacement in recessions and expansions in the model under the countercyclical baseline (current) policy and a procyclical policy which was set to be what turned out to be the optimal policy. Thus, we know that the optimal policy induces a larger spousal labor supply response upon the head's job displacement in recessions, and it does not alter the magnitude of this response much in expansions due to reasons discussed earlier.

Next, I compare the change in family consumption upon the head's job displacement in recessions and expansions under the current policy and the optimal policy. It shows that families experience a smaller consumption drop upon the head's displacement both in recessions and in expansions under the optimal policy. Moreover, family consumption fully recovers 6 years after displacements in recessions, and 5 years after in expansions under the optimal policy, 2 years earlier in recessions and 1 year earlier in expansions. While the earlier recovery in recessions under the optimal policy is explained by a larger spousal labor earnings response, the earlier recovery in expansions is explained by larger amount of transfer receipts during the initial years after displacement.[65] Furthermore, I find that the difference in consumption drop upon displacement between recessions and expansion under the optimal policy is 9 pp ($0.16 - 0.07 = 0.09$), which is the same as this cyclical gap under the current policy ($0.19 - 0.10 = 0.09$). The reason why the optimal policy does not narrow this gap is the offsetting effects of the increase in spousal earnings and the

[64] Krusell, Mukoyama, Şahin, and Smith (2009) study the welfare effects of eliminating both aggregate risk and its impact on idiosyncratic risk when there is a correlation between these two shocks. Their study is an extension of Lucas (1987) into an incomplete asset markets model with heterogeneous households. They find that the welfare gains of eliminating the cycle and its effect on idiosyncratic risk are as much as 1 percent in consumption equivalents. Given that public and private insurance in my model can only partially smooth the effects of business cycles, welfare gains from the optimal policy are much lower than the upper bound provided by Krusell, Mukoyama, Şahin, and Smith (2009).

[65] Figure A.4 and A.5 in Appendix C provide comparisons respectively for relative changes in family earnings and assets upon the head's displacement in recessions and expansions under the current policy and the optimal policy, both of which affect changes in family consumption.

Figure 9: Relative Consumption of the Family upon Job Displacement: Current Policy vs Optimal Policy



Note: This figure plots the changes in relative family consumption upon head's job displacement in recessions (left panel) and expansions (right panel) in the model under the countercyclical baseline (current) policy and the optimal policy. I estimate the changes in relative family consumption from a distributed lag-recession model using model simulated data, which is aggregated up to yearly period.

decline in transfer receipts under the optimal policy in recessions. The main conclusion of this section is that the optimal policy reduces the average drop in consumption both in recessions and in expansions, but does not improve the cyclical gap of initial consumption drops.

Effects of optimal policy on the macroeconomic outcomes I now discuss the effects of the optimal policy on the macroeconomic outcomes. Table 9 compares the steady state values of macroeconomic outcomes under the current policy and the optimal policy. Compared to the economy under the current policy, the economy under the optimal policy has a similar unemployment rate but much higher female labor force participation rate (LFPR) at 76 percent versus 71 percent. Under the optimal policy, larger spousal labor supply is induced by having lower means-tested transfers on average and lower total transfers in recessions. As a result, the median skill of females is larger under the optimal policy as they spend more time employed. The increase in employment reduces the income tax required to finance a similar average level of government transfers from 16.2 percent to 15.6 percent. The wealth distribution of families in the labor force also shifts right under the optimal policy, as we observe a sizeable decline in the fraction of families with non-positive liquid wealth, and an increase in the median value of asset-to-income distribution. These

Table 9: Macroeconomic Effects of the Optimal Policy

	Current Policy	Optimal Policy
Labor market and taxation		
Unemployment rate (%)	5.05	5.08
Female LFPR (%)	71	76
Median skill of female	0.98	1.1
Income tax (%)	16.2	15.6
Asset-to-income distribution		
Median asset-to-income ratio	1.1	1.45
Fraction with non. pos. wealth (%)	13	9.1
Consumption		
Mean	0.85	0.86
Median	0.77	0.79
Std. dev. of mean	0.0181	0.0178
Gini	0.41	0.41

Note: This table compares the stochastic steady state values of macroeconomic outcomes under the current policy and the optimal policy. These values are obtained by using model simulated data under these two policies. Moments related to asset-to-income distribution and consumption are calculated for families who are in the labor force. Volatility of average consumption is measured by the standard deviation of log deviations from an HP-trend with parameter 1600.

changes in the macroeconomy increases the average consumption level under the optimal policy for the families in the labor force. I find that the mean and the median of consumption across these families are respectively 1 and 2 pp larger under the optimal policy compared to the current policy. While the gini of consumption distribution is the same under these two policies, the volatility of the average consumption is only slightly lower under the optimal policy because of the offsetting effects of the increase in spousal earnings and the decline in transfer receipts under the optimal policy in recessions.[66]

5.2.2 Heterogeneous welfare gains from the optimal policy

Finally, I discuss heterogeneous ex-post welfare gains/losses from the optimal policy across different types of families. I group families by their employment status, asset level, and skill levels of male and

[66] Volatility of average consumption is measured by the standard deviation of log deviations from an HP-trend with parameter 1600.

Table 10: Heterogeneous Welfare Gains from the Optimal Policy

Family employment: Only head employed

		Female skill	
		$\leq p50$	$> p50$
Asset	$\leq p50$	0.50	1.09
	$> p50$	0.29	0.38

Family employment: Only head employed

		Male skill	
		$\leq p50$	$> p50$
Asset	$\leq p50$	0.73	0.42
	$> p50$	0.35	0.25

Family employment: Both unemployed

		Female skill	
		$\leq p50$	$> p50$
Asset	$\leq p50$	1.21	1.66
	$> p50$	0.28	0.78

Family employment: Both unemployed

		Male skill	
		$\leq p50$	$> p50$
Asset	$\leq p50$	1.31	0.91
	$> p50$	0.76	0.41

Note: This table shows the heterogeneous welfare gains from the optimal policy on various type-groups. Cutoffs for the asset and skill groups are obtained from the respective distributions under the stationary distribution of the economy before the government changes the policy to the optimal policy. Welfare gains are in percent lifetime equivalent consumption terms and they are computed relative to the baseline countercyclical policy.

female based on their states on the stationary distribution of the economy before the government changes the policy to the optimal policy. I then calculate $\bar{x}$ from Equation (10) for each group by only integrating over families which belong to that group.

Table 10 shows the heterogeneous welfare impacts of the optimal policy on various type-groups, where columns represent male or female skill groups across families in which only head is employed or both are unemployed, and rows represent the asset holdings of families.

I find that most of the welfare gains are enjoyed by wealth-poor families with an unskilled male who is married to a skilled female, both among families in which only head is employed and among families in which the head and spouse are unemployed. Welfare gains are highest for such family types when both members are unemployed. It is precisely for this family for whom a spouse's participation in the labor force can bring the largest gains in consumption to the family especially when a displacement of the head occurs. On the contrary, the lowest welfare gains are enjoyed by wealth-rich families with skilled male and unskilled female for whom spouses are less likely to enter into labor force and the need for any insurance is the least.

Table 11: Optimal Policy in the Baseline vs Exogeneous Spousal Labor Supply Model

Labor Productivity	Means-tested	Employment-tested	Total
Optimal Policy in the Baseline Model			
Average	1.40	1.18	2.58
Recession	0.40	1.34	1.74
Optimal Policy in the Exogeneous Spousal Labor Supply Model			
Average	2.58	0.32	2.90
Recession	2.69	0.40	3.09

Note: This table compares per recipient transfer amounts as a multiple of minimum wage under the optimal policy of the baseline model and under the optimal policy in the exogenous spousal labor supply model. Separate comparisons are presented for when the aggregate labor productivity z is at its average level $\bar{z}$, and its minimum level, i.e. deep recession. Minimum wage in the model is exogeneous to changes in policy and thus reporting transfer amounts as a multiple of minimum wage presents a useful interpretation.

5.3 Optimal policy in the exogenous spousal labor supply model

I now explore the implications of assuming that spousal labor supply is exogenous to changes in government policy. In particular, I consider an alternative environment in which female labor force participation decisions are invariant to changes in government policy. In order to do so, I fix spousal labor supply decisions to be those under the current (old) policy for any new (proposed) policy n, i.e. $s_f^n(\cdot) = s_f^o(\cdot)\ \forall n$. Then, I solve for the optimal policy of this model using the same methodology as before. Table 11 compares per recipient transfer amounts as a multiple of minimum wage under the optimal policy of the baseline model with endogenous female labor supply and under the optimal policy in the exogenous spousal labor supply model.

When labor productivity is at its average level, total transfers paid under the optimal policy of the alternative model is more generous than the optimal policy under the baseline model. Recall that, in Table 7, I have documented that spousal labor supply elasticity to government policy is large, especially among low income households. When we abstract from the responsiveness of spousal labor supply to changes in government policy, we disregard the policy's crowding-out effect on spousal labor supply. As a result, the optimal policy features more generous transfers on average in this alternative model. Moreover, according to this optimal policy, around 90 percent of total transfers are paid under means-tested transfers in the exogenous spousal labor supply model since means-tested transfers better target insurance toward families who need it the most and their incentive costs are now small.

Furthermore, the optimal policy in this case features countercyclical means-tested and employment-tested transfers. This is because the optimal cyclicality of government transfers is mostly determined by the cyclicality of insurance benefits, which is larger in recessions during when more families experience unemployment and get closer to borrowing limits. Meanwhile, the incentive costs of transfers are now unaccounted for.

Overall, this exercise shows that endogenizing the spousal labor supply response to changes in government policy is a critical determinant of both the optimal level and cyclicality of transfers.

6 Extensions and Robustness

In this section, I provide a list of extensions and robustness checks of the optimal policy analysis. In my main welfare analysis in Section 5.2, I have searched for the optimal level and cyclicality of means-tested and employment-tested transfers as well as the implied tax rate that balances the government budget. In Section 6.1, I now optimize over the level of asset and income thresholds $\underline{a}$ and $\underline{y}$ of eligibility for means-tested transfers as well as the level and cyclicality of employment-tested transfer expiration rate $e(\cdot)$. In Section 6.2, I relax a list of assumptions in the baseline model and compute the welfare gains from the optimal policy of the baseline model. [67]

6.1 Extensions

Due to computational reasons, in Section 5.2, I solved for the optimal policy only by searching over the optimal level and cyclicality of means-tested and employment-tested transfers as well as the implied tax rate that balances the government budget. There are three other policy instruments in this model: the level of asset and income thresholds $\underline{a}$ and $\underline{y}$ of eligibility for means-tested transfers, and employment-tested transfer expiration rate $e(\cdot)$. In this section, I search for the optimal $\underline{a}$, $\underline{y}$, and $e(\cdot)$ in steps, taking as given the optimal level and cyclicality of means-tested

[67] I also check the implications of these exercises on results of Section 4. Sizeable welfare gains from the baseline optimal policy in these cases imply that less generous transfers in recessions still induce spouses to supplement family earnings by working.

