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ABSTRACT

The flow opportunity cost of moving from unemployment to employment consists of foregone public benefits and foregone utility from non-working time relative to consumption. Using detailed microdata, administrative data, and the structure of the search and matching model with concave and non-separable preferences, we document that the opportunity cost of employment is as procyclical as, and more volatile than, the marginal product of employment. The empirically-observed cyclicality of the opportunity cost implies that unemployment volatility in search and matching models of the labor market is far smaller than that observed in the data. This result holds irrespective of the level of the opportunity cost or whether wages are set by Nash bargaining or by an alternating-offer bargaining process. We conclude that appealing to aspects of labor supply does not help search and matching models explain aggregate employment fluctuations.

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1 Introduction

Understanding the causes and the consequences of labor market fluctuations ranks among the most important and difficult issues in economics. In recent years, the theory of unemployment with search and matching frictions described in Mortensen and Pissarides (1994) (hereafter MP model) has emerged as the workhorse building block of the labor market in macroeconomic models. As emphasized in influential work by Shimer (2005), the standard MP model with wages set according to Nash bargaining fails to account quantitatively for the observed volatility of unemployment. This has led to a significant amount of research effort devoted to reconciling the search and matching model with the data.

The flow value of the opportunity cost of employment (which we denote by z) plays a crucial role in the MP model and in some of the leading proposed solutions to the unemployment volatility puzzle (for example, Hagedorn and Manovskii (2008) and Hall and Milgrom (2008)). While the importance of this variable has generated debate about its level, the literature has almost uniformly adopted the assumption that z is constant over the business cycle. Our contribution starts from the observation that not only the level, but also the cyclicality of z matters for unemployment fluctuations. Movements in z correspond loosely to shifts in labor supply, making it unsurprising that they would affect unemployment. While this insight goes back as far as Pissarides (1985), we are not aware of any existing research that has comprehensively assessed the cyclical properties of the opportunity cost in the data.

We document thoroughly the cyclical properties of z and find that it is as procyclical as, and more volatile than, the marginal product of employment (which we denote by p^e). Our preferred estimate of the elasticity of z with respect to p^e is one. This estimated cyclicality poses a strong challenge to the ability of the MP model to match the volatility of unemployment in the data. For example, both the Hagedorn and Manovskii (2008) solution of making z close to p^e and the Hall and Milgrom (2008) alternating-offer bargaining model fail to generate volatility in unemployment under the empirically-observed cyclicality of z.

We reach this conclusion by measuring z using detailed microdata, administrative data, and the structure of the search and matching model with concave and non-separable preferences. We call this model the MP/RBC model, as it combines elements from both the MP model and the real business cycle (RBC) model. In its basic form, the MP/RBC model with perfect risk sharing between the unemployed and the employed has been studied extensively in the literature (Merz, 1995; Andolfatto, 1996; Shimer, 2010). We use an extended version of the model to derive an expression for z which can be taken to the data.

The flow value of the opportunity cost of employment z has two components. The first component (which we call b) is related to public benefits that an unemployed person forgoes upon employment. Our approach to measuring b departs from the literature in three significant ways. First, we differentiate between unemployment insurance (UI) benefits which are directly related to unemployment status, and non-UI benefits such as supplemental nutritional assistance (SNAP), welfare assistance (AFDC/TANF), and health care (Medicaid). The latter belong in the opportunity cost to the extent that receipt of these benefits changes with unemployment status. Second, we focus on effective rather than statutory benefit rates. Third, we take into account UI benefits expiration, and we model and measure the utility costs (e.g. filing and time costs) associated with taking up UI benefits. These utility costs allow the model to match the fact that roughly one-third of eligible unemployed do not actually take up benefits.

We use both micro survey data and administrative data to measure b empirically. Using household and individual-level data from the Current Population Survey (CPS) and the Survey of Income and Program Participation (SIPP), we estimate the share of each program's spending (for UI, SNAP, TANF, and Medicaid) that belongs in b. To circumvent the noise and the undercounting of benefits in the microdata, we benchmark our microdata estimates to totals from administrative data sources. Our estimated b is countercyclical, rising in every recession since 1961. However, because our estimates take into account the limited receipt of benefits, the costs associated with take-up, and expiration, we find that the level of b is on average only 3.5 percent of the marginal product.

The second component of z (which we call ξ) results from consumption and work differences between the employed and unemployed. This component resembles the marginal rate of substitution between non-working time and consumption in the RBC model, with the difference being that the extra value of non-working time is calculated along the extensive margin. In the RBC model, an intraperiod first-order condition equates the marginal rate of substitution between non-working time and consumption to the marginal product of labor. While the search and matching literature has appealed to this equality to motivate setting the *average* level of z close to that of p^e, the same logic suggests that the ξ component of z would move *cyclically* with p^e just as in the RBC model. Indeed, we find that ξ is highly procyclical. Intuitively, the household values most the contribution of the employed (through higher wage income) relative to that of the unemployed (through higher non-working time) when market consumption is low and non-working time is high.

We discipline fluctuations in ξ by calibrating the preference parameters to match stylized facts from the microdata. Specifically, using the Consumption Expenditure Survey (CE) and the Panel Study of Income Dynamics (PSID), we estimate a 20 percent drop in expenditure on nondurable goods and services upon unemployment. Both our estimates of the drop in consumption and our preference parameters are broadly consistent with estimates found in the literature, including Aguiar and Hurst (2005), Hall and Milgrom (2008), and Hall (2009).

Combining our estimates of the component of the opportunity cost associated with benefits b with our estimates of the component of the opportunity cost associated with consumption and work differences ξ, we find that $z = b + \xi$ is procyclical and more volatile than the marginal product of employment p^e. The significant procyclicality of z occurs despite b being countercyclical and very volatile. This is because the level of b is small, so the ξ component of the opportunity cost accounts for the majority of the fluctuations in z.

We illustrate the importance of the cyclicality of z in the context of two leading proposed solutions to the unemployment volatility puzzle. Hagedorn and Manovskii (2008) show that increasing the level of z close to that of p^e and making z constant over the business cycle allows the MP model to generate realistic unemployment fluctuations. Intuitively, a high level of z

means that the total surplus from an employment relationship is small on average. Then even modest increases in p^e can generate large percent increases in the surplus, incentivizing firms to significantly increase their job creation.[1] However, if changes in p^e are accompanied by equal percent changes in z, the surplus from a new hire remains relatively stable over the business cycle. As a result, the fluctuations in unemployment generated by the model are essentially neutral with respect to the level of z.

Hall and Milgrom (2008) generate volatile unemployment fluctuations by replacing the assumption of Nash bargaining over match surplus with an alternating-offer wage setting mechanism. With Nash bargaining, the threat point of an unemployed depends on the wage other jobs would offer in case of bargaining termination. In the alternating-offer bargaining game, the threat point depends instead mostly on the worker's flow value z if bargaining continues. With constant z, wages respond weakly to increases in p^e, which incentivizes firms to significantly increase their job creation. Allowing instead z to comove with p^e as in the data, the unemployed's threat point again becomes sensitive to aggregate conditions. This increases the flexibility of wages and reduces the volatility of unemployment.

Our results also have implications for explanations of labor market fluctuations beyond those based on shifts in productivity in the search and matching class of models. Mulligan (2012) and Hagedorn, Karahan, Manovskii, and Mitman (2013) emphasize the expansion of social safety net benefits as an explanation for the persistent decline in labor following the Great Recession. We find, however, that the endogenous decline in ξ more than offsets the rise in the opportunity cost resulting from more generous benefits. From an empirical perspective, our paper complements research on the reservation wage (see Krueger and Mueller (2013) and the references therein). Relative to survey-based measures that ask respondents directly about their reservation wage, the model-based approach used here provides an alternative means of

[1] A number of papers have followed this reasoning to set a relatively high level of z. In Hagedorn and Manovskii (2008), $z = 0.955$ and $p^e = 1$. Examples of papers before Hagedorn and Manovskii (2008) include Mortensen and Pissarides (1999), Mortensen and Pissarides (2001), Hall (2005), and Shimer (2005), which set z at 0.42, 0.51, 0.40, and 0.40. Examples of papers after Hagedorn and Manovskii (2008) include Mortensen and Nagypal (2007), Costain and Reiter (2008), Hall and Milgrom (2008), and Bils, Chang, and Kim (2012), which set z at 0.73, 0.745, 0.71, and 0.82. See Hornstein, Krusell, and Violante (2005) for a useful summary of this literature.

assessing the reservation wage and facilitates analysis of its cyclicality.

The rest of the paper proceeds as follows. Section 2 presents the MP/RBC model and derives the opportunity cost z. In Section 3, we use microdata, administrative data, and labor market data to estimate key parts of b and derive empirical moments necessary for estimating ξ. Section 4 discusses the remainder of the calibration. Section 5 reports the cyclicality of z. Sections 6 and 7 present implications for unemployment under Nash bargaining and alternating-offer bargaining, respectively. Section 8 discusses the cyclicality of z under alternative risk sharing arrangements between the employed and the unemployed. Section 9 concludes.

2 Model

We develop our measure of the opportunity cost of employment within the context of the labor market search and matching framework of Mortensen and Pissarides (1994) and Pissarides (2000) as embedded in a real business cycle model by Merz (1995) and Andolfatto (1996). Following this literature, we start our analysis by assuming that wages are set according to the generalized Nash bargaining solution. We discuss the alternating-offer wage setting mechanism used by Hall and Milgrom (2008) in Section 7.

Time is discrete and the horizon is infinite, $t = 0, 1, 2, ...$ We denote the vector of exogenous shocks by $\mathbf{Z}_t$. Consumption is the numeraire good. There is a representative firm producing output with capital and labor. There is a representative household that owns the firm and rents its capital stock K_t in a perfect capital market at a rate R_t. The household consists of a continuum of ex-ante identical workers with measure one. At the beginning of each period t, there are e_t employed who produce output and $u_t = 1 - e_t$ unemployed who search for jobs.

The labor market is subject to search and matching frictions. The firm posts vacancies v_t to increase employment in the next period. Each vacancy costs κ_t in terms of the numeraire good. Trade in the labor market is facilitated by a constant returns to scale matching technology that converts searching by the unemployed and vacancies by the firm into new matches, $m_t = m_t(v_t, u_t)$. We denote market tightness by $\theta_t = v_t/u_t$. Let the probability of an unemployed worker being matched with a firm be $f_t(\theta_t) = m_t/u_t$ and the probability that a vacancy is filled be $q_t(\theta_t) = m_t/v_t = f_t(\theta_t)/\theta_t$. In each period fraction s_t of the employed are exogenously separated and become unemployed in the next period. Employment evolves according to $e_{t+1} = (1 - s_t)e_t + m_t$.

2.1 Household

The representative household maximizes the expected discounted utility flows of its members by choosing consumption for the employed and the unemployed, C_t^e and C_t^u, purchases of investment goods X_t, and the share ζ_t of eligible unemployed to take up UI benefits. There is perfect risk sharing among the members of the household, so the household allocates consumption between employed and unemployed to equalize their marginal utilities. The assumption of perfect risk sharing simplifies the analysis, facilitates comparison to existing literature, and allows us to estimate the opportunity cost in the data in a transparent way. In Section 8 we show that relaxing this assumption does not qualitatively change our results.

In solving its problem, the household takes as given the path of prices and the outcome of the bargaining game described below. The problem is:

$$W^h(e_0, \omega_0, K_0, \mathbf{Z}_0) = \max E_0 \sum_{t=0}^{\infty} \beta^t \left[e_t U_t^e(C_t^e, N_t) + (1 - e_t) U_t^u(C_t^u, 0) - (1 - e_t)\phi_t \tilde{\psi}_t(\zeta_t) \right], \tag{1}$$

where $U_t^e(C_t^e, N_t)$ is the flow utility of the employed, $U_t^u(C_t^u, 0)$ is the flow utility of the unemployed excluding costs associated with taking up benefits, ϕ_t is the share of unemployed who take up UI benefits, $\tilde{\psi}_t$ is the cost per UI recipient, and N_t is hours per employed worker.

The new element in the household's objective function is the utility costs of UI take-up. These filing costs capture foregone time and effort associated with providing information to the UI agency and any stigma from claiming benefits. In a seminal study, Blank and Card (1991) found that roughly one-third of unemployed workers eligible for UI do not claim the benefit. Furthermore, they provide state-level evidence that take-up responds to the benefit level, a finding confirmed by Anderson and Meyer (1997) using administrative microdata and by our own findings in Section 4 using aggregate time series data. The fact that eligible forgo their UI entitlement indicates either an informational friction or a cost associated with take-up. The comovement of take-up with benefit levels suggests that informational frictions cannot fully explain the low take-up rate, unless these frictions are correlated with benefit levels. Hence the available evidence points to costs associated with claiming UI, and these must also enter into the opportunity cost of employment.[2]

We assume that the cost per recipient $\tilde{\psi}_t$ is increasing in ζ_t. Letting $\psi_t(\zeta_t) = \tilde{\psi}_t(\zeta_t)\zeta_t$ denote the total costs per eligible unemployed, this implies that $\psi_t'(\zeta_t) > 0$ and the elasticity $\alpha = \psi_t'(\zeta_t)\zeta_t/\psi_t(\zeta_t) > 1$. This (constant) elasticity determines the household's surplus from receiving benefits. The lower is α, the smaller is the difference between the UI benefits received and the consumption value of costs associated with collecting UI benefits.

For our estimates of z_t, it is important that the model match both the ratio of consumptions C_t^u/C_t^e and the difference $C_t^e - C_t^u$ between employed and unemployed observed in the data. If Y_t denotes total output in the economy, the expenditure side must allow for spending by agents other than the employed or unemployed to make the difference $C_t^e - C_t^u$ consistent with the data. Let C_t^o denote the (exogenous) resources consumed by agents other than the employed and the unemployed.[3] Then total output equals the sum of consumption of the employed, consumption of the unemployed, other types of spending, private investment spending, and vacancy creation costs, $Y_t = e_t C_t^e + (1-e_t)C_t^u + C_t^o + X_t + \kappa_t v_t$.

The budget constraint of the household is given by:

$$e_t C_t^e + (1-e_t)C_t^u + C_t^o + X_t + T_t = w_t e_t N_t + (1-e_t)B_t + R_t K_t + \Pi_t, \tag{2}$$

where T_t are lump sum taxes, w_t is the wage per hour worked, B_t is benefits received per unemployed, and Π_t is dividends from ownership of the firm. Capital K_t accumulates as $K_{t+1} = (1-\delta)K_t + X_t$, where δ denotes the depreciation rate.

Benefits received from the government include UI benefits as well as other transfers such

[2] The non-UI programs discussed below (SNAP, TANF, and Medicaid) also have take-up rates below unity. We do not adjust the benefits for those programs for the take-up cost, however, because the decision and timing of take-up for those programs does not generally coincide with the timing of an unemployment spell.

[3] Spending C_t^o includes items such as consumption of people out of the labor force, net exports, and government consumption and investment spending. We lump government spending and consumption of people out of the labor force in C_t^o without loss of generality in order to simplify the notation.

as supplemental nutritional assistance, welfare assistance, and health care. We denote all non-UI benefits per unemployed by $B_{n,t}$. We denote UI benefits per unemployed by $B_{u,t}$. Benefits per unemployed from UI are the product of the fraction of unemployed who are eligible for benefits ω_t, the fraction of eligible unemployed who receive benefits ζ_t, and benefits per recipient unemployed $\tilde{B}_t$, so $B_{u,t} = \omega_t \zeta_t \tilde{B}_t = \phi_t \tilde{B}_t$. Benefits per recipient $\tilde{B}_t$ exceed benefits per unemployed $\phi_t \tilde{B}_t$ when some unemployed are not eligible for benefits or when eligible unemployed do not claim benefits. Finally, we define benefits per unemployed as $B_t = B_{n,t} + B_{u,t}$. Benefits are financed by lump-sum taxes, $T_t = (1 - e_t)B_t$.[4]

To derive a law of motion for the fraction ω_t of unemployed who are eligible for UI, let u_t^E denote the stock of eligible unemployed and let $u_t - u_t^E$ denote the stock of ineligible unemployed. Eligible unemployed who do not find a job in period t maintain their eligibility in period $t+1$ with probability ω_{t+1}^u, while newly separated workers become eligible for benefits with probability ω_{t+1}^e. Hence the stock of eligible unemployed in period $t+1$ is given by $u_{t+1}^E = \omega_{t+1}^u (1 - f_t) u_t^E + \omega_{t+1}^e s_t e_t$, where f_t denotes the job finding rate and s_t denotes the separation rate in period t. As a result, the fraction of eligible unemployed $\omega_{t+1} = u_{t+1}^E / u_{t+1}$ follows the law of motion:

$$\omega_{t+1} = \left(\omega_{t+1}^u (1 - f_t) \frac{u_t}{u_{t+1}} \right) \omega_t + \omega_{t+1}^e s_t \frac{e_t}{u_{t+1}}. \tag{3}$$

Denoting by λ_t the multiplier on the budget constraint, the first-order conditions are:

$$\lambda_t = \frac{\partial U_t^e}{\partial C_t^e} = \frac{\partial U_t^u}{\partial C_t^u}, \tag{4}$$

$$\lambda_t = E_t \beta \lambda_{t+1} \left(R_{t+1} + 1 - \delta \right), \tag{5}$$

$$\lambda_t \tilde{B}_t = \psi_t'(\zeta_t). \tag{6}$$

Equation (4) says that the household allocates consumption to different members in order to equate their marginal utilities. Equation (5) is the Euler equation for capital. Finally, equation (6) is the first-order condition for the optimal take-up rate ζ_t. This says that the household

[4] Note that B_t includes the part of the benefit that a worker loses upon moving from unemployment to employment. This is without loss of generality because the part of the benefit not dependent on employment status can be subsumed into T_t.

will allocate eligible unemployed to claim benefits up to the point where the marginal utility gain of receiving benefits equals the marginal utility cost.

