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Cyclicality of Wages, Separations and Unemployment

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Abstracts

We introduce worker differences in labor supply, reflecting difference assets, into a model of separations, matching, and unemployment over the business cycle. Separating from employment when unemployment duration is long is particularly costly for workers with high labor supply. This provides a rich set of testable predictions across workers: those with higher labor supply, say due to lower assets, should display more procyclical wages and less countercyclical separations. Consequently, the model predicts that the pool of unemployed will sort toward workers with lower labor supply in a downturn. Because these workers generate lower rents to employers, this discourages vacancy creation and exacerbates the cyclicality of unemployment and unemployment durations. In SIPP data, we find that wages are much more procyclical while separations from employment are much less cyclical for those who work more. We see a strong compositional shift during recessions among the unemployed toward workers who typically work less.

KRF Classification : B030108
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Ⅰ. Introduction

Many authors have emphasized the role of wage rigidities in business cycle fluctuations. Most recently, Shimer (2004), Hall (2005a), and Gertler and Trigari (2006) show how restricting wage responses in a model with search frictions can greatly magnify cyclical fluctuations in unemployment. This work is motivated by findings, particularly in Shimer (2005), that a calibrated Mortenson-Pissarides (1994) model with flexible wages yields much less cyclicality in unemployment and unemployment durations relative to wages than seen in the data. But judging the empirical rigidity of wages relative to model predictions is precarious. The prediction that wages are strongly procyclical assumes: (a) that the shocks driving labor fluctuations act largely by shifting labor demand, and (b) that workers do not easily substitute between market and non-market activities. These assumptions are not readily tested.[1)] Most acutely, testing the model prediction relies on having a genuine measure of cyclical movements in the price of labor. Although measured aggregate real wages are relatively acyclical, wage rates for new hires are much more procyclical, as we document below. The key measure of labor cost for vacancy creation is the anticipated value of wages over the life of the employment match. If wages are smoothed relative to the shadow price of labor (e.g., Hall, 1980), this cost can vary considerably without corresponding movements in aggregate real wages.

A more robust prediction of wage flexibility is that employment

1) Related to (a) a number of potential cyclical shocks, for instance investment-specific technology shocks (e.g., Fisher, 2006), act in general equilibrium by shifting marginal rates of substitution as much as through labor's marginal product. Related to (b) Hagedorn-Manovski (2008) discuss parameterizing the Mortenson-Pissarides model, especially valuing payoffs to non-market activities such that the model matches the relative volatilities of unemployment and wages.

decisions are driven by comparative advantage. For this reason, we focus on our model's prediction for wage and employment cyclicality across workers. More precisely, we introduce worker heterogeneity in labor supply into a business cycle model of separations, matching, and unemployment under flexible wages. Workers with relatively low assets are predicted to have low reservation match qualities in order to stay in an employed match; these are workers with high labor supply. Recessions are times of longer unemployment duration. A worker who desires high labor supply will avoid separating into unemployment during these downturns---entering unemployment when unemployment duration is long is antithetical to high labor supply. This yields our key model predictions: Workers with high desired labor supply will exhibit more cyclical wages and less cyclical separations. We examine these predictions for workers in the Survey of Income and Program Participation (SIPP). As predicted by our model, wages are much more procyclical for workers who work more with this pattern mirrored by separations that are much less countercyclical.

As in Mortensen and Pissarides (1994), we model employment matches as facing changes in match quality, with bad draws possibly leading to endogenous separations. We depart from Mortensen and Pissarides in two important ways. We allow for diminishing utility in market goods, imperfect insurance as in Aiyagari (1994), and for leisure from not working; as a result, the incentive to trade work for search is increasing in a worker's wealth. We also depart from Mortensen and Pissarides by allowing for worker heterogeneity in assets.

Key to our model is that, because workers exhibit diminishing marginal utility in consumption and face imperfect insurance, the match-separation decision depend on a worker's wealth as well as match quality. Cyclicality of separations then hinges on the cross-sectional distribution of reservation match qualities, reflecting individuals' savings, which cannot be addressed in a representative agent construct. In a related model that abstracts from search frictions, Chang and Kim (2006, 2007) show that the cross-sectional distributions of wealth and productivity play a critical role in determining the elasticity of aggregate labor supply in a competitive equilibrium. Nakajima (2007) and Shao and Silos (2007) have also recently adopted diminishing marginal utility in consumption and imperfect risk sharing into the Mortenson-Pissarides model.[2)] However, Nakajima does not allow for heterogeneous productivity; and the paper allows for neither bargaining between individual workers and firms nor endogenous separation. These elements give us a much richer set of predictions for cyclicality in wages and separations across workers and generate our result that unemployment sorts toward workers with lower labor supply in a downturn, magnifying cyclicality in vacancies and unemployment.

