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

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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 additional insurance is most valuable. I investigate whether the small response is an outcome of the crowding-out effects of existing government transfers, using a model where labor supply elasticities with respect to transfers are in line with microeconomic estimates both in aggregate and across subpopulations. Counterfactual experiments reveal that generous transfers in recessions discourage the spousal labor supply significantly. I then show that the optimal policy features procyclical means-tested and countercyclical employment-tested transfers, unlike the existing policy.

JEL-Codes: E24, E32, H31, J64
Keywords: Unemployment, Business Cycles, Fiscal Policy and Household Behavior, Job Search

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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 losses within households.\(^1\) Importantly, the magnitude of the 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 the family head’s job displacement, they may crowd out private insurance in the form of the 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 the spousal labor supply is endogenous to government policy?

To answer these questions, I first measure the impact of a family head’s job displacement both in recessions and in expansions on family labor earnings (i.e., sum of the family head’s and spouse’s 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. I address this gap by documenting two novel results. First, families enjoy some insurance from the presence of a second earner at the time of the head’s displacement. In particular, the average decline in family labor earnings is around two-thirds of the average 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 the head’s displacement, the average change in spousal earnings of that family relative to the spousal earnings of a family with a 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.

I argue that the small spousal earnings response in recessions is an outcome of crowding-out effects of existing government transfers, which are more generous 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

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

\(^2\)In my sample, the family head is almost always male.
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 rates increase, while job finding rates endogenously decrease in recessions since firms reduce vacancy postings when labor productivity is lower. This recognizes that besides crowding out effects of generous transfers, spousal labor supply responses can also be muted in recessions because of lower job finding rates in recessions. Finally, 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 losses upon job displacement, ii) job finding rates, and iii) government transfers, it generates a small change in spousal earnings upon the head’s displacement in recessions, as in the data.

Using this model, I implement a counterfactual experiment that allows me to isolate the effects of government policy changes on the labor supply. In this experiment, where government transfers are designed to be less generous in recessions and more generous 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, the spousal earnings response to the head’s displacement is small and almost inelastic to government-transfer generosity. Importantly, I show that the model-implied female labor supply elasticities – that underlie these results – 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 the spousal labor supply is more elastic to transfers in recessions, when the head’s earnings losses are larger and household income is lower.

The results of this counterfactual experiment show that the incentive costs of transfers in the form of a 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.4

The Supplemental Nutrition Assistance Program (SNAP), Earned Income Tax Credit (EITC), 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 displaced members.

4When solving for the optimal means-tested and employment-tested transfers, I follow a large literature that uses
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 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 the 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. Moreover, the economy under the optimal policy is wealthier and has a lower fraction of families with non-positive net liquid wealth. These differences in the macroeconomy result in a higher average consumption level and 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 whether accounting for the endogeneity of the spousal labor supply to transfers is critical in determining the optimal policy, I modify the baseline model such that the 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 the spousal labor supply results in an optimal policy that is more generous on average than the optimal policy in the model with an 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 now driven largely by the cyclicality of insurance benefits, which is larger in recessions. This exercise shows that endogenizing the spousal labor supply 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 the spousal labor supply, and generous payments to these households make them worse-off due to large crowding out.

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. This literature studies 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).
ature estimates the contemporaneous change in spousal earnings upon the head’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). 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 an endogenous labor supply can match well these empirically estimated labor supply and consumption responses to wage shocks within the family.\footnote{Previously, Attanasio, Low, and Sánchez-Marcos (2005) also quantify the role of the 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 a joint search problem of households and show that a higher wage offer received by a spouse allows 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 the family’s wealth.} In this paper, I condition the change in spousal earnings and hours in response to the head’s job displacement on the aggregate state of the economy, rather than looking at an average spousal response. Empirically, I find that while the presence of a second earner in the family provides sizeable private insurance, the change in spousal earnings and hours in response to the head’s job displacement is small, especially in recessions. In expansions, the response of the spousal labor supply is positive and statistically significant, but only a few years after the head’s displacement. I then explore the role of more generous government transfers in explaining 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 modeling choices and welfare analysis. The first group of papers studies the optimal design of transfers using models with an endogenous family labor supply but without aggregate fluctuations (Ortigueira and Siassi 2013, Fernandez-Blanco 2017, Haan and Prowse 2017, Mankart and Oikonomou 2017, Choi and Valladares-Esteban 2019).\footnote{Among these papers, my paper is closest to Mankart and Oikonomou (2017), as they also incorporate aggregate fluctuations into their baseline model to explain the acyclicity 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.} The second group studies the optimal design of taxes or transfers in a model with aggregate fluctuations but without an endogenous family labor supply as a private insurance mechanism (Mitman and Rabinovich 2015, McKay and Reis 2017, Birinci and See 2018, Bhandari, Evans, Golosov, and Sargent 2018, Kekre 2018, Landais, Michaillat, and Saez 2018).\footnote{Among these papers, my paper is closest to Birinci and See (2018). 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 an 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.} This paper combines these two groups of studies because it analyzes the optimal level and cyclicity of means-tested and employment-tested transfers using a model with an endogenous family labor supply and aggregate fluctuations. I overcome the computational difficulties encountered in models of this nature through an application of segmented job 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 find that more than half of the welfare gains from the optimal policy are attributable to its cyclicality. Relative to the second group of papers, I show that endogenizing the spousal labor supply to policy changes the optimal level and cyclicality of transfers.

Finally, this paper contributes to the growing literature on the effects of job displacement on individual earnings. Empirically, previous papers have already documented that job displacement has large negative and long-lasting effects on individual labor 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 and show that earnings losses are larger when displacement happens in recessions. Davis and Von Wachter (2011) also show that standard search and matching models fail to generate such large negative and persistent effects of job displacement on earnings. Motivated by this, Jarosch (2015), Huckfeldt (2016), Krolikowski (2017), and Jung and Kuhn (2018) develop variants of such models that can endogenously generate persistent and negative effects of job displacement on earnings. In this paper, I rather focus on the effects of job displacement over the business cycle on the labor supply behavior of the secondary earner.10 I first estimate the impact of a head’s job displacement in recessions and expansions on spousal earnings and hours. This helps me to quantify the available spousal insurance to displaced individuals in recessions and expansions. I then use these empirical findings in a model to understand the effects of government transfers on the spousal earnings response to the head’s displacement and study the optimal design of 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 analyzes the effects of transfer policies on the spousal labor supply response to the head’s displacement. Section 5 studies the optimal design of government transfers. Section 6 provides a list of extensions and robustness checks. Finally, Section 7 concludes.

9To 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.

10Pruitt and Turner (2018) measure the spousal earnings response to earnings fluctuations of the household head both in recessions and in expansions using Social Security Administration (SSA) data but do not focus on measuring the response to job displacement shocks specifically. 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.

11A 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 the 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 incure 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 these, as I show that a decline in the implicit tax rate of work during recessions increases the spousal labor supply upon a large permanent decline in household income.
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 the labor supply decisions of both members of the household to changes in government transfers.

2.1 Environment

**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., $i \in \{m, f\}$ $\forall j$. 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 $\zeta_R$. Retired households die with probability $\zeta_D$, and they are replaced by new households entering into the labor force. Households discount the future at rate $\beta$.

Households are heterogeneous in terms of their asset holdings $a$, human capital level $h$ of each member, and employment status $l_i$ of each member. An individual can be classified into one of the following employment statuses: employed $E$, unemployed and eligible for employment-tested UI benefits $U_b$, unemployed and 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

$$U(c, s_m, s_f) = u(c) + \sum_i \eta_i (1 - s_i)$$

where $u(\cdot)$ 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 $\eta_i$ is the value of leisure. Employed individuals work full-time and there is no on-the-job-search. Thus, the above functional form assumes that individuals only enjoy the 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 $\Gamma$ is the distribution of households across individual states.

**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 $\kappa$ of posting a vacancy. On the other side of the labor market,

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12Throughout 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.

13The only parameter that defines gender in this model is $\eta_i$. This implies that the utility cost of work or search is different between males and females to capture the employment differences between them.

14In 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).
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; i.e., \( \theta (h; \mu) = \frac{v(h; \mu)}{u(h; \mu)} \). Let \( M(v, u) \) 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, \( p(h; \mu) = \frac{M(v(h; \mu), u(h; \mu))}{u(h; \mu)} \) is the job finding rate and \( q(h; \mu) = \frac{M(v(h; \mu), u(h; \mu))}{v(h; \mu)} \) is the vacancy filling rate in submarket \( h \) when the aggregate state is \( \mu \). The constant-returns-to-scale assumption on the matching function guarantees that the equilibrium object \( \theta \) suffices to determine the job finding and vacancy filling rates since \( p(\theta) = \frac{M(v, u)}{u} = M(\theta, 1) \) while \( q(\theta) = \frac{M(v, u)}{v} = M(1, \frac{1}{\theta}) \).

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 a strictly increasing function of each worker’s human capital level \( h \) and aggregate productivity \( z \). The 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, the worker receives a \( \alpha \) share of the period output as a wage, which implies that \( w(h, z) = \alpha g(h, z) \).

The firm-worker pair continues to operate until the match exogenously dissolves with probability \( \delta(h, z) \in [0, 1] \) or the worker retires with probability \( \zeta_R \). \( \delta(\cdot) \) is a decreasing function of both \( h \) and \( z \).

**Human capital dynamics** An individual’s human capital level \( h \) lies in an equispaced grid \( \mathcal{H} \equiv \{ h_L, \ldots, h_H \} \). 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:

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

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

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

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

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15 This assumption is similar to that in Herkenhoff, Phillips, and Cohen-Cole (2017) and it serves two purposes. First, when I analyze the role of government transfers in explaining the small changes in spousal earnings upon the head’s displacement in a recession, this assumption implies that varying the government policy does not affect equilibrium wages and thus firm vacancy posting decisions, leaving the labor demand the same across policies. This allows me to better isolate the effect of transfers on labor supply. The second reason is tractability, 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 from 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.
Sargent (1998) is that I allow $\Delta U$ 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).\(^{16}\)

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

Eligibility for means-tested transfers is determined at the household level. A household is eligible for means-tested transfers if the amount of household assets $a$ is lower than an asset threshold $a_0$, and the amount of household labor income $y$ (which is the summation of the labor income of both the head and the spouse) is lower than an income threshold $y$. Both $a$ and $y$ 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 vary over the business cycle, and it is given as follows:\(^{17}\)

\[
\phi(z; a, y) = \begin{cases} 
\phi(z) & \text{if } y < y, a < a_0 \\
0 & \text{otherwise}
\end{cases}
\]

Eligibility for 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 is actively searching for a job; i.e., $s_i > 0$.\(^{18}\) Employment-tested transfers stochastically expire at rate $e(z) \in [0, 1]$, as in 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 amount of employment-tested transfers vary over the business cycle, and it is given as follows:

\[
b(z; l_i, s_i) = \begin{cases} 
b(z) & \text{if } l_i = U_b, s_i > 0 \\
0 & \text{otherwise}
\end{cases}
\]

To finance these programs, the government levies a flat income tax $\tau$ applied to labor income,

---

\(^{16}\)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, an extra assumption on larger human capital loss when unemployed in recessions is needed. Moreover, this assumption is in fact reasonable, given that most 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 $\mu$ only through the current aggregate productivity $z$ and not through the distribution of individuals across states $\Gamma$. This restriction allows my model to retain block recursivity, which I explain in Section 2.4.

\(^{18}\)Here, I assume that the government can observe the search behavior of the unemployed. In the United States, UI offices may verify job search activities of UI recipients by asking them to fill out a form requiring the name, location, and contact information of any employer recently contacted. In Section 6, I remove the assumption that search effort is observable to the government and check the implications on my main results.
employment-tested transfers, and retirement transfers.\textsuperscript{19} The government balances the following budget constraint in expectation:\textsuperscript{20}

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

where the terms in the bracket respectively are total income tax revenues generated from employed individuals and sum of net transfers paid to eligible individuals/households.

\textbf{Timing} Every single period \( t \) is divided into three stages. In the first stage, a \( \zeta_R \) fraction of households in the labor force retire and a \( \zeta_D \) fraction of retired households die and are replaced with new households entering into the labor force. Then, aggregate productivity \( z \) is realized. The period productivity level \( z \) completely determines i) the generosity of employment-tested transfers \( b(z) \), its expiration rate \( e(z) \), the generosity of means-tested transfers \( \phi(z) \) and ii) the exogenous job separation rate \( \delta(h, z) \) in each submarket \( h \). This implies that a \( \delta(h, z) \) fraction of those employed in \( t-1 \) in each submarket \( h \) lose their job and must spend at least one period 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 unemployed individuals look for a job in a submarket that is compatible with their own human capital level. Then, \( p(h, z) \) fraction of unemployed individuals searching for a job in submarket \( h \) find a job. Human capital stochastically evolves based on labor market outcomes. The third stage is the production and consumption stage. Each firm-worker pair produces \( g(h, z) \) units of goods. Wages are paid to workers and transfers are paid to eligible households, and they make their joint saving/borrowing decision. Finally, households jointly decide whether their unemployed members will supply labor in the labor market stage at time \( t+1 \), where the forgone utility of leisure for the member with positive labor supply is incurred at time \( t \).