We now define $J_t^h = \partial W^h(e_t, \omega_t, K_t, \mathbf{Z}_t)/\partial e_t$ as the household's marginal value of an additional employed worker, starting from a number of employed e_t and a share of eligible unemployed ω_t in period t. We express the marginal value in consumption units by dividing it by the marginal utility of consumption λ_t. Appendix B shows that this value is given by:

$$\frac{J_t^h}{\lambda_t} = w_t N_t - \left[b_t + (C_t^e - C_t^u) - \frac{U_t^e - U_t^u}{\lambda_t}\right] + (1 - s_t - f_t) E_t \left(\frac{\beta \lambda_{t+1}}{\lambda_t}\right) \frac{J_{t+1}^h}{\lambda_{t+1}}. \tag{7}$$

The marginal value of an employed worker in terms of consumption consists of a flow value plus the expected discounted marginal value in the next period. The flow value consists of a flow gain from increased wage income, $w_t N_t$, and a flow loss associated with moving a worker from unemployment to employment. We define the (flow) opportunity cost of employment as the bracketed term in equation (7):

$$z_t = b_t + (C_t^e - C_t^u) - \frac{U_t^e - U_t^u}{\lambda_t} = b_t + \xi_t, \tag{8}$$

where b_t denotes the component of the opportunity cost related to benefits and ξ_t denotes the component of the opportunity cost related to consumption and work differences between the employed and the unemployed.[5]

2.1.1 Opportunity Cost of Employment: Benefits

The first component of the opportunity cost of employment, b_t, relates to benefits. In Appendix B we show that:

$$b_t = B_{n,t} + B_{u,t}\left(1 - \frac{1}{\alpha}\right)\left[1 - E_t\left(\frac{\beta\lambda_{t+1}}{\lambda_t}\right)\left(\frac{\tilde{B}_{t+1}\zeta_{t+1}}{\tilde{B}_t\zeta_t}\right)\left(\frac{\omega_{t+1}^e}{\omega_t} - \omega_{t+1}^u\right)\left(\frac{s_t(1-f_t)}{1-e_{t+1}}\right)\Gamma_{t+1}\right], \tag{9}$$

[5] This expression for z_t remains unchanged if we allowed for endogenous labor force participation. To see this, let h_t denote the workers out of the labor force, e_t the employed workers, and $u_t = 1 - e_t - h_t$ the unemployed workers. Household's flow utility is $e_t U_t^e + (1 - e_t - h_t) U_t^u + h_t U_t^h$ and the budget constraint is $e_t C_t^e + (1 - e_t - h_t) C_t^u + h_t C_t^h + C_t^o + X_t + T_t = w_t e_t N_t + (1 - e_t - h_t) B_t + h_t B_t^h + R_t K_t + \Pi_t$, where now C_t^o denotes spending other than consumption of employed, unemployed, and people out of the labor force, and B_t^h denotes benefits per person out of the labor force (e.g. disability insurance). The household now additionally chooses how many workers h_t to move out of the labor force and how many workers to keep as unemployed u_t in each period. This choice is captured by the first-order condition $(U_t^u - U_t^h)/\lambda_t = C_t^u - C_t^h - (B_t - B_t^h)$, where λ_t denotes the common marginal utility of consumption across all household members. The marginal value of adding an employed worker is still given by equation (7) and the opportunity cost of employment is still given by equation (8).

where $\Gamma_{t+1} = \left(1 - \frac{\beta\lambda_{t+1}}{\lambda_t}\omega^u_{t+1}(1-f_t)\frac{u_t}{u_{t+1}}\right)^{-1} > 1$. The first term in equation (9) for b_t is simply non-UI benefits per unemployed, $B_{n,t}$. The second term consists of UI benefits per unemployed $B_{u,t}$, multiplied by an adjustment for the disutility of take-up and an adjustment for benefits expiration. This term is smaller than UI benefits per unemployed $B_{u,t}$.

The term $1 - 1/\alpha$ captures the surplus from receiving benefits. The first-order condition (6) says that the household will send eligible to collect benefits up to the point where the marginal benefit per recipient equals the marginal utility cost of collecting benefits, $\lambda_t\tilde{B}_t = \psi'_t(\zeta_t)$. The household's surplus per recipient equals the benefit per recipient less the utility cost per recipient, $\lambda_t\tilde{B}_t - \psi_t(\zeta_t)/\zeta_t$. Equivalently, the utility surplus per recipient is given by the difference between the marginal and the average cost, $\psi'_t(\zeta_t) - \psi_t(\zeta_t)/\zeta_t$. This difference depends on the elasticity of the cost function α. If this elasticity is close to one, that is, when the average cost per recipient is roughly constant, then there is a small surplus from receiving benefits as the household always incurs a cost per recipient that approximately equals the benefit per recipient. When this elasticity is much greater than one, that is, when the average cost per recipient is below the marginal cost, the household enjoys a larger surplus from receiving benefits.

The term in brackets captures the adjustment for benefits expiration. This term is lower than one when the probability that newly separated workers receive benefits, ω^e_{t+1}, exceeds the probability that previously eligible workers continue to receive benefits, $\omega^u_{t+1}\omega_t$. Intuitively, increasing employment in the current period entitles workers to future benefits which lowers the opportunity cost. The term Γ_{t+1} captures the dynamics of this effect over time, since increasing employment in the current period affects the whole path of future eligibility.

2.1.2 Opportunity Cost of Employment: Consumption and Work Differences

The second component of the opportunity cost of employment, ξ_t, results from consumption and work differences between employed and unemployed. To understand the intuition captured by this term, it is useful to write it as:

$$\xi_t = \frac{[U^u_t(C^u_t, 0) - \lambda_t C^u_t] - [U^e_t(C^e_t, N_t) - \lambda_t C^e_t]}{\lambda_t}. \tag{10}$$

The first term in the numerator, $U_t^u - \lambda_t C_t^u$, is the total utility of the unemployed less the utility of the unemployed from consumption. It has the interpretation of the utility the unemployed derive solely from non-working time. Similarly, the term $U_t^e - \lambda_t C_t^e$ represents the utility of the employed from non-working time. The difference between the two terms represents the additional utility the household obtains from non-working time when moving a worker from employment to unemployment. The denominator of ξ_t is the common marginal utility of consumption. Therefore ξ_t represents the value of non-working time relative to consumption. This is similar to the marginal rate of substitution between non-working time and consumption in the RBC model, with the difference being that the additional value of non-working time is calculated along the extensive margin.[6]

To understand the cyclical properties of the opportunity cost associated with ξ_t, we linearize it around its trend. Letting x_t^* denote the approximation point of a variable x_t and $\hat{x}_t = x_t/x_t^* - 1$ be the percent deviation from the approximation point, we obtain:

$$\xi_t = (\xi_t)^* - \left[\frac{(U_t^u)^* - (U_t^e)^*}{(\lambda_t)^*}\right]\hat{\lambda}_t + (p_t^e)^*\,\hat{N}_t, \tag{11}$$

where

$$\hat{\lambda}_t = -\rho_t^* \hat{C}_t^e + \sigma_t^* \hat{N}_t = -\rho_t^* \hat{C}_t^u. \tag{12}$$

The parameter $\rho_t > 0$ denotes the absolute value of the elasticity of the marginal utility of consumption with respect to consumption, $\sigma_t > 0$ denotes the elasticity of the marginal utility of consumption with respect to hours per employed worker, and p_t^e denotes the marginal product of an employed worker.

Equation (11) states that cyclical variation in ξ_t comes from two sources. First, movements in the marginal utility of consumption affect ξ_t. When λ_t rises, the value of earning income that

[6]When employed's flow utility equals unemployed's flow utility, this term collapses to $\xi_t = C_t^e - C_t^u$. In this case, our estimates in Section 3 imply that the level of z_t is roughly 11 percent. To justify a z_t higher than that, $(U_t^u - U_t^e)/\lambda_t$ has to be positive. The interpretation of $(U_t^u - U_t^e)/\lambda_t > 0$ is that non-working time is valued at a sufficiently high level relative to consumption. This is a standard assumption in the literature. See Rogerson and Wright (1988) for a general discussion of utility flow differences between employed and unemployed in economies with risk sharing. We note that in the model discussed below with incomplete asset markets and heterogeneous asset holdings, the unemployed's expected present value of discounted utility flows can be lower than the employed's expected present value of discounted utility flows even when flow utilities satisfy $U_t^u > U_t^e$.

can be used for market consumption rises relative to the value of non-working time. Second, variation in hours per employed N_t affect ξ_t. Because N_t gives the difference in non-working time between the unemployed and the employed, when N_t falls the contribution of the unemployed relative to the employed to household utility declines. In sum, the household values most the contribution of the employed (who generate higher wage income) relative to that of the unemployed (who have higher non-working time) during recessions, when market consumption is lower and the difference in non-working time between employed and unemployed is smaller.

2.2 Firm

The firm chooses vacancies and capital to maximize the discounted present value of dividends. It produces output using a constant returns to scale technology $Y_t = F_t(K_t, e_t N_t)$, with marginal products given by $p^k_t = \partial F_t/\partial K_t$, $p^n_t = \partial F_t/\partial(e_t N_t)$, and $p^e_t = \partial F_t/\partial e_t = p^n_t N_t$. In solving its problem the firm takes as given the path of prices and the outcome of the bargaining game. The firm maximizes its value:

$$W^f(e_t, \mathbf{Z_t}) = \max_{K_t, v_t} \left\{ Y_t - R_t K_t - w_t e_t N_t - \kappa_t v_t + E_t \tilde{\beta}_{t+1} W^f(e_{t+1}, \mathbf{Z_{t+1}}) \right\}, \tag{13}$$

subject to the law of motion for employment $e_{t+1} = (1 - s_t)e_t + m_t = (1 - s_t)e_t + q_t v_t$. In the maximization problem, the firm takes as given the stochastic discount factor of the household $\tilde{\beta}_{t+1} = \beta\lambda_{t+1}/\lambda_t$, market tightness θ_t, and the vacancy-filling probability $q_t(\theta_t)$.

Value maximization implies that the firm sets the marginal product of capital equal to the rental rate of capital, $p^k_t = R_t$. The first-order condition for vacancies requires that the cost of creating a vacancy κ_t multiplied by the expected duration of a vacancy $1/q_t$ equals the marginal benefit of posting a vacancy (the next period's marginal product net of wages and the savings from future vacancy posting):

$$\frac{\kappa_t}{q_t(\theta_t)} = E_t \tilde{\beta}_{t+1} \left(\left(p^n_{t+1} - w_{t+1}\right) N_{t+1} + \frac{\kappa_{t+1}(1 - s_{t+1})}{q_{t+1}(\theta_{t+1})} \right). \tag{14}$$

The marginal value of an additional employed worker for the firm J^f_t consists of the increase in flow profits plus the expected discounted future marginal value:

$$J^f_t = \frac{\partial W^f(e_t, \mathbf{Z}_t)}{\partial e_t} = \left(p^n_t - w_t\right) N_t + (1 - s_t) E_t \tilde{\beta}_{t+1} J^f_{t+1}. \tag{15}$$

2.3 Labor Market Matching and Bargaining

The household and the firm split the surplus from an additional match according to the generalized Nash bargaining solution. Let μ denote the bargaining power of the household. We assume that matching is random and the firm cannot discriminate between unemployed of different durations. Bargaining takes place over the wage w_t and hours worked N_t. The total surplus associated with the formation of an additional match, in terms of the numeraire good, is $S_t = J_t^h/\lambda_t + J_t^f$, where J_t^h/λ_t is given by equation (7) and J_t^f is given by equation (15).

Hours are determined implicitly from the first-order condition:

$$\frac{\partial S_t}{\partial N_t} = 0 \Longrightarrow -\frac{\partial U_t^e}{\partial N_t} = \lambda_t p_t^n, \tag{16}$$

which equates the marginal product of labor to the employed's marginal utility of non-working time relative to the marginal utility of consumption. With efficient bargaining, hours are chosen to maximize the joint surplus whereas the wage allocates the surplus between the household and the firm. Wages are determined from the surplus-splitting rule, $(1-\mu)J_t^h/\lambda_t = \mu J_t^f$. In Appendix B we show that this results in a standard wage equation:

$$w_t = \left(\frac{1}{N_t}\right)\left(\mu p_t^e + (1-\mu)z_t + \mu\kappa_t\theta_t\right). \tag{17}$$

3 Data and Measurement

We construct a dataset of U.S. time series at quarterly frequency between 1961(1) and 2012(4). We use the HP-filter to detrend variables. Appendix A provides greater detail on the many data sources used.

We begin by discussing a few general principles of our measurement exercise. The first is an aggregation result. Following Mortensen and Nagypal (2007), we assume that employers cannot discriminate ex-ante in choosing a potential worker with whom to bargain. Then, even if individuals have heterogeneous opportunity costs, the vacancy creation decision of the firm depends on the average opportunity cost over the set of unemployed persons. Accordingly, we estimate foregone government benefits and the expenditure decline for the average unemployed.

Our second general principle concerns the definition of the unemployed. Our model follows much of the literature in abstracting from the labor force participation margin. We recognize that this abstraction omits potentially important flows into and out of participation, and that it affects our measurement insofar as people move directly from non-participation to employment. Nonetheless, lacking good data on search intensity, we conform whenever possible to the official Bureau of Labor Statistics U-3 definition of unemployment.

3.1 Benefits

The social safety net in the United States provides assistance to unemployed persons. The variable $B_t = B_{n,t} + B_{u,t}$ in the model corresponds to the average value of such income that individuals receive while unemployed and would forgo upon employment. We split benefits per unemployed into non-UI benefits $B_{n,t}$ and UI benefits $B_{u,t}$ because eligibility for the latter is directly linked to unemployment status.

We depart from the literature in measuring the component of the opportunity cost of employment associated with benefits b_t in three significant ways. First, following the logic of our aggregation result, we measure the average benefit across all unemployed, rather than statutory benefit rates. This matters because, for example, only about one-third of unemployed persons receive UI on average in our sample. Second, the safety net includes a number of other programs such as supplemental nutritional assistance payments (SNAP, formerly known as food stamps), welfare assistance (TANF, formerly AFDC), and health care (Medicaid). Income from all of these programs belongs in $B_{n,t}$ to the extent that unemployment status correlates with receipt of these benefits. Finally, for UI benefits we differentiate between monetary benefits per unemployed $B_{u,t}$ and the part of these benefits associated with the opportunity cost of employment. As equation (9) shows, the latter is lower than $B_{u,t}$ both because there exist utility costs associated with taking up benefits and because benefits expire.

Our empirical approach to measuring benefits combines micro survey data with program administrative data. Let $B_{k,t}$ denote each of the four components of total benefits, with $B_t =$

$\sum_k B_{k,t}$ for programs $k \in \{\text{UI, SNAP, AFDC/TANF, Medicaid}\}$.[7] To measure $B_{k,t}$, we first use the microdata to determine the fraction of each program's total spending that belongs in $B_{k,t}$, denoted by $B_{k,t}^{\text{share}}$. To correct for underreporting and noise in the microdata, we then apply $B_{k,t}^{\text{share}}$ to administrative data on each program's total spending. Therefore, benefits per unemployed in category k are given by:

$$B_{k,t} = B_{k,t}^{\text{share}} \left(\frac{\text{total administrative dollars in category } k \text{ in period } t}{\text{number of unemployed in period } t} \right). \tag{18}$$

To measure $B_{k,t}^{\text{share}}$, first define $y_{k,i,t}$ as income from category k received by household or person i. We use the microdata to estimate the change in $y_{k,i,t}$ following an employment status change. An individual may spend part of the reporting period employed and part unemployed. We handle this time-aggregation problem by positing that the data generating process for instantaneous income of type k for an individual with labor force status $l \in \{e, u\}$ is:

$$y_{k,i,t}^{l} = \phi_k \mathbf{X}_i + y_{k,t}^{e} + \beta_{k,t} \mathbb{I}\{l_{i,t} = u\} + \epsilon_{k,i,t}, \tag{19}$$

where $\mathbf{X}_i$ denotes a vector of individual characteristics, $y_{k,t}^{e}$ denotes the income of a hypothetical employed, and $\mathbb{I}\{l_{i,t} = u\}$ is an indicator function taking the value of one if the individual is unemployed at time t. According to this process, an individual's income from program k increases discretely by $\beta_{k,t}$ during an unemployment spell. Integrating over the reporting period and taking first differences over time yields the estimating equation:

$$\Delta y_{k,i,t}^{D} = \beta_{k,t}^{0} + \beta_{k,t} \Delta D_{i,t} + \Delta \beta_{k,t} D_{i,t-1} + \Delta \epsilon_{k,i,t}, \tag{20}$$

where the time effect is given by $\beta_{k,t}^{0} = \Delta y_{k,t}^{e}$, and the variable $D_{i,t}$ measures the fraction of the reporting period that an individual spends as unemployed. Taking first differences over time eliminates the individual fixed effect.

We implement equation (20) using both the matched March CPS starting in 1989 and the SIPP starting in 1996. The CPS has a short panel structure, wherein households participate for four months, exit for eight months, and then reenter for another four months. This means

[7] We also investigated the importance of housing subsidies. We found their importance quantitatively trivial, so we omit them from the analysis.

that up to fifty percent of the participants from the monthly sample in each March Supplement also appear in the following year's Supplement, allowing us to estimate the first difference specification (20). The SIPP has a longer panel structure with households interviewed once every four months for up to four years. Appendix A details the construction of the two samples.