Once a role for labor supply is allowed in separations, it naturally leads to differing separation decisions along the lines of comparative advantage. Workers with lower savings, and therefore lower consumption, are less willing to separate in the face of high unemployment. We reinforce this impact of savings by constraining allowable borrowing. This factor of low savings, ones associated with high labor supply, produce a comparative disadvantage in separating to unemployment during a recession. Our model employs flexible wage setting. Workers with higher labor supply, say due to lower savings, are more willing to take a wage cut in recessions to maintain employment. This generates a prediction for

2) Other papers that entertain wealth effects in modeling search include Pissarides (1987), Gomez, Greenwood, and Rebelo (2001), and Hall (2006).

wages that inversely mirrors that in separations---workers with higher labor supply should exhibit more cyclical wages as well as less cyclical separations.

Shimer (2005), Hall (2005a), and Costain and Reiter (2008) have each argued that reasonable calibrations of standard search and matching models with flexible wages yield predictions dramatically at odds with the data---the models generate much more procyclical wages and much less procyclical job finding rates than observed. Wage-setting rigidities can mute the inducement from lowered wages to create vacancies during recessions. Our model, despite flexible wage setting, produces an effect that, qualitatively like wage rigidity, suppresses vacancy creation in recessions. When unemployment duration increases in a downturn this shifts separations, and thereby the pool of unemployed, toward workers with low labor supply. Creating vacancies for these workers is less attractive because their employment generates smaller expected surplus. For our model calibrations we find this cyclical sorting can contribute importantly to cyclicality in unemployment and unemployment durations. In the SIPP data, especially for men, we do see a strong compositional shift during recessions among the unemployed toward workers who typically work less independently of the stage of the cycle. We see a similar cyclical compositional shift among the set of workers transiting from unemployed to employed. Thus the data support our model's prediction that during recessions vacancies must draw from workers who exhibit lower labor supply.

The paper is organized as follows. We present the model in the next section. In Section Ⅲ, we calibrate the model to mimic average separation, and solve the equilibrium numerically. In Section Ⅳ, we introduce the SIPP data and illustrate how separations behave cyclically. We do see patterns consistent with our model of comparative advantage. In particular, wages are more cyclical and separations from employment less cyclical for workers who work more. Similarly consistent with the model, workers with few assets relative to earnings show more cyclical wages and less cyclical employment separations, though this latter effect is only marginally significant. Unlike our simulated model, we find that higher-wage workers actually show more cyclical employment separations. Section Ⅴ discusses possible interpretations of this finding and concludes.

Ⅱ. Model

There is a continuum of infinitely-lived workers with total mass equal to one. Each worker has preferences defined by

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_t^{1-\gamma}-1}{1-\gamma} + B \cdot l_t \right\},$$

where $0 < \beta < 1$ is the discount factor, and $c_t(>0)$ is consumption. The parameter B denotes the utility from leisure when unemployed. l_t is 1 when unemployed and otherwise zero. In Mortenson and Pissarides (1994), and many extensions, there is no valuation of leisure; so a marginal rate of substitution between consumption and leisure is not defined. Here the marginal rate of substitution ($c^{-\gamma}/B$) is decreasing in c. This provides the basis for a worker's reservation match quality to be increasing in consumption and thereby savings.

Each period a worker either works (employed) or searches for a job (unemployed). A worker, when working, earns wage $w. If unemployed, a worker receives an unemployment benefit b. Each can borrow or lend at a given real interest rate r by trading the asset a. But there is a limit, $\underline{a}$, that one can borrow; that is $a_t \geq \underline{a}$. Real interest rate r is determined exogenously to fluctuations in this particular economy (small open economy).