Table 12: Welfare Gains under Optimality of Other Policy Instruments

	Welfare gains
Baseline optimal	0.61
Optimal $\underline{a}$, $\underline{y}$	0.81
Optimal $\underline{a}$	0.63
Optimal $\underline{y}$	0.77
Optimal e	0.63

Note: This table first shows the welfare gains from the baseline optimal policy calculated in Section 5.2, through optimizing over transfer level and cyclicality of both means-tested and employment-tested transfers (first row). Then, on top of this optimal policy, it shows welfare gains from optimizing over i) both levels of asset and income thresholds $\underline{a}$ and $\underline{y}$ of eligibility for means-tested transfers (second row), ii) only level of asset threshold $\underline{a}$ (third row), iii) only level of income threshold $\underline{y}$ (fourth row), and finally iv) only level and cyclicality of employment-tested transfer expiration rate $e(\cdot)$ (fifth row). In all of these cases, I solve for the income tax that balances government budget. Welfare gains are in percent lifetime equivalent consumption terms and they are computed relative to the baseline countercyclical policy.

and employment-tested transfers obtained in Section 5.2.[68]

Table 12 first shows the welfare gains from the baseline optimal policy calculated in Section 5.2, through optimizing over transfer level and cyclicality of both means-tested and employment-tested transfers (first row). Then, on top of this optimal policy (i.e. under the optimal level and cyclicality of means-tested and employment-tested transfers obtained in Section 5.2), it shows welfare gains from optimizing over i) both levels of asset and income thresholds $\underline{a}$ and $\underline{y}$ of eligibility for means-tested transfers (second row), ii) only level of asset threshold $\underline{a}$ (third row), iii) only level of income threshold $\underline{y}$ (fourth row), and finally iv) only level and cyclicality of employment-tested transfer expiration rate $e(\cdot)$ (fifth row). In all of these cases, I solve for the income tax that balances government budget. Welfare gains are in percent lifetime equivalent consumption terms and they are computed relative to the baseline countercyclical policy.

I find that, on top of the baseline optimal policy, jointly optimizing over asset and income thresholds yields welfare gains of 0.81 percent additional lifetime consumption relative to the current policy. In this case, optimal asset and income thresholds are 0.028 and 0.275 respectively. Under the current policy, asset and income thresholds are 0.068 and 0.240. This means that the optimal policy allows families with slightly higher total labor income to be eligible for means-tested transfers, while it makes asset eligibility criteria more restrictive, when compared to the current policy.

[68] Again due to computational reasons, it is not feasible to solve for full set of optimal policy instruments at the same time. Thus, I solve for optimal $\underline{a}$, $\underline{y}$, and $e(\cdot)$ one at a time.

In order to understand which of these two instruments are more powerful in increasing welfare gains, I next search for only optimal asset threshold and only optimal income threshold separately, again taking as given the baseline optimal policy. In the former case, welfare gains are 0.63, with an optimal asset threshold of 0.049. In the latter case, welfare gains are 0.77, with an optimal income threshold of 0.272. These results show that optimizing over the income threshold provides higher welfare gains.

Finally, I solve for the optimal level and cyclicality of employment-tested transfer expiration rate $e(\cdot)$, again taking as given the baseline optimal policy. According to the optimal $e(\cdot)$, employment-tested transfers should expire on average in 1.7 quarters, and that the duration should be extended to 1.8 quarters in recessions, implying that the optimal duration is only slightly countercyclical. Under the current policy, the duration is 2 quarters on average, and 7.6 quarters in recessions. Even if there is significant difference between the degree of countercyclicality of the current and optimal policies, this change provides only little welfare gains. Welfare gains from the optimal policy of this case are 0.63, which is only slightly higher than the welfare gains of 0.61 under the baseline optimal policy that does not optimize over $e(\cdot)$.

6.2 Robustness

In this section, I relax a list of assumptions in the baseline model and compute the welfare gains from the baseline optimal policy. Specifically, I show welfare gains from the optimal policy in Section 5.2, when an assumption of the baseline model is changed.[69] Results are summarized in Table 13, where welfare gains are in percent lifetime equivalent consumption terms, and they are computed relative to the baseline countercyclical policy.

Incorporating Medicaid to means-tested transfers In the calibration of the model, I did not incorporate Medicaid transfers into the calibration of the means-tested transfer policy instruments given that the baseline model does not incorporate extra eligibility risk such as health status or presence of a young children requirements. Now, I incorporate Medicaid transfers into the calibration of parameters of means-tested transfers and a new eligibility indicator for all means-

[69] I acknowledge that the optimal policy of the baseline model may not be the optimal policy of a model when some of the assumptions of the baseline model are different. However, this exercise at least shows us if there is a large quantitative effect of an assumption on welfare results.

Table 13: Welfare Gains from the Baseline Optimal Policy under Alternative Assumptions

	Welfare gains
Baseline optimal	0.61
Incorporating Medicaid to means-tested transfers	0.51
Removing job search requirements for employment-tested transfers	0.48
Progressive taxation	0.95
Non-separable preferences	0.68
Endogenous wages	0.66

Note: This table provides a list of robustness checks for the optimal policy analysis. It first shows the welfare gains from the optimal policy for the baseline model (first row). Then, it shows welfare gains from the same optimal policy, when an assumption of the baseline model is changed. Welfare gains are in percent lifetime equivalent consumption terms and they are computed relative to the baseline countercyclical policy.

tested transfers. Means-tested transfers are now given as follows:

$$\phi\left(z;\,a,\,y,\,\chi\right)=\begin{cases}\phi\left(z\right) & \text{if} \quad y<\underline{y},\,a<\underline{a},\,\chi=1\\ \iota\phi\left(z\right) & \text{if} \quad y<\underline{y},\,a<\underline{a},\,\chi=0\\ 0 & \text{otherwise}\end{cases}$$

where χ is a non-financial eligibility indicator for all means-tested transfers, which can be interpreted as health status or presence of a young children requirements. In the above specification, if a family is financially eligible but non-financially ineligible (i.e. $y<\underline{y}$, $a<\underline{a}$, $\chi=0$), then I assume that family receives only SNAP transfers, which typically does not have any non-financial eligibility requirements, and SNAP is ι fraction of total means-tested transfers. χ is a state variable of family, and a random variable is drawn from a uniform distribution each period to determine the value of χ.

I assume that 60 percent of families are non-financially eligible for means-tested transfers. I externally calibrate $\iota=0.107$ because total SNAP transfers is around 10.7 percent of total means-tested transfers on average across years. I then recalibrate this model and calculate the welfare gains from the optimal policy obtained in Section 5.2 under this model.[70] Here, I implement this

[70] Among the changes to the parameter values, important ones to mention here are as follows. Average generosity of means-tested transfers $\bar{\phi}=0.51$ instead of $\bar{\phi}=0.15$ in the baseline calibration given the inclusion of generous Medicaid transfers. Moreover, the cyclicality of means-tested transfers now becomes $\omega_{\phi}=2.8$ instead of $\omega_{\phi}=0.96$

exercise in two different ways given the large difference between the levels of $\bar{\phi}$ in the baseline model and in this model. First, I compute welfare gains directly from the baseline optimal policy, in which $\bar{\phi} = 0.13$. In this case, I find welfare gains of the baseline optimal policy, relative to the new calibration of the current policy under this model (i.e. $\bar{\phi} = 0.51$, $\omega_\phi = 2.8$, and so on), as much as 1.84 percent in consumption equivalent. In the second way, I replaced the average generosity of means-tested transfers in the optimal policy from $\bar{\phi} = 0.13$ to $\bar{\phi} = 0.51$ to understand the effects of only changing the cyclicality of means-tested transfers (from $\omega_\phi = 2.8$ in the current policy to $\omega_\phi = -3.54$ in the optimal policy, together with the changes in other policy parameters except $\bar{\phi}$). In this case, welfare gains are 0.51 in consumption equivalent, which is the value I report in Table 13. Both of these exercises show that less generous and procyclical means-tested transfer policy is welfare improving, which is consistent with my main results.

Removing job search requirements for employment-tested transfers In the baseline model, I assume that government can observe the search behavior of the unemployed. Here, I remove that assumption and check the implications on welfare gains from the baseline optimal policy.

In this case, employment-tested transfers are now given as follows:

$$b\left(z;\, l_i\right) = \begin{cases} b\left(z\right) & \text{if} \quad l_i = U_b \\ 0 & \text{otherwise} \end{cases}.$$

Then, I recalibrate the model and calculate welfare gains from the baseline optimal policy. I find that the optimal policy yields 0.48 percent additional lifetime consumption relative to the current policy in this model. Thus, I find smaller welfare gains in this model. This is possibly because of the increase in incentive costs of employment-tested transfers due to removal of job search requirement for eligibility.

in the baseline model. In fact, the standard deviation of detrended means-tested transfers per recipient is still 0.06, as in the baseline calibration, but the increase in level of means-tested transfers requires adjustments in ω_ϕ as well to match the same value. Finally, income tax rate that balances the budget $\tau = 20.6$ percent instead of $\tau = 16.2$ percent.

Progressive taxation In the baseline model, I assume that government levies a flat income tax τ to finance the transfer programs. Now, I change this assumption and study the effects of progressive income taxation on the welfare gains from the optimal policy of the baseline model.

Let x be the total taxable income of family. For families in the labor force, x includes total labor income and income from employment-tested transfers. For retired families, x includes only retirement income.[71] Then, following Heathcote, Storesletten, and Violante (2014), after tax income of family is given by $\tilde{x} = \lambda x^{1-\nu}$ where λ determines the level of taxation and $\nu \geq 0$ determines the rate of progressivity built into the tax system. Then, tax revenues of the government from a family with total taxable income x is given by $T(x) = x - \lambda x^{1-\nu}$.

In this case, I recalibrate the parameters of the model, where I set $\nu = 0.151$ as in Heathcote, Storesletten, and Violante (2014), and search for λ that balance the government budget in the long-run and find $\lambda = 0.834$. Then, I calculate welfare gains from the optimal policy of the baseline model, where tax policy is also progressive at the same degree, and level parameter under the optimal policy becomes $\lambda = 0.844$ in equilibrium. I find that the optimal policy yields 0.95 percent additional lifetime consumption relative to the current policy in this model. Thus, I find larger welfare gains when taxation is progressive. This is intuitive given that most of the welfare gains are enjoyed by poor families as shown in Section 5.2. When the tax system is progressive, it is this group of families whose spouses are induced to work more under the optimal policy and they receive higher net earnings since they have low marginal tax rates.

Non-separable preferences I consider a utility function in which consumption and leisure are non-separable, following Blundell, Browning, and Meghir (1994) and Attanasio and Weber (1995). I now define preferences as follows:

$$U(c,\, l_m,\, l_f,\, s_m,\, s_f) \quad = \quad \frac{\left[c \times \prod_{i\in\{m,f\}} \exp\left(\eta_i \times \mathbf{1}\left(l_i \neq E,\ \text{and } s_i = 0\right)\right)\right]^{1-\sigma}}{1-\sigma}$$

This is similar to functional form used in Low, Meghir, and Pistaferri (2010). Then, I recalibrate the model under this preference. Next, I calculate welfare gains from the baseline optimal policy and find that it yields 0.68 percent additional lifetime consumption relative to the current policy in

[71] For a better comparison of results with the baseline model, I assume that x does not include capital (savings) income, which is also not taxed in the baseline model.

this model. This implies that welfare gains from the baseline optimal policy are not much affected when we change the preferences.