In each survey, we construct a measure of unemployment at the individual level that mimics the BLS U-3 definition. The U-3 definition of unemployment counts an individual as working if he had a job during the week containing the 12^{th} of the month (the survey reference week), and as in the labor force if he worked during the reference week, spent the week on temporary layoff, or had any search in the previous four weeks. Our constructed measures differ slightly from the official measure in ways that generate slightly lower unemployment rates. In the March Supplement, we count an individual as in the labor force only for those weeks where he reports being on temporary layoff or actually searching during the previous year. In the SIPP, we count an individual as employed if he worked in any week of the month, rather than only if he worked during the BLS survey reference week. Accordingly, we define the fraction of time an individual is unemployed as:

$$D_{i,t}^{\text{CPS}} = \left[\frac{\text{weeks searching or on temporary layoff in year } t}{\text{weeks in the labor force in year } t}\right]_i,$$
$$D_{i,t}^{\text{SIPP}} = \frac{1}{4}\sum_{m=1}^{4} \mathbb{I}\left\{[\text{non-employed, at least 1 week of search or layoff}]_{i,t-m}\right\}.$$

We aggregate unemployment and income up to the level at which the benefits program is administered. In particular, in the regressions with UI income as the dependent variable, the unit of observation is the individual and we cluster standard errors at the household level. In regressions for SNAP, TANF, and Medicaid, the unit of observation is the family average of unemployment and the family total of income.

Figure 1 reports annual estimates (CPS) and monthly estimates (SIPP) of $\beta_{k,t}$ from equation (20). Thus the plotted coefficients give the survey-implied change in income when moving from fully employed to fully unemployed. With the exception of UI at the end of the sample, the two surveys yield broadly similar, if somewhat noisy, results.[8] The agreement between the two

[8]The gap between the CPS and SIPP for UI at the end of the sample likely reflects in part reporting rates, as

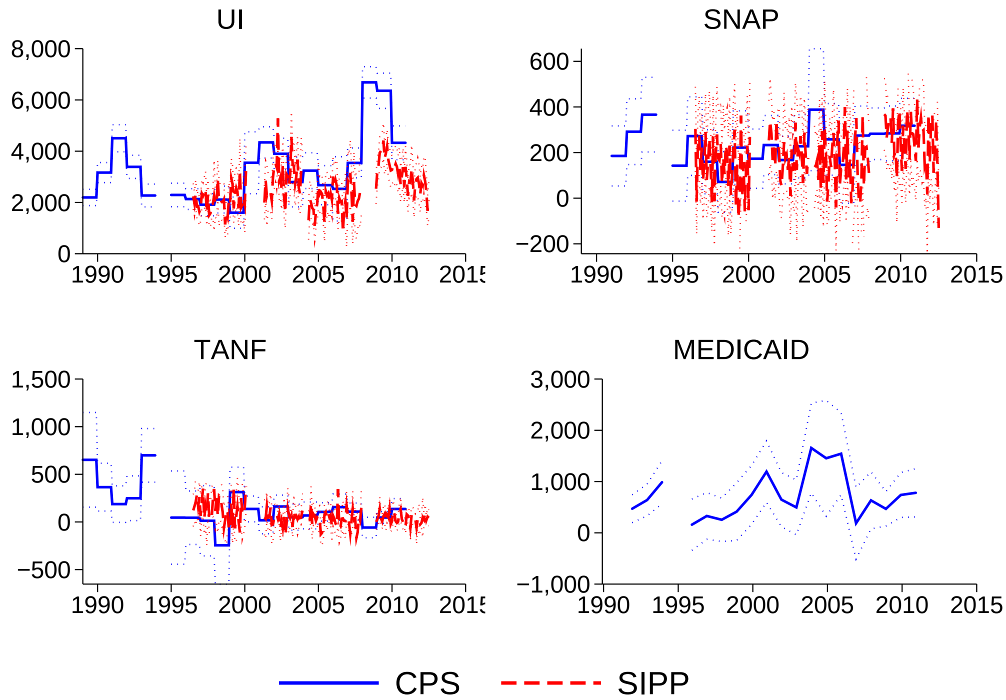

Figure 1: Change in Benefits Upon Unemployment

Notes: The solid and dashed lines report estimates of $\beta_{k,t}$ from equation (20), in constant 2009 dollars, using data from the March CPS and the SIPP, respectively. The dotted lines give 95 percent confidence interval bands based on robust standard errors (CPS, non-UI) or standard errors clustered at the household level (CPS UI and SIPP), and truncated in selected observations to enhance readability. The regressions are weighted using survey sampling weights. Regressions using the SIPP also trim the smallest and largest 0.05 percent of non-zero values of the dependent variable.

datasets suggests that the quantitative findings are robust to different survey designs and recall periods.

Given estimates of $\beta_{k,t}$ from equation (20), the share $B_{k,t}^{\text{share}}$ of income reported in the survey that belongs in $B_{k,t}$ is:

$$B_{k,t}^{\text{share}} = \frac{(\text{extra dollars by unemployed})_{k,t}}{(\text{total dollars})_{k,t}} = \frac{\sum_i \omega_{i,t} D_{i,t} \left(y_{k,i,t}^{u} - y_{k,i,t}^{e} \right)}{\sum_i \omega_{i,t} y_{k,i,t}} = \hat{\beta}_{k,t} \frac{\sum_i \omega_{i,t} D_{i,t}}{\sum_i \omega_{i,t} y_{k,i,t}}, \tag{21}$$

where $\omega_{i,t}$ is the survey sampling weight for individual i in period t.

We have correlated the cyclical component of the estimated $B_{k,t}^{\text{share}}$ with the cyclical component of the unemployment rate, and in almost all cases we cannot reject the hypothesis that

in recent years the CPS has captured a substantially higher share of UI income than the SIPP (Meyer, Mok, and Sullivan, 2009).

Table 1: Share of Government Program Benefits Belonging to B

	UI	SNAP	TANF	Medicaid
CPS (1989-2012)				
B^{share}	0.880	0.072	0.063	0.026
Standard error	(0.018)	(0.005)	(0.011)	(0.003)
Observations	455,216	255,310	296,340	255,310
SIPP (1996-2012)				
B^{share}	0.632	0.037	0.036	
Standard error	(0.009)	(0.002)	(0.004)	
Observations	1,480,993	968,718	968,779	
Mean of B^{share} (CPS and SIPP)	0.756	0.054	0.049	0.026

The table reports summary statistics based on OLS regressions of equation (22), where B^{share} is defined by equation (21). The regressions are weighted using sampling weights in each year, with the weights normalized such that all years receive equal weight. Standard errors are based on heteroskedastic robust (CPS, non-UI), heteroskedastic robust and clustered by family (CPS, UI), or heteroskedastic robust and clustered by household (SIPP) variance matrix.

$B^{\text{share}}_{k,t}$ is acyclical.[9] As a result, we constrain $B^{\text{share}}_{k,t}$ to be time-invariant, $B^{\text{share}}_{k,t} = B^{\text{share}}_{k}$. This means that B_t inherits directly the cyclical properties of the program administrative data. Substituting equation (21) into equation (20) gives a direct time-invariant estimate of B^{share}_{k} from the regression:

$$\Delta y^{D}_{k,i,t} = \beta^{0}_{k,t} + B^{\text{share}}_{k} \Delta \tilde{D}_{i,t} + \Delta \beta_{k,t} D_{i,t-1} + \Delta \epsilon_{k,i,t}, \tag{22}$$

where $\Delta \tilde{D}_{i,t} = \Delta D_{i,t} \sum_i \omega_{i,t} y_{k,i,t} / \sum_i \omega_{i,t} D_{i,t}$.

Table 1 reports results based on OLS regressions of equation (22). For UI, the average B^{share} is 0.76. If only unemployed persons received UI, then this share would equal one. In fact, roughly one-quarter of UI income reported in a year goes to recipients who report having had no unemployment spells. These individuals may have had part-time employment in states that have positive labor income caps for receipt of UI, or may have claimed UI without actually

[9] Specifically, the largest absolute correlation is 0.33, and the mean correlation is 0.07. Only in the case of SNAP in the SIPP can we reject a zero correlation at a ten percent confidence level.

exerting search effort.[10]

Only five percent of SNAP and TANF and three percent of Medicaid spending appear in $B_{n,t}$. We find these estimates reasonable. Beginning with the latter, roughly two-thirds of Medicaid payments accrue to persons who are over 65, blind, or disabled (Centers for Medicare and Medicaid Services, 2011, table II.4). Moreover, even prior to implementation of the Affordable Care Act, all states had income limits for coverage of children of at least 100 percent of the poverty line, and half of states provided at least partial coverage to working adults with incomes at the poverty line (Kaiser Family Foundation, 2013). Similarly for SNAP, tabulations from the monthly quality control files provided by Mathematica indicate that no more than one-quarter of SNAP benefits go to households with at least one member unemployed. Given observed statutory phase-out rates and deductions, 5 percent appears as a reasonable estimate.

To summarize, to measure $B_{n,t}$ and $B_{u,t}$ we first use micro-survey data to estimate the share of each program's total spending associated with unemployment, $B_{k,t}^{\text{share}}$. Using equation (18), we then apply this share to the total spending observed in administrative data. Although the $B_{k,t}^{\text{share}}$'s for the non-UI programs are small, the standard errors strongly indicate that they are not zero.

3.2 Consumption Differences

The decline in consumption expenditure upon unemployment is a key moment for estimating the component of the opportunity cost related to consumption and work differences between employed and unemployed, ξ_t. Let $\tilde{C}_{k,i,t}$ denote the expenditure in category k by individual i at time t as measured in the microdata. We use "tildes" to differentiate between spending observed in the microdata and spending recorded in the national accounts. We model the instantaneous expenditure of an individual with labor force status $l \in \{e, u\}$ as a fraction of the expenditure of a hypothetical employed $\tilde{C}_{k,t}^{e}$:

$$\tilde{C}_{k,i,t}^{l} = \left[\gamma_{k,t}\mathbb{I}\left\{l_{i,t} = u\right\} + 1 - \mathbb{I}\left\{l_{i,t} = u\right\}\right] \exp\left\{\phi_{k,t}\mathbf{X}_{i,t} + \epsilon_{k,i,t}\right\} \tilde{C}_{k,t}^{e}, \tag{23}$$

[10] The fraction of UI income reported by non-unemployed has also risen since the early 1990s, such that part of the difference in the B^{share} found in the CPS and the SIPP stems from the longer CPS sample.

where $\mathbf{X}_{i,t}$ denotes a vector of demographic characteristics and other controls and $\epsilon_{k,i,t}$ denotes an idiosyncratic component. The coefficient $\gamma_{k,t}$ parameterizes the instantaneous drop in consumption expenditure k upon unemployment.

Integrating over the reporting period, taking logs, and approximating $\ln\left[1-\left(1-\gamma_{k,t}\right)D_{i,t}\right]$ by $\left(\gamma_{k,t}-1\right)D_{i,t}$, yields the estimating equation:

$$\ln \tilde{C}^{D}_{k,i,t} = \gamma^{0}_{k,t} + \phi_{k,t}\mathbf{X}_{i,t} + \left(\gamma_{k,t}-1\right)D_{i,t} + \epsilon_{k,i,t}, \tag{24}$$

where $\gamma^{0}_{k,t} = \ln \tilde{C}^{e}_{k,t}$ is a time effect. The variable $D_{i,t}$ measures the fraction of time an individual spends as unemployed.[11] Finally, taking first differences in equation (24) and assuming that $\phi_{k,t} = \phi_k$ yields:[12]

$$\Delta \ln \tilde{C}^{D}_{k,i,t} = \Delta\gamma^{0}_{k,t} + \left(\gamma_{k,t}-1\right)\Delta D_{i,t} + \Delta\gamma_{k,t}D_{i,t-1} + \Delta\epsilon_{i,k,t}. \tag{25}$$

A survey with repeated observations of a comprehensive measure of consumption and employment status on the same individual or household does not exist for the United States. Instead, we estimate the cross-sectional regression (24) using the CE, which combines quarterly observations of all nondurable goods and services expenditure with information on employment status over the previous year. We validate our estimates using the PSID, in which we can implement the panel regression (25) for food expenditure using a long panel and for a broader category of expenditure in a shorter panel.

Our CE sample covers 1983-2012 and consists of respondents where the household completed all four interviews, and with a household head between 30 and 55 years old at the time of the final interview. Because equation (24) identifies $\gamma_{k,t}$ from the cross-section of household expenditure, $\mathbf{X}_{i,t}$ must include proxies for permanent income. We include as controls the mean age of the household head and spouse; the mean age squared; the marital status; an

[11] The derivation of equation (24) assumes that $\gamma_{k,t}$ does not vary with unemployment duration $D_{i,t}$. In unreported regressions, we have estimated $\gamma_{k,t}$ non-parametrically by grouping households into bins of weeks unemployed. Our estimated $\gamma_{k,t}$ for each bin indicates a duration-independent $\gamma_{k,t}$. This finding supports the assumption in the model that the instantaneous consumption of the unemployed does not depend on duration.

[12] In results not shown, we have also estimated equation (25) relaxing the assumption $\phi_{k,t} = \phi_k$. Specifically, when we interact a set of controls (sex of household head, whether a spouse is present, number of children, dummies for educational attainment of the household head, age of the head, and age squared of the head) with year categorical variables, the PSID results in Table 2 remain essentially unchanged.

indicator variable for Caucasian or not; indicator variables for four categories of education of the household head (less than high school, high school diploma, some college, college degree) interacted with year; indicator variables for owning a house without a mortgage, owning a house with a mortgage, or renting a house, interacted with year; indicator variables for quantiles of the value of the home conditional on owning, by region and year, interacted with year; a binary variable for having positive financial assets; family size; and family size squared.

The CE asks respondents for the number of weeks worked over the previous year, but does not ask questions about search activity while not working. To define $D_{i,t}$, we first drop respondents "out of the labor force" who reported working zero weeks but did not report "unable to find job" as the reason for not working. For the rest of the respondents, we define:

$$D_{i,t}^{\text{CE}} = 1 - \frac{(\text{weeks worked})_{i,t}}{52}.$$

Restricting the sample to households with head between 30 and 55 years old helps to mitigate the concern that members of the household move in and out of the labor force during the same year. Since we run our regressions at the household level, $D_{i,t}$ is the household average of the individual's fraction of time not working.

Figure 2 reports the estimated $\gamma_{k,t}$ by year, for the aggregate category of nondurable goods and services, less housing, health, and education.[13] The estimated $\gamma_{k,t}$ for nondurable goods and services has a mean of 0.795 over time. It does not exhibit any apparent cyclicality, with the correlation between the cyclical component of $\gamma_{k,t}$ and the cyclical component of the unemployment rate being -0.05. Given this result, we restrict the expenditure drop upon unemployment to be constant, $\gamma_{k,t} = \gamma_k$.

We complement our results from the CE with estimates from the PSID. The PSID began in 1968 as a survey of 4,000 households. Since then, it has reinterviewed members of the 1968 sample along with members of new households formed by previous members of PSID households, giving rise to a long panel of a representative sample of U.S. households. The survey has asked about food expenditure since its inception, and in 2005 began asking about

[13]We assign households to the calendar year containing the majority of their reporting period.

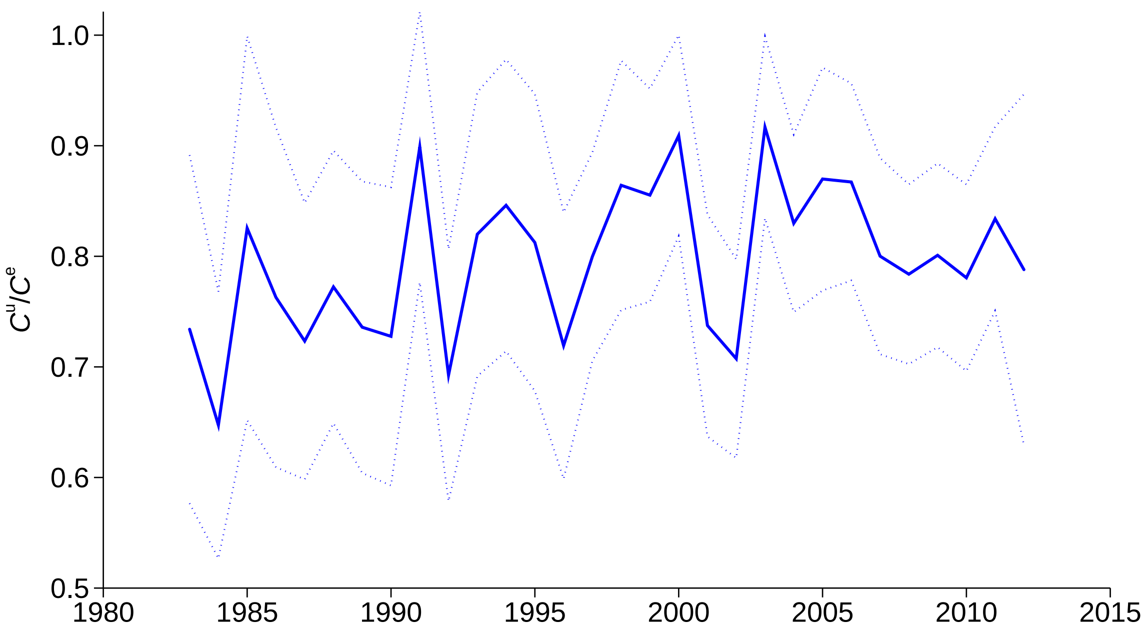

Figure 2: Decline in Nondurables and Services Upon Unemployment

Notes: The solid line reports the estimates of $\gamma_{k,t}$ from equation (24) using data from the CE. The dotted lines give 95 percent confidence interval bands based on robust standard errors. Regressions are weighted using survey sampling weights. See the text for included covariates.

clothing, recreation and entertainment, and vacation expenditure. The panel dimension permits implementation of equation (25), thus removing the concern that unobserved permanent income differences bias the estimation. The PSID also asks questions about unemployment status, allowing us to construct the $D_{i,t}$ variable as:

$$D_{i,t}^{\mathrm{PSID}} = \left[\frac{\text{weeks searching or on temporary layoff in year } t}{\text{weeks in the labor force in year } t}\right]_i .$$

Table 2 reports estimates of equation (24) for the CE and of equation (25) for the PSID, with γ_k constrained to be constant across years. For total food, the PSID suggests a somewhat larger γ_k than the CE. While this could reflect imperfect controls for permanent income in the CE, there are aspects of the PSID design that may cause an upward bias. The PSID asks about "usual" weekly expenditure on food at home, and then asks about food away from home without prompting a frequency. This has led some researchers to interpret the food questions as applying to the time of the interview, while others argue that they correspond to the previous year. We follow the recent literature in mapping the questions to the previous year's expenditure

Table 2: Relative expenditure of the unemployed γ

	Total food		Food, clothing recreation, vacation		Nondurables and services
	CE	PSID	CE	PSID	CE
γ	0.830	0.865	0.775	0.775	0.803
	(0.011)	(0.031)	(0.012)	(0.088)	(0.010)
Observations	47,333	46,689	47,333	4,607	47,333

Notes: The parameter γ gives the spending of an unemployed person as a fraction of what the person would spend if employed. The CE columns cover reporting years 1983-2012. The PSID columns cover reporting years 1969-71, 1974-86, 1989-1996, 1998, 2000, 2002, 2004, 2006, 2008, and 2010 for food and years 2004, 2006, 2008, and 2010 for clothing, recreation, and vacations. Equation (24) is used for the CE and equation (25) is used for the PSID. Regressions are weighted using sampling weights. Standard errors are in parentheses and are based on heteroskedastic robust (CE) or heteroskedastic robust and clustered by household head (PSID) variance matrix.