There is also a continuum of identical agents we refer to as entrepreneurs (or firms). Entrepreneurs have the ability to create job vacancies with a cost κ per vacancy. Entrepreneurs are risk neutral (diversifying ownership of their investments across many vacancies and across economies) and maximize the discounted present value of profits:

$$E_0 \sum_{t=0}^{\infty} \left(\frac{1}{1+r} \right)^t \pi_t.$$

There are two technologies in this economy, one that describes the production of output by a matched worker-entrepreneur pair and another that describes the process by which workers and entrepreneurs become matched. A matched pair produces output:

$$y_t = z_t x_t,$$

where z_t is aggregate productivity and x_t is idiosyncratic match-specific productivity. Both aggregate productivity and idiosyncratic productivity evolve over time according to the Markov process $\Pr[z_{t+1} \leq z' | z_t = z] = D(z'|z)$ and $\Pr[x_{t+1} \leq x' | x_t = x] = F(x'|x)$, respectively. For newly formed matches, idiosyncratic productivity starts at the mean value of the unconditional distribution, which is denoted by $\overline{x}$. In addition to productivity shocks, each matched pair faces a probability of destruction of match λ at the end of period.

The number of new meetings between the unemployed and vacancies is determined by a matching function:

$$m(v,u) = \eta u^{1-\alpha} v^{\alpha},$$

where v is the number of vacancies and u is the number of unemployed workers for that market. The matching rate for an unemployed worker is $p(\theta) = m(v,u)/u = \eta\theta^{\alpha}$, where $\theta = v/u$ is the vacancy-unemployment ratio, the labor market tightness. The probability that a vacant job matches with a worker is $q(\theta) = m(v,u)/v = \eta\theta^{\alpha-1}$.

The timing of events can be summarized as follows:

1. At the beginning of each period, matching outcomes from the previous period's search and matching are realized. Also aggregate productivity z and each match's idiosyncratic productivity x is realized.
2. Upon observing x and z, matched workers and entrepreneurs decide whether to continue (or commence) as an employed match. Workers breaking up with an entrepreneur become unemployed. (There is no later recall of matches.)
3. For employed matches, production takes place with the wage reflecting worker-firm bargaining. Also at this time, unemployed and vacancies engage in the search/matching process.
4. After production, a fraction λ of employed matches are destroyed.

It is useful to consider a recursive representation. Let W, U, J, and V respectively denote the values of employed, unemployed, matched job, and vacancy. All value functions depend on the measures of workers. In each labor market, two measures capture the distribution of workers: $\mu(a,x)$ and $\psi(a)$, respectively, represent the measures of workers engaged in work and unemployed engaged in search during the period.[3] The evolution of these measures is given by $\boldsymbol{T}$, i.e., $(\mu', \psi') = T(\mu, \psi, z)$. For notational convenience, let $\boldsymbol{s} = (\mu, \psi, z)$.

From the model discussion, it follows that the worker's value of being employed is:

$$W(a, x, \boldsymbol{s}) = \max_{a_e'} \left\{ \begin{array}{l} u(c_e) + \beta\lambda E\left[U(a_e', \boldsymbol{s}')|z \right] \\ + \beta(1-\lambda)E\left[\max\{ W(a_e', \boldsymbol{s}', U(a_e', \boldsymbol{s}')\}|z, x \right] \end{array} \right\} \quad (1)$$

subject to

$$c_e = (1+r)a + w - a_e',$$

$$a_e' \geq \underline{a}.$$

The value of being unemployed is:

$$U(a, \boldsymbol{s}) = \max_{a_u'} \left\{ \begin{array}{l} u(c_u) + \beta(1 - p(\theta(\boldsymbol{s})))E[U(a_u', \boldsymbol{s}')|z] \\ \qquad + \beta p(\theta(\boldsymbol{s}))E[W(a_u', \overline{x}, \boldsymbol{s}')|z] \end{array} \right\} \quad (2)$$

subject to

$$c_u = (1+r)a + b - a_u'$$

$$a_u' \geq \underline{a}.$$

For an entrepreneur the value of a matched job is:

$$J(a, x, \boldsymbol{s}) = zx - w(a, x, \boldsymbol{s}) + \beta\lambda V(\boldsymbol{s}') + \beta(1-\lambda)E\left[\max\{J(a_e', x', \boldsymbol{s}'), V(\boldsymbol{s}')\}|x, z\right] \quad (3)$$