\textbf{2.2 Household Problem}

A household’s state vector consists of the net asset level \( a \in A \equiv [a_{L}, a_{H}] \subseteq \mathbb{R} \), 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 \( h_i \in H \equiv \{h_{L}, \ldots, h_{H}\} \).

The aggregate state is denoted by \( \mu = (z, \Gamma) \), where \( z \in \mathcal{Z} \subseteq \mathbb{R}_+ \) denotes the current aggregate productivity and \( \Gamma : \{E, U_b, U_n, R\} \times \{E, U_b, U_n, R\} \times A \times H \times H \rightarrow [0, 1] \) denotes the distribution

\textsuperscript{19} According to the United States 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.

\textsuperscript{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 the federal UI trust fund when they meet certain federal requirements, and thus they are allowed to run budget deficits during some periods.
of agents across employment statuses, asset levels, 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. In the main text, I will lay out the recursive problem of three types of households: i) one member is employed, the other is unemployed and eligible for UI, ii) both members are unemployed and eligible for UI, and iii) both members are employed. I will then discuss the changes in 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 a household when the male’s employment status is \( l_m \) and female’s employment status is \( l_f \) after search and matching has occurred, i.e., the value at the start of the third stage of a period. Let \( h \equiv (h_m, h_f) \) and \( l \equiv (l_m, l_f) \) be the human capital and employment state vectors of the household. To simplify the notation further in the recursive formulations below, let \( \delta_i = \delta (h_i, z) \) and \( p_i = p (h_i, z) \) be the job displacement rate and job finding rate of individual \( i \in \{m, f\} \), and \( \delta'_i \) 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, \( \lambda'_b \) and \( \lambda'_n \) denote the respective probabilities in the next period.

### 2.2.1 Employed-unemployed household

First, consider a household in which the head is employed and the spouse is unemployed and eligible. The recursive problem of this household is given as follows:

\[
V^{EU_b} (a, h; \mu) = \max_{a' \geq a_L, s_f \in \{0, 1\}} \left[ u (c) + \eta_f (1 - s_f) \right] + \beta \left[ (1 - \zeta_R) \mathbb{E}_{h', \mu'} \left[ V^{l' \mu'} (a', h'; \mu') \mid s_f, l, h, \mu \right] + \zeta_R V^R (a') \right] \tag{2}
\]

subject to

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

In the current period, the household decides their savings and the female’s 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 the current employment statuses, the human capital levels of both members, and the job search decision for the female. If the household retires with probability \( \zeta_R \), then the only relevant state variable is assets \( a \). The household will be eligible to receive employment-tested transfers only if the female

---

\(^{21}\)The problem of the symmetric household is identical to this household’s problem with the change of indices for \( m \) and \( f \).
searches for a job in the current period. Given that the male is the only employed member of the household, the 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 searches 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:\textsuperscript{22}

\[
\mathbb{E}_{V',h',\mu'} \left[ V'(a', h'; \mu') \right] = \mathbb{E}_{h',\mu'} \left[ s_f \left( 1 - \delta'_m \right) \left( p'_f V^{EE} (a', h'; \mu') + \left( 1 - p'_f \right) \sum_{k \in \{b,n\}} \lambda'_k V^{EU_k} (a', h'; \mu') \right) + s_f \delta'_m \left( p'_f \sum_{k} \lambda'_k V^{U_k} (a', h'; \mu') + \left( 1 - p'_f \right) \sum_{k,d \in \{b,n\}} \lambda'_k \lambda'_d V^{U_k U_d} (a', h'; \mu') \right) + \left( 1 - s_f \right) \left( 1 - \delta'_m \right) \sum_{k} \lambda'_k V^{EE} (a', h'; \mu') + \left( 1 - s_f \right) \delta'_m \sum_{k,d \in \{b,n\}} \lambda'_k \lambda'_d V^{U_k U_d} (a', h'; \mu') \right] h, \mu
\]

where I drop the conditions of the expectation on the left-hand side to save space. The first line on the right hand side is the case when the female is unemployed and searching for a job in the current period and the male keeps his current job. In this case, if she finds a 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 the female is searching for a job and the male 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.\textsuperscript{23} If she cannot find a job, then both members 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 continues 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 employment-tested transfers.

For the household in which male is employed but the female is unemployed and ineligible, the

\textsuperscript{22}Expectations over human capital levels and aggregate states are relatively simpler and already discussed in the previous sections.

\textsuperscript{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 not meet requirements for wages earned or time worked during an established period of time referred to as the base period.
above expectation is the same except that she stays ineligible for employment-tested transfers if she does not find a job.\textsuperscript{24}

### 2.2.2 Unemployed-unemployed household

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

\[
V^{UU} (a, h; \mu) = \max_{a' \geq a_L, s_m, s_f \in \{0, 1\}} u(c) + \sum_{i \in \{m, f\}} \eta_i (1 - s_i) + \beta \left[ (1 - \zeta_R) \mathbb{E}_{V', h', \mu'} \left[ V^U (a', h'; \mu') \big| s_m, s_f, l, h, \mu \right] + \zeta_R V^R (a') \right] \\
\text{subject to} \quad c + a' \leq (1 + r) a + y + \phi (z; a, y) + \left[ b (z; U_b, s_m) + b (z; U_b, s_f) \right] (1 - \tau) \\
\Gamma' = \Lambda (\mu, z') \quad \text{and} \quad z' \sim \Phi (z' | z).
\]

Given that both members of the household are now unemployed, the household chooses the 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 could both be 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 even if he/she searches for a job.

The expectation term on 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 the male and female are employed. The recursive problem of this household is given as follows:

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

\textsuperscript{24}This captures the fact that according to current UI policy in the United States, 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.
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 the net wages of the male and female.

The expectation term on the right hand side of Equation (4) is similar to the one I discussed in Equation (2) except that the 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 transfer $b_R$ upon retirement. In every period, retired households die with probability $\zeta_D$ and 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 retired households are not allowed to re-enter into the labor market and that they 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:

$$V^R(a) = \max_{a' \geq a_L} u(c) + \beta (1 - \zeta_D) V^R(a')$$

subject to

$$c + a' \leq (1 + r) a + b_R. \tag{5}$$

### 2.3 Firm Problem

First, consider a firm that is matched with a worker in submarket $h$ when the aggregate state is $\mu$. 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 $\zeta_R$. Let $J(h; \mu)$ be the value of a matched firm in submarket $h$ when the aggregate state is $\mu$. 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

---

\(^{25}\)Relaxing the assumptions about leisure or transfer payments to retired households has only small quantitative effects on the baseline calibration of the model.
state \( \mu \) is given by

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

where \( \kappa \) 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 face the trade-off between the probability of filling a vacancy and the level of surplus from a match. This trade-off exits 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:

\[
\theta(h; \mu) = \begin{cases} 
q^{-1} \left( \frac{\kappa}{\tau(h; \mu)} \right) & \text{if } h \in H(\mu) \\
0 & \text{otherwise} \end{cases} \tag{8}
\]

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 \( \{b(z), e(z), \phi(z), a, y, b_R, \tau\} \) \( z \in Z \), a recursive equilibrium is a list of household policy functions for assets \( \{a_{lm}^{mf}(a, h, \mu)\}_{l \in \{E, U\}, f \in \{R\}} \), and the labor supply of unemployed members of the household \( \{s_i(a, h, \mu)\}_{i \in \{m, f\}} \), 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), (5), 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 \( \Gamma \) 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 a block recursive equilibrium (BRE) developed by Menzio and Shi (2010, 2011).

**Definition of the 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 $\mu$, only through the aggregate productivity $z$ and not through the aggregate distribution of agents across states $\Gamma$.

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 the unemployed to self-select into a specific submarket to search for a job compatible with their own human capital level, once the firm is inside this submarket, it does not need to know the entire distribution of the 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 the vacancy filling rate and their surplus from a match, and the free-entry condition for firms guarantees the entry of firms until profits are run down to zero. Finally, the constant-returns-to-scale feature of the matching function implies that the relative ratio of the number of vacancies to the number of unemployed visiting each submarket, i.e., 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 a 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 a 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 $\Gamma$. 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 the level and cyclicality of i) heads’ earnings losses upon job displacement, 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 is 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 their incentive costs on the 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 for the family.

Next, I validate the calibrated model against the change in family earnings and spousal earnings upon the head’s job displacement 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 the head’s job displacement on his own earnings, family earnings, and spousal earnings, as these turn out to be key in understanding the effects of transfers on the spousal labor supply as well as in correctly quantifying the insurance benefits and incentive costs of these transfers. Thus, I now measure these moments in the data. The magnitude of the head’s own earnings losses upon displacement will be a calibration input, while the effects of the head’s displacement on family and spousal earnings will be validation inputs.

3.1 Earnings losses upon job displacement over the business cycle

3.1.1 Data and methodology

In this section, I use data from the PSID for 1968-2015 to study the changes in head earnings and hours, spousal 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 the ages of 20 and 60 and not in the Latino sample.26 I drop families with only one year of observations and those above the 99th percentile of the family labor income distribution.27 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 a firm closure, layoff or firing.28 The resulting unbalanced sample of families contains 86,541 observations on 9,383 families: 1,204 with at least one displacement in a recession and 2,269 with at least one displacement in an expansion. The family head’s of 674 families had at least one displacement in a recession and one in an expansion. 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 had never been displaced with characteristics of families in which the head been displaced at least once. Couples of the families in which the head had been displaced are slightly younger and less educated than families in which

26Based on the definition of the head in the PSID, the family head is almost always male. In my sample, only 49 observations have a female head among the 86,541 observations.
27Table A.1 and Table A.2 in Appendix B show that the main results of this section are robust to alternative sample selections.
28The latter category includes workers who report that they have been fired, which is typically not considered an exogenous job displacement event. However, Boisjoly, Duncan, and Smeeding (1994) report that only 16 percent of the workers in the layoff or fired categories have indeed been fired.
the head had never been displaced. On average, heads who head been displaced and their spouses worked relatively fewer hours than couples who had never been displaced, even in the year prior to displacement.

To study the effects of the 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:

\[ y_{it} = \beta X_{it} + \sum_{k \geq -2}^{10} \psi_k D_{kt} + \alpha_i + \gamma_t + \epsilon_{it} \]  \hfill (9)

The outcome variable \( y_{it} \) includes the real annual labor earnings of the head, the spouse, and the family (defined as the sum of the head’s and the spouse’s labor earnings), as well as the head’s and spouse’s annual working hours.\(^\text{29}\) 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 children younger than 6 years of age. \( \alpha_i \) captures a time-invariant unobserved error component associated with family \( i \), and \( \gamma_t \) is an error component common to all families in the sample at year \( t \). The vector of dummy variables \( D_{kt} \)

\(^\text{29}\) Labor earnings include wages and salaries, bonuses, overtime, tips, commissions, professional practice or trade, market gardening, miscellaneous labor income, and extra job income.

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

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

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 any 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). The data are obtained from the PSID 1968-2015 surveys for families in which both the husband and the wife are between the ages of 20 and 60 and not in the Latino sample.

* Averages are obtained using all observations for families with a never-displaced head.
° Averages are obtained from the survey year prior to the displacement year of the head.
indicates a job displacement of the head in a future, current, or previous year. For example, $D_{it}^3 = 1$ if the individual $i$ is displaced at time $t - 3$ and zero otherwise. I estimate the impact of a head’s job displacement on individual and spousal earnings and hours as well as family earnings in the two years preceding the job loss ($k = -2, -1$), in the year of the job loss ($k = 0$), and in every year until 10 years after the job loss ($k = 1, 2, ..., 10$). Thus, $\psi_k$ captures the effect of job displacement on outcome variables in families whose head was displaced $k$ years prior/after (treatment group) relative to families whose head had 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.\footnote{Individuals who experience an unemployment spell because of reasons other than displacement (such as quitting) are part of the control group.}

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 occurred 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 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 $\psi_k$ 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 lines show the estimated coefficients $\{\psi_k\}_{k=-2}^{10}$ as a percent of the pre-displacement mean labor earnings of displaced heads and the dashed light-blue lines show the 90 percent confidence interval. I compare these results obtained from the PSID with the estimates of Davis and von Wachter (2011), who use SSA data between 1974-2008.\footnote{My econometric model is slightly different from the model that Davis and von Wachter (2011) use. In their analysis, they regress Equation (9) for every year, obtain $\delta_k$ for each of these years, and then report the average values of $\delta_k$ across these years. Given that my sample size from the PSID is smaller, I follow the baseline specification applied by Jacobson, Lalonde, and Sullivan (1993) and Stevens (1997) who also use the PSID. However, I still compare my results to Davis and von Wachter’s (2011) results because they provide the only empirical baseline for the cyclicality of the magnitude of earnings losses upon job displacement.} I find that the magnitude of the average drop in the 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. These results are consistent with the findings of Davis and von Wachter (2011), as they also document larger earnings losses upon displacements 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
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 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 the PSID. The solid-blue lines shows the point estimates, and the dashed light blue-lines show the 90 percent confidence intervals. The orange lines compare these results to the estimates of Davis and von Wachter (2011).