(Blundell, Pistaferri, and Preston, 2008). However, if some respondents' interpret the question as referencing food expenditure at the time of the interview, the resulting measurement error in unemployment status would bias the estimated γ_k in the PSID regressions upward.[14]

We also exploit the new questions in the PSID covering broader measures of consumption expenditure. Here the estimated γ_k from the PSID appears indistinguishable from the γ_k from the CE for the same set of categories. Importantly, for the new categories, the PSID questionnaire contains an explicit reference to the previous year as the reporting period. The overall similarity between the CE and the PSID results suggest that the control variables in $\mathbf{X}_{i,t}$ proxy well for permanent income. Because of non-homotheticities across consumption categories, our preferred results come from the CE for total nondurable goods and services. Accordingly, in what follows we set γ_k to 0.80, the mean value from Figure 2.

The estimates in Table 2 lie comfortably within the range of those found in previous studies. In an early assessment, Burgess, Kingston, St. Louis, and Sloane (1981) report results from a survey of UI recipients after five weeks of unemployment. They find that expenditure on the categories of food, clothing, entertainment, and travel fell by 25.7 percent relative to before the

[14]Additionally, while the CE asks households about detailed categories every three months, the PSID asks about the broad categories of food at home and food away and over a longer recall period. Hence even if respondents interpret the question as referring to the previous year, recall bias may cause their response to partly reflect their current consumption patterns.

unemployment spell. Gruber (1997) reports a smaller decline in food expenditure of 6.8 percent in the PSID for the period up to 1987. The difference between his results and ours stems from the removal of households with a threefold change in consumption from his sample. Browning and Crossley (2001) use a survey of Canadians unemployed for six months that asks about total expenditure over the previous month as well as expenditure in the month before unemployment. They find a mean decline of 14 percent. Aguiar and Hurst (2005) find a 19 percent decline in food expenditure among the unemployed using scanner data. Finally, Eusepi and Preston (2013) estimate a 23 percent decline in consumption expenditure upon non-employment using CE data of two-earner households split between those working above or below 2040 hours.

The final step in our methodology is to derive a time series for the consumption of employed C_t^e and unemployed C_t^u. In Appendix A we derive $\tilde{C}_t^e$, the hypothetical reported CE consumption of an average unemployed had this person been employed. Our measure of consumption of the employed C_t^e corrects for noise and under-reporting in the CE by multiplying NIPA per capita consumption by a constant ratio of $\tilde{C}_t^e$ to average per capita consumption across all households in the CE (including those out of the labor force). As a result, C_t^e inherits the cyclical properties of NIPA expenditure on nondurable goods and services.

3.3 Other Variables

As explained in section 2.1.1, to measure the opportunity cost of employment related to benefits b_t one has to take into account the limited take-up of UI and the effects of benefits expiration. For this reason we need to separate UI dollars per unemployed $B_{u,t}$ into the fraction of unemployed eligible for UI ω_t, the take-up rate ζ_t, and benefits per recipient $\tilde{B}_t$. Data on the number of UI recipients in all tiers (state regular benefits, extended benefits, and federal emergency benefits) are available from the Department of Labor beginning in 1986. We extend this series back to 1961 using data from Statistical Appendix B of the Economic Report of the President. Dividing the NIPA total of UI benefits paid by the number of UI recipients gives a time series of UI benefits per recipient $\tilde{B}_t$. We obtain a time series for the fraction of unemployed receiving benefits as $\phi_t = \omega_t \zeta_t = B_{u,t}/\tilde{B}_t$.

We split ϕ_t into its components using information on benefits expiration together with the law of motion for ω_t in equation (3) and the estimate of the average take-up rate from Blank and Card (1991). Whittaker and Isaacs (2013) report the national maximum potential duration of UI receipt since the program's inception. We set ω_t^u, the probability that an unemployed remains eligible, such that the expected potential duration of eligibility equals the national maximum adjusted for the fact that not every unemployed individual has the maximal potential duration.[15] Finally, we jointly solve for ω_t^e and ζ_t such that ζ_t has a sample mean of 0.65, consistent with the evidence in Blank and Card (1991).[16]

The number of employed comes from the monthly CPS for consistency with our unemployment variable (BLS series LNS12000000). With a constant labor force, the number of newly unemployed workers equals the product of the previous period's separation rate s_{t-1} and stock of employed workers e_{t-1}. We therefore define the separation rate s_t at quarterly frequency as the ratio of the number of workers unemployed for fewer than 15 weeks in quarter $t+1$ (using the sum of BLS series LNS13008397 and LNS13025701) to the number of employed workers in t. The separation rate and the unemployment rate allow us to calculate the job-finding rate f_t from the law of motion for unemployment $u_{t+1} = u_t(1-f_t) + s_t(1-u_t)$.[17]

Hours N_t are defined as hours per worker in the business sector from the BLS Productivity

[15] Potential duration in most states depends on the worker's earnings history. For 1959-2013, data from the ETA give a mean potential duration of regular state benefits of 24 weeks, while the national maximum counts a potential duration of regular state benefits of 26 weeks. Additionally, benefits extensions under extended benefits or federal emergency programs may depend on a state's unemployment rate, such that not every state has a maximum potential duration equal to the national maximum. Unpublished data provided via email by Chad Stone and William Chen of the Center on Budget and Policy Priorities show that since 2008 the average state has had a maximum potential duration of 0.81 of the national maximum. Combining these two elements, we conservatively set the average potential duration to 0.8 of the national maximum potential duration.

[16] In so doing we need to take a stand on the relative cyclicality of ω_t^e and ζ_t. Our approach is as follows. Given a path of u_t, ω_t^u, s_t, and f_t and assuming a constant ζ of 0.65, equation (3) for ω_t and the time series of ϕ_t uniquely define a path $\tilde{\omega}_t^e$ which loads all of the cyclicality onto ω_t^e. We then assume that ω_t^e is given by the HP trend of $\tilde{\omega}_t^e$ using a smoothing parameter of 10,000. Finally, we construct $\zeta_t = \phi_t/\omega_t$ and verify that the in-sample average of ζ_t is close to 0.65. We have considered alternative values for the smoothing parameter (ranging from 1,600 to infinity), with small effect on our results.

[17] We recognize the point of Shimer (2012) that this procedure understates the amount of gross flows between unemployment and employment because some workers will separate and find a new job within the period. However, a discrete time calibration must accept this shortcoming if both the law of motion for unemployment holds and the share of newly unemployed matches the share in the data. For our purposes, matching the share of newly unemployed matters more than matching the level of gross flows. Estimating s_t and f_t at a monthly frequency, which should substantially mitigate the bias from within-period flows, and then averaging at the quarterly level makes little difference for our results.

and Costs index series. We normalize the mean of N_t in the sample to be one. The marginal product of employment p_t^e is defined as $1-\nu$ multiplied by real GDP and then divided by the number of employed, where $\nu = 0.333$ is the elasticity of output with respect to capital in the production function. The marginal product of labor is defined as $p_t^n = p_t^e / N_t$. We divide in the data variables such as GDP, consumption, benefits, and the opportunity cost of employment by the mean of the marginal product of employment in the sample. Therefore, all variables (both in the data and in the model) are expressed relative to the mean level of $p^e = 1$.

4 Parameterization

We parameterize the model so that in the deterministic steady state it matches key features of the United States economy between 1961(1) and 2012(4). Appendix C defines formally the equilibrium of the model. Variables without time subscripts denote steady state values.

We start by discussing the functional forms. The production function and matching technology are Cobb-Douglas:

$$Y_t = A_t K_t^{\nu} \left(e_t N_t\right)^{1-\nu}, \tag{26}$$

$$m_t = M_t v_t^{\eta} u_t^{1-\eta}, \tag{27}$$

where A_t is the exogenous technology level, ν denotes the elasticity of output with respect to capital, M_t is the exogenous matching efficiency, and η is the elasticity of matches with respect to vacancies. The cost function for taking up benefits is given by:

$$\psi_t = \frac{\Psi_t}{\alpha} \zeta_t^{\alpha}, \tag{28}$$

where Ψ_t denotes an exogenous shifter of the cost function and α denotes the elasticity of the cost function with respect to the take-up rate.

The utility functions of the employed and the unemployed are given by:

$$U_t^e = \left(\frac{1}{1-\rho}\right)\left((C_t^e)^{1-\rho}\left(1 - \frac{(1-\rho)\chi\epsilon}{1+\epsilon} N_t^{1+1/\epsilon}\right)^{\rho} - 1\right), \tag{29}$$

$$U_t^u = \left(\frac{1}{1-\rho}\right)\left((C_t^u)^{1-\rho} - 1\right) + Q. \tag{30}$$

Table 3: Parameter Values

	Parameter	Value	Parameter	Value
External	β	0.990	δ	0.025
	ν	0.333	ϵ	0.700
	η	0.400	μ	0.600
	ω^e	0.612	ω^u	0.492
	$\tilde{B}$	0.215	B_n	0.015
	s	0.045	Q	varies with z
Internal	M	0.802	A	0.619
	κ	varies with z	χ	2.812
	ρ	1.223	C^o	varies with z
	α	1.535	Ψ	1.226

The parameter Q in the utility of the unemployed is a separable shifter that we will use to target different levels of z. This parameter has the interpretation of the additional utility from consuming non-market goods produced at home by the unemployed. In our baseline results Q does not vary over time. Equivalently, the value of home production in terms of market consumption, Q/λ_t, changes over time because of variations in the marginal utility of market consumption and not because of home production shocks. We show below using data from the American Time Use Survey (ATUS) that this is a conservative assumption for our results.

The preferences given by equation (29) are consistent with balanced growth and feature a constant Frisch elasticity of labor supply ϵ (Shimer, 2010; Trabandt and Uhlig, 2011). The parameter χ determines the disutility of hours worked. The parameter ρ governs both the intertemporal elasticity of substitution $(1/\rho)$ and the degree of complementarity between consumption and hours worked. When $\rho \to 1$ utility becomes separable between consumption and hours worked. The employed consume more (market) goods than the unemployed in our model when $\rho > 1$, that is, when consumption and hours worked are complements.

Table 3 summarizes the calibrated parameters. Recall that a model period equals a quarter. We set the discount factor to $\beta = 0.99$, the depreciation rate to $\delta = 0.025$, and the elasticity of output with respect to capital to $\nu = 0.333$. Following Pistaferri (2003) and Hall (2009), we set the Frisch elasticity of labor supply to $\epsilon = 0.70$. Following Mortensen and Nagypal (2007), we set the elasticity in the matching function to $\eta = 0.40$. We set the worker's bargaining power to $\mu = 0.60$ to satisfy the Hosios condition.

To calibrate the model we take averages over 1961(1) and 2012(4) of the variables constructed in Section 3. We estimate an average separation rate of $s = 0.045$. Together with an average job-finding probability of $f = 0.704$, this implies a steady state unemployment rate of $u = 0.06$. We find in-sample averages of the UI eligibility parameters $\omega^e = 0.612$ and $\omega^u = 0.492$. Finally, we estimate $\tilde{B} = 0.215$ and $B_n = 0.015$, both expressed relative to the mean marginal product of employment.

We calibrate the eight parameters $\{M, A, \kappa, \chi, \rho, C^o, \alpha, \Psi\}$ to match eight targets estimated from the data. Inverting the matching function and imposing that in steady state the job-finding rate is $f = 0.704$ gives the matching efficiency parameter M. The technology level A is chosen such that the marginal product of labor equals $p^n = 1$.

To calibrate the vacancy creation costs κ we use the fact that the steady state equilibrium tightness is given by:

$$\theta = \left(\frac{1}{\kappa}\right)\left(\frac{f\beta(1-\mu)}{1-\beta(1-s-\mu f)}\right)(p^e - z)\,. \tag{31}$$

den Haan, Ramey, and Watson (2000) estimate a monthly job-filling probability of 71 percent, which translates to $q = 0.975$ at a quarterly frequency. Given the value of $f = 0.704$, this produces a market tightness of $\theta = f/q = 0.722$. Below we will set parameters such that $N = 1$ and hence $p^e = p^n N = 1$. Given a value of z, this leaves κ as the only free parameter in equation (31), so for each z we calibrate κ to hit the same level of $\theta = 0.722$.

The parameters χ and ρ in the utility function and other spending C^o in the budget constraint are jointly calibrated so that in the steady state of the model $N = 1$, $C^u/C^e = 0.795$, and $(C^e - C^u)/p^n = 0.075$. We sketch the procedure here and leave the details to Appendix B. From the risk sharing condition (4), $C^u/C^e = 0.795$ requires $\rho = 1.223$. This estimate implies an intertemporal elasticity of substitution for consumption of around 0.82 and an elasticity of hours with respect to the marginal utility of wealth equal to $\epsilon_{N\lambda} = \epsilon/\rho = 0.57$.[18] Given ρ, the parameter χ is chosen to normalize hours in the steady state to $N = 1$ and the parameter C^o is chosen so that the consumption difference between employed and unemployed is 7.5 percent of the marginal product of employment. We note that in the absence of C^o from the model, the difference $C^e - C^u$ would be greater than 20 percent of the marginal product, which in turn would lead to very different calibrated values for ρ and χ.

To parameterize the costs of taking up benefits, we note that the first-order condition (6) implies:

$$\hat{\zeta}_t = \left(\frac{1}{\alpha - 1}\right)\left(\hat{\lambda}_t + \hat{\tilde{B}}_t\right). \tag{32}$$

In our sample, a regression of the percent deviation of ζ_t from its trend on the percent deviation of $\lambda_t \tilde{B}_t$ from its trend yields an estimated value of $\alpha = 1.535$ (standard error 0.086). Given this value of α, we pick the parameter Ψ to target a steady state take-up rate of $\zeta = 0.650$.

We consider three baseline values for the level of the opportunity cost of employment z. The value $z = 0.447$ comes from setting $Q = 0$ in the utility of the unemployed in equation (30). This value turns out to be close to the value of 0.4 used in Shimer (2005). However, it results from a calibration strategy very different from that of Shimer (2005), and one much more similar in spirit to the strategy used by Hall and Milgrom (2008). Hall and Milgrom also compute the part of the opportunity cost associated with consumption and work differences ξ using a utility function with curvature. Our calibration differs from theirs, however, in that our estimated opportunity cost associated with benefits b is much smaller. Specifically, because we find $b = 0.035$, when we set $Q = 0$ we obtain $\xi = 0.412$ and $z = b + \xi = 0.447$. Hall and Milgrom (2008) have $z = 0.710$ with $b = 0.25$, and so their implied $\xi = 0.46$ is close to our calibrated value of ξ under $Q = 0$.[19]

[18] These values are close to the values of 0.5 and 0.4 used in Hall (2009), with the difference explained by the fact that our estimated ρ is lower than the ρ implicit in Hall's formulation.

[19] Our b is much lower than that used in the literature despite the fact that we also add non-UI benefits. The sample-average benefit per recipient $\tilde{B}$ is 21.5 percent of the marginal product, close to the statutory replacement rates assumed in Hall and Milgrom (2008) and much of the previous literature. However, only about one-third of unemployed actually receive benefits. As a result, even without accounting for eligibility expiration and costs associated with taking up benefits, benefits per unemployed B_u is only 7.2 percent of the marginal product. Adjusting for the fact that benefits expire with some probability and the costs associated with taking up benefits explains the remaining difference.