The value of a vacancy is:

$$V(\boldsymbol{s}) = -\kappa + \beta q(\theta(\boldsymbol{s})) \int E\left[J(a_u', \overline{x}, \boldsymbol{s}')|z\right] d\widetilde{\psi}(a_u')$$

3) Let $\boldsymbol{A}$ and $\boldsymbol{X}$ denote sets of all possible realizations of a and x, respectively. Then $\mu(a, x)$ is defined over σ-algebra of $\boldsymbol{A} \times \boldsymbol{X}$ while $\psi(a)$ is defined over σ-algebra of $\boldsymbol{A}$.

$$+\beta(1-q(\theta(\boldsymbol{s})))\,V(\boldsymbol{s}'), \tag{4}$$

where $\widetilde{\psi}(a_u{}')$ denotes the measure of unemployed workers at the end of a period after the asset accumulation decision is made.

Now, we turn to wage determination mechanism. A matched worker-firm constitutes a bilateral monopoly. Following the literature, we assume the wage is set by a Nash bargaining solution such that

$$\arg\max_w\,(W(a,x,\boldsymbol{s};w)-U(a,\boldsymbol{s};w))^{\frac{1}{2}}(J(a,x,\boldsymbol{s};w)$$
$$-V(\boldsymbol{s};w))^{\frac{1}{2}} \tag{5}$$

for all $(a,x,\boldsymbol{s})$.

The Nash solution can generate a wage that is increasing in a worker's assets, reflecting that the value being unemployed is less painful for a worker with greater assets. In turn, this makes the vacancy creation decision depend on the assets of the unemployed and, more generally, any characteristic affecting the reservation wage for the pool of unemployed.

The two measures of workers, $\mu(a,x)$ and $\psi(a)$, evolve as follows.

$$\mu'(A^0,X^0)=(1-\lambda)\int_{A^0,X^0}\int_{\boldsymbol{A},\boldsymbol{X}}1_{\{x'\geq x^*(a',\boldsymbol{s}'),a'=a_e{}'(a,x,\boldsymbol{s})\}}$$
$$dF(x'|x)d\mu(a,x)da'dx'$$
$$+p(\theta(\boldsymbol{s}))\int_{A^0}\int_{\boldsymbol{A}}1_{\{x'=\bar{x},a'=a_u{}'(a,\boldsymbol{s})\}}d\psi(a)da'dx' \tag{6}$$

$$\psi'(A^0)=(1-\lambda)\int_{A^0}\int_{\boldsymbol{A},\boldsymbol{X}}1_{\{x'<x^*(a',\boldsymbol{s}'),a'=a_e{}'(a,x,\boldsymbol{s})\}}$$
$$dF(x'|x)d\mu(a,x)da'$$

$$+\lambda \int_{A^0} \int_{\boldsymbol{A},\boldsymbol{X}} 1_{\{a' = a_e'(a,x,\boldsymbol{s})\}} d\mu(a,x) da'$$
$$+(1-p(\theta(\boldsymbol{s}))) \int_{A^0} \int_{\boldsymbol{A}} 1_{\{a' = a_u'(a,\boldsymbol{s})\}} d\psi(a) da' \qquad (7)$$

for all $A_0 \subset \boldsymbol{A}$ and $X_0 \subset \boldsymbol{X}$.

We close the model description by specifying the definition of equilibrium of each labor market. The equilibrium consists of a set of value functions, $\{W(a,x,\boldsymbol{s}), U(a,\boldsymbol{s}), J(a,x,\boldsymbol{s})\}$, a set of decision rules for consumption, asset holdings and separating, $\{c_e(a,x,\boldsymbol{s}), c_u(a,\boldsymbol{s}), a'_e(a,x,\boldsymbol{s}), a'_u(a,\boldsymbol{s}), x^*(a,x,\boldsymbol{s})\}$, the wage schedule $w(a,x,\boldsymbol{s})$, the labor-market tightness $\theta(\boldsymbol{s})$, and a law of motion for the distribution, $(\mu',\psi') = \boldsymbol{T}(\mu,\psi,z)$ such that

1. Given θ, w, μ, ψ and $\boldsymbol{T}$, a' solves the Bellman equations for W, U, J and V in (1), (2), (3), and (4).
2. Given W, U, J, V, μ, ψ and $\boldsymbol{T}$, x^* satisfies $J(a,x^*,\boldsymbol{s}) = 0$.
3. Given W, U, J and V, w satisfies (5).
4. Given w, x^*, J, μ, ψ and $\boldsymbol{T}$, the vacancies are posted until $V=0$.
5. Given a'_e, a'_u and x^*, the law of motion for distribution $(\mu',\psi') = \boldsymbol{T}(\mu,\psi,z)$ is described in (6) and (7).