Model with endogenous wages Finally, in the baseline model, I assume that the wage for each human capital level is a fraction of period aggregate labor productivity. This assumption implies that wages and firm vacancy posting decisions are exogenous to changes in government policy in the baseline model, which allowed me to isolate the effects of transfers on labor supply.

To analyze the quantitative effects of this assumption on the welfare gains from the optimal policy, I now consider a directed search model in which wage choices of unemployed individuals are endogeneous. In this model, submarkets in the labor market are indexed by the wage offer w of the firms and human capital level h of the job. This means that unemployed individuals now direct their search effort toward a specific wage offered by a job that is compatible with their own skill level. In this case, wage levels of the employed members of the household become extra state variables. Household and firm optimization problems as well as a discussion on the equilibrium of this model are given in Appendix D.

I recalibrate the parameters of this model and find that the baseline optimal policy yields 0.66 percent additional lifetime consumption relative to the current policy. Changes in government transfer generosity now affect the wage choice of the unemployed endogeneously. Less generous public insurance in recessions induces unemployed individuals to look for low paying jobs for which job finding rates are higher. Thus, under the baseline optimal policy, reemployment wages are lower but unemployment duration is shorter compared to the baseline model. While the former channel reduces the welfare gains from the baseline optimal policy, the latter channel increases welfare gains. As a result, welfare gains from the baseline optimal policy in this model are similar to the welfare gains in the baseline model.

7 Conclusion

Previous literature has documented that a large negative and persistent effect of job displacement on individual labor earnings. Moreover, these effects are more pronounced when the displacement happens in recessions. In this paper, I first analyze the change in spousal earnings upon the head's job displacement both in recessions and in expansions using PSID data. I show that the change in spousal earnings in response to the head's job displacement is small. The response is even smaller upon displacements that occur in recessions. This result is particularly interesting because one might expect a stronger spousal earnings response during times when the head experiences larger earnings losses.

I investigate whether this small response is an outcome of the crowding-out effects of existing government transfers. To achieve this, I use an incomplete asset markets model with family labor supply and aggregate fluctuations. I first show that the model implied female labor supply elasticities with respect to transfers are in line with microeconomic estimates both in aggregate and across subpopulations. Then, in a model counterfactual, I find that existing generous transfers in recessions discourage spousal labor supply significantly after the head's job displacement. The results of this counterfactual experiment imply that the incentive costs of transfers in the form of reduced spousal labor supply are larger in recessions and smaller in expansions. Given that existing transfers are more generous in recessions, this motivates an analysis of redesigning the government transfers over the business cycle.

Next, I solve for optimal means-tested transfers paid to low-income and low-wealth families and employment-tested transfers paid to the unemployed. Unlike the existing policy that maintains generous transfers of both types in recessions, I find that the optimal policy features procyclical means-tested and countercyclical employment-tested transfers. Overall, the optimal policy is procyclical because there are welfare gains of reducing transfers in recessions to induce spouses to work more when the head experiences larger earnings losses. This is a direct implication of the model's result that spousal labor supply is more elastic to transfers in recessions, which is in line with the data.

In an alternative environment in which spousal labor supply were invariant to transfer generosity, I show that the average transfer generosity of the optimal policy increases. Moreover, the optimal policy in this case would instead feature countercyclical transfers of both types since the insurance benefits are larger in recessions and the incentive costs in on spousal labor supply would be unaccounted for. As a result, I argue that endogenizing the spousal labor supply response to changes in government policy is critical in determining both the optimal level and cyclicality of government transfers.

In this paper, I focus on the macroeconomic implications of how public insurance programs interact with private insurance for married households. Hence, policy implications of this study may not apply to singles. Importantly, when we consider an environment with married and single households, government transfers would affect incentives to marry, and thus the amount and the distribution of private insurance in the economy. I will pursue this in future research.

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Appendix

A. Model

In this section, I lay out and discuss the expectation over the transition of employment statuses of unemployed - unemployed and employed - employed households respectively. These supplement the discussion in Section 2.2 of the main text.

Unemployed - unemployed household

$$\begin{aligned}\mathbb{E}_{\mathbf{l}',\mathbf{h}',\mu'}\left[V^{l'}\left(a',\mathbf{h}';\mu'\right)\right] = \mathbb{E}_{\mathbf{h}',\mu'}\Bigg[& s_m s_f p'_m \left(p'_f V^{EE}\left(a',\mathbf{h}';\mu'\right) + \left(1-p'_f\right)\sum_{k\in\{b,n\}}\lambda'_k V^{EU_k}\left(a',\mathbf{h}';\mu'\right)\right)\\
&+ s_m s_f\left(1-p'_m\right)\left(p'_f\sum_k \lambda'_k V^{U_kE}\left(a',\mathbf{h}';\mu'\right) + \left(1-p'_f\right)\sum_{k,d\in\{b,n\}}\lambda'_k\lambda'_d V^{U_kU_d}\left(a',\mathbf{h}';\mu'\right)\right)\\
&+ s_m\left(1-s_f\right)\left(p'_m\sum_k \lambda'_k V^{EU_k}\left(a',\mathbf{h}';\mu'\right) + \left(1-p'_m\right)\sum_{k,d\in\{b,n\}}\lambda'_k\lambda'_d V^{U_kU_d}\left(a',\mathbf{h}';\mu'\right)\right)\\
&+ \left(1-s_m\right)s_f\left(p'_f\sum_k \lambda'_k V^{U_kE}\left(a',\mathbf{h}';\mu'\right) + \left(1-p'_m\right)\sum_{k,d\in\{b,n\}}\lambda'_k\lambda'_d V^{U_kU_d}\left(a',\mathbf{h}';\mu'\right)\right)\\
&+ \left(1-s_m\right)\left(1-s_f\right)\sum_{k,d\in\{b,n\}}\lambda'_k\lambda'_d V^{U_kU_d}\left(a',\mathbf{h}';\mu'\right)\,\Bigg|\,\mathbf{h},\mu\Bigg]\end{aligned}$$

where I drop the conditions of the expectation in the left hand side to save space. The first line in the right hand side shows the case when both male and female search for a job in the current period, and he finds a job. In this case, if she finds a job, the household will be an employed - employed household, otherwise the household will be an employed - unemployed household but she may retain or lose eligibility for employment-tested transfers. The second line is the case when both of them search for a job and he does not find it. Then, if she finds a job, the household will be an unemployed - employed household where he may or may not be eligible for employment-tested transfers. If she cannot find a job, then both members of the household will continue to be unemployed, and they will both face eligibility risk for the employment-tested transfers. The third and fourth lines are cases when one of them searches for a job and the other does not. In these cases, if the searcher finds a job, then the household will have one employed member and the other faces eligibility risk, otherwise both members will continue to be unemployed and both face eligibility risk. Finally, the last line shows the case when both members do not search for a job, continue to be unemployed, and face eligibility risk.

Similarly, for the household in which any unemployed member is ineligible unemployed, the above expectation is the same except that this member stays ineligible for employment-tested transfers if he/she does not find a job.

Employed - employed household

$$\begin{aligned}\mathbb{E}_{\mathbf{l}',\mathbf{h}',\mu'}\left[V^{l'}\left(a',\,h';\,\mu'\right)\right] = \mathbb{E}_{\mathbf{h}',\mu'}\Bigg[&(1-\delta'_m)\left(\left(1-\delta'_f\right)V^{EE}\left(a',\mathbf{h}';\mu'\right)+\delta'_f\sum_{k\in\{b,n\}}\lambda'_k V^{EU_k}\left(a',\mathbf{h}';\mu'\right)\right)\\ &+\delta'_m\left(\left(1-\delta'_f\right)\sum_k \lambda'_k V^{U_kE}\left(a',\mathbf{h}';\mu'\right)+\delta'_f\sum_{k,d\in\{b,n\}}\lambda'_k\lambda'_d V^{U_kU_d}\left(a',\mathbf{h}';\mu'\right)\right)\Bigg|\,\mathbf{h},\mu\Bigg]\end{aligned}$$

where I drop the conditions of the expectation in the left hand side to save space. The first line in the right hand side shows cases when male keeps his job, female may or may not lose her job, and face eligibility risk if she loses it. The second line gives cases in which he loses his job and face eligibility risk, and again female may or may not lose her job, and face eligibility risk if she loses it.

B. Data

In this section, I first discuss sample selection and construction of some of the important variables for the PSID data that is used in Section 3.1 of the main text. Second, I show that the main empirical conclusions of Section 3.1 remain almost unaltered if under alternative data samples. Third, I document the relative change in annual working hours of the head and the spouse upon head's job displacement in recessions and in expansions. These supplement the discussions in Section 3.1. Finally, I explain the details of calculating asset-to-income distribution from the PSID and the SCF data, both of which are used in Section 3.3 of the main text.

B.1. PSID Data

In Section 3.1, I use data from PSID in order to analyze the impact of head's job displacement over the business cycle on his own labor earnings, spousal labor earnings, and family labor earnings as well as working hours of the head and the spouse. The PSID is a nationally representative survey that was conducted in the United States annually from 1968 to 1997 and biannualy from 1997 to 2015. I use all of these waves of the data. The PSID provides information on labor market outcomes such as annual labor earnings and working hours, as well as characteristics of the family such as age, education, and number of children of the couples. Labor earnings of the head or spouse include wages and salaries, bonuses, overtime, tips, commissions, professional practice or trade, market gardening, miscellaneous labor income, and extra job income.[72]

While I take many of the variables that I use in the main analysis directly from the PSID, there are several variables I must create using the other available information in the data. First, to address inconsistencies for the variable defining the age of the individuals, I create a new age variable separately for the head and the spouse by an increase based on the age reported in the first observation of the family. Next, I use completed years of education to create potential years of labor market experience for both head and spouse in any of their available observation as $Age - Education - 6$ if the individual's years of completed education is larger than or equal to 12, and as $Age - 18$ if otherwise. This way, individuals with fewer years of completed education are not assigned large values for their labor market experience. I also create the total number of children and young children (defined as the number of children with age less than 6) of the family in any of their available observation using the relation of each individual in the family unit to the head of the family.

I create variables for involuntary job displacement using a question that asks the reason for loss of the previous job to the individuals who are either without a job or have been employed in their current job for less than a year. Following the literature, I define an involuntary job loss as a separation due to firm closure, layoff or firing. As Stevens (1997) and Stephens (2002) point out, the timing of the displacement is not precisely identified in all years of the survey. This is because while the earnings and hours questions are designed to obtain information for the previous year, the question that I use to determine job displacement is not year specific. To better understand this, consider a head of the family who reports to be displaced according to the definition above in 1992 survey of the PSID. This implies that the head may be displaced in any time between January of 1991 and the survey date in 1992. Thus, the econometrician may assign such displacement either in

[72]PSID defines the head of a family unit as the individual with the most financial responsibility who is at least 18 years old. In the case that this person is a female and she has a spouse or partner or a boyfriend with whom she has been living for at least one year, then he is assigned to be the head of the family unit.

1991 (previous calendar year) or in 1992 (survey year). In my analysis, following Stephens (2002), I assume that displacements occur in the previous calendar year to align the displacement year with the earnings and hours information.