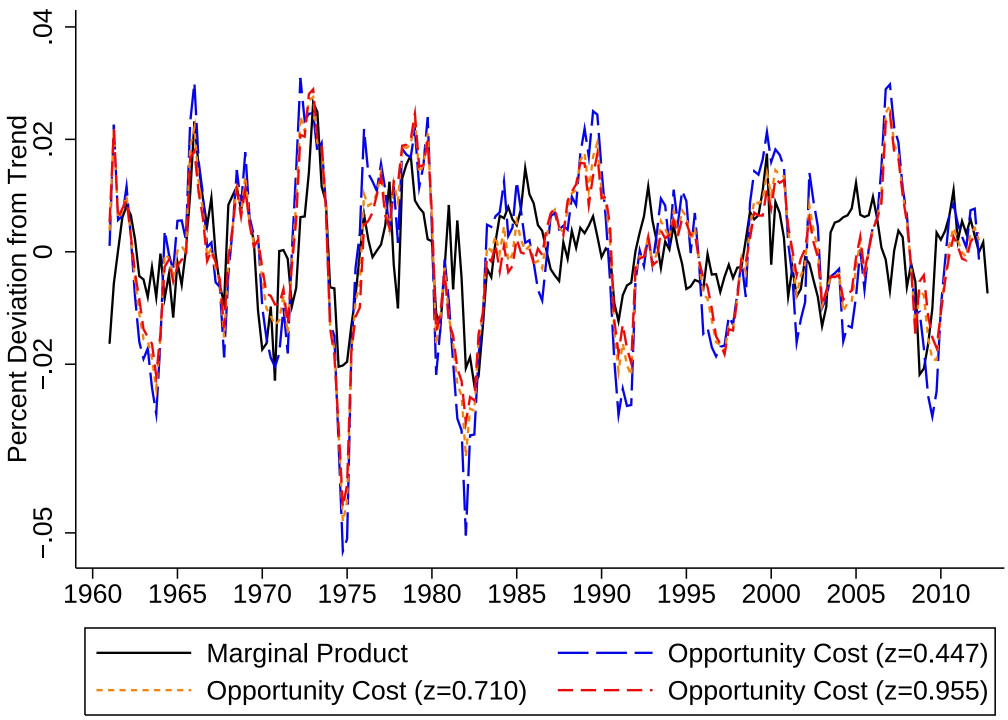

Figure 3: Cyclicality of Opportunity Cost of Employment

Notes: The solid line is the percent deviation of the cyclical component of the marginal product of employment p^e from its trend. The three dashed lines are the percent deviations of the cyclical components of the opportunity cost of employment z from their trends. Each dashed line corresponds to a different level of z, generated with different values of the parameter Q in equation (30).

The second level of z that we consider is the Hall and Milgrom (2008) value of $z = 0.710$. To achieve this value of z, we set Q in the utility function of the unemployed at a level such that Q/λ equals 0.263 (relative to a marginal product of one). The final value that we consider is taken from Hagedorn and Manovskii (2008). Specifically, we calibrate Q to achieve a level of $z = 0.955$. This requires setting the utility value of home production goods in terms of consumption goods to $Q/\lambda = 0.508$.

5 The Opportunity Cost of Employment in the Data

We are now in a position to document the cyclical properties of the opportunity cost z_t. Figure 3 plots the percent deviation of the opportunity cost of employment from its trend, $\hat{z}_t$, along with the percent deviation of the marginal product from its trend, $\hat{p}^e_t$, between 1961(1) and 2012(4). We plot $\hat{z}_t$ for the three levels of z discussed above. The figure shows that the opportunity cost

Table 4: Business Cycle Statistics, 1961(1)-2012(4)

Statistic	$z = 0.447$	$z = 0.710$	$z = 0.955$
$\mathrm{sd}\left(\hat{Y}\right)$	1.53	1.53	1.53
$\mathrm{sd}\left(\hat{u}\right)$	11.82	11.82	11.82
$\mathrm{sd}\left(\hat{p}^e\right)$	0.89	0.89	0.89
$\mathrm{sd}\left(\hat{z}\right)$	1.57	1.30	1.21
$\mathrm{corr}\left(\hat{p}^e, \hat{y}\right)$	0.73	0.73	0.73
$\mathrm{corr}\left(\hat{z}, \hat{y}\right)$	0.65	0.68	0.68
$\mathrm{corr}\left(\hat{p}^e, \hat{u}\right)$	-0.38	-0.38	-0.38
$\mathrm{corr}\left(\hat{z}, \hat{u}\right)$	-0.48	-0.52	-0.52
$\epsilon\left(\hat{u}, \hat{p}^e\right)$	-5.02	-5.02	-5.02
Standard error	(0.95)	(0.95)	(0.95)
$\epsilon\left(\hat{z}, \hat{p}^e\right)$	1.10	0.91	0.82
Standard error	(0.13)	(0.13)	(0.13)
$\epsilon\left(\hat{u}, \hat{p}^e\right)$ (IV with A)	-6.91	-6.91	-6.91
Standard error	(0.99)	(0.99)	(0.99)
$\epsilon\left(\hat{z}, \hat{p}^e\right)$ (IV with A)	1.23	1.06	0.98
Standard error	(0.12)	(0.10)	(0.10)

Notes: Variables are logged and HP-filtered with a smoothing parameter 1,600. We denote the percent deviation of some variable x_t from its trend by $\hat{x}_t$. The elasticity $\epsilon\left(\hat{x}_1, \hat{x}_2\right)$ is the regression coefficient of $\hat{x}_1$ on $\hat{x}_2$. Newey-West standard errors with four lags are in parentheses.

comoves positively with the marginal product over the business cycle.

Table 4 presents business cycle statistics of the opportunity cost and the marginal product. The opportunity cost is more volatile than the marginal product of employment. It is slightly less positively correlated with output than the marginal product, but more negatively correlated with unemployment. To measure the comovement between two variables x_1 and x_2 in a way that takes into account both the correlation between the two variables and the relative volatilities, the table also reports the elasticity $\epsilon\left(\hat{x}_1, \hat{x}_2\right)$, defined as the regression coefficient of $\hat{x}_1$ on $\hat{x}_2$. We find an elasticity of $\hat{z}$ with respect to $\hat{p}^e$ of between 0.82 and 1.10. When we instrument $\hat{p}^e_t$ with $\hat{A}_t$ (measured using the Fernald (2012) unadjusted TFP series), the elasticity of $\hat{z}$ with respect to $\hat{p}^e$ increases in magnitude. Overall, these estimates lead to our preferred value of the elasticity of $\hat{z}$ with respect to $\hat{p}^e$ of roughly one.

The procyclicality of z_t reflects the outcome of two opposing forces. As discussed in Section 2.1.2, the ξ_t component of the opportunity cost falls in recessions because of the increase in the marginal utility of consumption relative to the value of non-working time. This makes the household more willing to move workers from unemployment to employment. On the other hand, the component of the opportunity cost related to benefits b_t tends to increase in recessions, partly offsetting the increase in ξ_t. In the data, the procyclicality of ξ_t dominates the countercyclicality of b_t.

Four aspects of our empirical work lead to this result. First, the marginal utility of consumption is quite volatile over the business cycle. The percent standard deviation of $\hat{\lambda}_t$ is 1.07, and the correlations of $\hat{\lambda}_t$ with $\hat{Y}_t$ and $\hat{u}_t$ are -0.62 and 0.50 respectively. As a benchmark, if instead the consumption drop upon unemployment approached zero ($\rho \to 1$), the percent standard deviation of the marginal utility of consumption would simply equal the percent standard deviation of consumption per employed, which is 0.98 in our sample.

Second, the procyclicality of hours per worker N_t contributes to the procyclicality of ξ_t, as it implies a decline in the value of non-working time relative to consumption in recessions. Making N_t constant, i.e. shutting down the intensive margin of labor supply, would result in an opportunity cost roughly 65 to 90 percent as volatile as that shown across the columns of Table 4.

Third, non-UI benefits per unemployed $B_{n,t}$ decrease in recessions, offsetting the strong countercyclicality of the UI component. Figure 4 shows the UI component of b_t (the solid line) and the non-UI component $B_{n,t}$ (the dashed line). The lines typically move opposite to each other over the business cycle, making the overall b_t less countercyclical than the UI component alone.

Fourth, the UI component of b_t has a relatively low level. This reduces the impact of the strong countercyclicality of the UI component of b_t on the total z_t. It would require raising the average level of B_u by a factor of 3 to 4 without changing its cyclicality to offset the other

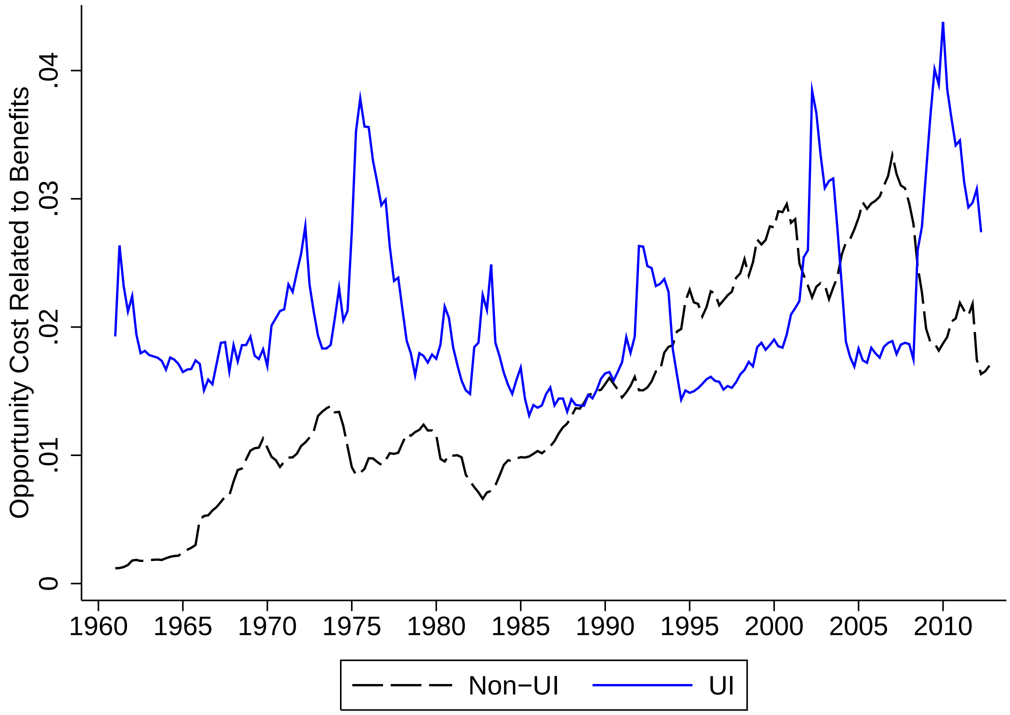

Figure 4: Benefits

Notes: The figure shows the two components of the opportunity cost of employment related to benefits defined in equation (9). Variables are divided by the mean marginal product in the sample.

components and make z_t acyclical.

A countercyclical Q_t would ameliorate the procyclicality of z_t. Recall that Q_t has the interpretation of the value (net of utility costs) the unemployed derive from producing goods in the home sector relative to that of an employed.[20] While home production output data do not exist, input data do. Let $Q_t = Q\left(\tau_t^h, .\right)$, where τ_t^h denotes time spent on home production. The ATUS provides reliable data on time spent on home production by labor force status between 2003 and 2012. We use these data to ask whether home production time per unemployed person increases in recessions.

Specifically, under the assumption that the cyclicality of τ_t^h is a good proxy for the cyclicality of Q_t, we test the assumption of an acyclical Q_t by regressing:

$$\tau_{i,s,t}^j = \beta_1^j \mathbb{I}\left\{l_{i,s,t} = u\right\} + \beta_2^j \mathbb{I}\left\{l_{i,s,t} = u\right\} u_{s,t} + \beta_3^j \mathbb{I}\left\{l_{i,s,t} = u\right\} u_{s,t}^2 + \phi^j \mathbf{X}_{i,s,t} + \epsilon_{i,s,t}^j, \tag{33}$$

where $\tau_{i,s,t}^j$ denotes the time use in category j of individual i living in state s at time t,

[20] Because Q enters additively in (30), we can normalize the Q for the employed to zero without loss of generality.

$\mathbb{I}\{l_{i,s,t} = u\}$ takes the value of one if the individual is unemployed, $u_{s,t}$ denotes the state unemployment rate from the BLS, and $\mathbf{X}_{i,s,t}$ denotes a vector of covariates. In $\mathbf{X}_{i,s,t}$ we include the state unemployment rate and the square of the state unemployment rate. We additionally include a set of quarterly dummies, dummies for gender, marital status, the presence of children, spousal employment and race, five age dummies, and four educational dummies. The time use categories we consider are home production time $j = h$ (excluding child care) and market work hours $j = m$ as defined in Aguiar, Hurst, and Karabarbounis (2013). Our sample includes only unemployed and employed persons between the ages of 18 and 65.

The object of interest is the "offset rate" defined as:

$$Q_t = \left(\frac{\Delta\tau^h}{\Delta\tau^m}\right)_t = -\frac{\beta_1^h + \beta_2^h u_t + \beta_3^h u_t^2}{\beta_1^m + \beta_2^m u_t + \beta_3^m u_t^2}. \tag{34}$$

The offset rate measures the increase in hours spent in home production in response to a one hour decline in market hours due to an unemployment shock. By including interactions of the unemployment status with the state unemployment rate and including a full set of time dummies at the quarterly frequency, we identify the offset rate as a function of aggregate unemployment from cross-sectional differences. We include the interaction of individual unemployment with the square of the state unemployment rate to investigate whether non-linearities are important for the relationship between the offset rate and the aggregate unemployment rate.

Figure 5 shows the offset rate Q_t on the left-axis, when we plug into equation (34) the national unemployment rate. The right-axis plots aggregate home production $u_t Q_t$. As in Aguiar, Hurst, and Karabarbounis (2013), we find that aggregate home production time increases during recessions. However, the relevant question for the cyclicality of z_t is not whether aggregate home production time rises, but whether home production time per unemployed increases. We find it does not. On average a one hour decline in market hours due to unemployment is associated with a 33 percent increase in time spent on home production. This increase, however, becomes diminished when unemployment rises beginning in 2008. Based on this evidence, we conclude that Q_t is not countercyclical and, if anything, the assumption of a constant Q is

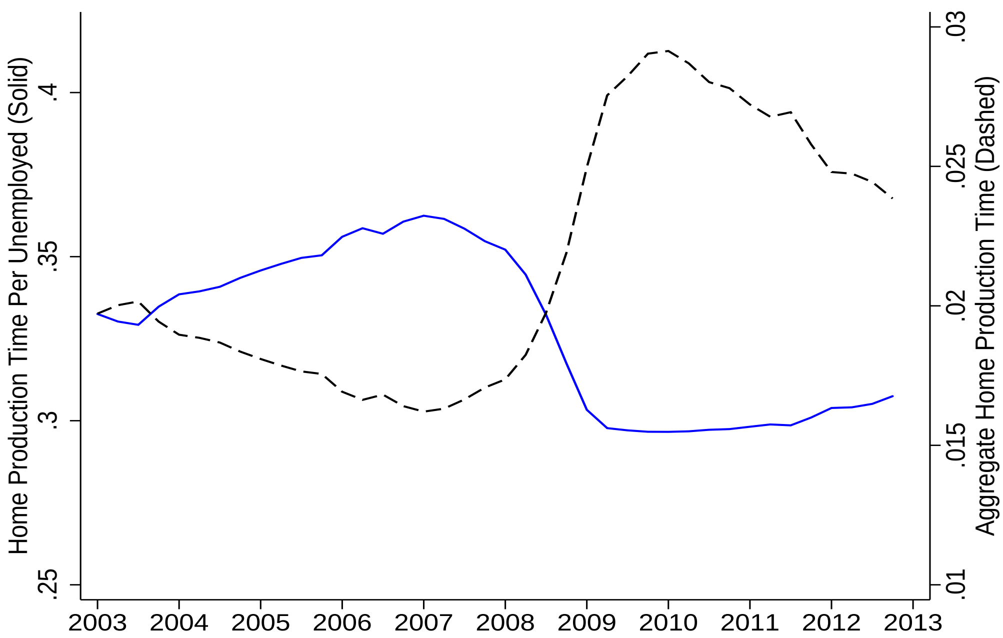

Figure 5: Home Production Time

Notes: In the left-axis (solid line) we plot estimates of equation (34) between 2003 and 2012. The underlying estimates are based on equation (33). In the right-axis (dashed line) we plot the product of the line in the left-axis and the national unemployment rate u_t.

conservative for our results.[21]

6 Implications for Unemployment Fluctuations

In this section we discuss the implications of the cyclicality of z for unemployment fluctuations. In the model developed so far, wages are set according to Nash bargaining as in Hagedorn and Manovskii (2008). Section 7 shows that the implications of the cyclicality of z for unemployment fluctuations carry over to the alternating-offer bargaining model of Hall and Milgrom (2008).

We start our analysis by following much of the literature in treating steady state movements in the marginal product of employment p^e and the opportunity cost of employment z as exogenous.[22] Differentiating equation (31) with respect to p^e, recognizing that f is a function of θ,

[21]In unreported regressions, we find that the same result holds when changes in market hours occur along the intensive margin of labor supply rather than due to unemployment.

[22]We have also solved the model across steady states allowing for endogenous movements in p^e and z. Our results become even stronger relative to the case of exogenous p^e and z. However, this exercise overstates the change in the marginal utility of consumption, which causes too much variation in z. For the case of endogenous movements in p^e and z we instead simulate the model at business cycle frequencies where the consumption smoothing motive is operational.