Ⅲ. Quantitative Analysis

In this section, we examine the quantitative properties of our model in the steady state and also over the business cycles. In order to do so, we calibrate the model, numerically solve the equilibrium. We display the steady-state properties of the model, in particular showing how assets of the unemployed affect their reservation wages and the value to firms of hiring. We also examine the properties of business cycles generated by the model, emphasizing the role of cyclical sorting into unemployment by reservation wage.

3.1. Calibration

In calibrating the model parameters, we target that the unemployment rate be 6% and the standard deviation of cyclical unemployment be about ten times the standard deviation in productivity.

Starting with preferences, we assume a relative risk aversion γ equal to one. The borrowing constraint has a relatively small impact on average asset holdings. We set the borrowing constraint to six times the worker's human capital, so approximately six month's labor income, as we see few households in the SIPP with unsecured debt exceeding this amount. We choose a discount factor β equal to 0.99481 so the model economy displays an average level of assets equal to 18 months of labor earnings, which is about the median ratio of net worth to family earnings reported in the SIPP data. We assume that an annualized real interest rate is fixed at 6%.[4] Since only labor is used for production, this fixed real interest rate may be justified in a small open economy environment where agents insure their stochastic income shock through trading foreign assets.

For aggregate productivity shocks we use $\rho_z = 0.95$ and $\sigma_z = 0.0037$. This yields a time series for (logged) TFP with

4) The real interest rate in the real business cycle literature is typically assumed to be 4% annually. However, we adopt a slightly higher real interest rate here because we want this to represent an average rate of return from all sorts of financial and physical assets that involve different degree of risk. In the literature, the average of risk premia is estimated about 6%. Hence, the annual real interest rate of 6% (risk-free rate + risk premium) is a good approximation to the real world.

autocorrelation of 0.965 and standard deviation, after HP filtering, of 1%. This is smaller than the standard deviation reported by Shimer for U.S. labor productivity, but is fairly consistent with the standard deviation for labor productivity of 1.2% measured for 1984-2003 corresponding to the years of the SIPP data.

We choose a monthly separation rate of 2%. This is roughly consistent with rates we report for the SIPP data below. We assume that half of separations are exogenous, so $\lambda = 0.01$.[5] Given an unemployment rate of 6%, the separation rate of 2% implies a steady-state job finding rate, of 31.3%. This is consistent with hazards reported by Meyer (1990). The vacancy posting cost κ is chosen so that the vacancy-unemployment ratio (θ) is normalized to 1 in the steady state. The matching technology is of Cobb-Douglas, i.e., $m(v,u) = 0.313 v^{\alpha} u^{1-\alpha}$ and the matching power parameter, α, is set to 0.5.

The returns received when unemployed and the magnitude of match specific shocks are key factors in determining the cyclical volatility of separations and unemployment. When unemployed, persons receive the utility B from leisure as well as unemployment insurance b. These parameter values define the surplus value of employment. If unemployment is made more attractive, everything else equal, this clearly leads to higher separation and

5) Den Haan, Ramey and Watson (2000) employ a breakdown of about two-thirds of separations being exogenous. They base this on data suggesting that about two-thirds of separating workers attribute the separation to a quit; and they choose to classify worker-labeled quits as exogenous separations. For the last two panels of the SIPP, conditional on an individual separating from a job, the worker reports a reason for the separation. We also see about two-thirds of separations are labeled by the worker as quits. But many of these quits are to take another job, which does not speak to the model breakdown of exogenous versus endogenous. Another important category of quits reflect workers saying they did not like the pay or hours, which would better fit deciding an endogenous separation. So we believe it is conservative to label half of separations as endogenous.

unemployment rates. The return while being unemployed is also key in generating unemployment volatility in the Mortensen and Pissarides framework (Hagedorn and Manovski, 2005, and Mortensen and Nagypal, 2007)---higher values for b and B increase cyclical volatility of vacancies and unemployment. By contrast, greater volatility of match specific productivity (higher σ_x) has opposite impacts on the level versus cyclical volatility of unemployment. Greater match shocks create more separations and higher average unemployment, but actually reduce the cyclical volatility of separations and unemployment. With greater match quality shocks, workers become sorted over time into matches with significant match surplus. This makes their separations less responsive to cyclical fluctuations in productivity.