Given that I also use the data from biannual survey years of the PSID (1997-2015), displacements that occur in between these years have information only for every other year. However, I still prefer to keep this time period in my main sample especially to incorporate the Great Recession period to my analysis to better analyze the differential effects of displacements over the business cycle on the labor market outcomes of couples. Furthermore, given that 1968 survey only identifies workers who have been displaced within the past ten years, it is not possible to determine the exact year of such displacement within these ten years. Therefore, I do not incorporate displacements that occur in 1968 into my analysis.

The PSID has four samples: Survey Research Center (SRC), Survey of Economic Opportunities (SEO), Immigrant, and Latino samples. I obtain the main results in Section 3.1 using SRC, SEO, and Immigrant samples. However, the main conclusions of the empirical section remain almost unaltered if I use other combinations of these samples. Table A.1 presents the results for the impact of head's displacement over the business cycle on relative spousal earnings and hours under the alternative samples of the PSID using proper weights. The table presents similar results to those obtained in the main text, given that spousal earnings and hours response is small on average in recessions, and slightly positive in expansions.

In Section 3.1, I restrict the baseline sample to families in which both the husband and the wife are between the ages of 20 and 60 with at least two years of observation. I also drop families whose family labor income is above the 99th percentile of family labor income distribution. Table A.2 summarizes the results for the impact of head's displacement over the business cycle on relative spousal earnings and hours under alternative restrictions in the baseline sample. First, I change the age limits in the baseline sample so that I only use information until age 55 as in Davis and von Wachter (2011). Second, I include family head's who are single into the baseline sample. Third, I keep families whose family labor income is above the 99th percentile of family labor income distribution. Fourth, I drop families with family labor income below the bottom 1 percentile and families with family labor income above the top 1 percentile. Fifth, I drop families when any member of the family is not living in the family unit. Finally, in Section 3.1, I estimate Equation

Table A.1: Spousal Labor Earnings and Hours Response to Head's Displacement in Recessions and Expansions under Alternative Samples of the PSID

Years since displacement	Spouse Earnings Recession	Spouse Earnings Expansion	Spouse Hours Recession	Spouse Hours Expansion	Spouse Earnings Recession	Spouse Earnings Expansion	Spouse Hours Recession	Spouse Hours Expansion
	Baseline Sample				Keep all Samples			
−2	−0.02	−0.02	0.01	−0.02	0.01	−0.04	0.03	−0.04
	(0.87)	(0.88)	(0.91)	(0.87)	(0.90)	(0.42)	(0.65)	(0.35)
0	0.12	−0.07	0.07	0.04	0.11	−0.05	0.08	0.04
	(0.42)	(0.26)	(0.49)	(0.35)	(0.43)	(0.95)	(0.41)	(0.40)
2	−0.14	−0.01	−0.05	0.03	−0.13	0.08	−0.04	0.02
	(0.33)	(0.88)	(0.60)	(0.52)	(0.33)	(0.50)	(0.66)	(0.58)
4	0.09	0.09	−0.02	0.11	0.09	0.10	−0.02	0.11
	(0.56)	(0.18)	(0.84)	(0.03)	(0.58)	(0.14)	(0.84)	(0.02)
6	0.02	0.14	−0.03	0.16	0.03	0.10	−0.03	0.13
	(0.88)	(0.02)	(0.71)	(0.00)	(0.85)	(0.14)	(0.67)	(0.00)
8	−0.17	0.17	−0.11	0.09	−0.16	0.15	−0.11	0.09
	(0.12)	(0.01)	(0.10)	(0.03)	(0.14)	(0.02)	(0.10)	(0.02)
10	−0.11	0.07	−0.08	0.10	−0.09	0.10	−0.07	0.08
	(0.30)	(0.16)	(0.20)	(0.01)	(0.37)	(0.17)	(0.28)	(0.01)
	Keep SRC and SEO Samples				Keep only SRC Sample			
−2	−0.03	−0.02	−0.04	−0.03	−0.02	−0.02	0.04	−0.03
	(0.73)	(0.69)	(0.81)	(0.46)	(0.87)	(0.71)	(0.80)	(0.47)
0	0.12	−0.07	0.06	0.04	0.17	−0.05	0.10	0.06
	(0.42)	(0.26)	(0.52)	(0.40)	(0.29)	(0.43)	(0.35)	(0.21)
2	−0.15	−0.01	−0.06	0.02	−0.18	0.01	−0.09	0.02
	(0.29)	(0.92)	(0.53)	(0.65)	(0.23)	(0.86)	(0.35)	(0.59)
4	0.09	0.09	−0.02	0.11	0.06	0.09	−0.05	0.12
	(0.58)	(0.19)	(0.78)	(0.03)	(0.74)	(0.18)	(0.52)	(0.02)
6	0.00	0.14	−0.05	0.16	0.02	0.15	−0.03	0.17
	(0.99)	(0.02)	(0.48)	(0.00)	(0.91)	(0.02)	(0.74)	(0.00)
8	−0.19	0.17	−0.13	0.09	−0.22	0.17	−0.17	0.09
	(0.10)	(0.01)	(0.05)	(0.03)	(0.07)	(0.01)	(0.02)	(0.03)
10	−0.10	0.07	−0.08	0.09	−0.10	0.07	−0.06	0.08
	(0.32)	(0.17)	(0.22)	(0.01)	(0.38)	(0.18)	(0.39)	(0.03)

Note: The PSID has four samples: Survey Research Center (SRC), Survey of Economic Opportunities (SEO), Immigrant, and Latino samples. The baseline sample consists of SRC, SEO, and Immigrant samples. All results are obtained using Equation (9) with proper weights but I only show the estimated values (as a percent of mean predisplacement earnings) for every other year to save space.

Table A.2: Spousal Labor Earnings and Hours Response to Head's Displacement in Recessions and Expansions under Alternative Restrictions in the Baseline Sample

Years since	Spouse Earnings		Spouse Hours		Spouse Earnings		Spouse Hours	
displacement	Recession	Expansion	Recession	Expansion	Recession	Expansion	Recession	Expansion
	Alternative Age Limits				Include Singles			
−2	−0.01	−0.02	0.03	−0.03	−0.07	−0.08	−0.09	−0.08
	(0.94)	(0.88)	(0.75)	(0.50)	(0.18)	(0.45)	(0.75)	(0.43)
0	0.13	−0.11	0.04	0.04	−0.03	−0.20	−0.07	0.01
	(0.37)	(0.11)	(0.65)	(0.47)	(0.92)	(0.23)	(0.76)	(0.91)
2	−0.22	−0.03	−0.04	0.01	−0.55	−0.00	−0.24	0.09
	(0.14)	(0.60)	(0.64)	(0.76)	(0.08)	(0.99)	(0.24)	(0.44)
4	0.05	0.06	−0.00	0.11	−0.19	0.12	−0.14	0.31
	(0.75)	(0.38)	(0.96)	(0.05)	(0.55)	(0.51)	(0.40)	(0.02)
6	−0.05	0.13	−0.03	0.16	−0.16	0.24	−0.08	0.39
	(0.72)	(0.04)	(0.70)	(0.00)	(0.60)	(0.14)	(0.64)	(0.00)
8	−0.12	0.13	−0.08	0.07	−0.40	0.22	−0.20	0.11
	(0.23)	(0.05)	(0.22)	(0.10)	(0.12)	(0.15)	(0.18)	(0.24)
10	−0.08	0.03	−0.07	0.09	−0.33	0.13	−0.23	0.20
	(0.36)	(0.58)	(0.35)	(0.02)	(0.11)	(0.32)	(0.10)	(0.02)
	Keep Top 1 Percentile				Drop Both Bottom 1 and Top 1 Percentile			
−2	−0.02	−0.04	0.04	−0.03	−0.02	−0.02	−0.01	−0.04
	(0.85)	(0.45)	(0.57)	(0.40)	(0.87)	(0.77)	(0.95)	(0.40)
0	−0.02	0.00	0.03	0.03	0.13	−0.09	0.08	0.03
	(0.87)	(0.95)	(0.66)	(0.46)	(0.40)	(0.16)	(0.44)	(0.59)
2	−0.21	0.08	−0.06	0.03	−0.15	−0.03	−0.05	0.02
	(0.15)	(0.35)	(0.46)	(0.40)	(0.33)	(0.67)	(0.59)	(0.62)
4	−0.01	0.06	0.04	0.06	0.09	0.06	0.01	0.08
	(0.94)	(0.25)	(0.63)	(0.10)	(0.59)	(0.36)	(0.94)	(0.12)
6	−0.06	0.10	0.01	0.09	0.02	0.11	−0.02	0.12
	(0.66)	(0.06)	(0.85)	(0.03)	(0.92)	(0.09)	(0.83)	(0.01)
8	−0.14	0.11	−0.03	0.06	−0.21	0.15	−0.13	0.08
	(0.20)	(0.04)	(0.66)	(0.08)	(0.09)	(0.02)	(0.07)	(0.06)
10	−0.09	0.06	−0.01	0.04	−0.15	0.08	−0.09	0.09
	(0.39)	(0.32)	(0.82)	(0.26)	(0.18)	(0.16)	(0.20)	(0.01)
	Drop when Couples are not living in Family Unit				Keep Displaced in Recessions and Expansions			
−2	−0.03	−0.02	−0.01	−0.03	0.01	−0.02	0.02	−0.03
	(0.80)	(0.88)	(0.86)	(0.48)	(0.84)	(0.66)	(0.76)	(0.32)
0	0.11	−0.07	0.07	0.04	0.02	−0.05	0.01	0.02
	(0.44)	(0.25)	(0.50)	(0.37)	(0.79)	(0.21)	(0.81)	(0.44)
2	−0.14	−0.01	−0.05	0.03	−0.03	−0.02	−0.00	0.05
	(0.34)	(0.87)	(0.60)	(0.54)	(0.64)	(0.62)	(0.97)	(0.13)
4	0.09	0.09	−0.01	0.11	0.04	0.03	−0.04	0.06
	(0.56)	(0.18)	(0.86)	(0.03)	(0.62)	(0.45)	(0.40)	(0.08)
6	0.02	0.14	−0.03	0.16	0.11	0.08	0.04	0.10
	(0.88)	(0.02)	(0.71)	(0.00)	(0.12)	(0.04)	(0.45)	(0.00)
8	−0.17	0.16	−0.11	0.08	0.00	0.11	−0.01	0.08
	(0.12)	(0.01)	(0.10)	(0.04)	(0.97)	(0.01)	(0.89)	(0.00)
10	−0.11	0.07	−0.08	0.10	−0.03	0.07	−0.01	0.07
	(0.30)	(0.16)	(0.20)	(0.01)	(−0.54)	(0.06)	(0.85)	(0.01)

Note: All results are obtained using Equation (9) but I only show the estimated values for every other year to save space.