3.1.3 Family and spousal earnings

The main focus of this section is to measure the effects of a head’s job displacement in recessions and in 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 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 a second earner simultaneously employed with the head prior to his displacement. Having the spouse retain employment results in family earnings dropping by one-third less than...
Second, the initial cyclical gap of family earnings losses upon the head’s job displacement in a recession versus in an expansion (28 − 15 = 13 pp) is not very different from the initial cyclical gap of the head’s earnings losses (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 recover 4 years after displacements in recessions (1 year earlier than the head’s earnings recovery), and 3 years after displacements in expansions (2 years earlier than the head’s earnings recovery). However, it is important to notice from the figure that the slopes of the recoveries of the head’s earnings and the family earnings look similar to each other. This hints that earlier recoveries of family earnings are mostly due to a smaller initial drop coming from already working spouses rather than the behavioral response 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 this behavioral response is always insignificant across years after the head’s displacement in recessions. The mean of the post-displacement coefficients is only −0.8 percent for displacement 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 to a comparably smaller sample size, but also because of the small average behavioral spousal response to the head’s displacement in recessions. On the other hand, in expansions, there is a slight positive trend in

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32 The presence of a second earner reduces the initial earnings losses by $100 \times ((39-28)/39) = 28$ percent in recessions and $100 \times ((22-15)/22) = 32$ percent in expansions.
spousal earnings upon the head’s displacement, but the 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 joint significance test of the post-displacement coefficients allow us to reject the hypothesis that they are jointly significant ($p = 0.35$ in recessions and $p = 0.11$ in expansions).\textsuperscript{33}

Figure A.2 in Appendix B measures the effect of the head’s job displacement over the business cycle on annual spousal hours. I also find that the change in spousal hours upon the head’s displacement in recessions is very small, 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 increase by up to 15 percent. The mean of the post-displacement coefficients in expansions is 10.1 percent, and the p-value of the joint significance test is $p = 0.02$.

As a result, I find no evidence for significantly positive spousal earnings or hours responses to the head’s displacement in recessions, when the drop the in head’s earnings is much larger. On the other hand, the spousal earnings and hours responses to the 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 displacement, with the hours increasing 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.

\textsuperscript{33}The 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 the head’s unemployment (Heckman and MaCurdy 1980, 1982, Cullen and Gruber 2000).
3.1.4 Summary of empirical results

It is useful to summarize 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 the head’s displacement on his own labor earnings and that the magnitude of the earnings losses 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 responses to the head’s displacements in recessions, when the drop in the head’s earnings is much larger. On the other hand, the spousal earnings and hours responses to the head’s displacement in expansions become significantly positive at least 3 years after the displacement, with the hours increasing by as much as 15 percent.

The last empirical result is particularly interesting because one could expect stronger spousal earnings and hours responses 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 the head’s displacement in recessions. In the next section, I calibrate the model to match the first empirical result above. Then, I use the second and the third empirical findings to validate my model against. Next, using the model, I investigate the role of the countercyclical generosity of current government transfers on the small labor earnings response to the head’s displacement in recessions.

3.2 Calibration

3.2.1 Functional forms

The model period is set to be a quarter. The utility function over consumption is

$$u(c_t) = c_t^{1-\sigma}$$

with risk aversion parameter $\sigma$. The labor market matching function is

$$M(v, u) = \frac{uv}{[u^\gamma + v^\gamma]^{1/\gamma}}$$

as in den Haan, Ramey, and Watson (2000). This functional form implies that the job finding rate

$$p(\theta) = \theta (1 + \theta^\gamma)^{-1/\gamma}$$

and vacancy filling rate

$$q(\theta) = (1 + \theta^\gamma)^{-1/\gamma}$$

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 differ:

$$\delta(h, z) = \bar{\delta} \times \exp \left( \omega_{z}^\delta \times (z - \bar{z}) \right) \times \exp \left( \omega_{h}^\delta \times (h - \bar{h}) \right),$$

where $\bar{\delta}$ is mean of the displacement rate over time; $\omega_{z}^\delta$ captures the volatility of the job displacement rate over time; $\omega_{h}^\delta$ captures the variation of the 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, the production function is set to

$$g(h, z) = h z.$$
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:

$$\ln z_{t+1} = \rho \ln z_t + \sigma \epsilon_{t+1},$$

where $0 \leq \rho < 1$, $\sigma > 0$, and $\epsilon$ 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 nonfarm 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 Hodrick-Prescott (HP) filtered to obtain deviations from trend.\(^{34}\) 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 $\sigma = 0.0086$.

### 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 of $\sigma = 2$. I set the value of leisure for males to be 0, implying that they are always searching for a job. Hence, changes in government transfers do not affect the search behavior of the household’s primary earner in the model.\(^{35}\)

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

I use data from 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 the worker’s share of output $\alpha$ 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 human capital increases by one step with probability $\pi^E$ when employed. This implies $\Delta^E = 0.084$. Moreover, I set the probability of human capital depreciation when unemployed $\pi^U$ to be 0.75.\(^{36}\)

I also calibrate the asset and income thresholds $g$ and $y$ 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: SNAP, EITC, and TANF.\(^{37}\)

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\(^{34}\)I exclude the 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.

\(^{35}\)The average labor force participation rate of married men is 92 percent, implying that $\eta_m$ would be small if anything. Moreover, this assumption allows me to focus on the effects of government transfers on the spousal labor supply.

\(^{36}\)Ljungqvist and Sargent (1998) set $\pi^U = 0.2$ in the calibration of their model, where the model period is 2 weeks. For a quarterly calibration (i.e., around a 6-period unemployment spell), this implies that the probability of experiencing human capital loss is around 0.75.

\(^{37}\)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
The asset threshold of eligibility for SNAP was $2000 between 1997 and 2007, according to the program reports published by the U.S. Department of Agriculture.\textsuperscript{38} The asset threshold of eligibility for EITC was $2350 in 1995 and $2900 in 2007, according to the program reports published by the U.S. Internal Revenue Service (IRS).\textsuperscript{39} Finally, in 2007, while the asset limit for TANF eligibility varied across different states, most states applied $2000 as the asset limit, according to the program report published by U.S. Department of Health and Human Services.\textsuperscript{40} 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.\textsuperscript{41} I find that this ratio is around 0.73 in the data. Then, I set $a$ in the model so that the ratio of the asset limit $a$ to quarterly minimum labor earnings, $a h_L z_L$, in the model is the same as its counterpart in the data.\textsuperscript{42} As a result, I set $a$ to 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 of this value to the same quarterly minimum labor earnings in the data and find a ratio of around 2.58. Then, I set $y$ in the model so that the ratio of the income limit $y$ to quarterly minimum labor earnings in the model is the same as its counterpart in the data. As a result, I set $y$ to 0.24.

Finally, the average duration of UI payments is around 26 weeks (i.e., 2 quarters). This duration is typically extended during recessions. For example, during the Great Recession, the UI payment duration was extended to 99 weeks (i.e., 7.6 quarters). Hence, I set the expiration rate of employment-tested transfers to 0.5 (i.e., 1/2) when the labor productivity is greater or equal to its mean, and set it to 0.13 (i.e., 1/7.6) when labor productivity is at its lowest level.\textsuperscript{43}

### 3.2.3 Internal calibration

I jointly estimate the remaining 15 parameters using the model to match the moments of the U.S. economy. Table 3 summarizes the results of this estimation.

I choose two parameters, the discount factor $\beta$ and borrowing limit $a_L$, to match two data moments of the asset-to-income distribution from the 2007 SCF: the fraction of households with

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\textsuperscript{38}These reports are titled “Characteristics of Supplemental Nutrition Assistance Program Households” and have been published every fiscal year since 1997. Reports are available at https://www.fns.usda.gov/ops/supplemental-nutrition-assistance-program-snap-research.

\textsuperscript{39}These reports are available at https://www.irs.gov/pub/irs-prior.

\textsuperscript{40}This report is available at https://www.acf.hhs.gov/sites/default/files/opre/wel_rules07.pdf

\textsuperscript{41}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 by average quarterly minimum labor earnings in the data.

\textsuperscript{42}Notice that quarterly minimum labor earnings in the model are invariant to policy changes. This allows me to calibrate both $a$ and $y$ outside of the model.

\textsuperscript{43}Specifically, the grid for $e$ is set to be $[1/(99/13), 1/(75/13), 1/(26/13), 1/(26/13), 1/(26/13), 1/(26/13)]$, where 75 weeks reflect the intermediary extensions of UI transfers.
Table 2: Externally calibrated parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Explanation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho$</td>
<td>Autocorrelation of productivity process</td>
<td>0.7612</td>
</tr>
<tr>
<td>$\sigma_c$</td>
<td>Standard deviation of productivity process</td>
<td>0.0086</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Risk aversion</td>
<td>2</td>
</tr>
<tr>
<td>$\eta_m$</td>
<td>Value of leisure for male</td>
<td>0</td>
</tr>
<tr>
<td>$r$</td>
<td>Interest rate</td>
<td>0.005</td>
</tr>
<tr>
<td>$\zeta_R$</td>
<td>Retirement probability</td>
<td>0.00625</td>
</tr>
<tr>
<td>$\zeta_D$</td>
<td>Death probability</td>
<td>0.01666</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Worker’s share of output</td>
<td>0.477</td>
</tr>
<tr>
<td>$h_L$</td>
<td>Lowest human capital</td>
<td>0.2</td>
</tr>
<tr>
<td>$h_H$</td>
<td>Highest human capital</td>
<td>1.8</td>
</tr>
<tr>
<td>$\Delta^E$</td>
<td>Human capital increase when employed</td>
<td>0.084</td>
</tr>
<tr>
<td>$\pi^U$</td>
<td>Prob. of human capital depreciation when unemployed</td>
<td>0.75</td>
</tr>
<tr>
<td>$a$</td>
<td>Asset threshold of means-tested transfers</td>
<td>0.068</td>
</tr>
<tr>
<td>$y$</td>
<td>Income threshold of means-tested transfers</td>
<td>0.240</td>
</tr>
<tr>
<td>$e$</td>
<td>Mean expiration rate of employment-tested transfers</td>
<td>0.5</td>
</tr>
</tbody>
</table>

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

non-positive liquid wealth and the median ratio of the credit limit to quarterly labor income. Section 3.3 and Appendix B provide the details of calculating these moments from the data.

The utility value of leisure for females $\eta_f$ controls the level of opportunity cost of a female searching for a job. I choose $\eta_f$ to match the female labor force participation rate (LFPR) relative to the male LFPR in the data. I use monthly data from the 2000-2007 CPS to compute the average LFPR of males and females separately for a sample of married or cohabiting couples between ages 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 BLS data for 1948 to 2007, and choose the cost of posting a vacancy $\kappa$ to match the same level in the model. Next, I target the volatility of job finding rate in the data by choosing the elasticity of matching function $\gamma$. I use quarterly CPS data for 1948 to 2007 and compute standard deviations as log deviations from an HP trend with

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44I 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.
Table 3: Internally calibrated parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Explanation</th>
<th>Value</th>
<th>Target</th>
<th>Source</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>Discount factor</td>
<td>0.983</td>
<td>Frac. of households with non-positive liquid wealth</td>
<td>SCF 2007</td>
<td>0.097</td>
<td>0.13</td>
</tr>
<tr>
<td>$a_L$</td>
<td>Borrowing limit</td>
<td>$-0.67$</td>
<td>Median ratio of credit limit to quarterly labor income</td>
<td>SCF 2007</td>
<td>0.64</td>
<td>0.65</td>
</tr>
<tr>
<td>$\eta_f$</td>
<td>Leisure value (female)</td>
<td>0.51</td>
<td>Relative female LFPR</td>
<td>CPS 2000-2007</td>
<td>0.77</td>
<td>0.77</td>
</tr>
</tbody>
</table>

**Labor Market**

| $\kappa$   | Vacancy posting cost | 2.9 | Unemployment rate | BLS 1948-2007 | 0.056 | 0.051 |
| $\gamma$   | 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 |
| $\omega_s^\delta$ | Displacement rate vol. | $-5.8$ | Std. dev. of job disp. rate | JOLTS 2000-2018 | 0.06 | 0.06 |
| $\omega_h^\delta$ | Displacement rate across $h$ | $-0.52$ | Ratio of median earnings | PSID 1968-2015 | 0.76 | 0.77 |

**Human Capital Process**

| $\Delta^U$ | Human capital decrease (unemp.) | $[0.59, 0.34]$ | Cyclicality of head’s initial | PSID 1968-2015 | $[0.39, 0.22]$ | $[0.39, 0.22]$ |
| $\pi^E$    | Prob. of human capital increase (emp.) | 0.04 | Labor earnings p90/p10 | PSID 2007 | 7.60 | 6.20 |