Table 5: Steady State Elasticity of Unemployment With Respect to the Marginal Product

	$z = 0.447$	$z = 0.710$	$z = 0.955$
$\epsilon(\hat{z}, \hat{p}^e) = 0.00$	-0.714	-1.360	-8.747
$\epsilon(\hat{z}, \hat{p}^e) = 0.25$	-0.634	-1.120	-6.661
$\epsilon(\hat{z}, \hat{p}^e) = 0.50$	-0.554	-0.877	-4.574
$\epsilon(\hat{z}, \hat{p}^e) = 0.75$	-0.474	-0.637	-2.485
$\epsilon(\hat{z}, \hat{p}^e) = 1.00$	-0.394	-0.394	-0.394
$\epsilon(\hat{z}, \hat{p}^e) = 1.25$	-0.314	-0.154	1.698

and holding constant κ, μ, β, s, and M gives an expression for the elasticity of labor market tightness θ with respect to p^e shocks:

$$\epsilon(\hat{\theta}, \hat{p}^e) = \left[\frac{\mu f + \frac{1-\beta(1-s)}{\beta}}{\mu f + (1-\eta)\frac{1-\beta(1-s)}{\beta}} \right] \left(\frac{p^e - z\epsilon(\hat{z}, \hat{p}^e)}{p^e - z} \right). \tag{35}$$

The response of unemployment is then given by $\epsilon(\hat{u}, \hat{p}^e) = -\eta(1-u)\epsilon(\hat{\theta}, \hat{p}^e)$. Equation (35) generalizes the expressions given in Shimer (2005), Mortensen and Nagypal (2007), and Hagedorn and Manovskii (2008) to allow z to change in response to changes in p^e. The magnitude of this response is given by $\epsilon(\hat{z}, \hat{p}^e)$.

Table 5 presents the elasticity of unemployment with respect to the marginal product of employment $\epsilon(\hat{u}, \hat{p}^e)$ as a function of the level of the opportunity cost z and the cyclicality of the opportunity cost $\epsilon(\hat{z}, \hat{p}^e)$. Recall from Table 4 that $\epsilon(\hat{u}, \hat{p}^e)$ is -5 in the data without instrumenting and -7 if we instrument using TFP. In the first row of the table z is constant. The response of unemployment to shocks in the marginal product is small when the calibrated value of z is small, consistent with the result in Shimer (2005). Moving across columns to higher levels of z, the response of unemployment increases. As in Hagedorn and Manovskii (2008), this reflects the fact that as z increases firm's steady state profits shrink and so an increase in the productivity of a match causes profits to change by a larger percent. As a result, the incentive to create vacancies increases and unemployment becomes more volatile.

A key result of our analysis can be seen by moving down the rows of Table 5, as we allow z

to vary cyclically. A positive value of $\epsilon(\hat{z}, \hat{p}^e)$ means that in response to p^e shocks, z increases. The higher is the responsiveness of z, the smaller is the increase in the net flow surplus of the match, $p^e - z$, and the weaker is the firm's incentive to create vacancies. As a result, holding constant the level of z, the response of unemployment becomes smaller when $\epsilon(\hat{z}, \hat{p}^e)$ is higher.

Equation (35) shows that under our preferred estimate of $\epsilon(\hat{z}, \hat{p}^e) = 1$, so that both z and p^e change by the same percent, the elasticity of θ and u with respect to the marginal product is independent of the level of z. Table 5 shows that when $\epsilon(\hat{z}, \hat{p}^e) = 0.75$, the elasticity of unemployment with respect to the marginal product is 66 percent of the elasticity obtained under a constant $z = 0.447$, 47 percent of the elasticity obtained under a constant $z = 0.710$, or 28 percent of the elasticity obtained under a constant $z = 0.955$. When $\epsilon(\hat{z}, \hat{p}^e) > 1$ and z is relatively high, it is even possible that the sign of the response of unemployment changes.

The intuition regarding the role of cyclical movements of z for unemployment fluctuations is quite general. It can be shown that the numerator of the second term in equation (35) changes from $p^e - z\epsilon(\hat{z}, \hat{p}^e)$ to $p^e\epsilon(\hat{p}^e, \hat{x}) - z\epsilon(\hat{z}, \hat{x})$ for any shock x other than shocks to κ, μ, β, s, and M. The crucial determinant of unemployment volatility is the responsiveness of z relative to the responsiveness of p^e when some shock x hits the economy.

To show our neutrality result for the level of z when p^e and z endogenously change over the business cycle, we now simulate the model. For transparency and compatibility with previous literature, we assume that A_t is the only shock driving the economy's fluctuations.

We parameterize the productivity process as $A_t = A\exp(u_t^A)$, where A is the steady state level of technology and u_t^A is the productivity shock. We assume that the shock follows the AR(1) process $u_t^A = \rho_A u_{t-1}^A + \sigma_A \epsilon_t^A$, where ϵ_t^A is normal with mean zero and unit variance. We calibrate the parameters of the stochastic process to match the AR(1) coefficient of $\hat{p}_t^e$ and the standard deviation of $\hat{p}_t^e$ in the data. We find that $\rho_A = 0.96$ and $\sigma_A = 0.0068$. All other parameters are given in Table 3.

Table 6 presents our results for the three steady state levels of z discussed above. For each z we report statistics from the data, from a model in which the z that enters the wage equation

Table 6: Business Cycle Statistics: Model and Data

Statistic	$z = 0.441$			$z = 0.710$			$z = 0.955$		
	Data	Fixed	Varying	Data	Fixed	Varying	Data	Fixed	Varying
$\text{sd}(\hat{u})/\text{sd}\left(\hat{Y}\right)$	7.72	0.59	0.37	7.72	1.11	0.32	7.72	5.42	0.63
$\text{sd}(\hat{p}^e)/\text{sd}\left(\hat{Y}\right)$	0.58	0.97	0.98	0.58	0.95	0.99	0.58	0.75	0.99
$\text{sd}(\hat{z})/\text{sd}\left(\hat{Y}\right)$	1.03	0.00	0.83	0.85	0.00	0.97	0.79	0.00	0.99
$\epsilon(\hat{z}, \hat{p}^e)$	1.23	0.00	0.84	1.06	0.00	0.98	0.98	0.00	1.00
$\epsilon(\hat{u}, \hat{p}^e)$	−6.91	−0.41	−0.25	−6.91	−0.79	−0.23	−6.91	−3.66	−0.19

(17) is always fixed at its steady state level, and our model in which z is allowed to vary. Increasing the level of z when z is fixed substantially increases the volatility of unemployment. However, in the model with time-varying z, z moves roughly as much as p^e over the business cycle. Consistent with our previous results, allowing for the empirically-observed cyclicality of z makes the volatility of unemployment essentially neutral with respect to the level of z.

7 Alternative Wage Setting Mechanisms

The Nash bargaining wage setting mechanism adopted thus far implies that the threat point of an unemployed depends on the wage other jobs would offer in case of bargaining termination. This feature makes the outside option of workers during bargaining sensitive to productivity shocks. With a low and constant z, wages increase substantially following positive productivity shocks, and this increase in wages ameliorates the firm's incentive to create jobs.

Hall and Milgrom (2008) replace Nash bargaining with an alternative wage setting mechanism. In their alternating-offer bargaining game, when a firm with a vacancy meets an unemployed worker, the firm offers a compensation package $\tilde{w}$. The worker can accept the offer and commence work, or prolong the bargaining and make a counteroffer $\tilde{w}'$. Crucially, z parameterizes the flow opportunity cost to the worker of prolonging the bargaining, and hence the threat point if the worker deems the employer's initial offer too low.[23] With a constant z, wages therefore respond weakly to increases in p^e. The rigidity of wages incentivizes firms to significantly increase their job creation.[24] Allowing instead z to comove with p^e in the alternating-offer bargaining model makes the unemployed's threat point again sensitive to aggregate conditions. This increases the flexibility of wages and reduces the volatility of unemployment.

We illustrate this point using the linear search and matching model presented in Hall and Milgrom (2008). We first replicate their results for three linear models: the Nash bargaining model with $z = 0.71$ ("Standard MP"), the Nash bargaining model with $z = 0.93$ ("Hagedorn-Manovskii"), and the alternating-offer bargaining model with $z = 0.71$ ("Hall-Milgrom"). Then, we introduce in these three linear models a cyclical z with $\epsilon(\hat{z}, \hat{p}^e) = 1$. Appendix D presents the equations and parameters of Hall and Milgrom (2008), which we adopt here for our analysis.

Table 7 summarizes our results. We first discuss results under Nash bargaining, building on the intuition of the previous section. The first row shows the slope of the expected present value of utility flows for the unemployed $\tilde{U}^u$ with respect to the expected present value of a newly hired worker's product $\tilde{p}^e$. With Nash bargaining, $\tilde{U}^u$ is the outside option of the unemployed while bargaining. It helps to separate $\tilde{U}^u$ into the sum of two components, the expected present value from receiving z discounted by the probability the worker remains unemployed, and the value of obtaining a job in a future period discounted by the probability of exiting unemployment in that period. In the Standard MP model with constant z, $\tilde{U}^u$ responds substantially when $\tilde{p}^e$ increases. Intuitively, low z means that future job prospects contribute relatively more to $\tilde{U}^u$, and higher $\tilde{p}^e$ increases the probability of an unemployed finding a high-wage job. In the Hagedorn-Manovskii calibration, a high fixed z makes the expected discounted value of future z's a more important component of $\tilde{U}^u$. As a result, total $\tilde{U}^u$ responds less to the better job

[23]Another important parameter is the probability that the bargaining exogenously falls apart and the worker returns to the general search pool. This probability governs the extent to which the wage depends on z rather than on wage offers at other firms. See Appendix D for further details of the bargaining setup.

[24]Christiano, Eichenbaum, and Trabandt (2013) embed the Hall and Milgrom (2008) model of wage bargaining into a New-Keynesian dynamic general equilibrium model and show that the estimated model outperforms the standard MP model in several dimensions including volatility in the labor market.

Table 7: Cyclicality of Wages and Unemployment Fluctuations

Statistic	Standard MP		Hagedorn-Manovskii		Hall-Milgrom	
	Fixed z	Cyclical z	Fixed z	Cyclical z	Fixed z	Cyclical z
Slope $d\tilde{U}^u/d\tilde{p}^e$	1.14	1.30	0.87	1.32	1.19	1.31
Slope $d\tilde{w}/d\tilde{p}^e$	0.93	0.98	0.71	0.98	0.69	0.91
Elasticity $\epsilon(\hat{u}, \hat{p}^e)$	-1.51	-0.44	-5.87	-0.40	-6.02	-1.75

prospects created by higher $\tilde{p}^e$.

The second row shows the slope of the expected present value of wage payments $\tilde{w}$ with respect to $\tilde{p}^e$. With constant z, the increase in the worker's outside option in the standard MP model makes wages respond flexibly to productivity as well. In the Hagedorn-Manovskii model, the insensitivity of the outside option to movements in productivity makes the wage more rigid. This difference explains the success of the Hagedorn-Manovskii calibration in generating volatile unemployment fluctuations, shown in the third row of Table 7.

Turning to the Hall and Milgrom model with constant z, here too the change in job prospects of an unemployed makes $\tilde{U}^u$ sensitive to variations in $\tilde{p}^e$. However, with alternating-offer bargaining, returning to the general search pool with value $\tilde{U}^u$ no longer constitutes the worker's outside option. Instead, the unemployed's threat point is to continue to bargain, in which case he receives a flow value z. Therefore, wages do not respond significantly to productivity variations, and the volatility of unemployment increases.

Summing up, both the Hagedorn and Manovskii (2008) calibration and the Hall and Milgrom (2008) alternating-offers model achieve volatile unemployment in part by generating endogenous wage rigidity. In both cases, the wage rigidity comes from increasing the importance of z to the worker's outside option, in Hagedorn and Manovskii (2008) by calibrating a higher z, and in Hall and Milgrom (2008) by changing the bargaining game to increase the weight of z in the outside option. This logic makes clear why both models no longer generate volatile unemployment if z moves cyclically. In that event, the outside option in both models again becomes sensitive to productivity, wages become volatile, and the firm's incentive to increase employment following a positive shock to $\tilde{p}^e$ becomes weaker. The columns labeled Cyclical z in Table 7 illustrate this point quantitatively.[25]

8 Risk Sharing versus Self Insurance

Our analysis so far uses a model in which idiosyncratic employment risk is perfectly shared across agents. This follows from the assumption of a single budget constraint with a household-level asset (the capital stock), from which the marginal utilities of consumption of the employed and unemployed must equalize in all states of the world. We now show that the economic intuition for a cyclical z is robust to allowing for imperfections in risk sharing. With full risk sharing, the opportunity cost of employment changes in response to uninsurable aggregate risk that causes changes in the (common) marginal utility of consumption. When employed and unemployed cannot share their idiosyncratic risks, the existence of aggregate risk still leads to fluctuations of the (different) marginal utilities and generates a procyclical opportunity cost.

To illustrate this result, we focus on a stripped down version of our model. The most prominent simplification is that we look at the problem of a household from a partial equilibrium perspective. We denote by x_t the exogenous aggregate state of the economy and by $\pi(x_{t+1}|x_t)$ the probability that the exogenous state transits from some x_t to some x_{t+1}. In the model with perfect risk sharing, the household's value function is:

$$V(x_t, a_t) = e_t U^e(C_t^e, N_t) + (1 - e_t) U^u(C_t^u, 0) + \beta \sum_{x_{t+1}} \pi(x_{t+1}|x_t) V(x_{t+1}, a_{t+1}), \qquad (36)$$

subject to the single budget constraint $e_t C_t^e + (1-e_t) C_t^u + a_{t+1} + T_t = e_t w_t N_t + (1-e_t) b_t + (1+r_t) a_t$ and the borrowing constraint $a_{t+1} \geq \bar{a}$. As before, the opportunity cost of employment is $z_t^R = b_t + (U_t^u/\lambda_t - C_t^u) - (U_t^e/\lambda_t - C_t^e)$, where λ_t is the common marginal utility of consumption, and the R superscript stands for "risk sharing."

[25] With cyclicality in z, the Hall-Milgrom model performs better than the Hagedorn-Manovskii model. This is because in the Hall-Milgrom model wages partly depend on a firm-specific cost of continuing bargaining which is assumed to be constant over the business cycle.

Now consider the problem of a worker who cannot share risks perfectly with other members of the household, but instead accumulates assets to self insure against idiosyncratic employment shocks. The value function of an employed worker starting with assets a_t is:

$$V^e(x_t, a_t) = U^e(C_t^e, N_t) + \beta \sum_{x_{t+1}} \pi(x_{t+1}|x_t) \left((1-s_t)V^e(x_{t+1}, a_{t+1}^e) + s_t V^u(x_{t+1}, a_{t+1}^e)\right), \quad (37)$$

subject to the budget constraint $C_t^e + a_{t+1}^e + T_t = w_t N_t + (1+r_t)a_t$ and the borrowing constraint $a_{t+1}^e \geq \bar{a}$. The value function of an unemployed worker starting with assets a_t is:

$$V^u(x_t, a_t) = U^u(C_t^u, 0) + \beta \sum_{x_{t+1}} \pi(x_{t+1}|x_t) \left((1-f_t)V^u(x_{t+1}, a_{t+1}^u) + f_t V^e(x_{t+1}, a_{t+1}^u)\right), \quad (38)$$

subject to the budget constraint $C_t^u + a_{t+1}^u + T_t = b_t + (1+r_t)a_t$ and the borrowing constraint $a_{t+1}^u \geq \bar{a}$. Note that the lump sum transfer T_t does not depend on employment status.

We define the surplus from employment starting from assets a_t as $J_t^S = V^e(x_t, a_t) - V^u(x_t, a_t)$, where S stands for "self insurance." We define next period's surplus from employment in the scenario that the path of assets are given by a_{t+1}^u as $J_{t+1}^S = V^e(x_{t+1}, a_{t+1}^u) - V^u(x_{t+1}, a_{t+1}^u)$. By substituting (37) and (38) into J_t^S we obtain:

$$\frac{J_t^S}{\lambda_t^u} = w_t N_t - z_t^S + (1 - s_t - f_t) E_t \frac{\beta \lambda_{t+1}^u}{\lambda_t^u} \frac{J_{t+1}^S}{\lambda_{t+1}^u}, \quad (39)$$

where

$$z_t^S = b_t + \left(\frac{U_t^u}{\lambda_t^u} - C_t^u\right) - \left(\frac{U_t^e}{\lambda_t^u} - C_t^e\right) + z_t^A, \quad (40)$$

and where z_t^A denotes a component of the opportunity cost related to the differential asset accumulation between the employed and the unemployed.[26]

To simulate the model, we assume that the state x_t includes the employment rate e_t, the separation rate s_t, the wage w_t, hours per employed worker N_t, and benefits per unemployed b_t. To assess the cyclicality of the opportunity cost, we define a "good state" in which the exogenous

[26] This term is $z_t^A = -\frac{\beta}{\lambda_t^u} E_t \left[(1-s_t)\left(V^e(x_{t+1}, a_{t+1}^e) - V^e(x_{t+1}, a_{t+1}^u)\right) + s_t \left(V^u(x_{t+1}, a_{t+1}^e) - V^u(x_{t+1}, a_{t+1}^u)\right)\right] + a_{t+1}^e - a_{t+1}^u$. Moving a worker from unemployment to employment (holding constant initial assets at a_t) causes a "budgetary" loss due to the fact that employed accumulate more assets. This is the $a_{t+1}^e - a_{t+1}^u$ term. There is an offsetting utility effect because in the next period the worker will start with higher assets. This is captured by the term in brackets, and depends on future employment. With probability $1 - s_t$ the worker will remain employed, so the asset differential is valued under the value function V_{t+1}^e. With probability s_t the worker will become separated, so the asset differential is valued under the value function V_{t+1}^u.