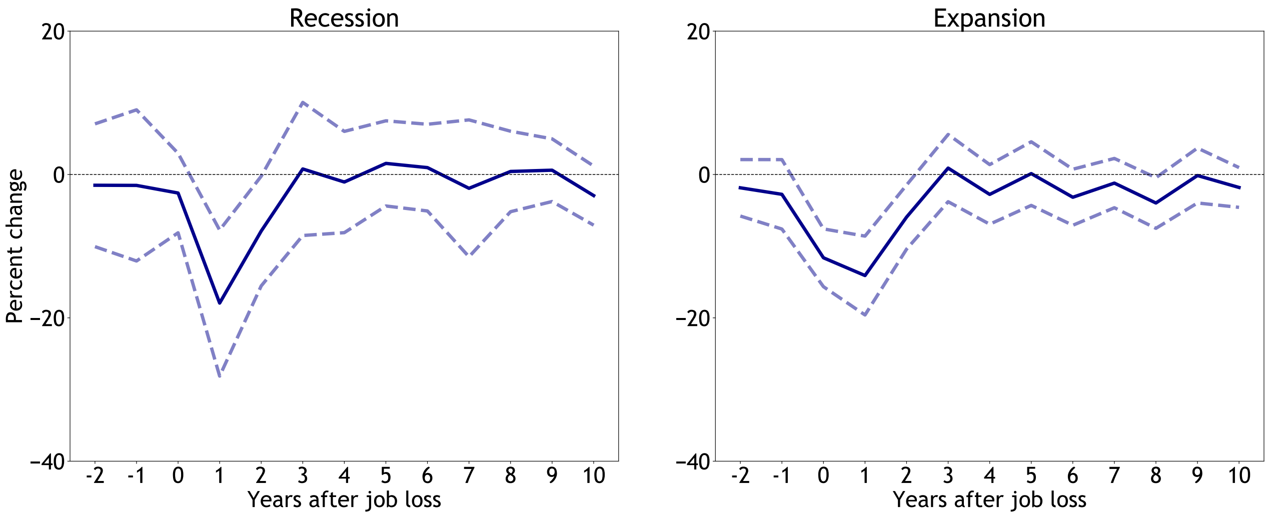
(9) separately for i) a treatment group where the head is displaced only in recessions and a control group where the head is never displaced, and ii) a treatment group where head is displaced only in expansions and a control group where head is never displaced. This allows me to better isolate the differential effect of head's displacement in recessions and expansions on families since I do not incorporate families whose head is displaced both in recessions and expansions in these separate regressions. The last robustness exercise of Table A.2 presents results when I incorporate such families to each of the two separate regressions. Overall, this table shows that the main result remains robust across all of these alternative restrictions, given that spousal earnings and hours response is small on average in recessions, and slightly positive in expansions.

Head and spouse hours upon head's job displacement Figure A.1 shows that magnitude of the drop in head's relative hours when the head is displaced in recessions (18 percent) is similar to the one in expansions (14 percent) in the year following displacement. Moreover, it shows that the relative hours recover just after 2 years upon displacement both in recessions and expansions. These suggest that both the cyclical gap in earnings loss upon displacements over the business cycle and the persistence of the earnings loss are largely explained by drop in wages rather than drop in hours. Previously, Ruhm (1991), Stevens (1997), and Huckfeldt (2016) have already documented this quick recovery of relative hours of the displaced workers using PSID. My findings complement their results as I provide additional evidence that hours recover relatively quickly upon displacements both in recessions and expansions, and that it wage losses explain most of the cyclical gap in earnings losses.

Figure A.2 shows the change in relative spousal hours upon head's job displacement in recessions and in expansions. I find that the average change in spousal hours upon head's displacements in recessions is small, while spousal hours upon head's displacements in expansions increases by up to 15 percent and coefficients remain significant after 3 years following the displacement. According to my results, the average postdisplacement change is −0.1 percent in recessions and 10.1 percent in expansions.[73]

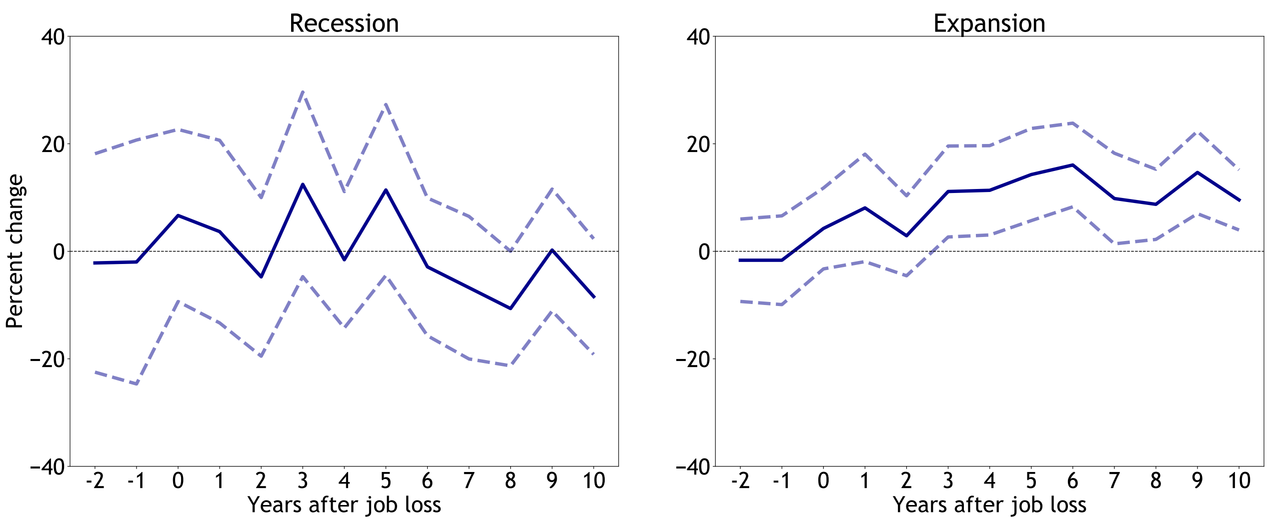
[73] Previously, Stephens (2002) uses PSID to study the impact of head's job displacement on relative working hours of spouses and finds that the average increase in relative spousal hours is 11 percent across all years after head's displacement.

Figure A.1: Relative Working Hours of Family Head upon Job Displacement



Note: This figure plots the changes in relative working hours of the family head upon his job displacement in recessions (left panel) and expansions (right panel). I estimate the changes in relative labor earnings from a distributed lag-recession model using PSID. The solid blue line shows the point estimates and the dashed light blue line shows the 90 percent confidence interval.

Figure A.2: Relative Working Hours of Spouse upon Job Displacement



This figure plots the changes in relative working hours of the spouse upon family head's job displacement in recessions (left panel) and expansions (right panel). I estimate the changes in relative spousal hours from a distributed lag-recession model using PSID. The solid blue line shows the point estimates and the dashed light blue line shows the 90 percent confidence interval.

Asset-to-income distribution Starting from 1999 survey, PSID provides information on asset holdings of households in every two years. However, the amount of credit card debt is only available after 2011. For this reason, I choose to present the asset-to-income distribution for the latest survey of PSID in 2015.

I calculate the net liquid wealth of each households in my main sample for the PSID by adding the amount of checking and saving account, the amount of bonds and other assets, the amount of stocks, and the amount of vehicle equity, and then deducting the amount of credit card debt. Then, fraction of families of non-positive liquid wealth is simply given by ratio of the total number of families with non-positive values of this net liquid wealth measure to the total number of families. Next, I calculate the net liquid wealth to quarterly labor income ratio by dividing this measure of net liquid wealth to total quarterly family labor income (i.e. sum of head and spouse labor income) for each family with positive total family labor income.[74] Finally, I calculate the weighted distribution of this net liquid wealth to quarterly labor income ratio across these families. The percentiles of the PSID 2015 distribution given in Table 6 in the main text are obtained from this calculation.

B.2. SCF Data

I also calculate the net liquid asset-to-income distribution from the SCF 2007. In order to do so, I first construct a sample of family head's with the following restrictions: i) marital status is married or cohabiting, and ii) ages of the head and spouse are between 20 and 60. This way, the SCF sample will be similar to the PSID sample.

The SCF provides information on the i) amount in up to seven different checking accounts, ii) amount in up to seven different savings/money market accounts, iii) value of all certificates of deposits, iv) total value of all types of mutual funds, v) total value of all savings bonds, vi) total value of all bonds other than saving bonds, vii) total value of publicly traded stocks, viii) total value of all the cash or call money (brokerage) accounts, ix) amount in annuity and trust accounts, x) other assets such as money owed to family or gold, silver, and other jewelry, and xi) value in vehicle equity. Summation of these values gives the total liquid wealth of the family. I then subtract the

[74] I obtain the total quarterly family labor income by dividing the annual amount of total family labor income by 4.

total credit card debt to obtain the net liquid wealth of each family. Then, fraction of families of non-positive liquid wealth is simply given by ratio of the total number of families with non-positive values of this net liquid wealth measure to the total number of families. Next, I calculate the net liquid wealth to quarterly labor income ratio by dividing this measure of net liquid wealth to total quarterly family labor income for each family with positive total family labor income.[75] Finally, I calculate the weighted distribution of this net liquid wealth to quarterly labor income ratio across these families. The percentiles of the SCF 2007 distribution given in Table 6 in the main text are obtained from this calculation. Moreover, the median ratio of credit limit to quarterly labor income in Table 3 is also obtained from this dataset, using the information on the total credit limit and total quarterly family labor income of each family.

B.3. SIPP Data

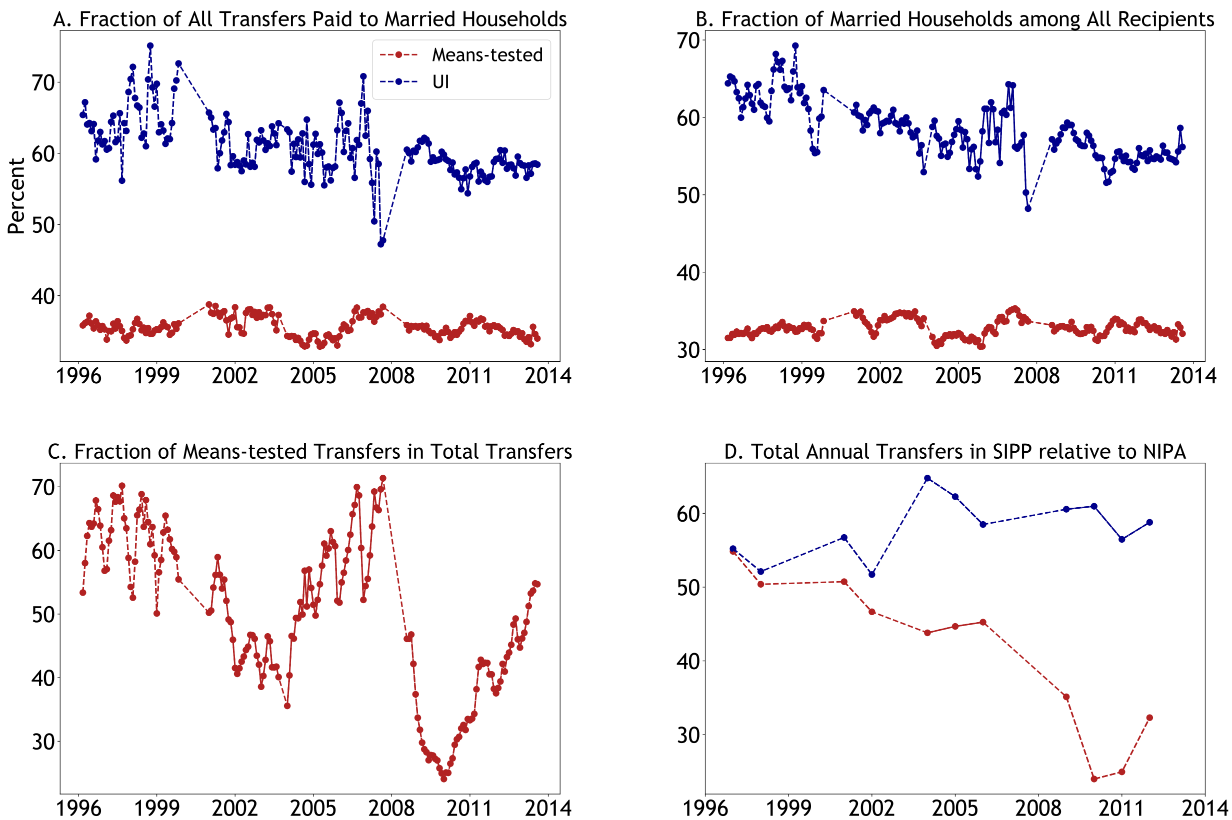
In this section, I document the amount and incidence of transfer receipts by married households. To do so, I use monthly data from the SIPP 1996 to 2008 Panels (covering December 1995 to August 2013) that provide information on monthly amounts of means-tested transfers and unemployment insurance transfers received by the family. Figure A.3 shows the results.