**Government Transfers**

| $\bar{\delta}$  | Average means-tested transfers | 0.15 | Ratio of total means-tested | NIPA 1976-2007 | 0.74 | 0.76 |
| $\bar{b}$       | Average emp.-tested transfers | 0.08 | Ratio of total UI trans. per | NIPA 1948-2007 | 0.36 | 0.37 |
| $\omega_{\phi}$ | Cyclicality of means-tested transfers | 0.96 | Std. dev of means-tested | NIPA 1976-2007 | 0.06 | 0.08 |
| $\omega_b$      | Cyclicality of emp.-tested transfers | 0.64 | Std. dev. of total UI | 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.
I use the three parameters $\bar{\delta}$, $\omega^\delta_\delta$, and $\omega^\delta_h$ 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. According to Job Openings and Labor Turnover Survey (JOLTS) data, between 2008 and 2018, the average quarterly total separation rate was around 9 percent of total employment, with an average 38 percent of all separations due to layoff or discharge. This implies a quarterly average job displacement rate of 3.4 percent. I find that the standard deviation of the job displacement rate is 0.06. Finally, I calculate the ratio of the median predisplacement labor earnings of displaced household heads (i.e., labor earnings one year prior to displacement) to the median labor earnings of never-displaced heads using the PSID data under the sample created in Section 3.1. I find that this ratio is 76 percent in the data, which implies that displacement risk is relatively higher for lower-paying jobs. In the model, $\omega^\delta_h$ controls the heterogeneity in job displacement risk across jobs with different human capital, and as a result different wages given that skill level directly affect wages in the model. Hence, I choose $\omega^\delta_h$ 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 magnitudes of the declines in human capital $\Delta^U$ vary across displacement in recessions and in expansions, so 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 realizations 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 $\bar{z}$. Figure 4 compares head earnings losses upon job displacement in recessions and in expansions between the model and the data, where the latter were obtained in Section 3.1. While the model generates the same magnitudes of earnings losses one year after displacement in recessions and in expansions, as they are targeted in the calibration, the recovery of the head’s earnings losses is slightly later in the model than in the data.

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

46 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 into 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 opposite directions.

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

48 Notice that these values of $\Delta^U$ 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 $h = 1$ loses his job in a recession, he would lose 60 percent of his skill with probability $\pi^U$ 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 losses. In this paper, I do not aim to endogenously generate the cyclicality of earnings losses, but rather take this as a calibration target and analyze its effects on spousal behavior. Moreover, one could interpret a relatively larger loss of human capital in recessions as “occupational displacement,” as similarly interpreted by 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 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 the PSID. The solid-blue lines show the point estimates and the dashed light-blue lines show the 90 percent confidence intervals. I compare these results to the estimates obtained from the same regression using the model-simulated data, which is aggregated to yearly periods. Earnings losses one year after displacements both in recessions and expansions are targeted in the model calibration.

Next, the probability of human capital accumulation $\pi^E$ controls skill distribution and thus the labor earnings distribution in the model. For example, if $\pi^E$ is very large, then workers would quickly accumulate their human capital, and the resulting dispersion of labor earnings would be small. I calculate the ratio of the 90th to the 10th percentile of labor earnings distribution of employed individuals from the PSID 2007 survey and find a ratio of 7.6. I choose $\pi^E$ to match the same ratio in the model.

Finally, the remaining five parameters of the model are related to government transfers. I measure the average generosity of means-tested transfers by the ratio of total quarterly means-tested transfers per recipient to minimum quarterly labor earnings using NIPA data for 1976 - 2007 and NIPA reports. 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 in the data. Similarly, I calculate the average ratio of total quarterly UI transfers per unemployed individual to minimum quarterly labor earnings, using data on UI transfer amounts from NIPA and data on the total number of unemployed from the BLS for 1948 - 2007, and find a ratio of 0.36. Again, I choose the average level of employment-tested transfers $\bar{b}$ so that this statistic in the model is the same as in the data. Using micro data from Survey of Income and Program Participation (SIPP) for 1996

\[49\] For each program, the program reports published by the government agencies provide information on the number of recipients each year. Using this data together with data from NIPA, I calculate the total transfer amount per recipient for each program in 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.
- 2014, I find that, on average, around 35 percent of total 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 married households are means-tested transfers. Figure A.3 in Appendix B presents these results.

Next, I measure the cyclicality of means-tested transfers by the standard deviation of total means-tested transfers per recipient. The standard deviation of this value across years in the data is 0.06. In the model, I choose $\omega_\phi$ to generate the same value for the standard deviation of means-tested transfers per recipient.\textsuperscript{50} 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 $\omega_\phi$ to match the value of this statistic in the data. Last, I choose retirement transfers $b_R$ to match the average ratio of total Social Security payments to GDP between 1976 - 2007 in NIPA.\textsuperscript{51}

### 3.3 Validation

In this section, I compare model outcomes with a list of important untargeted data moments. I emphasize that the model endogenously generates reasonable changes in family earnings and spousal earnings upon the head’s displacement over the business cycle when compared to data. This is important for two reasons. First, it later allows me to quantify the crowding-out effects of government transfers (incentive costs) on the spousal earnings response to displacement. 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.

#### 3.3.1 Family and spousal earnings upon the head’s job displacement

Figure 5 compares the change in family earnings upon the head’s job displacement in recessions and in expansions between the model and the data. In the model, the magnitudes of the in family earnings losses one year after the head’s displacement 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 those of family earnings in the data fully recover, both in recessions and in expansions.

Next, Figure 6 compares the change in spousal earnings upon the head’s job displacement in recessions and in expansions between the model and the data. In the model, changes in spousal earnings upon the head’s displacement both in recessions and expansions are limited, as in the data.

\textsuperscript{50}The standard deviation of this annual time series is computed as log deviations from an HP trend with parameter 100.

\textsuperscript{51}There is a large increase in Social Security transfers between 1948 - 1975, which has since mostly disappeared. 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.
Figure 5: Relative Labor Earnings of the Family upon Job Displacement: Model vs Data

Note: This figure plots the changes in the relative family labor earnings 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 the PSID. The solid-blue lines show the point estimates, and the dashed light-blue lines show 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 to yearly periods.

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 with −0.8 (8) percent in the data.

This comparison shows that when the model is calibrated to match the levels and cyclicalities of i) the head’s earnings losses upon job displacement, ii) government transfers, and iii) job finding rates and job separation rates, it is able to generate a small change in spousal earnings upon the 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 the head’s job displacement in the model and in the data. Several papers in the literature estimate 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.52 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 percent decline using Canadian Out of Employment Panel (COEP)

52 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, a decline in consumption of around 24 percent is implied.
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 the head’s displacement, which is in line with the available empirical estimates discussed above.

### 3.3.3 MPC: the 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 MPC data moments that I 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
Table 4: Average MPCs: Model vs Data

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average economy-wide quarterly MPC</td>
<td>0.22</td>
<td>0.12 – 0.30</td>
</tr>
<tr>
<td>Semiannual MPC increase for...</td>
<td>0.10</td>
<td>0.08</td>
</tr>
</tbody>
</table>

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. The MPC of each family type is calculated by computing the fraction consumed out of an unexpected $500 transfer. The model-generated average values are then compared with available empirical estimates in the literature.

The results show that the model-generated average quarterly MPC lies in the middle of the range of estimates provided by Parker, Souleles, Johnson, and McClelland (2013). However, the cyclicality of the MPC for borrowing-constrained individuals is slightly larger in the model than in the data. This means that the insurance benefits in recessions are probably slightly overestimated in the model.

In order to quantitatively understand how MPCs differ across heterogeneous families in the economy, Table 5 presents the average quarterly MPCs of groups of families based on the different employment, wealth, and skill levels of the head. Noticeably, wealth-poor families with an unskilled head exhibit the 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 the spouse.

3.3.4 Asset-to-income distribution

Wealth distribution in 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 in the data counterpart. For this reason, the fraction of families with non-positive liquid wealth are taken as a calibration target in Table 3, while the percentiles of the distribution presented below are not.

To normalize wealth and better capture the level of self-insurance available to families, I com-
Table 5: MPCs across Heterogeneous Households in the Model

<table>
<thead>
<tr>
<th>Family employment: Only head employed</th>
<th>Family employment: Both unemployed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head skill</td>
<td>Head skill</td>
</tr>
<tr>
<td>≤ p50</td>
<td>≤ p50</td>
</tr>
<tr>
<td>&gt; p50</td>
<td>&gt; p50</td>
</tr>
<tr>
<td>Asset ≤ p50</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>0.67</td>
</tr>
<tr>
<td>Asset &gt; p50</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>0.02</td>
</tr>
</tbody>
</table>

Note: This table shows the average quarterly MPCs across families grouped by 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. The MPC of each family type is calculated by computing the fraction consumed out of an unexpected $500 transfer.

I compute the assets-to-income ratio by dividing net liquid assets by quarterly family labor income both in the PSID for 2015 and the SCF for 2007.\(^{55}\) I use net liquid asset holdings as the primary measure of wealth because of their 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, for many U.S. states the countable assets for the asset-eligibility threshold of means-tested transfers often include vehicles. For this reason, I incorporate vehicle equity into the liquid assets calculation. Appendix B provides more details on the calculation of empirical distributions for 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 holds 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 richest families.

3.3.5 Correlated spells of family members

Finally, if the spouse is also displaced in the same year of the head’s displacement and also experiences earnings losses, then we would not expect to observe positive spousal earnings and hours responses upon the family head’s job displacement. In order to test whether this is the case in the data, 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 the spousal displacement probability upon the head’s displacement both in the model and in the data. It shows that there is at most a 2-percentage-point increase in the spousal displacement probability upon the head’s displacement. The model successfully generates a similar pattern given that there is no such correlation of unemployment between household members in the model. Overall, this allows me to eliminate the hypothesis that

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\(^{55}\) The PSID collects information on the amount of credit card debt starting with the 2011 survey. Since this information is needed to calculate net liquid wealth, we can calculate the asset-to-income distribution only after 2011. Here, I choose to present the data from the latest survey.
spousal earnings response to the head’s displacement may also be muted in recessions if spouses are also displaced.

4 Effects of Transfers on Spousal Earnings Response

In this section, I present two main results. First, I implement a counterfactual experiment to discuss the role of more generous-government transfers during recessions in explaining the small change of spousal earnings upon the head’s displacement in recessions. Second, I compare the model-implied spousal labor supply elasticities to existing microeconomic estimates both in aggregate and across subpopulations to provide external validation for the model’s predictions.

4.1 Counterfactual experiment

I now analyze the change in spousal earnings in response to the 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 labor supply. I achieve this in two steps. First, I normalize the value of leisure for males $\eta_m$ to be 0 to make male workers inelastic to changes in government policy. Second, I assume that the wages paid in each human capital submarket are a fraction of the period’s aggregate labor productivity. This implies that wages and firm vacancy-posting decisions are invariant to government policy in the baseline model.\textsuperscript{56} These two assumptions allow me to focus on changes in the spousal labor supply response to displacement under different government policies.

Figure 8 compares the changes in spousal earnings upon the head’s job displacement in recessions and in expansions in the model under the countercyclical baseline/existing policy and a procyclical policy.\textsuperscript{57} It shows that under the procyclical policy, spousal earnings increase by up to 15 percent

\textsuperscript{56}In Section 6, I explore the implications of allowing for endogenous wage choices by households, to capture the effects of transfers on labor demand.

\textsuperscript{57}The procyclical policy here is the optimal policy obtained in the next section.
Figure 7: Change in Spousal Displacement Probability upon Head’s Displacement: Model vs Data

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

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

Note: This figure plots the changes in relative spousal labor earnings upon the head’s job displacement in recessions (left panel) and in expansions (right panel) in the model under the countercyclical baseline policy and a procyclical policy. The procyclical policy here is the optimal policy obtained in the next section. I estimate the changes in relative spousal earnings from a distributed lag-recession model using model-simulated data, which are aggregated to a yearly period.
in recessions but remain 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 countercyclical policy. For expansions, it is 2.9 percent under the procyclical policy and 5.2 percent under the countercyclical policy.

This result is driven by the fact that in recessions, the large earnings losses incurred by the family head are mitigated by generous transfers from the government under the existing policy. These transfers lower the marginal utility of consumption of the family and thus lower 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 low regardless of the generosity of transfers. As such, the spousal response is small and inelastic to the generosity of government transfers.

4.2 Spousal labor supply elasticities: Data vs Model

I now implement an external validation exercise to test whether the magnitude of model implied spousal labor supply elasticities with respect to changes in wages and government policies are reasonable. This is important because, for example, if the magnitude of the elasticity with respect to transfers is much larger in the model than in the data, then the crowding-out effects of transfers would be overestimated in recessions, during which 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 this elasticity estimates identified from permanent wage changes resulting from tax reforms across seven different studies. They report female participation elasticity as the change in log employment rates divided by the change in log net-of-tax wages. The employment rate is typically defined as positive work hours in a year. The magnitude of these empirical estimates on female participation elasticity with respect to net earnings lies between 0.15 and 0.43.