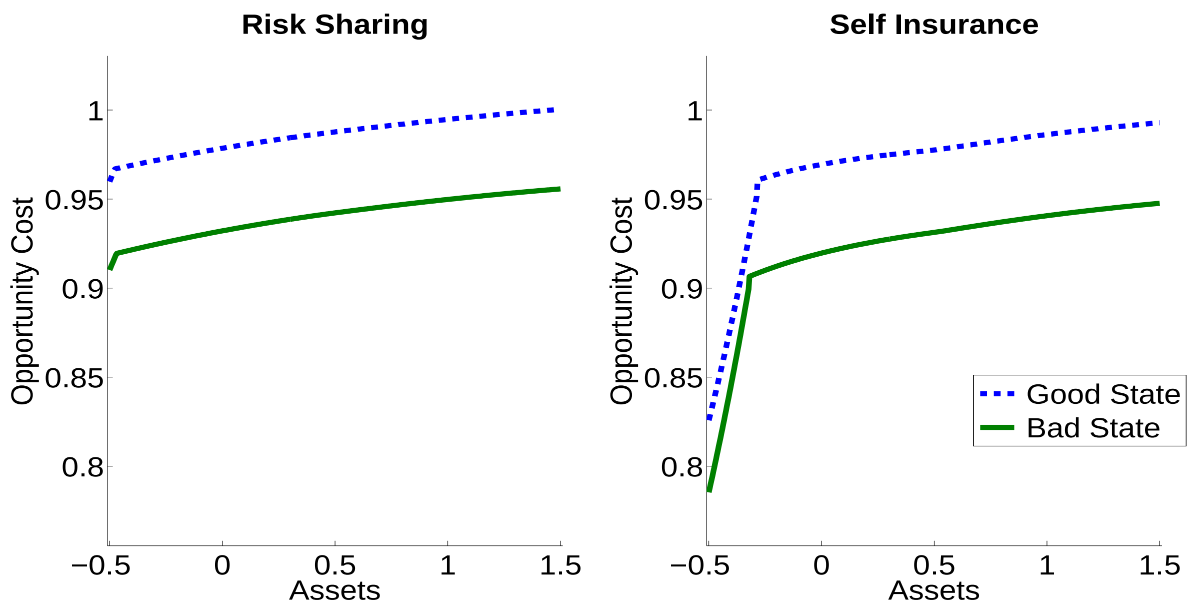

Figure 6: Opportunity Cost Under Alternative Risk Sharing Arrangements

Notes: The left panel plots the opportunity cost of employment z_t^R for the model with perfect risk sharing in a good state (dashed line) and in a bad state (solid line). The right panel plots the opportunity cost of employment z_t^S for the model with self insurance.

shocks e_t, w_t, and N_t are two standard deviations above their trend and the exogenous shocks s_t and b_t are two standard deviations below their trend, and define a "bad state" symmetrically. We set the borrowing constraint to $\bar{a} = -0.5$. Parameters are similar to those in Table 3 with a few exceptions.[27]

Figure 6 plots the opportunity costs of employment, z_t^R and z_t^S, in the models with perfect risk sharing and self insurance for different starting assets and aggregate states. Several results are worth highlighting. First, the opportunity cost is in general lower in the model with self insurance. With imperfect risk sharing, workers save more to insure against idiosyncratic shocks. Lower consumption for a given level of assets means that the marginal utility of consumption for both the unemployed and the employed is higher relative to the model with perfect risk sharing. As initial assets increase, the probability of hitting the borrowing constraint becomes smaller, and the opportunity cost in the model with self insurance approaches the level of the

[27] We pick the lump sum transfer T_t such that the C^u/C^e ratio in the model with self insurance is 10 percentage points lower than the ratio of 0.795 that we target for the model with perfect risk sharing. We calibrate χ to target an opportunity cost of roughly 0.955 in the space of assets shown in Figure 6. Accordingly, we adjust ρ such that $C^u/C^e = 0.795$ with perfect risk sharing. Finally, we discretize the state in five values and assume that the transition matrix is given by $\pi(x_{t+1} = x_j | x_t = x_i) = 0.96$ for $j = i$ and $\pi(x_{t+1} = x_j | x_t = x_i) = 0.01$ for $j \neq i$.

opportunity cost in the model with perfect risk sharing.

Second, in both models the opportunity cost increases in the level of assets, indicating less willingness to work for wealthier workers. This increase is much sharper for workers close to the borrowing constraint in the model with self insurance. These workers have a very high marginal utility of consumption and so become more willing to work for a given wage. The positive relationship between assets and the opportunity cost implies procyclical movements of the opportunity cost in both models if in recessions the equilibrium capital stock declines.

Third, in both models the opportunity cost is procyclical, as evidenced by the upward shift of the dashed line relative to the solid line. This reflects the fact that in the good state the marginal utility of consumption falls relative to the value of non-working time. Additionally, unemployed workers in the bad aggregate state face a lower job finding probability. In the model with self insurance, this further raises their precautionary savings and lowers their marginal utility.[28]

9 Conclusion

This paper has shown that the flow value of the opportunity cost of employment falls during recessions. The key mechanism is that the household values most the contribution of the employed (through higher wage income) relative to that of the unemployed (through higher non-working time) when market consumption is low and non-working time is high. This more than offsets the effect of the increase in government benefits. Our preferred estimate of the elasticity of the opportunity cost with respect to the marginal product of employment is unity. With this value, fluctuations in unemployment generated by the model are essentially neutral with respect to the level of z, and remain far smaller than unemployment fluctuations in the data.

An interpretation of our results is that endogenous forms of wage rigidity, such as accom-

[28] These results are robust in the region where the unemployed do not hit the borrowing constraint in the next period, corresponding to the right of the kink in the right panel of Figure 6. While the figure shows an increase in the opportunity cost to the left of the kink, this result depends on the parameterization. Because in equilibrium a positive capital stock implies the average household has positive assets, we find the region to the right of the kink (away from the borrowing constraint) to be the most relevant.

plished by Hagedorn and Manovskii (2008) and by Hall and Milgrom (2008), do not survive the introduction of a cyclical flow opportunity cost. Without rigid wages, these models cannot generate volatile unemployment. This pessimistic conclusion does not apply to models where wages are exogenously sticky or selected according to some process that does not depend on worker's opportunity cost of employment. The extent to which actual wages vary cyclically remains an open and important question.

Our quantitative results also apply only to the extensive margin of labor supply. The same economic reasoning that makes the extensive margin choice sensitive to the marginal utility of consumption relative to the value of non-working time would also affect the intensive margin choice. However, we have not modeled the complicated set of benefit phase-out schedules that give rise to high implicit marginal tax rates at the low end of the income distribution (Mulligan, 2012), and so cannot say quantitatively whether cyclical variation in benefits phase-outs overwhelms the effect of the higher marginal utility of consumption relative to the value of non-working time during recessions.

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Appendix

A Data

This Appendix describes the data sources used in the paper and details some further issues related to the construction of the samples and the definitions of our variables.

CPS. The Census Bureau administers the March CPS Social and Economic Supplement to the approximately 57,000 households in the basic monthly CPS sample, and in recent years to an additional 42,000 households drawn from surrounding months. An address selected for the monthly CPS sample will be asked to complete interviews in eight calendar months. The CPS employs a rotating sample, where the household will participate in the survey for four consecutive months, not participate for eight months, and then reenter the sample for four more months. Addresses that complete their first, second, third, or fourth interview in March of year t will therefore also appear in the sample in March of year $t+1$. Hence up to half of the respondents in the March Supplement drawn from the basic monthly CPS sample appear in consecutive Supplements.

The CPS March Supplement documentation files contain instructions for matching observations in consecutive Supplements. We follow Madrian and Lefgren (1999) in validating matches using demographic characteristics reported in both years. In particular, we require that matched observations report the same sex and race in both years, report levels of educational attainment no more than one year apart and non-decreasing, and report a difference in age of not more than two years and non-decreasing. Matching of the 1995 and 1996 Supplements is not possible because of the introduction of the 1990 Census design sample in the 1996 Supplement.

SIPP. The SIPP began in 1979 as a longitudinal survey with the objective of interviewing individuals in a representative sample of households once every four months for a 32 month period. In 1996 the survey underwent a major redesign, including increasing the size of the initial sample, increasing the interview period to four years, and oversampling households from high poverty areas. We use the 1996, 2001, 2004, and 2008 panels. In each wave of a panel, the household reports employment status and income for each of the previous four months. We average employment status and aggregate income for each four month period, and then take first differences to obtain equation (20). Because of gaps between panels, the SIPP does not have any observations in certain months of 2000, 2001, 2004, and 2008.

CE. The Consumer Expenditure Survey interviews households every three months for up to five interviews. The first interview initiates the household into the sample and collects basic demographic information. At interviews 2-5, the respondent reports expenditure over the prior three months on a detailed set of categories designed to cover the universe of household expenditure. Interview 2 and interview 5 collect information about weeks worked over the twelve month period ending at the time of the interview. Hence at the fifth interview, we have information on both weeks worked and total expenditure over the previous year.

Our CE sample covers 1983-2012 and consists of respondents where the household completed all four interviews, and with a household head between 30 and 55 years old at the time of the final interview. We additionally restrict the sample to households which did not change size over the 12 month interview period, the head did not work in farming, forestry, fishing, or armed services, and in which food expenditure over the year exceeds 500 dollars in 2009 dollars.

Our definition of nondurable goods and services less housing, health, and education follows conventional NIPA definitions. We use a crosswalk provided by Cooper (2010) to map the PSID categories of clothing, recreation, and vacation into CE UCC codes.

PSID. The PSID began in 1968. The initial sample contained 2,930 families drawn from a nationally representative sampling frame, and 1,872 "SEO" families drawn from a low-income sampling frame. Each year from 1968-1996, the PSID attempted to reinterview all persons living in families in the 1968 sample, as well as anyone born to or adopted by a previous PSID respondent. Our sample includes all households derived from the 1968 sample, and we use sampling weights to adjust for the low-income over-sample and attrition. Our sample also includes the roughly 500 immigrant families added in 1997, but does not include the Latino sample added in 1990 and dropped after 1995. Also in 1997, the PSID stopped following roughly one-quarter of the original sample, and began conducting interviews every other year.

To facilitate comparisons with the CE, we restrict the PSID sample to households with a head between 30 and 55 at the time of the interview, with no change in family composition between interview years, and with real food expenditure in both years of at least 500 dollars.

UI Administrative Data. NIPA table 2.6 (line 21) reports the dollar value of all benefits, by month, including extended benefit and emergency compensation tiers, based on unpublished data from the Employment Training Administration (ETA). The data begin in 1959.[29] Data on the number of claimants in all tiers come from the ETA for 1986-2013.[30] Prior to 1986, we collect data on the number of claimants in regular and extended benefits tiers from the statistical Appendix to the Economic Report of the President (ERP). Each year, the ERP lists the number of claimants in regular and extended benefit tiers, by month, for the previous two years. We digitize these data, seasonally-adjust the regular claims and benefits using X-11, and then add the unadjusted data for extended benefits tiers to form a single monthly time-series of recipients and benefits. Finally, we adjust the recipients series by the ratio of benefits payments for all tiers from the NIPA to benefits payments in regular and extended benefits tiers in the ERP to arrive at a series for the number of claimants in all tiers beginning in 1959.

Medicaid Administrative Data. NIPA table 2.6 (line 20) reports the dollar value of Medicaid spending, by month.

Food Stamps/SNAP Administrative Data. For 1980-2012, we use monthly data on benefits disbursements from the Quality Control files maintained by Mathematica. The Quality Control files provide microdata on a representative sample of SNAP recipients used to assess

[29]See http://www.bea.gov/national/pdf/mp5.pdf for a description of the source data for the NIPA estimates of UI, SNAP, TANF, and AFDC/TANF.

[30]http://ows.doleta.gov/unemploy/docs/persons.xls.

program fraud, and contain weights that aggregate up to the administrative total of recipients and benefits each month.[31] Prior to 1980, we use the annual dollar value as reported in NIPA table 3.12 (line 21), and linearly interpolate over the year.

AFDC/TANF. NIPA table 3.12 (line 35) reports the dollar value of AFDC/TANF spending, by year. We convert the annual total to monthly values by assuming that the within-year time path of spending equals the within-year distribution of caseloads. We obtain monthly caseloads for 1960-2011 from the U.S. Department of Health and Human Services Office of Family Assistance.[32]

Calculating C_t^e and C_t^u. Here we show how to construct C_t^e, which is the counterfactual level of expenditure an unemployed individual would consume had he been employed. The procedure accounts for the fact that the average person experiencing unemployment has demographic characteristics associated with lower lifetime income than the population average, suggesting a consumption which is lower than average per capita consumption.

In levels, the consumption of an individual of duration $D_{i,t}$ is

$$\tilde{C}_{k,i,t}^{D} = \exp\left(\phi_{k,t}\mathbf{X}_{i,t} + \left(\gamma_{k,t} - 1\right) D_{i,t} + \epsilon_{k,i,t}\right) \tilde{C}_{k,t}^{e}.$$

The average per household expenditure of persons in the labor force is given by:

$$\sum_i \omega_{i,t}\tilde{C}_{k,i,t}^{D} \approx \tilde{C}_{k,t}^{e} \sum_i \omega_{i,t} \exp\left(\phi_{k,t}\mathbf{X}_{i,t} + \left(\gamma_{k,t} - 1\right) D_{i,t}\right),$$

where $\omega_{i,t}$ is the sampling weight. From this equation we can solve for the consumption of a hypothetical employed evaluated at the demographic characteristics of the average unemployed in the CE:

$$\tilde{C}_{k,t}^{e} = \frac{\sum_i \omega_{i,t}\tilde{C}_{k,i,t}^{D}}{\sum_i \omega_{i,t} \exp\left(\phi_{k,t}\mathbf{X}_{i,t} + \left(\gamma_{k,t} - 1\right) D_{i,t}\right)}.$$

[31] See http://hostm142.mathematica-mpr.com/fns/2011/tech%20doc%202011.pdf for further description of the QC data.

[32] http://archive.acf.hhs.gov/programs/ofa/data-reports/caseload/caseload_current.htm.

Finally, we adjust for the under-reporting of consumption expenditure in the CE relative to the NIPA by making $C^e_{k,t}$ a fixed multiple of NIPA per capita consumption using the formula:

$$C^e_{k,t} = C^{\text{NIPA}}_{k,t} \left(\frac{1}{T} \sum_t \frac{\tilde{C}^e_{k,t}}{\sum_i \omega_{i,t} \tilde{C}_{k,i,t}} \right),$$

where the denominator measures average per capita consumption across all households (including those out of the labor force) in the CE.

We estimate an internally consistent measure of the consumption of the unemployed C^u_t using the series of C^e_t together with our estimated preference parameters and the risk-sharing condition (4). The time series of C^u_t using the risk sharing condition lie comfortably within the confidence interval shown in Figure 2. While for internal consistency we prefer to infer C^u_t from the risk sharing condition, an alternative is to simply set $C^u_t = (1-\gamma)C^e_t$ for our estimated $\gamma = 0.795$ and then infer the time-varying wedge that would make the risk sharing condition hold exactly in the data. These two approaches yield very similar results.

B Derivations

Equations (7), (8), and (9). To simplify the notation, we suppress the dependence of the value function on the capital stock K_t and the exogenous shocks $\mathbf{Z}_t$ and write the value function as $W^h(e_t, \omega_t)$ instead of $W^h(e_t, \omega_t, K_t, \mathbf{Z}_t)$. The maximization problem of the household in recursive form is:

$$W^h(e_t, \omega_t) = \max \left\{ e_t U^e_t + (1-e_t) U^u_t - (1-e_t)\omega_t \zeta_t \tilde{\psi}(\zeta_t) + \beta E_t W^h(e_{t+1}, \omega_{t+1}) \right\}, \quad \text{(A.1)}$$

subject to the budget constraint (2), the law of motion for employment $e_{t+1} = (1-s_t)e_t + m_t = f_t + (1-s_t-f_t)e_t$, and the law of motion for the share of eligible unemployed (3). Differentiating (A.1) with respect to e_t we take:

$$\frac{\partial W^h(e_t,\omega_t)}{\partial e_t} = U^e_t - U^u_t + \omega_t \psi(\zeta_t) + \lambda_t \left(w_t N_t - C^e_t + C^u_t - B_{n,t} - B_{u,t} \right) + \\ \beta E_t \frac{\partial W^h(e_{t+1},\omega_{t+1})}{\partial e_{t+1}} \frac{\partial e_{t+1}}{\partial e_t} + \beta E_t \frac{\partial W^h(e_{t+1},\omega_{t+1})}{\partial \omega_{t+1}} \frac{\partial \omega_{t+1}}{\partial e_t}, \quad \text{(A.2)}$$

where $\psi(\zeta_t) = \zeta_t \tilde{\psi}(\zeta_t)$. The first derivative in equation (A.2) can be calculated using the law of motion for employment:

$$\frac{\partial W^h(e_{t+1}, \omega_{t+1})}{\partial e_{t+1}} \frac{\partial e_{t+1}}{\partial e_t} = (1 - s_t - f_t) \frac{\partial W^h(e_{t+1}, \omega_{t+1})}{\partial e_{t+1}}. \tag{A.3}$$

For the second derivative in equation (A.2), we first calculate the derivative of ω_{t+1} with respect to e_t using the law of motion for the share of eligible unemployed (3):

$$\frac{\partial \omega_{t+1}}{\partial e_t} = \left(\omega^e_{t+1} - \omega^u_{t+1}\omega_t\right) \frac{s_t(1 - f_t)}{(1 - e_{t+1})^2}. \tag{A.4}$$

Note that an increase in employment in period t increases the fraction of eligible unemployed in $t+1$ if the probability that newly unemployed workers receive benefits exceeds the probability that long-term unemployed receive benefits, $\omega^e_{t+1} > \omega^u_{t+1}\omega_t$. While the household recognizes the effect of employment on future benefit eligibility, it treats the job-finding probability $f_t(\theta_t)$ as constant when contemplating a change in the number of employed.