In Panel A, I show the total means-tested and employment-tested (UI) transfers paid to married households as a fraction of aggregate means-tested and employment-tested transfers separately. On average, around 35 percent of all means-tested transfers and 60 percent of total UI transfers are paid to married households. According to Panel B, married households constitute around 33 percent of all means-tested transfer recipients and 58 percent of all UI recipients. Finally, Panel C shows that around 60 percent of all transfers received by the married households are means-tested transfers. However, this value drops to as low as 30 percent after 2008. This is because, starting from this year, the survey data drastically underestimates total annual means-tested transfers when compared to total government means-tested government transfers in NIPA tables, as shown in Panel D.

Overall, Figure A.3 documents that means-tested transfers consitute a large fraction of total transfer receipts of married households.

[75] I obtain the total quarterly family labor income by dividing the annual amount of total wages and salaries income of family (IRS Form 1040 Line 7) by 4.

Figure A.3: Transfer Receipts by Married Households



Note: Panel A plots the total means-tested and employment-tested (UI) transfers paid to married households as a fraction of aggregate means-tested and employment-tested transfers separately. Panel B shows the total number of married household heads receiving means-tested and employment-tested transfers as a fraction of all recepients of these transfers separately. Panel C shows the ratio of total means-tested transfers to total transfers (sum of means-tested and UI) received by married households. Finally, Panel D plots the total annual transfer amounts in SIPP data as a fraction of aggregate transfer amounts in NIPA tables, separately for means-tested and employment-tested transfers. Values in Panel A-C are obtained from SIPP 1996-2008 panels. NIPA amounts in Panel D are obtained from Table 3.12, where I classify EITC, SNAP, and TANF payments as means-tested transfers, and UI as employment-tested transfer. Dashed lines indicate time periods when the data is not available.

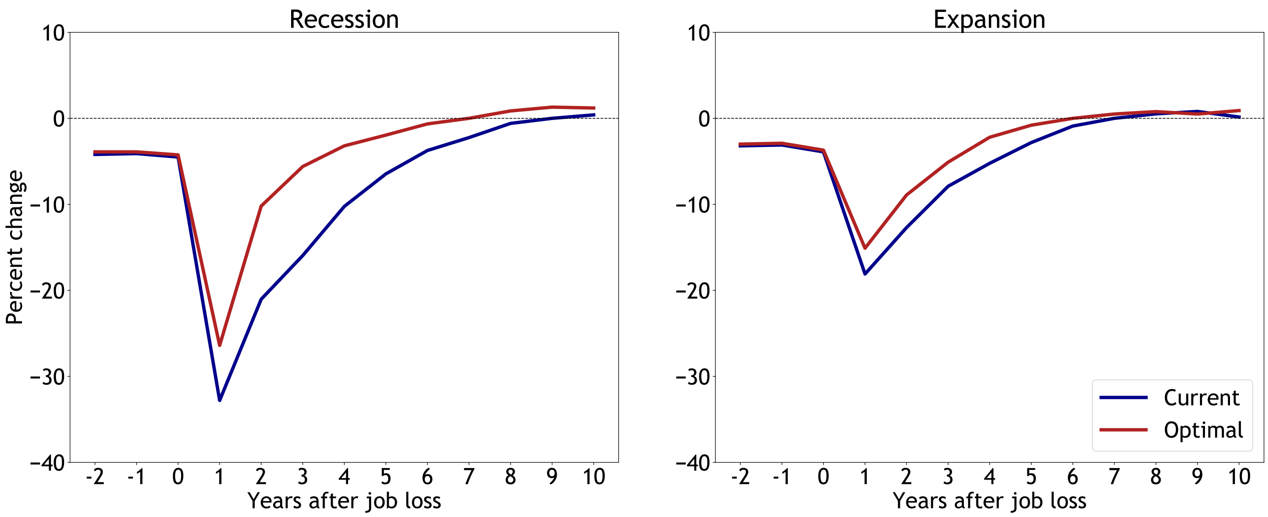
C. Effects of optimal policy on family upon displacement

In Section 5.2, I discuss the change in family outcomes upon head's job displacement in recessions and expansions in the model under the countercyclical baseline (current) policy and the optimal policy. In the main text, I show comparisons for spouse earnings, transfer receipts, and family consumption. The goal of this section is now to understand the effects of the optimal policy on the other components of the household budget: total family earnings and assets. This allows us to decompose the changes in family consumption.

Figure A.4 compares the change in family earnings upon head's job displacement in recessions and in expansions in the model under the countercyclical baseline (current) policy and the optimal policy. There are three results that I want to highlight. First, the magnitudes of initial drops of family earnings upon head's job displacement both in recessions and in expansions are lower under the optimal policy than their counterparts under the current policy. This is because of higher labor force participation rates of spouses and their higher labor earnings due to the increase in their human capital. Second, the gap between the magnitudes of initial drops under the current and optimal policies are larger in recessions ($0.33 - 0.26 = 0.07$) than in expansions ($0.18 - 0.15 = 0.03$). This is because, under the optimal policy, the change in spousal earnings in response to head's displacement in recessions is larger than its counterpart in expansions, as shown in Figure 8 in the main text. As a result, the contribution of spouses to their family income under the optimal policy is larger in recessions. Finally, while the recovery of family earnings under the optimal policy is faster than the recovery under the current policy in recessions, the recovery under the optimal policy is similar to the recovery under the current policy in expansions. This is due to the persistent increase in spousal earnings upon head's displacement in recessions under the optimal policy, as shown in Figure 8 in the main text.

Figure A.5 compares the change in family assets upon head's job displacement in recessions and in expansions in the model under the current policy and the optimal policy. I find that families dissave less upon head's displacement both in recessions and expansions under the optimal policy since larger fraction of spouses are already working at the time of head's displacement under the optimal policy, and this allows families to self-insure more through spousal earnings and less through savings. Similarly, this effect is more pronounced in recessions due to larger spousal labor earnings

Figure A.4: Relative Labor Earnings of the Family upon Job Displacement: Current Policy vs Optimal Policy



Note: This figure plots the changes in relative labor earnings of the family upon head's job displacement in recessions (left panel) and expansions (right panel) in the model under the countercyclical baseline policy and the optimal policy. I estimate the changes in relative family earnings from a distributed lag-recession model using model simulated data, which is aggregated up to yearly period.

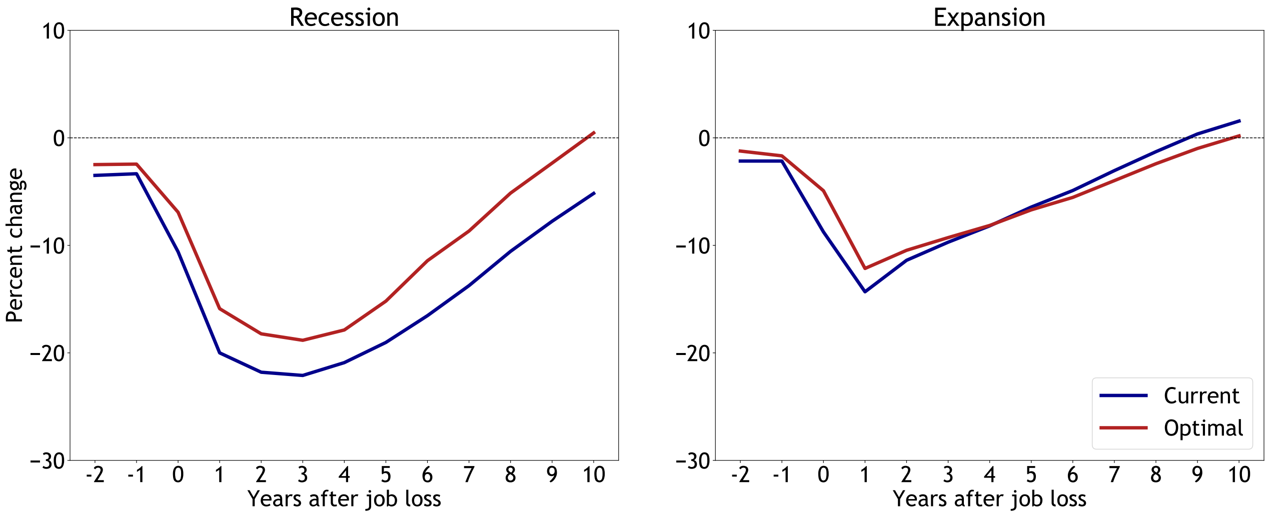
response. As a result, family assets recover earlier in recessions under the optimal policy. However, the recovery of assets in expansions is a bit slower under the optimal policy due to slightly smaller increase in spousal earnings upon head's displacement in expansions under the optimal policy than under the current policy, as shown in Figure 8 in the main text.

D. Model with endogenous wages

In this section, I present an extension of the baseline model with endogenous wages. This is a directed search model in which wage choices of unemployed individuals are endogeneous. In this model, submarkets in the labor market are indexed by the wage offer w of the firms and human capital level h of the job. This means that unemployed individuals now direct their search effort toward a specific wage offered by a job that is compatible with their own skill level. In this case, wage levels of the employed members of the household become extra state variables.

Below, I first lay out household problem, and then show firm problem. Next, I prove the existence of BRE of this model.

Figure A.5: Relative Assets of the Family upon Job Displacement: Current Policy vs Optimal Policy



Note: This figure plots the changes in relative asset holdings of the family upon head's job displacement in recessions (left panel) and expansions (right panel) in the model under the countercyclical baseline policy and the optimal policy. I estimate the changes in relative family earnings from a distributed lag-recession model using model simulated data, which is aggregated up to yearly period.

Household problem I write down the problems of several types of households, and the rest follows from similar explanations as in the baseline model.