In order to calculate the magnitude of female participation elasticity with respect to net-of-tax wages in the model, I implement an unexpected and permanent decline in $\tau$ 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 the tax rate, increases by 10 percent. This way, the model generates permanent changes in wages resulting from income tax reform, which is similar to the identification used in the microeconomic studies. I then calculate the model-implied female participation elasticity with

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58Chetty, 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 benchmarks.
Table 7: Magnitudes of Female Labor Supply Elasticities: Data vs Model

<table>
<thead>
<tr>
<th>All households</th>
<th>Low-income households</th>
<th>High-income households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female participation elasticity with respect to net wages</td>
<td>Data</td>
<td>0.15 – 0.43</td>
</tr>
<tr>
<td></td>
<td>Model</td>
<td>0.31</td>
</tr>
<tr>
<td>Female labor earnings elasticity with respect to transfers</td>
<td>Data</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>Model $\bar{\phi}$</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>Model $\bar{b}$</td>
<td>0.01</td>
</tr>
</tbody>
</table>

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 the participation elasticities are summarized by Chetty, Guren, Manoli, and Weber (2012), and the empirical estimates of the earnings elasticity are calculated 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.

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 females in low-income households. This is because these three studies focus on either married women 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 the 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 females who are married to high-income males as 0.15. As a result, in the data, the participation elasticity is much larger for females in low-income households than in high-income households.

These estimates in the literature allow me to compare the heterogeneity of female participation elasticity across families with different income levels in the model. I compute the magnitude of female participation elasticity with respect to net wages separately for women in low-income households and high-income households using the same calculations as before.\(^{59}\) I find that the


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magnitudes of the participation elasticities are 0.38 for spouses in low-income households and 0.21 for spouses in high-income households. Hence, the model also generates quantitatively reasonable differences among the participation elasticities of females across different household income groups. However, the model overestimates the magnitude of female participation elasticity for high-income households. This is because, as shown in Section 3, the model does not generate the high amount of wealth held by the households in the right tail of the asset-to-income distribution for whom these elasticities are excepted to be 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 the spousal labor supply response to the head’s job displacement. In order to do so, I compare the change in spousal earnings upon the head’s job displacement for households living in either the U.S. states providing the most-generous transfer payments or the U.S. 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 with 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. As a result, I obtain post-displacement changes in the dollar amounts of spousal earnings and transfer receipts for households with a displaced head relative to households without a displaced head separately for these two groups. Then, I calculate the ratio of the difference in log spousal earnings to the difference in log transfer receipts of displaced households between the most-generous states and the least-generous states, and find a ratio of 0.44. I take this ratio as the magnitude female labor earnings elasticity with respect to transfers in the data.

I perform a similar exercise in the model by separately implementing a permanent 10 percent decline in the 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 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 low-income households as those with total gross labor earnings less than or equal to 4.62 times the model’s minimum wage. On the other hand, the data sample in Liebman and Saez (2006) that is used to calculate elasticities for high-income families includes heads whose earnings are above the 75th percentile. Hence, in the model, I classify households as high-income 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.

U.S. states with the most-generous safety net programs are Vermont, District of Columbia, North Dakota, Massachusetts, and Minnesota. U.S. states with the least-generous safety net programs are 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 the 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. This result implies a higher spousal labor supply response when government transfers are less generous. Similarly, Bredimann, Otten, and Rulff (2017) use data from 28 European countries between 2004 and 2013, and document that wives’ labor supply in response 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).
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. On the other hand, the eligibility for means-tested transfers require low family labor income, which discourages spousal labor supply when transfer amount is large.

Finally, I calculate the 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 $\phi$ 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 household income and this makes the spousal labor supply more responsive to changes in government transfers. Hence, reducing the generosity of transfers in recessions increases the 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 the spousal labor supply are larger in recessions and smaller in expansions. Since 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.

5.1 Welfare calculation

I use two measures to calculate the changes in welfare due to a government policy reform. The first measure, $\lambda_1(x)$, is constructed for each individual state $x$ possible in the economy separately, i.e., $x \in \mathcal{X} \equiv \{E, U_b, U_n, R\} \times \{E, U_b, U_n, R\} \times \mathcal{A} \times \mathcal{H} \times \mathcal{H}$. This measure allows me to compute the welfare gains/losses for each type of household in the economy and thus makes it possible to analyze the heterogeneous welfare effects of a policy reform. Moreover, it is also possible to aggregate $\lambda_1(\cdot)$ across all individual states to obtain a welfare measure for the entire economy, which I will call $\bar{\lambda}_1$. The second measure, $\bar{\lambda}_2$, is motivated by Lucas (1987). This measure provides one aggregated welfare measure for the entire economy and allows a better comparison with the existing literature.

I now formally define these two measures. Let $(c^o, s^o_m, s^o_f)$ denote the allocations under the existing (old) policy $o$ according to the historical patterns of the government transfer programs in the United States. Let $(c^n, s^n_m, s^n_f)$ denote the allocations under a proposed (new) policy $n$.

$\lambda_1(x)$ is the percent additional lifetime consumption that must be endowed at all future dates and states to a household with individual state $x$ under the stationary distribution of the economy where policy $o$ is implemented so that the household’s welfare will be the same as that under an economy where policy $n$ is instead started to be implemented forever. Formally, for all $x \in \mathcal{X}$,
\( \lambda_1(x) \) satisfies the following equation:

\[
E_T \sum_{t=T}^{\infty} \beta^{t-T} U \left( c_t^o(x) \left( 1 + \lambda_1(x) \right), s_{m,t}^o(x), s_{f,t}^o(x) \right) = E_T \sum_{t=T}^{\infty} \beta^{t-T} U \left( c_t^o(x), s_{m,t}^o(x), s_{f,t}^o(x) \right)
\]

where \( T \) is the time period when the policy changes from \( o \) to \( n \). Once we obtain \( \lambda_1(x) \) for all \( x \in \mathcal{X} \) by solving this equation, we can obtain an aggregate welfare measure by integrating over the stationary distribution \( \Gamma_{ss}^o \) in the baseline economy with policy \( o \):

\[
\tilde{\lambda}_1 = \int_{x \in \mathcal{X}} \Gamma_{ss}^o(x) \times \lambda_1(x).
\]

\( \tilde{\lambda}_2 \) is the percent additional lifetime consumption that must be endowed at all future dates and states to all households under the stationary distribution of the economy where policy \( o \) is implemented so that the average welfare will be the same as that under an economy where policy \( n \) is instead started to be implemented forever. Formally, \( \tilde{\lambda}_2 \) satisfies the following equation:

\[
\int_{x \in \mathcal{X}} \Gamma_{ss}^o(x) E_T \sum_{t=T}^{\infty} \beta^{t-T} U \left( c_t^o(x) \left( 1 + \tilde{\lambda}_2 \right), s_{m,t}^o(x), s_{f,t}^o(x) \right) = \int_{x \in \mathcal{X}} \Gamma_{ss}^o(x) E_T \sum_{t=T}^{\infty} \beta^{t-T} U \left( c_t^o(x), s_{m,t}^o(x), s_{f,t}^o(x) \right)
\]

The government chooses the policy instruments to maximize the ex-ante lifetime utility of a household who is born (under the veil of ignorance) into the stationary equilibrium under policy \( o \) subject to the government budget constraint. Specifically, the government’s objective is to maximize

\[
\int_{x \in \mathcal{X}} \Gamma_{ss}^o(x) E_T \sum_{t=T}^{\infty} \beta^{t-T} U \left( c_t^o(x), s_{m,t}^o(x), s_{f,t}^o(x) \right)
\]

subject to Equation (1) by choosing policy \( n \). The policy reform implemented at this time is unanticipated and permanent. Moreover, the welfare analysis here incorporates the effects of the transition path from the stationary distribution of the economy under policy \( o \) to that under policy \( n \).

In my main optimal policy analysis, the focus is to obtain the optimal level and cyclicity of means-tested and employment-tested transfer amounts. Thus, I jointly search over four policy parameters \( \left( \phi, \omega_\phi, \tilde{b}, \omega_b \right) \) together with the implied tax rate \( \tau \) to solve for the optimal transfer policy. Later in Section 6.1, I extend this analysis by also optimizing over the income and asset thresholds \( y \) and \( a \) of the means-tested transfers as well as the expiration rate \( e(\cdot) \) of the employment-tested transfers.

### 5.2 Optimal policy in the baseline model

Table 8 compares the per recipient transfer amount as a multiple of the minimum wage in the model paid under means-tested and employment-tested transfers in the current policy with that in the optimal policy. Separate comparisons are presented for when the aggregate labor productivity

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62Given the functional form of the utility function, there are no closed-form solutions for \( \lambda_1(x) \), \( \tilde{\lambda}_1 \), and \( \tilde{\lambda}_2 \).
Table 8: Current Policy vs Optimal Policy in the Baseline Model

<table>
<thead>
<tr>
<th>Labor Productivity</th>
<th>Means-tested</th>
<th>Employment-tested</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Policy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>1.61</td>
<td>0.86</td>
<td>2.48</td>
</tr>
<tr>
<td>Recession</td>
<td>1.90</td>
<td>1.04</td>
<td>2.94</td>
</tr>
<tr>
<td><strong>Optimal Policy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>1.40</td>
<td>1.18</td>
<td>2.58</td>
</tr>
<tr>
<td>Recession</td>
<td>0.40</td>
<td>1.34</td>
<td>1.74</td>
</tr>
</tbody>
</table>

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

$z$ is at its average level and its lowest level, i.e., in a deep recession. The minimum wage in the model is exogenous to changes in policy, as discussed previously in Section 3. Thus, reporting each transfer amount as a multiple of the minimum wage presents a useful interpretation.

The optimal level of transfers on average is determined by the tradeoff between insurance benefits and 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 than the current policy. 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 for government transfers.

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 in a recession the optimal policy provides less-generous means-tested transfers (procyclical), while the current policy provides more-generous means-tested transfers (countercyclical). In recessions, the optimal policy reduces the means-tested transfers paid per recipient household from 1.40 to 0.40 times the minimum wage, whereas the current policy increases them from 1.61 to 1.90. Less-generous transfers in recessions alleviate the large incentive costs of public insurance on the labor supply of spouses. This induces a higher female labor force participation in response to the larger increase in the marginal utility of consumption from the head’s larger earnings losses upon displacement in recessions. On the other hand, the optimal policy provides more-generous employment-tested transfers in recessions (countercyclical) and of comparable cyclicity with those from 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 the eligibility for employment-tested transfers is based on individual’s employment status, and it does not check spousal earnings. Moreover, these transfers are small payments and more importantly, limited in duration. These dampen the crowding-out effects on the spousal labor supply. This finding is corroborated by the results of Section 4.2, where I show that the magnitude of female labor supply elasticity with respect to changes in $b$ is small. Overall, total government transfers under the optimal policy are procyclical, while under the current policy they are countercyclical.

The optimal policy yields welfare gains equivalent to $\lambda_2 = 0.61$ percent of additional lifetime consumption compared with the current policy. Roughly half of these welfare gains are attributable to optimizing over the average level of transfers and the rest are attributable to optimizing over the cyclicality of transfers.63

### 5.2.1 Understanding the reasons behind the optimality

In order to better understand what makes for optimal policy, I compare family outcomes and macroeconomic outcomes under the optimal and current policies.

**Effects of optimal policy on family outcomes upon displacement**  Previously in Figure 8, I compare the change in spousal earnings upon the head’s job displacement in recessions and in expansions in the model under the countercyclical baseline (current) policy and under a procyclical policy. There, the procyclical policy is actually the optimal policy obtained in this section. Thus, we know from Figure 8 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 in expansions under the current policy and the optimal policy. I find that families experience a smaller consumption drop under the optimal policy upon the head’s displacement both in recessions and in expansions. Moreover, under the optimal policy, family consumption fully recovers 6 years after displacement in recessions, and 5 years after displacement in expansions, 2 years earlier than in recessions and 1 year earlier than in expansions under the current policy. 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 transfers.

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63Krusell, 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).
Figure 9: Relative Consumption of the Family upon the Head’s Job Displacement: Current Policy vs Optimal Policy

Note: This figure plots the changes in relative family consumption upon the head’s job displacement in recessions (left panel) and in 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 are aggregated to a yearly period.

Furthermore, I find that the difference in the drops in consumption upon displacement between recessions and expansion under the optimal policy is 9 percentage points ($0.16 - 0.07 = 0.09$), 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 because the increase in spousal earnings offsets the 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 alleviate the cyclical gaps from the initial drops in consumption.