To calculate $\partial W^h(e_{t+1}, \omega_{t+1})/\partial \omega_{t+1}$, we first calculate the partial derivative of the value function $W^h(e_t, \omega_t)$ with respect to ω_t and then we forward this equation by one period:

$$\frac{\partial W^h(e_{t+1}, \omega_{t+1})}{\partial \omega_{t+1}} = (1 - e_{t+1}) \left(-\psi_{t+1} + \lambda_{t+1}\zeta_{t+1}\tilde{B}_{t+1}\right) + \beta E_{t+1} \frac{\partial W^h(e_{t+2}, \omega_{t+2})}{\partial \omega_{t+2}} \frac{\partial \omega_{t+2}}{\partial \omega_{t+1}}, \tag{A.5}$$

where

$$\frac{\partial \omega_{t+2}}{\partial \omega_{t+1}} = \frac{\omega^u_{t+2}(1 - f_{t+1})u_{t+1}}{u_{t+2}}. \tag{A.6}$$

The fact that increasing employment in period t increases the fraction of eligible unemployed in period $t+1$ affects the future value of the household through two channels. The first term in equation (A.5) captures the direct effect of changes in ω_{t+1} on the value of the household. This direct effect consists of the gain from receiving future benefits less than the costs associated with collecting benefits. The second term in equation (A.5) captures the effect of changes in ω_{t+1} on the future eligibility probability ω_{t+2}.

One can forward equation (A.5) to solve for $\partial W^h(e_{t+1}, \omega_{t+1})/\partial \omega_{t+1}$ as a function of the discounted expected value of all future net gains $(1 - e_{t+j}) \left(-\psi_{t+j} + \lambda_{t+j}\zeta_{t+j}\tilde{B}_{t+j}\right)$ for all $j \geq 1$. To make measurement of the opportunity cost related to UI benefits in the data feasible, we impose the additional restriction that the household perceives the discounted future marginal value of increasing the current share of eligible unemployed to be constant over time.[33] Formally, we impose that household expectations in period $t+1$ are:

$$E_{t+1}\beta\frac{\partial W^h(e_{t+2},\omega_{t+2})}{\partial\omega_{t+2}}\frac{\partial\omega_{t+2}}{\partial\omega_{t+1}}=\frac{\partial W^h(e_{t+1},\omega_{t+1})}{\partial\omega_{t+1}}\frac{\partial\omega_{t+1}}{\partial\omega_t}\frac{\beta\lambda_{t+1}}{\lambda_t}. \tag{A.7}$$

Substituting (A.7) into (A.5) we obtain:

$$\frac{\partial W^h(e_{t+1},\omega_{t+1})}{\partial\omega_{t+1}}=(1-e_{t+1})\left(-\psi_{t+1}+\lambda_{t+1}\zeta_{t+1}\tilde{B}_{t+1}\right)\Gamma_{t+1}, \tag{A.8}$$

where $\Gamma_{t+1}=\left(1-\frac{\beta\lambda_{t+1}}{\lambda_t}\frac{\omega^u_{t+1}(1-f_t)u_t}{u_{t+1}}\right)^{-1}$.

The final step before deriving a recursive representation for the marginal value of employment is to derive the surplus per recipient from UI benefits. For any t we take:

$$\lambda_t\zeta_t\tilde{B}_t-\psi_t(\zeta_t)=\lambda_t\zeta_t\tilde{B}_t\left(1-\frac{\psi_t}{\psi_t'\zeta_t}\right)=\lambda_t\zeta_t\tilde{B}_t\left(1-\frac{1}{\alpha}\right), \tag{A.9}$$

where the first equality follows from the first-order condition (6) with respect to ζ_t and the second equality uses the definition of the elasticity of the cost function $\alpha=\psi_t'\zeta_t/\psi_t$.

Substituting equations (A.3), (A.4), (A.8), and (A.9) into equation (A.2), dividing by λ_t, and defining $J^h_t=\partial W^h\left(e_t,\omega_t,K_t,\mathbf{Z}_t\right)/\partial e_t$ leads to equations (7), (8), and (9) in the text.

Equation (14). Substituting the law of motion for employment $e_{t+1}=(1-s_t)e_t+m_t=(1-s_t)e_t+q_tv_t$ into equation (13) and taking the partial derivative with respect to v_t yields:

$$\frac{\kappa_t}{q_t}=E_t\tilde{\beta}_{t+1}\frac{\partial W^f\left(e_{t+1},\mathbf{Z}_{t+1}\right)}{\partial e_{t+1}}. \tag{A.10}$$

Note that the firm recognizes the effect of vacancy creation on future employment (through the law of motion of employment), but treats the vacancy-filling probability $q_t(\theta_t)$ as constant when choosing how many vacancies to post.

The Envelope condition is:

$$\frac{\partial W^f\left(e_t,\mathbf{Z}_t\right)}{\partial e_t}=\left(p^n_t-w_t\right)N_t+\frac{\kappa_t(1-s_t)}{q_t}. \tag{A.11}$$

[33] We have also experimented with using realizations of the term $(1-e_{t+j})\left(-\psi_{t+j}+\lambda_{t+j}\zeta_{t+j}\tilde{B}_{t+j}\right)$ in the data for large j's in order to measure the b_t component of the opportunity cost. This made no significant difference for our results.

Forwarding equation (A.11) by one period, multiplying by $\tilde{\beta}_{t+1}$, and taking expectations yields:

$$E_t\tilde{\beta}_{t+1}\frac{\partial W^f\left(e_{t+1},\mathbf{Z}_{t+1}\right)}{\partial e_{t+1}}=E_t\tilde{\beta}_{t+1}\left(\left(p^n_{t+1}-w_{t+1}\right)N_{t+1}+\frac{\kappa_{t+1}(1-s_{t+1})}{q_{t+1}}\right). \tag{A.12}$$

Finally, substituting (A.12) into (A.10) yields equation (14) in the text.

Equation (15). Equation (A.11) defines the firm's marginal value from an additional employed worker:

$$J^f_t=\frac{\partial W^f\left(e_t,\mathbf{Z}_t\right)}{\partial e_t}=\left(p^n_t-w_t\right)N_t+\frac{\kappa_t(1-s_t)}{q_t}. \tag{A.13}$$

To obtain the recursion in equation (15) of the text, we note that the first-order condition for vacancies in equation (A.10) implies that the last term of equation (A.13) can be written as:

$$\frac{\kappa_t(1-s_t)}{q_t}=(1-s_t)E_t\tilde{\beta}_{t+1}J^f_{t+1}. \tag{A.14}$$

This is a free-entry condition. The cost of posting one vacancy κ_t equals the expected marginal value of adding a worker, conditional on filling the vacancy and conditional on the worker not being separated in the next period.

Equation (17). To derive the wage equation we start with the surplus-splitting rule $(1-\mu)J^h_t/\lambda_t=\mu J^f_t$ and substitute the definitions of J^h_t/λ_t in equation (7), of J^f_t in equation (15):

$$(1-\mu)\left(w_tN_t-z_t+(1-s_t-f_t)E_t\beta\frac{J^h_{t+1}}{\lambda_t}\right)=\mu\left(p^n_tN_t-w_tN_t+(1-s_t)E_t\tilde{\beta}_{t+1}J^f_{t+1}\right). \tag{A.15}$$

We now need to substitute out the terms $E_t\beta J^h_{t+1}/\lambda_t$ and $E_t\tilde{\beta}_{t+1}J^f_{t+1}$. For the latter term, we use equation (A.14). For the former term, forward the surplus-splitting rule $(1-\mu)J^h_t=\mu\lambda_tJ^f_t$ by one period, and then multiply both sides by β/λ_t and take expectations:

$$E_t\beta\frac{J^h_{t+1}}{\lambda_t}=\frac{\mu}{1-\mu}E_t\tilde{\beta}_{t+1}J^f_{t+1}=\frac{\mu}{1-\mu}\frac{\kappa_t}{q_t}, \tag{A.16}$$

where the last equality uses once again equation (A.14).

As a result, equation (A.15) becomes:

$$(1-\mu)\left(w_tN_t-z_t+(1-s_t-f_t)\frac{\mu}{1-\mu}\frac{\kappa_t}{q_t}\right)=\mu\left(p^n_tN_t-w_tN_t+\frac{\kappa_t(1-s_t)}{q_t}\right). \tag{A.17}$$

Solving equation (A.17) for the wage and using $q_t = f_t/\theta_t$ and $p_t^e = p_t^n N_t$ yields equation (17) in the text.

Equation (31). We start with the surplus equation $S = J^h/\lambda + J^f$ in steady state. Substituting the definitions of J^h/λ in equation (7) and of J^f in equation (15) into the surplus equation, using $J^h/\lambda = \mu S$, and solving for the surplus yields:

$$S = \frac{J^h}{\lambda} + J^f = \frac{1}{1-(1-s-\mu f)\beta}\left(p^n N - z\right). \tag{A.18}$$

In steady state, the first-order condition for vacancy creation (A.14) becomes:

$$\frac{\kappa}{q} = \beta J^f = \beta(1-\mu)S \Longrightarrow S = \frac{\kappa}{q\beta(1-\mu)}. \tag{A.19}$$

Combining (A.18) and (A.19) and using $q = f/\theta$ and $p^e = p^n N$ yields equation (31) in the text.

Calibration of χ, ρ, and C^o. The first condition is the risk sharing condition in steady state:

$$\frac{C^e}{C^u} = 1 - (1-\rho)\frac{\chi\epsilon}{1+\epsilon}N^{1+\frac{1}{\epsilon}}. \tag{A.20}$$

Solving for ρ we take:

$$\rho(\chi) = 1 + \frac{C^e/C^u - 1}{\frac{\epsilon}{1+\epsilon}\chi N^{1+1/\epsilon}}. \tag{A.21}$$

Note that all terms on the right-hand side of this equation for ρ, except for χ, are either known parameters or known targeted moments from the data.

The second condition comes from the first-order condition for hours (16) after substituting the risk-sharing condition (A.20):

$$p^n = C^u(\chi)\rho(\chi)\chi N^{1/\epsilon}. \tag{A.22}$$

The third condition comes from the goods market clearing condition:

$$Y = eC^e + (1-e)C^u + C^o + \delta K + \kappa\theta(1-e). \tag{A.23}$$

By combining equations (A.22) and (A.23) we take solutions for C^o and C^u:

$$C^o(\chi) = Y - p^n e\frac{C^e - C^u}{p^n} - \frac{p^n}{\rho(\chi)\chi N^{1/\epsilon}} - \delta K - \kappa\theta(1-e). \tag{A.24}$$

$$C^u(\chi) = \left(\frac{1}{e\left(1-(1-\rho(\chi))\chi\frac{\epsilon}{1+\epsilon}N^{1+1/\epsilon}\right)+(1-e)} \right)(Y - \delta K - \kappa\theta(1-e) - C^o(\chi))\,. \tag{A.25}$$

Except for χ, all terms in the right-hand side of equations (A.24) and (A.25) are known parameters or targets.

The algorithm to calibrate χ, ρ, and C^o starts by solving equation (A.22) for χ after inserting equations (A.21), (A.24) and (A.25) and expressing all terms as a function of χ. After solving for χ, equation (A.21) yields ρ. Given ρ and χ, (A.24) gives a value for C^o.

C Solution of Model

Given a process for shocks $\mathbf{Z}_t$ and initial conditions for the capital stock K_0, employment e_0, and the share of eligible unemployed ω_0, we define an equilibrium of the model as a sequence of consumption for employed C_t^e, consumption for unemployed C_t^u, marginal utility λ_t, share of unemployed who take up benefits ζ_t, share of eligible unemployed for UI ω_{t+1}, investment X_t, capital K_{t+1}, hours per employed N_t, employment e_{t+1}, opportunity cost of employment related to benefits b_t, output Y_t, vacancies v_t, market tightness θ_t, marginal product of labor p_t^n, rental rate R_t, and wage w_t, such that:

1. The household maximizes its utility by satisfying the risk-sharing condition (4), the Euler equation (5), and the first-order condition for the optimal take-up rate (6).

2. The opportunity cost of employment related to benefits b_t is given by equation (9).

3. The firm sets the marginal product of capital $\partial Y_t/\partial K_t = R_t$ and chooses vacancies to satisfy the first-order condition (14).

4. Output is given by the production function $Y_t = F_t(K_t, e_t N_t)$ and the marginal product of labor satisfies $p_t^n = \partial Y_t/\partial(e_t N_t)$.

5. Hours per worker and wages are determined from bargaining according to equations (16) and (17).

6. Capital accumulates according to $K_{t+1} = (1-\delta)K_t + X_t$, employment evolves according to $e_{t+1} = (1-s)e_t + m_t(v_t, 1-e_t)$, and the share of eligible unemployed evolves according to $\omega_{t+1} = \omega_t \omega^u_{t+1}(1-f_t)u_t/u_{t+1} + \omega^e_{t+1} s_t e_t/u_{t+1}$.

7. Market tightness is defined as $\theta_t = v_t/u_t$.

8. The market for goods clears, $Y_t = e_t C^e_t + (1-e_t)C^u_t + C^o_t + X_t + \kappa_t v_t$.

These conditions define a system of 16 stochastic difference equations in 16 endogenous variables. This can be solved using standard methods for the solution of (linearized) systems of stochastic equations. Once these endogenous variables are solved for, one can solve in a straightforward manner for additional endogenous variables of the model (for example, the job-finding probability is $f_t = m_t(v_t, 1-e_t)/(1-e_t)$, and so on). The deterministic steady state of the economy is defined as an equilibrium of the model in which all variables are constant over time and agents expect no shocks to hit the economy.

D The Hall and Milgrom (2008) Model

Here we repeat elements from Hall and Milgrom (2008) that we borrow for our analysis in Section 7. The driving force in the model is productivity p^e_i where i is a discrete stationary state variable $i \in [1, 2, ..., N]$ with transition matrix $\pi_{i,i'}$. Workers and employers are risk neutral and discount future flows at a rate r.

The only change relative to Hall and Milgrom (2008) is that we allow the flow opportunity cost of employment to potentially vary across states z_i. Unemployed's value $\tilde{U}^u_i$ is given by:

$$\tilde{U}^u_i = z_i + \frac{1}{1+r}\sum_{i'} \pi_{i,i'}\left[f(\theta_i)\left(\tilde{w}_{i'} + \tilde{V}_{i'}\right) + (1-f(\theta_i))\tilde{U}^u_{i'}\right], \tag{A.26}$$

where $f(\theta_i)$ denotes the job finding probability, $\tilde{w}_{i'}$ denotes the present value of wages at the beginning of the next state i', and $\tilde{V}_{i'}$ denotes the value for the rest of the career conditional on being matched:

$$\tilde{V}_i = \frac{1}{1+r}\sum_{i'} \pi_{i,i'}\left[s\tilde{U}^u_{i'} + (1-s)\tilde{V}_{i'}\right]. \tag{A.27}$$

The present value of output produced over the course of a job is:

$$\tilde{p}_i^e = p_i^e + \frac{1}{1+r}\sum_{i'} \pi_{i,i'}(1-s)\tilde{p}_{i'}^e. \tag{A.28}$$

The zero-profit condition is given by:

$$q(\theta_i)\left(\tilde{p}_i^e - \tilde{w}_i\right) = \kappa. \tag{A.29}$$

Equations (A.26) to (A.29) are common in both the Nash bargaining model and in the alternating-offer bargaining model. With Nash bargaining the wage equation is given by:

$$\tilde{w}_i = \mu\tilde{p}_i^e + (1-\mu)\left(\tilde{U}_i^u - \tilde{V}_i\right). \tag{A.30}$$

In the alternating-offer model, we need to simultaneously solve for the offered payment $\tilde{w}_i$ from the employer and the counteroffer from the worker $\tilde{w}_i'$. The two equations replacing (A.30) are:

$$\tilde{w}_i + \tilde{V}_i = \delta\tilde{U}_i^u + (1-\delta)\left[z_i + \frac{1}{1+r}\sum_{i'} \pi_{i,i'}\left(\tilde{w}_{i'}' + \tilde{V}_{i'}\right)\right], \tag{A.31}$$

$$\tilde{p}_i^e - \tilde{w}_i' = (1-\delta)\left[-\gamma + \frac{1}{1+r}\sum_{i'} \pi_{i,i'}\left(\tilde{p}_{i'}^e - \tilde{w}_i\right)\right], \tag{A.32}$$

where δ denotes the probability that bargaining will exogenously terminate in the next period and γ denotes a cost that the employer incurs each period that bargaining continues.

Following Hall and Milgrom (2008), we discretize the productivity process in $N = 5$ points and use the transition matrix $\pi_{i,i'}$ shown in their Table 1. The Nash bargaining model consists of 25 equations that can be solved for 25 unknowns ($\tilde{U}_i^u$, $\tilde{V}_i$, θ_i, $\tilde{p}_i^e$, and $\tilde{w}_i$ for $i = 1, ..., 5$) and the alternating-offer bargaining model consists of 30 equations that can be solved for 30 unknowns ($\tilde{U}_i^u$, $\tilde{V}_i$, θ_i, $\tilde{p}_i^e$, $\tilde{w}_i$, and $\tilde{w}_i'$ for $i = 1, ..., 5$).

To solve these systems we use the Hall and Milgrom (2008) parameters listed in their Table 6. Hall and Milgrom (2008) discuss a separation rate of $s = 0.14/100$ in the text and show a separation rate of $s = 0.10/100$ in their Table 6. We set the separation rate to $s = 0.1383/100$ to make the steady state $\tilde{p}^e$ close to 636, which is the equilibrium value cited in Hall and Milgrom (2008).