Employed - unemployed household First, consider a household in which the male is employed and the female is eligible unemployed. The recursive problem of this household is given as follows:

$$
\begin{aligned}
V^{EU_b}\left(a,\, w_m,\, \mathbf{h};\, \mu\right) \quad &= \quad \max_{a' \geq a_L,\, s_f \in \{0,1\}} \quad u\left(c\right) + \eta_f\left(1 - s_f\right) \\
&+ \quad \max_{\tilde{w}_f} \left\{ \beta \left[\left(1 - \zeta_R\right) \mathbb{E}_{\mathbf{l}', \mathbf{h}', \mu'} \left[V^{l'}\left(a',\, w_m,\, \mathbf{h}';\, \mu'\right) \middle| s_f,\, \tilde{w}_f,\, \mathbf{l},\, \mathbf{h};\, \mu \right] + \zeta_R V^R\left(a'\right) \right] \right\}
\end{aligned}
$$

subject to

$$
\begin{aligned}
& c + a' \leq \left(1 + r\right) a + y + \phi\left(z;\, a,\, y\right) + b\left(z;\, U_b,\, s_f\right)\left(1 - \tau\right) \\
& y = w_m\left(1 - \tau\right) \\
& \Gamma' = \Lambda\left(\mu,\, z'\right) \quad \text{and} \quad z' \sim \Phi\left(z' \,|\, z\right).
\end{aligned}
$$

where we now have to keep track of wage level of the employed member of the household. Notice also that wage of the employed is not a direct function of the human capital level. Instead, unemployed members of the household may direct their search effort toward any wage submarket $\tilde{w}_f$, but the job finding rate for that wage submarket varies across human capital level of the unemployed. In that sense, we can think of different human capital submarkets that are present inside each wage submarket. Moreover, the expectation is also indexed by wage choice of the unemployed member of the household, given that her job finding rate will be affected by her wage choice. The rest of the explanation of this problem is similar to its counterpart in the baseline model.

It is also insightful to show the expectation over the transition of employment statuses of this household, which I lay out below:

$$\begin{aligned}
\mathbb{E}_{\mathbf{l}',\mathbf{h}',\mu'}\left[V^{l'}\left(a',\, w_m,\, \mathbf{h}';\, \mu'\right)\middle| s_f,\, \tilde{w}_f,\, \mathbf{l},\, \mathbf{h},\, \mu\right] = \mathbb{E}_{\mathbf{h}',\mu'}\Bigg[& s_f\left(1-\delta_m'\right)\Big(p_f'\left(\tilde{w}_f, h_f\right)V^{EE}\left(a', w_m, \tilde{w}_f, \mathbf{h}'; \mu'\right) \\
& + \Big(1-p_f'\left(\tilde{w}_f, h_f\right)\Big)\sum_{k\in\{b,n\}}\lambda_k' V^{EU_k}\left(a', w_m, \mathbf{h}'; \mu'\right)\Big) \\
& + s_f\delta_m'\Big(p_f'\left(\tilde{w}_f, h_f\right)\sum_k \lambda_k' V^{U_k E}\left(a', \tilde{w}_f, \mathbf{h}'; \mu'\right) \\
& + \Big(1-p_f'\left(\tilde{w}_f, h_f\right)\Big)\sum_{k,d\in\{b,n\}}\lambda_k'\lambda_d' V^{U_k U_d}\left(a', \mathbf{h}'; \mu'\right)\Big) \\
& + \left(1-s_f\right)\left(1-\delta_m'\right)\sum_k \lambda_k' V^{EU_k}\left(a', w_m, \mathbf{h}'; \mu'\right) \\
& + \left(1-s_f\right)\delta_m'\sum_{k,d\in\{b,n\}}\lambda_k'\lambda_d' V^{U_k U_d}\left(a', \mathbf{h}'; \mu'\right)\Big)\,\Bigg|\,\mathbf{h}, \mu\Bigg]
\end{aligned}$$

where $p_i'\left(\tilde{w}_i, h_i\right) \equiv p\left(\theta\left(\tilde{w}_i,\, h_i';\, \mu'\right)\right)\ \forall i \in \{m,\, f\}$. The explanation of the terms in the right hand side is similar to its counterpart in the baseline model.

Unemployed - unemployed household Second, consider a household in which both male and female are eligible unemployed. The recursive problem of this household is given as follows:

$$\begin{aligned} V^{U_b U_b}\left(a,\, \mathbf{h};\, \mu\right) &= \max_{a' \geq a_L,\, s_m, s_f \in \{0,1\}} \quad u\left(c\right) + \sum_{i \in \{m,\, f\}} \eta_i \left(1 - s_i\right) \\ &+ \max_{\tilde{w}_m, \tilde{w}_f} \left\{ \beta \Big[\left(1 - \zeta_R\right) \mathbb{E}_{\mathbf{l}', \mathbf{h}', \mu'} \Big[V^{l'}\left(a',\, \mathbf{h}';\, \mu'\right) \Big| s_m,\, s_f,\, \tilde{w}_m,\, \tilde{w}_f,\, \mathbf{l},\, \mathbf{h},\, \mu \Big] + \zeta_R V^R\left(a'\right) \Big] \right\} \end{aligned}$$

subject to

$$c + a' \leq \left(1 + r\right) a + \phi\left(z;\, a,\, 0\right) + \left[b\left(z;\, U_b,\, s_m\right) + b\left(z;\, U_b,\, s_f\right)\right]\left(1 - \tau\right)$$

$$\Gamma' = \Lambda\left(\mu,\, z'\right) \quad \text{and} \quad z' \sim \Phi\left(z' \,|\, z\right).$$

Again, I show the expectation over the transition of employment statuses of this household, which is given below:

$$\begin{aligned} \mathbb{E}_{\mathbf{l}', \mathbf{h}', \mu'} \Big[V^{l'}\left(a', \mathbf{h}'; \mu'\right) \Big| s_m,\, s_f,\, \tilde{w}_m,\, \tilde{w}_f,\, \mathbf{l},\, \mathbf{h},\, \mu \Big] = \mathbb{E}_{\mathbf{h}', \mu'} \Bigg[& s_m s_f p'_m\left(\tilde{w}_m, h_m\right) \Big(p'_f\left(\tilde{w}_f, h_f\right) V^{EE}\left(a', \tilde{w}_m, \tilde{w}_f, \mathbf{h}'; \mu'\right) \\ & + \Big(1 - p'_f\left(\tilde{w}_f, h_f\right)\Big) \sum_{k \in \{b,n\}} \lambda'_k V^{EU_k}\left(a', \tilde{w}_m, \mathbf{h}'; \mu'\right) \Big) \\ & + s_m s_f \left(1 - p'_m\left(\tilde{w}_m, h_m\right)\right) \Big(p'_f\left(\tilde{w}_f, h_f\right) \sum_k \lambda'_k V^{U_k E}\left(a', \tilde{w}_f, \mathbf{h}'; \mu'\right) \\ & + \Big(1 - p'_f\left(\tilde{w}_f, h_f\right)\Big) \sum_{k,d \in \{b,n\}} \lambda'_k \lambda'_d V^{U_k U_d}\left(a', \mathbf{h}'; \mu'\right) \\ & + s_m \left(1 - s_f\right) \Big(p'_m\left(\tilde{w}_m, h_m\right) \sum_k \lambda'_k V^{EU_k}\left(a', \tilde{w}_m, \mathbf{h}'; \mu'\right) \\ & + \left(1 - p'_m\left(\tilde{w}_m, h_m\right)\right) \sum_{k,d \in \{b,n\}} \lambda'_k \lambda'_d V^{U_k U_d}\left(a', \mathbf{h}'; \mu'\right) \Big) \\ & + \left(1 - s_m\right) s_f \Big(p'_f\left(\tilde{w}_f, h_f\right) \sum_k \lambda'_k V^{U_k E}\left(a', \tilde{w}_f, \mathbf{h}'; \mu'\right) \\ & + \left(1 - p'_m\left(\tilde{w}_m, h_m\right)\right) \sum_{k,d \in \{b,n\}} \lambda'_k \lambda'_d V^{U_k U_d}\left(a', \mathbf{h}'; \mu'\right) \Big) \\ & + \left(1 - s_m\right)\left(1 - s_f\right) \sum_{k,d \in \{b,n\}} \lambda'_k \lambda'_d V^{U_k U_d}\left(a', \mathbf{h}'; \mu'\right) \Big) \Bigg| \mathbf{h}, \mu \Bigg]. \end{aligned}$$

The explanation of the terms in the right hand side is similar to its counterpart in the baseline model.

Employed - employed household Next, consider a household in which both male and female are employed. The recursive problem of this household is given as follows:

$$V^{EE}(a,\, w_m,\, w_f,\, \mathbf{h};\, \mu) \;=\; \max_{a' \geq a_L} \quad u(c) + \beta\Big[(1-\zeta_R)\,\mathbb{E}_{\mathbf{l}',\mathbf{h}',\mu'}\Big[V^{l'}(a',\, w_m,\, w_f,\, \mathbf{h}';\, \mu')\,\Big|\mathbf{l},\, \mathbf{h},\, \mu\Big] + \zeta_R V^R(a')\Big]$$

subject to

$$c + a' \leq (1+r)\,a + y + \phi(z;\, a,\, y)$$

$$y = [w_m + w_f]\,(1-\tau)$$

$$\Gamma' = \Lambda(\mu,\, z') \quad \text{and} \quad z' \sim \Phi(z' \,|\, z)\,.$$

Similarly, I lay out the expectation over the transition of employment statuses of this household, which is given below:

$$\begin{aligned}
\mathbb{E}_{\mathbf{l}',\mathbf{h}',\mu'}\Big[V^{l'}(a',\, w_m,\, w_f,\, \mathbf{h}';\, \mu')\,\Big|\mathbf{l},\, \mathbf{h},\, \mu\Big] = \mathbb{E}_{h',\mu'}\Bigg[&(1-\delta'_m)\left(\left(1-\delta'_f\right)V^{EE}(a', w_m, w_f, \mathbf{h}'; \mu')\right.\\
&\left.+\,\delta'_f \sum_{k\in\{b,n\}} \lambda'_k V^{EU_k}(a', w_m, \mathbf{h}'; \mu')\right)\\
&+\,\delta'_m\left(\left(1-\delta'_f\right)\sum_k \lambda'_k V^{U_k E}(a', w_f, \mathbf{h}'; \mu')\right.\\
&\left.+\,\delta'_f \sum_{k,d\in\{b,n\}} \lambda'_k \lambda'_d V^{U_k U_d}(a', \mathbf{h}'; \mu')\right)\,\Bigg|\,\mathbf{h}, \mu\Bigg]
\end{aligned}$$

The explanation of the terms in the right hand side is similar to its counterpart in the baseline model.

Finally, the problem of retired households is identical to their problem in the baseline model.

Firm Problem First, consider a firm that is matched with a worker in submarket $(w,\, h)$ when the aggregate state is μ. The pair operates under a constant returns to scale technology and produces $g(h,\, z)$ units of output, and the worker is paid a wage of w. With some probability $\delta(h,\, z)$ the match dissolves, and the worker retires with probability ζ_R. Let $J(w,\, h;\, \mu)$ be the value of a matched firm in submarket $(w,\, h)$ when the aggregate state is μ. The recursive problem of this firm is given as follows:

$$J(w,\,h;\,\mu) \quad = \quad g(h,\,z) - w + \frac{1}{1+r}(1-\zeta_R)\,\mathbb{E}_{h',\mu'}\left[(1-\delta(h',\,z'))\,J(w,\,h';\,\mu')\,\Big|h,\,\mu\right] \quad \text{(A.1)}$$

subject to

$$\Gamma' = \Lambda(\mu,\,z') \quad \text{and} \quad z' \sim \Phi(z'\,|\,z)\,.$$

Meanwhile, the value of a firm that posts a vacancy in submarket $(w,\,h)$ under aggregate state μ is given by

$$V(w,\,h;\,\mu) = -\kappa + q(\theta(w,\,h;\,\mu))\,J(w,\,h;\,\mu)$$

where κ is a fixed cost of posting a vacancy that is financed by risk-neutral foreign entrepreneurs who own the firms.