Effects of optimal policy on the macroeconomic outcomes  I now discuss the effects of the optimal policy on macroeconomic outcomes. Table 9 compares the steady-state values of macroeconomic outcomes under the current policy with those under the optimal policy. Compared with the economy under the current policy, the economy under the optimal policy has a similar unemployment rate but much higher LFPR, 76 percent versus 71 percent. 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 level of total government transfers (as shown in Table 8) 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 the asset-to-

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64 Figure A.4 and A.5 in Appendix C respectively provide comparisons for relative changes in family earnings and assets upon the head’s displacement in recessions and expansions under the current policy and under the optimal policy, both of which affect changes in family consumption.
Table 9: Macroeconomic Effects of the Optimal Policy

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

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 the asset-to-income distribution and consumption are calculated for families in the labor force. The volatility of average consumption is measured by the standard deviation of log deviations from an HP trend with parameter 1600.

income distribution. These changes in the macroeconomy increase 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 percentage points larger under the optimal policy than under the current policy. While the Gini of the consumption distribution is the same under these two policies, the volatility of 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.

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. To do so, I first obtain welfare gains/losses \( \lambda_1 (x) \) for each type of household \( x \in X \) using Equation (10). Then, I group families by their employment status, asset level, and male and female skill level based on their states on the stationary distribution prior to policy reform and obtain an aggregate welfare for each group by only integrating over families which belong to that group. Table 10 summarizes the results.

I find that most of the welfare gains are enjoyed by wealth-poor families with an unskilled male
Table 10: Heterogeneous Welfare Gains from the Optimal Policy

<table>
<thead>
<tr>
<th>Family employment: Only head employed</th>
<th>Female skill</th>
<th></th>
<th>Family employment: Only head employed</th>
<th>Male skill</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ p50</td>
<td>&gt; p50</td>
<td></td>
<td>≤ p50</td>
<td>&gt; p50</td>
</tr>
<tr>
<td>Asset</td>
<td></td>
<td></td>
<td>Asset</td>
<td>≤ p50</td>
<td>&gt; p50</td>
</tr>
<tr>
<td>≤ p50</td>
<td>0.50</td>
<td>1.09</td>
<td>≤ p50</td>
<td>0.73</td>
<td>0.42</td>
</tr>
<tr>
<td>&gt; p50</td>
<td>0.29</td>
<td>0.38</td>
<td>&gt; p50</td>
<td>0.35</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Note: This table shows the heterogeneous welfare gains from the optimal policy for various 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 computed relative to the baseline countercyclical policy.

who is married to a skilled female, both among families in which only the head is employed and among families in which the head and the spouse 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 when the head is displaced. On the contrary, the lowest welfare gains are enjoyed by wealth-rich families with a skilled male and an unskilled female for whom spouses are less likely to enter the labor force as their need for any insurance is the least.

5.3 Optimal policy in the exogenous spousal labor supply model

I now explore the implications of assuming that the 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 \( \pi \); i.e., \( s_f^\pi(x) = s_f^\pi(x) \forall x \in \mathcal{X} \) and \( \forall \pi \). 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 the minimum wage under the optimal policy of the baseline model with an endogenous female labor supply and under the optimal policy of this alternative model with an exogenous spousal labor supply.

When labor productivity is at its average level, total transfers paid under the optimal policy of the alternative model is more generous than under the optimal policy of the baseline model. Recall that, in Table 7, I have documented that the spousal labor supply elasticity to government policy is large, especially among low-income households. When we abstract from the responsiveness of the
Table 11: Optimal Policy in the Baseline vs Exogeneous Spousal Labor Supply Model

<table>
<thead>
<tr>
<th>Labor Productivity</th>
<th>Means-tested</th>
<th>Employment-tested</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optimal Policy in the Baseline Model</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>1.40</td>
<td>1.18</td>
<td>2.58</td>
</tr>
<tr>
<td>Recession</td>
<td>0.40</td>
<td>1.34</td>
<td>1.74</td>
</tr>
<tr>
<td><strong>Optimal Policy in the Exogeneous Spousal Labor Supply Model</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>2.58</td>
<td>0.32</td>
<td>2.90</td>
</tr>
<tr>
<td>Recession</td>
<td>2.69</td>
<td>0.40</td>
<td>3.09</td>
</tr>
</tbody>
</table>

Note: This table compares per-recipient transfer amounts as a multiple of the 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 aggregate labor productivity $z$ is at its average level $\bar{z}$ and its minimum level, i.e., deep recession. The minimum wage in the model is exogeneous to changes in policy and thus reporting transfer amounts as a multiple of the minimum wage presents a useful interpretation.

spousal labor supply to changes in government policy, we disregard the policy’s crowding-out effect (i.e., the incentive costs) on the spousal labor supply. As a result, the optimal policy features more generous transfers on average under this alternative model. Moreover, according to this optimal policy, around 90 percent of total transfers are means-tested since means-tested transfers better target insurance toward families who need it the most and for whom incentive costs are now small, given that the spousal labor supply does not respond to changes in government policy.

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, 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. From the lens of my model, when we disregard this mechanism, the resulting optimal policy looks very similar to the existing/current policy in the United States. However, when taking into account the endogenous spousal labor supply response to policy, the optimal policy turns out to be largely different. As a result, policy makers should recognize that married households have an important source of self-insurance through adjustments in the spousal labor supply, and generous payments to these households make them worse-off due to large crowding out.

6 Extensions and Robustness

In this section, I provide a list of extensions and robustness checks of the main results.
Table 12: Welfare Gains under Optimality of Other Policy Instruments

<table>
<thead>
<tr>
<th>Welfare gains</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline optimal</td>
<td>0.61</td>
</tr>
<tr>
<td>Optimal $a$, $y$</td>
<td>0.81</td>
</tr>
<tr>
<td>Optimal $a$</td>
<td>0.63</td>
</tr>
<tr>
<td>Optimal $y$</td>
<td>0.77</td>
</tr>
<tr>
<td>Optimal $e$</td>
<td>0.63</td>
</tr>
</tbody>
</table>

*Note:* This table first shows the welfare gains from the baseline optimal policy calculated in Section 5.2, from optimizing over the transfer level and cyclicalities 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 $a$ and $y$ of eligibility for means-tested transfers (second row), ii) only the level of asset threshold $a$ (third row), iii) only the level of income threshold $y$ (fourth row), and finally iv) only the level and cyclicality of the employment-tested transfer expiration rate $e(\cdot)$ (fifth row). Welfare gains are based on $\bar{\lambda}_2$.

### 6.1 Extensions

Due to computational reasons, in Section 5.2, I solved for the optimal policy by searching over only 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 levels of the asset and income thresholds $a$ and $y$ of eligibility for means-tested transfers and the employment-tested transfer expiration rate $e(\cdot)$. In this section, I search for the optimal $a$, $y$, and $e(\cdot)$ in steps, taking as given the optimal levels and cyclicalities of the means-tested and employment-tested transfers obtained in Section 5.2.\(^{65}\)

Table 12 first shows the welfare gains from the baseline optimal policy calculated in Section 5.2, from optimizing over the levels and cyclicalities of both means-tested and employment-tested transfers (first row). Then, on top of this optimal policy (i.e., under the optimal levels and cyclicalities of the means-tested and employment-tested transfers obtained in Section 5.2), it shows welfare gains from optimizing over i) both levels of the asset and income thresholds $a$ and $y$ of eligibility for means-tested transfers (second row), ii) only the level of the asset threshold $a$ (third row), iii) only the level of the income threshold $y$ (fourth row), and finally iv) only the level and the cyclicality of the employment-tested transfer expiration rate $e(\cdot)$ (fifth row). Welfare gains are based on $\bar{\lambda}_2$.

I find that, on top of the baseline optimal policy, jointly optimizing over asset and income thresholds yields welfare gains of 0.81 percent of additional lifetime consumption relative to the current policy. In this case, the 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, respectively. 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 than the

\(^{65}\)Again due to computational reasons, it is not feasible to solve for the full set of optimal policy instruments at the same time. Thus, I solve for optimal $a$, $y$, and $e(\cdot)$ one at a time.
current policy.

In order to understand which of these two instruments is more powerful in increasing welfare gains, I next search for the optimal asset threshold and the 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 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 on average 2 quarters, and 7.6 quarters in recessions. Even if there is significant difference between the degrees of countercyclicality of the current and optimal policies, this change provides only little welfare gains. Welfare gains from the optimal policy in 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 (again based on \(\bar{\lambda}_2\)) from the optimal policy in Section 5.2, when an assumption of the baseline model is changed. Results are summarized in Table 13.

Incorporating Medicaid to means-tested transfers In the calibration means-tested transfers, I did not incorporate Medicaid transfers given that the baseline model does not incorporate extra eligibility risks such as health status or presence-of-young children requirements. Now, I incorporate Medicaid transfers into the calibration of parameters of means-tested transfers and include a new eligibility indicator for all means-tested transfers. Means-tested transfers are now given as follows:

\[
\phi(z; a, y, \chi) = \begin{cases} 
\phi(z) & \text{if } y < y, a < a, \chi = 1 \\
\nu \phi(z) & \text{if } y < y, a < a, \chi = 0 \\
0 & \text{otherwise,}
\end{cases}
\]

where \(\chi\) is a non-financial eligibility indicator for all means-tested transfers, which can be interpreted as health status or presence-of-young children requirements. In the above specification, if a family

\[^{66}\text{I also check the implications of these exercises on the results of Section 4. Sizeable welfare gains from the baseline optimal policy in these cases imply that less-generous transfers in recessions still induce spouses to supplement family earnings by working.}\]

\[^{67}\text{I acknowledge that the optimal policy of the baseline model may not be the optimal policy of a model with assumptions that differ from the baseline model. However, this exercise at least shows us if there is a large quantitative effect of an assumption on welfare results.}\]
Table 13: Welfare Gains from the Baseline Optimal Policy under Alternative Assumptions

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Welfare gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline optimal</td>
<td>0.61</td>
</tr>
<tr>
<td>Incorporating Medicaid into means-tested transfers</td>
<td>0.51</td>
</tr>
<tr>
<td>Removing job search requirements for employment-tested transfers</td>
<td>0.48</td>
</tr>
<tr>
<td>Progressive taxation</td>
<td>0.95</td>
</tr>
<tr>
<td>Non-separable preferences</td>
<td>0.68</td>
</tr>
<tr>
<td>Endogenous wages</td>
<td>0.66</td>
</tr>
</tbody>
</table>

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 based on $\lambda_2$.

is financially eligible but non-financially ineligible (i.e. $y < \bar{y}$, $a < \bar{a}$, $\chi = 0$), then I assume that the family receives only SNAP transfers, which typically do not have any non-financial eligibility requirements, and that SNAP is $\iota$ fraction of total means-tested transfers. $\chi$ is a state variable representing family type, and a random variable is drawn from a uniform distribution each period to determine the value of $\chi$.

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 are 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. Here, I implement this 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 equivalents. Next, I replace 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 changing only the cyclical 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 the 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.

68 Among the changes to the parameter values, an important one to mention is that the average generosity of means-tested transfers is $\bar{\phi} = 0.51$ instead of $\bar{\phi} = 0.15$ in the baseline calibration given the inclusion of generous Medicaid transfers. Moreover, the cyclical of means-tested transfers now becomes $\omega_\phi = 2.8$ instead of $\omega_\phi = 0.96$ as 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 the level of means-tested transfers requires adjustments in $\omega_\phi$ as well to make it the same value. Finally, the income tax rate that balances the budget is $\tau = 20.6$ percent instead of $\tau = 16.2$ percent.
Removing job search requirements for employment-tested transfers  In the baseline model, I assume that the 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:

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

Then, I recalibrate the model and calculate welfare gains from the baseline optimal policy. I find that in this model the optimal policy yields 0.48 percent additional lifetime consumption relative to the current policy. 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 the removal of job search requirement for eligibility.

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

Let $\Upsilon$ be the total taxable family income. For families in the labor force, $\Upsilon$ includes total labor income and income from employment-tested transfers. For retired families, $\Upsilon$ includes only retirement income. Then, following Heathcote, Storesletten, and Violante (2014), the after-tax income of the family is given by $\tilde{\Upsilon} = \Phi \Upsilon^{1-\nu}$, where $\Phi$ 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 $\Upsilon$ is given by $T(\Upsilon) = \Upsilon - \Phi \Upsilon^{1-\nu}$.

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 $\Phi$ that balance the government budget in the long run and find $\Phi = 0.834$. Then, I calculate welfare gains from the baseline optimal policy, where the progressivity of the tax policy is at the same and the level parameter under the optimal policy becomes $\Phi = 0.844$ in equilibrium. I find that the optimal policy of this model yields 0.95 percent additional lifetime consumption relative to the current policy. Thus, I find larger welfare gains when taxation is progressive. This is intuitive given that most of the welfare gains are enjoyed by wealth-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 now have lower marginal tax rates.

Non-separable preferences  Next, I consider a utility function in which consumption and leisure are non-separable, following Blundell, Browning, and Meghir (1994) and Attanasio and Weber

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69 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.
I define the preferences as follows:

\[ U(c, s_m, s_f) = \left[ c \times \prod_{i \in \{m, f\}} \exp(\eta_i (1 - s_i)) \right]^{1-\sigma} \]

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

**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 allows me to isolate the effects of transfers on the 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 endogenous. In this model, submarkets in the labor market are indexed by the wage offer \( w \) of the firm 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 endogenously. 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 than under the current policy. 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 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 find that the change in spousal earnings in response to the head’s job displacement is small, especially 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 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 counterfactual experiment, I find that existing generous transfers in recessions discourage the spousal labor supply significantly after the head’s job displacement.

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 when household income is lower, which is in line with the data.

In an alternative environment in which the spousal labor supply is 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 insurance benefits are larger in recessions and the incentive costs on the 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.
References


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

The expected value of an unemployed-unemployed household is given by:

$$
E_{l', h', \mu'} = E_{h', \mu'} \left[ V_{l'}(a', h'; \mu') \right] = E_{h', \mu'} \left[ s_{s, f} p'_{f} \left( p'_{f} V^{EE}(a', h'; \mu') + \left( 1 - p'_{f} \right) \sum_{k \in \{b, n\}} \lambda'_{k} V^{EU}_{k}(a', h'; \mu') \right) \right]
$$

where I drop the conditions of the expectation in the left hand side to save space. The first line on 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 one. Then, if she finds a job, the household will be an unemployed-employed household where he may retain or lose eligibility 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 he does not find one. Then, if she finds a job, the household will be an unemployed-employed household where he may retain or lose eligibility for employment-tested transfers. If she cannot find a job, then both members of the household will continue to be unemployed and face eligibility risk; otherwise, both members will continue to be unemployed and face eligibility risk.

58
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**

The expected value of an employed-employed household is given by:

$$
E[h', \mu'] \left[ V^E (a', h'; \mu') \right] = E[h', \mu'] \left[ (1 - \delta_m) \left( (1 - \delta_f') V^{EE} (a', h'; \mu') + \delta_f' \sum_{k \in \{b, n\}} \lambda_k V^{EU_k} (a', h'; \mu') \right) + \delta_m' \left( (1 - \delta_f') \sum_k \lambda_k V^{U_k} (a', h'; \mu') + \delta_f' \sum_{k, d \in \{b, n\}} \lambda_k \lambda_d V^{U_k U_d} (a', h'; \mu') \right) \right] \left| h', \mu \right],
$$

where I drop the conditions of the expectation on the left-hand side to save space. The first line on the right-hand side shows cases when the male keeps his job, the 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 faces eligibility risk, and again the 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 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 of the family and the spouse upon the head’s job displacement in recessions and expansions. These supplement the discussions in Section 3.1. Finally, I explain the details of calculating asset-to-income distribution from the PSID and 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 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 biannually from 1997 to 2015. I use all of these waves of 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. 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.\textsuperscript{70}

While I take many of the variables 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 \(\text{Age} - \text{Education} - 6\) if the individual’s number of years of completed education is larger than or equal to 12, and as \(\text{Age} - 18\) 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 children less than 6 years of age) in the family in any of their available observations 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 the loss of the previous job of 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 being displaced according to the definition above in the 1992 survey of the PSID. This implies that the head may be displaced any time between January of 1991 and the survey date in 1992. Thus, the econometrician may assign such displacement either in 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 into my analysis to better analyze the differential effects of displacements over the business cycle on the labor market outcomes of couples. Furthermore, given that the 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, SEO 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 she is assigned to be the head of the family unit.
Table A.1: Spousal Labor Earnings and Hours Responses to the Head’s Displacement in Recessions and Expansions under Alternative Samples of the PSID

<table>
<thead>
<tr>
<th>Years since displacement</th>
<th>Spousal Earnings</th>
<th>Spousal hours</th>
<th>Spousal Earnings</th>
<th>Spousal hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Recession</td>
<td>Expansion</td>
<td>Recession</td>
<td>Expansion</td>
</tr>
<tr>
<td>Baseline Sample</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>−2</td>
<td>−0.02</td>
<td>0.01</td>
<td>−0.02</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.87)</td>
<td>(0.91)</td>
<td>(0.87)</td>
<td>(0.90)</td>
</tr>
<tr>
<td></td>
<td>0.12</td>
<td>0.07</td>
<td>0.07</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>(0.42)</td>
<td>(0.49)</td>
<td>(0.35)</td>
<td>(0.43)</td>
</tr>
<tr>
<td></td>
<td>−0.14</td>
<td>−0.01</td>
<td>−0.05</td>
<td>−0.13</td>
</tr>
<tr>
<td></td>
<td>(0.33)</td>
<td>(0.60)</td>
<td>(0.52)</td>
<td>(0.33)</td>
</tr>
<tr>
<td></td>
<td>0.09</td>
<td>−0.02</td>
<td>0.11</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>(0.56)</td>
<td>(0.84)</td>
<td>(0.03)</td>
<td>(0.58)</td>
</tr>
<tr>
<td></td>
<td>0.02</td>
<td>−0.03</td>
<td>0.16</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(0.88)</td>
<td>(0.71)</td>
<td>(0.00)</td>
<td>(0.85)</td>
</tr>
<tr>
<td>6</td>
<td>0.02</td>
<td>0.14</td>
<td>0.16</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td>(0.71)</td>
<td>(0.00)</td>
<td>(0.85)</td>
</tr>
<tr>
<td></td>
<td>−0.17</td>
<td>−0.11</td>
<td>0.09</td>
<td>−0.16</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.10)</td>
<td>(0.03)</td>
<td>(0.14)</td>
</tr>
<tr>
<td></td>
<td>−0.11</td>
<td>−0.08</td>
<td>0.10</td>
<td>−0.09</td>
</tr>
<tr>
<td></td>
<td>(0.30)</td>
<td>(0.20)</td>
<td>(0.01)</td>
<td>(0.37)</td>
</tr>
<tr>
<td>Keeps all Samples</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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|                       |                 |               |                 |               |
|                       |                 |               |                 |               |

|                       |                 |               |                 |               |
|                       |                 |               |                 |               |
|                       |                 |               |                 |               |

| Keeps SRC and SEO Samples |                      |                 |                 |               |
| Keeps only SRC Sample    |                      |                 |                 |               |

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.
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 the 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 the spousal earnings and hours responses are 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 the 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 use only information until age 55, as in Davis and von Wachter (2011). Second, I include family heads who are single in the baseline sample. Third, I keep families whose family labor income is above the 99th percentile of the 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 where any member of the family is not living in the family unit. Finally, in Section 3.1, I estimate Equation (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 the head is displaced only in expansions, and a control group where the head is never displaced. This allows me to better isolate the differential effect of the 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 into 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 spousal hours upon head’s job displacement** Figure A.1 shows that the magnitude of the drop in the head’s relative hours when the head is displaced in recessions (18 percent) is similar to that 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 results suggest that both the cyclical gap in earnings losses upon displacements over the business cycle and the persistence of the earnings losses are largely explained by a drop in wages rather than a drop in hours. Previously, Ruhm (1991), Stevens (1997), and Huckfeldt (2016) documented this quick recovery of relative hours of the displaced workers using the 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 wage losses explain most of the cyclical gap in earnings losses.

Figure A.2 shows the change in relative spousal hours upon the head’s job displacement in
Table A.2: Spousal Labor Earnings and Hours Responses to the Head’s Displacement in Recessions and Expansions under Alternative Restrictions in the Baseline Sample

<table>
<thead>
<tr>
<th>Years since Displacement</th>
<th>Spousal Earnings</th>
<th>Spousal Hours</th>
<th>Spousal Earnings</th>
<th>Spousal Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Recession</td>
<td>Expansion</td>
<td>Recession</td>
<td>Expansion</td>
</tr>
<tr>
<td></td>
<td>Alternative Age Limits</td>
<td>Includes Singles</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>−2</td>
<td>(−0.01)</td>
<td>(0.03)</td>
<td>(−0.03)</td>
<td>(0.07)</td>
</tr>
<tr>
<td></td>
<td>(0.94)</td>
<td>(0.75)</td>
<td>(0.50)</td>
<td>(0.18)</td>
</tr>
<tr>
<td></td>
<td>0.13</td>
<td>0.04</td>
<td>0.04</td>
<td>−0.03</td>
</tr>
<tr>
<td></td>
<td>(0.37)</td>
<td>(0.65)</td>
<td>(0.47)</td>
<td>(0.92)</td>
</tr>
<tr>
<td></td>
<td>−0.22</td>
<td>−0.04</td>
<td>0.01</td>
<td>−0.55</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.64)</td>
<td>(0.76)</td>
<td>(0.08)</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>−0.00</td>
<td>0.11</td>
<td>−0.19</td>
</tr>
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<td></td>
<td>(0.75)</td>
<td>(0.96)</td>
<td>(0.05)</td>
<td>(0.55)</td>
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<td>−0.05</td>
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<td>(0.72)</td>
<td>(0.70)</td>
<td>(0.00)</td>
<td>(0.60)</td>
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<td>−0.12</td>
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<td>−0.08</td>
<td>−0.40</td>
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<tr>
<td></td>
<td>(0.23)</td>
<td>(0.22)</td>
<td>(0.10)</td>
<td>(0.12)</td>
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<tr>
<td></td>
<td>−0.08</td>
<td>0.03</td>
<td>−0.07</td>
<td>−0.33</td>
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<tr>
<td></td>
<td>(0.36)</td>
<td>(0.35)</td>
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<td>(0.11)</td>
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<table>
<thead>
<tr>
<th>Keeps Top 1 Percentile</th>
<th>Drops Both Bottom 1 and Top 1 Percentile</th>
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</thead>
<tbody>
<tr>
<td>−2</td>
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<tr>
<td></td>
<td>(0.04)</td>
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<tr>
<td></td>
<td>−0.03</td>
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<td>(0.20)</td>
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<tr>
<td></td>
<td>(0.01)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drops cases where Couples are not living in Family Unit</th>
<th>Keeps those Displaced in Recessions and Expansions</th>
</tr>
</thead>
<tbody>
<tr>
<td>−2</td>
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</tr>
<tr>
<td></td>
<td>(0.02)</td>
</tr>
<tr>
<td></td>
<td>−0.01</td>
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<tr>
<td></td>
<td>(−0.03)</td>
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<tr>
<td></td>
<td>(0.01)</td>
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<td></td>
<td>(0.02)</td>
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<td>(0.01)</td>
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<td>(0.14)</td>
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<td>(0.10)</td>
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<tr>
<td></td>
<td>(0.30)</td>
</tr>
</tbody>
</table>

Note: All results are obtained using Equation (9), but I only show the estimated values for every other year to save space.
recessions and in expansions. I find that the average change in spousal hours upon heads’ displace-
m ents in recessions is small, while the average change in spousal hours upon heads’ displacements in expansions increase by up to 15 percent, and coefficients remain significant after 3 years following
the displacement. The average post-displacement change is −0.1 percent in recessions and 10.1
percent in expansions.\footnote{\cite{stephens2002}}

\textbf{Asset-to-income distribution} \ Starting from a 1999 survey, PSID provides information on asset
holdings of households for 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 household in my main sample for the PSID by adding
the amount in checkings and savings accounts, the amount of bonds and other assets, the amount
of stocks, and the amount of vehicle equity, and then by deducting the amount of credit card debt.
Then, the fraction of families of non-positive liquid wealth is simply given by the 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 by total quarterly family labor income (i.e., the sum of head and
spouse labor income) for each family with positive total family labor income.\footnote{I obtain the total quarterly family labor income by dividing the annual amount of total family labor income by 4.} Finally, I calculate
the ratio of the weighted distribution of this net liquid wealth to quarterly labor income across

\footnote{Previously, Stephens (2002) used PSID to study the impact of the head’s job displacement on relative working
hours of spouses and found that the average increase in relative spousal hours is 11 percent across all years after the
head’s displacement.}
Figure A.2: Relative Working Hours of Spouse upon Job Displacement

This figure plots the changes in relative working hours of the spouse upon the 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.

B.2. SCF Data

I also calculate the net liquid asset-to-income distribution from the SCF 2007. To do so, I first construct a sample of family heads 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 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 total credit card debt to obtain the net liquid wealth of each family. Then, the fraction of families of non-positive liquid wealth is simply given by the 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 by total quarterly family labor income for each family with positive total family labor income.\textsuperscript{73} Finally, I calculate the ratio of the weighted distribution of this net liquid wealth to

\textsuperscript{73}I obtain the total quarterly family labor income by dividing the annual amount of total wages and salaries income
Figure A.3: Transfer Receipts by Married Households

Panel A separately plots the total means-tested and employment-tested (UI) transfers paid to married households as a fraction of total transfers. Panel B shows the total number of married household heads receiving means-tested and employment-tested transfers as a fraction of all recipients. 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 separately plots the total annual transfer amounts in SIPP data as a fraction of aggregate transfer amounts in NIPA tables for means-tested and employment-tested transfers. Values in Panels 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 are not available.