The free entry condition implies that profits are just enough to cover the cost of filling a vacancy in expectation. As a result, the owner of the firm makes zero profits in expectation. Thus, $V(w,\,h;\,\mu) = 0$ for any submarket $(w,\,h)$ such that $\theta(w,\,h;\,\mu) > 0$. Then, imposing the free entry condition yields the equilibrium market tightness:

$$\theta(w,\,h;\,\mu) = \begin{cases} q^{-1}\left(\frac{\kappa}{J(w,\,h;\,\mu)}\right) & \text{if} \quad w \in \mathcal{W}(\mu) \text{ and } h \in \mathcal{H}(\mu) \\ 0 & \text{otherwise.} \end{cases} \tag{A.2}$$

The equilibrium market tightness contains all the relevant information needed by households to evaluate the job finding probabilities at each submarket.

Equilibrium Definition of Recursive Equilibrium is very similar to that under Section 2.4 of the main text, with indexing relevant policy functions with extra state of wage level w. The directed search feature of this model, together with the other assumptions discussed in Section 2.4, allows this model to admit a BRE as well. This time unemployed endogenously choose wage submarkets compatible with their own skill to direct their search effort, rather than being automatically assigned to skill submarkets based on their own skill. This extra feature of the extended model deserve a proof on the existence of BRE.

Proposition: *If i) utility function $u(\cdot)$ is strictly increasing, strictly concave, and satisfies Inada* *conditions; ii) choice sets $\mathcal{W}$ and $\mathcal{A}$, human capital set $\mathcal{H}$, and set of exogenous process $\mathcal{Z}$ are bounded, iii) matching function M exhibits constant returns to scale, and iv) government policy instruments are restricted to be only a function of current aggregate labor productivity, then there exists a Block Recursive Equilibrium for this economy.*

Proof: This proof is an extension of the proof given in Birinci and See (2017) in two ways: i) this model incorporates endogenous labor supply decision, and ii) submarkets are also indexed by skill levels.

I prove the existence of the BRE in two steps. In the first step, I show that the firm value functions and the corresponding labor market tightness depend on the aggregate state of the economy only through the current aggregate labor productivity. Then, in the second step, given that government policy instruments are restricted to be a function of the current aggregate labor productivity z, I show that the household value functions do not depend on the aggregate distribution of households across states Γ. As a result, I show that given the government policy, the solution of the household's problem together with the solution of the firm's problem and labor market tightness, constitute a block recursive equilibrium.

Let $\mathcal{J}(\mathcal{W}, \mathcal{H}, \mathcal{Z})$ be the set of bounded and continuous functions J such that $J : \mathcal{W}\times\mathcal{H}\times\mathcal{Z} \to \mathbb{R}$ and let T_J be an operator associated with (A.1) such that $T_J : \mathcal{J} \to \mathcal{J}$. Then, using Blackwell's sufficiency conditions for a contraction and the assumptions of the boundedness of sets of exogenous process $\mathcal{Z}$, choice set $\mathcal{W}$, and human capital set $\mathcal{H}$, we know that T_J is a contraction and has a unique fixed point $J^* \in \mathcal{J}$. Thus, the firm value function satisfying (A.1) depends on the aggregate state of the economy μ only through the aggregate labor productivity z. This means that the set of wages posted by the firms in equilibrium $\mathcal{W}$ for each element in the set of possible skill level $\mathcal{H}$ is determined by the aggregate labor productivity z as well. Then, plugging J^* into (A.2) yields

$$\theta^*(w, h; z) = \begin{cases} q^{-1}\left(\frac{\kappa}{J^*(w, h; z)}\right) & \text{if} \quad w \in \mathcal{W}(z) \text{ and } h \in \mathcal{H}(z) \\ 0 & \text{otherwise.} \end{cases}$$

Notice that, as explained in the main text for the baseline model, the constant-returns-to-scale property of the matching function M is crucial here so that we can write the job finding rate and vacancy filling rate as a function of θ only.[76] Hence, I show that equilibrium market tightness θ^* does not depend on the distribution of households across states Γ as well.

Next, using this result and the assumption that the government policy only depends on z, I show that the household value functions do not depend on the aggregate distribution of households across states Γ. To do so, I first collapse the problem of households into one functional equation and show that it is a contraction. Then, I show that the functional equation maps the set of functions that depend on the aggregate state μ only through z.

Let Ω denote the possible realizations of the aggregate state μ and define a value function $K : \{0,1,2\} \times \{0,1,2\} \times \{0,1\} \times \{0,1\} \times \mathcal{A} \times \mathcal{W} \times \mathcal{W} \times \mathcal{H} \times \mathcal{H} \times \Omega \to \mathbb{R}$ such that

$$\begin{aligned}
K\left(l_m=1, l_f=1, d_m=0, d_f=0, a, w_m, w_f, h_m, h_f; \mu\right) &= V^{EE}\left(a, w_m, w_f, h_m, h_f; \mu\right) \\
K\left(l_m=1, l_f=0, d_m=0, d_f=1, a, w_m, w_f, h_m, h_f; \mu\right) &= V^{EU_b}\left(a, w_m, h_m, h_f; \mu\right) \\
K\left(l_m=1, l_f=0, d_m=0, d_f=0, a, w_m, w_f, h_m, h_f; \mu\right) &= V^{EU_n}\left(a, w_m, h_m, h_f; \mu\right) \\
K\left(l_m=0, l_f=0, d_m=1, d_f=0, a, w_m, w_f, h_m, h_f; \mu\right) &= V^{U_bU_n}\left(a, h_m, h_f; \mu\right) \\
K\left(l_m=2, l_f=2, d_m=0, d_f=0, a, w_m, w_f, h_m, h_f; \mu\right) &= V^{R}\left(a\right)
\end{aligned}$$

and so on for other types of households with different employment statuses.

Then, we define the set of functions $\mathcal{K} : \{0,1\}\times\{0,1\}\times\{0,1\}\times\{0,1\}\times\mathcal{A}\times\mathcal{W}\times\mathcal{W}\times\mathcal{H}\times\mathcal{H}\times\mathcal{Z} \to$

[76] The free entry condition (8) is also important to pin down market tightness.

$\mathbb{R}$ and let T_K be an operator such that

$$(T_K K)(\mathbf{l},\mathbf{d},a,w_m,w_f,\mathbf{h};z)=l_m l_f\left[\max_{a'\geq a_L}\quad u(c)+\beta\Big[(1-\zeta_R)\,\mathbb{E}_{\mathbf{l}',\mathbf{h}',\mu'}\left[K\left(\mathbf{l}',\mathbf{d}',a',w_m,w_f,\mathbf{h};z\right)\right]+\zeta_R K\left(\mathbf{l}'=\mathbf{2},\cdot\right)\Big]\right]$$

$$+\,l_m(1-l_f)\left[\max_{a'\geq a_L,\,s_f\in\{0,1\}}u(c)+\eta_f(1-s_f)+\max_{\tilde{w}_f}\left\{\beta\Big[(1-\zeta_R)\,\mathbb{E}_{\mathbf{l}',\mathbf{h}',\mu'}\left[K(\cdot)\right]+\zeta_R K\left(\mathbf{l}'=\mathbf{2},\cdot\right)\Big]\right\}\right]$$

$$+\,(1-l_m)\,l_f\left[\max_{a'\geq a_L,\,s_m\in\{0,1\}}u(c)+\eta_m(1-s_m)+\max_{\tilde{w}_m}\left\{\beta\Big[(1-\zeta_R)\,\mathbb{E}_{\mathbf{l}',\mathbf{h}',\mu'}\left[K(\cdot)\right]+\zeta_R K\left(\mathbf{l}'=\mathbf{2},\cdot\right)\Big]\right\}\right]$$

$$+\,(1-l_m)(1-l_f)\Bigg[\max_{a'\geq a_L,\,s_m,s_f\in\{0,1\}}\quad u(c)+\sum_{i\in\{m,f\}}\eta_i(1-s_i)$$

$$+\max_{\tilde{w}_m,\tilde{w}_f}\left\{\beta\Big[(1-\zeta_R)\,\mathbb{E}_{\mathbf{l}',\mathbf{h}',\mu'}\left[K(\cdot)\right]+\zeta_R K\left(\mathbf{l}'=\mathbf{2},\cdot\right)\Big]\right\}\Bigg]$$

subject to

$$c+a'\leq(1+r)\,a+y+\phi(z;\,a,\,y)+\Big[(1-l_m)\,d_m b(z;\,U_b,\,s_m)+(1-l_f)\,d_f b(z;\,U_b,\,s_f)\Big](1-\tau)$$
$$y=\Big[l_m w_m+l_f w_f\Big](1-\tau)$$
$$z'\sim\Phi\left(z'\,|\,z\right)$$

where none of the terms inside expectations (δ'_m, δ'_f , λ'_b, λ'_n, p'_m, or p'_f) and value functions K inside these expectations depend on Γ.[77]

Assuming the utility function is bounded and continuous, $\mathcal{K}$ is the set of continuous and bounded functions. Then, we can show that the operator T_K maps a function from $\mathcal{K}$ into $\mathcal{K}$ (i.e., $T_K : \mathcal{K}\to\mathcal{K}$). Then, using Blackwell's sufficiency conditions for a contraction and the assumptions of boundedness of sets of exogenous process $\mathcal{Z}$, choice set $\mathcal{W}$ and $\mathcal{A}$, and human capital set $\mathcal{H}$, we can show that T_K is a contraction and has a unique fixed point $K^*\in\mathcal{K}$. Thus, the solution to the household problem does depend on Γ. This constitutes a BRE along with the solution to the firm's problem and the implied labor market tightness that does not depend on Γ, given that the government policy is a function of z only.

[77] Here, I refrain the write out expectation explicitly to save space. However, these expectations are shown above for reference.

E. Computational Algorithm

Given that the model is block recursive, none of the equilibrium value functions, policy functions, or market tightness depend on aggregate distribution of agents across states Γ. This means that block recursive equilibrium (BRE) depends on μ only through z. BRE is solved using the following steps:

1. Solve for the value function of the firm $J(h, z)$.

2. Using the free-entry condition $0 = -\kappa + q(\theta(h, z)) J(h, z)$ and the functional form of $q(\theta)$, we can solve for market tightness for any given human capital submarket h and aggregate productivity z:
$$\theta(h, z) = q^{-1}\left(\frac{\kappa}{J(h, z)}\right),$$
where we set $\theta(h, z) = 0$ when the market is inactive.

3. Given the function θ, I can then solve for the household value functions and policy functions using standard value function iteration. In order to decrease computation time, I implement Howard's improvement algorithm (policy-function iteration).

4. Once household policy functions are obtained, I simulate aggregate dynamics of the model.

Computational algorithm of the model with endogenous wages is the same as the baseline model with an addition that equilibrium objects are also functions of wage.