Note: Panel A, separately plots the total means-tested and employment-tested (UI) transfers paid to married households as a fraction of total transfers. Panel B shows the total number of married household heads receiving means-tested and employment-tested transfers as a fraction of all recipients. 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 separately plots the total annual transfer amounts in SIPP data as a fraction of aggregate transfer amounts in NIPA tables for means-tested and employment-tested transfers. Values in Panels 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 are not available.

quarterly labor income 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.

Panel A separately plots the total means-tested and employment-tested (UI) transfers paid to
married households as a fraction of total transfers. 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 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 transfers in NIPA tables, as shown in Panel D.

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

C. Effects of optimal policy on family upon displacement

In Section 5.2, I discuss the change in family outcomes upon the 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 spousal earnings, transfer receipts, and family consumption. The goal of this section is to understand the effects of the optimal policy on 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 the head’s job displacement in recessions and 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 magnitude of initial drops of family earnings upon the head’s job displacement in both recessions and expansions is lower under the optimal policy than its counterpart under the current policy. This is because of higher spousal labor force participation rates and higher spousal labor earnings due to the increase in their human capital. Second, the gap between the magnitude of initial drops under the current and optimal policies is 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 the 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 the 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 the head’s job displacement in recessions and expansions in the model under the current policy and the optimal policy. I find that families dissave less upon the head’s displacement in both recessions and expansions under the optimal policy since a larger fraction of spouses is already working at the time of the 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 a larger spousal labor earnings 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 a slightly smaller increase in spousal earnings upon the head’s displacement than it is 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 are indexed by the wage offer $w$ of firms and human capital level $h$ of jobs. This means that unemployed individuals now direct their search efforts 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 the household problem and then show the firm problem. Next, I prove the existence in BRE of this model.

**Household problem**  I present 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
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 the 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 are aggregated to a yearly period.

follows:

$$V^{Eu}(a, w_m, h, \mu) = \max_{a' \geq a_L, s_f \in \{0, 1\}} u(c) + \eta_f (1 - s_f)$$

$$+ \max_{\tilde{w}_f} \left\{ \beta \left[ (1 - \zeta_R) E^{V'}(a', w_m, h'; \mu') \mid s_f, \tilde{w}_f, 1, h; \mu \right] + \zeta_R V^R(a') \right\}$$

subject to

$$c + a' \leq (1 + r) a + y + \phi(z; a, y) + b(z; U_b, s_f) (1 - \tau)$$

$$y = w_m (1 - \tau)$$

$$\Gamma' = \Lambda(\mu, z')$$ and $$z' \sim \Phi(z' \mid z),$$

where we now have to keep track of the wage level of the employed member of the household.

Notice also that the wage of the employed is not a direct function of the human capital level. Instead, unemployed members of the household may direct their search efforts 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 as being 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:

$$\mathbb{E}_{\nu', h', \mu'} \left[ V^{U} (a', w, m, \nu'; \mu') | s_f, \tilde{w}_f, 1, h, \mu \right] = \mathbb{E}_{\nu', h', \mu'} \left[ s_f (1 - \delta'_m) \left( p'_f (\tilde{w}_f, h_f) V^{EE} (a', w, \tilde{w}_f, h'; \mu') \right. \right. \\
+ \left. \left. (1 - p'_f (\tilde{w}_f, h_f)) \sum_{k \in \{b, n\}} \lambda'_k V^{EU}_k (a', w, h'; \mu') \right) \\
+ s_f \delta'_m \left( p'_f (\tilde{w}_f, h_f) \sum_{k} \lambda'_k V^{EU}_k (a', \tilde{w}_f, h'; \mu') \right) \\
+ \left. (1 - p'_f (\tilde{w}_f, h_f)) \sum_{k, d \in \{b, n\}} \lambda'_k \lambda'_{d} V^{EU}_d (a', h'; \mu') \right) \\
+ (1 - s_f) (1 - \delta'_m) \sum_{k} \lambda'_k V^{EU}_k (a', w, h'; \mu') \\
\left. + (1 - s_f) \delta'_m \sum_{k, d \in \{b, n\}} \lambda'_k \lambda'_{d} V^{EU}_d (a', h'; \mu') \right] | h, \mu,$$

where $p'_f (\tilde{w}_i, h_i) \equiv p(\theta (\tilde{w}_i, h_i'; \mu')) \forall i \in \{m, f\}$. The explanation of the terms on 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:

$$V^{U}_{a, b} (a, \nu; \mu) = \max_{a' \geq a, s_m, s_f \in \{0, 1\}} u (c) + \sum_{i \in \{m, f\}} \eta_i (1 - s_i) \\
+ \max_{\tilde{w}_m, \tilde{w}_f} \left\{ \beta \left[ (1 - \zeta_R) \mathbb{E}_{\nu', h', \mu'} \left[ V^{U} (a', \nu'; \mu') | s_m, s_f, \tilde{w}_m, \tilde{w}_f, 1, h, \mu \right] + \zeta_R V^{U}_R (a') \right] \right\}$$

subject to

$$c + a' \leq (1 + \tau) a + \phi (z; a, 0) + [b (z; U_b, s_m) + b (z; U_b, s_f)] (1 - \tau) \\
\Gamma' = \Lambda (\mu, z') \quad \text{and} \quad z' \sim \Phi (z' | z).$$
Again, I show the expectation over the transition of employment statuses of this household:

\[
\mathbb{E}_{l', h', \mu'} [V^{l'} (a', h'; \mu')] | s_m, s_f, \bar{w}_m, \bar{w}_f, \mathbf{l}, h, \mu] = \mathbb{E}_{h', \mu'} \left[ \sum_{m} s_m s_f p_{m}^{l'} (\bar{w}_m, h_m) \left( p_{f}^{l'} (\bar{w}_f, h_f) V^{EE} (a', \bar{w}_m, \bar{w}_f, h', \mu') \right. \right.
\]
\[
\left. + \left(1 - p_{f}^{l'} (\bar{w}_f, h_f) \right) \sum_{k \in \{b, n\}} \lambda_k^{l'} V^{EU_k} (a', \bar{w}_m, h'; \mu') \right) \right.
\]
\[
\left. + s_m s_f (1 - p_{m}^{l'} (\bar{w}_m, h_m)) \left( p_{f}^{l'} (\bar{w}_f, h_f) \sum_{k} \lambda_k^{l'} V^{UE_k} (a', \bar{w}_m, h'; \mu') \right) \right.
\]
\[
\left. + \left(1 - p_{f}^{l'} (\bar{w}_f, h_f) \right) \sum_{k, d \in \{b, n\}} \lambda_k^{l'} \lambda_d^{l'} V^{UD} (a', h'; \mu') \right]
\]
\[
\left. + s_m (1 - s_f) \left( p_{m}^{l'} (\bar{w}_m, h_m) \sum_{k} \lambda_k^{l'} V^{EU_k} (a', \bar{w}_m, h'; \mu') \right) \right.
\]
\[
\left. + \left(1 - p_{m}^{l'} (\bar{w}_m, h_m) \right) \sum_{k, d \in \{b, n\}} \lambda_k^{l'} \lambda_d^{l'} V^{UD} (a', h'; \mu') \right)
\]
\[
\left. + (1 - s_m) s_f \left( p_{f}^{l'} (\bar{w}_f, h_f) \sum_{k} \lambda_k^{l'} V^{UE_k} (a', \bar{w}_f, h'; \mu') \right) \right.
\]
\[
\left. + \left(1 - p_{f}^{l'} (\bar{w}_f, h_f) \right) \sum_{k, d \in \{b, n\}} \lambda_k^{l'} \lambda_d^{l'} V^{UD} (a', h'; \mu') \right]
\]
\[
\left. + (1 - s_m) (1 - s_f) \sum_{k, d \in \{b, n\}} \lambda_k^{l'} \lambda_d^{l'} V^{UD} (a', h'; \mu') \right) | h, \mu].
\]

The explanation of the terms on 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:

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

\[
\mathbb{E}_{h', \mu'} \left[ V' (a', w_m, w_f, h'; \mu') \mid l, h, \mu \right] = \mathbb{E}_{h', \mu'} \left[ (1 - \delta'_m) \left( (1 - \delta'_f) V^{EE} (a', w_m, w_f, h'; \mu') + \delta'_f \sum_{k \in \{b, n\}} \lambda'_k V^{EU_k} (a', w_m, h'; \mu') \right) \right.
\]

\[
+ \delta'_m \left( (1 - \delta'_f) \sum_k \lambda'_k V^{U_k} (a', w_f, h'; \mu') \right) \left. \sum_{k, d \in \{b, n\}} \lambda'_k \lambda'_d V^{U_k U_d} (a', h'; \mu') \mid h, \mu \right] (A.1)
\]

The explanation of the terms on 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 \(\mu\). 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 \(\zeta_R\). Let \(J(w, h; \mu)\) be the value of a matched firm in submarket \((w, h)\) when the aggregate state is \(\mu\). The recursive problem of this firm is given as follows:

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

subject to

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

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

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

where \(\kappa\) 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 following equilibrium market tightness:

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

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

Equilibrium The Definition of Recursive Equilibrium is very similar to that in 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 the unemployed endogenously choose wage submarkets compatible with their own skills to direct their search effort, rather than being automatically assigned to skill submarkets based on their skills. This extra feature of the extended model deserves 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 \( W \) and \( A \), human capital set \( \mathcal{H} \), and set of exogenous process \( Z \) 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 (2018) in two ways: i) This model incorporates an endogenous labor supply decision, and ii) submarkets are also indexed by skill levels.

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

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

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 \( \theta \) only.\(^74\) Hence, I show that equilibrium market tightness \( \theta^* \) does not depend on the distribution of households across states \( \Gamma \) as well.

Next, using this result and the assumption that government policy only depends on \( z \), I show that the household’s value functions do not depend on the aggregate distribution of households across states \( \Gamma \). To do so, I first collapse the problem of households into one functional equation

\(^74\)The free entry condition (8) is also important to pin down market tightness.
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 $\mu$ only through $z$.

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

$$K (l_m = 1, l_f = 1, d_m = 0, d_f = 0, a, w_m, w_f, h_m, h_f; \mu) = V^{EE} (a, w_m, w_f, h_m, h_f; \mu)$$

$$K (l_m = 1, l_f = 0, d_m = 0, d_f = 1, a, w_m, w_f, h_m, h_f; \mu) = V^{EU_b} (a, w_m, h_m, h_f; \mu)$$

$$K (l_m = 0, l_f = 0, d_m = 0, d_f = 0, a, w_m, w_f, h_m, h_f; \mu) = V^{EU_u} (a, w_m, h_m, h_f; \mu)$$

$$K (l_m = 2, l_f = 2, d_m = 0, d_f = 0, a, w_m, w_f, h_m, h_f; \mu) = V^{R} (a),$$

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

Then, we define the set of functions $\mathcal{K} : \{0, 1\} \times \{0, 1\} \times \{0, 1\} \times \{0, 1\} \times A \times W \times W \times H \times H \times \mathcal{Z} \rightarrow \mathbb{R}$ and let $T_K$ be an operator such that

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

$$+ l_m (1 - l_f) \left[ \max_{a' \geq a_L, s_{f} \in \{0, 1\}} u (c) + \eta_f (1 - s_f) + \max_{a' \geq a_L} \left[ \beta \left[ (1 - \zeta_R) \mathbb{E}_{\mathcal{K}} [K (\cdot)] + \zeta_R K (l' = 2, .) \right] \right] \right]$$

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

$$+ (1 - l_m) (1 - l_f) \left[ \max_{a' \geq a_L, s_m, s_{f} \in \{0, 1\}} u (c) + \sum_{i \in \{m, f\}} \eta_i (1 - s_i) + \max_{a' \geq a_L} \left[ \beta \left[ (1 - \zeta_R) \mathbb{E}_{\mathcal{K}} [K (\cdot)] + \zeta_R K (l' = 2, .) \right] \right] \right]$$

subject to

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

$$y = \left[ l_m w_m + l_f w_f \right] (1 - \tau)$$

$$z' \sim \Phi (z' | z),$$

where none of the terms inside expectations ($\delta_m', \delta_f', \lambda_b', \lambda_n', p_m', \text{or} \ p_f'$) and value functions $K$
inside these expectations depend on $\Gamma$.\textsuperscript{75}

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., $T_K : \mathcal{K} \rightarrow \mathcal{K}$). Then, using Blackwell’s sufficiency conditions for a contraction and the assumptions of

\textsuperscript{75}Here, I refrain from writing out expectation explicitly to save space.
boundedness of sets of exogenous process $Z$, choice set $W$ and $A$, and human capital set $H$, 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 $\Gamma$. This constitutes a BRE along with the solution to the firm’s problem and the implied labor market tightness that does not depend on $\Gamma$, given that government policy is a function of $z$ only.

### 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 $\Gamma$. This means that BRE depends on $\mu$ 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 $\theta$, I can then solve for the household’s value functions and policy functions using standard value-function iteration. 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.

The 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.