Turning to these parameters, first consider unemployment insurance, b. Shimer (2005) uses $b = 0.4$; but for his calibration, with linear utility, b should also capture utility benefits associated with unemployment from leisure or home production. Hall (2005b) shows that the replacement rate has been about 10% to 15% in recent years. We set $b = 0.25$. We view this as capturing partly unemployment insurance and partly home production that substitutes nearly perfectly with purchased goods. We set the persistence of the match specific shock to be quite high, $\rho_x = 0.97$.[6] Finally, we vary the leisure value of unemployment B and the volatility of innovations to match shocks σ_x to be

6) Many different values for the persistence of idiosyncratic productivity in the literature depending on what to measure by this parameter and what individual characteristics to be controled in estimation. See Heaton and Lucas (1996), and Storesletten, Telmer and Yaron (1999). We calibrate the match specific productivity quite persistent since we want to focus on the role of incomplete markets in workers' decision on labor supply. As will be shown laber in Table 2, endogenous sorting into unemployment due to asset positions plays an important role in the volatilities of unemployment and separation rate.

consistent with both an average unemployment rate of 6% and a standard deviation of unemployment that is ten times that of productivity. This nails down these parameters because, as just discussed, the level of unemployment is increasing in both B and σ_x, but its cyclicality responds oppositely to the two parameters. This is achieved by the combination of values $B = 0.66$ and $\sigma_x = 0.0058$. Table 1 summarizes the parameter values.

【Table 1】 Parameter Values for Benchmark Economy

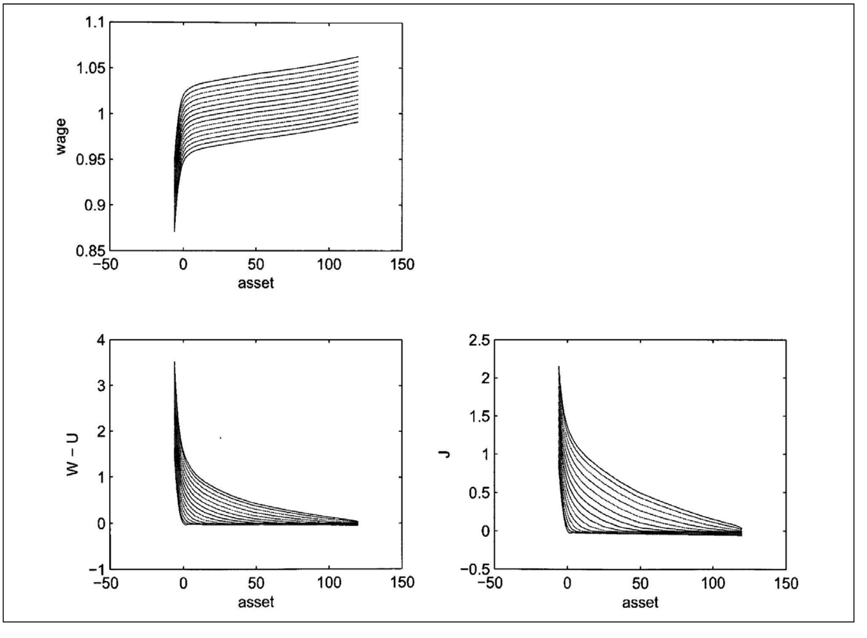
Parameter	Value	Description
γ	1	Relative risk aversion
r	6%	Real interest rate (annualized)
β	0.99481	Discount factor
$\underline{a}$	-6.0	Borrowing constraint
θ	1	Steady state v/u ratio (normalized)
α	0.5	Matching technology $m(v,u) = 0.3133v^{\alpha}u^{1-\alpha}$
κ	0.073	Vacancy posting cost
b	0.25	Unemployment benefit
B	0.659	Utility from leisure
ρ_x	0.97	Persistence of idiosyncratic productivity $\ln x$
σ_x	0.58%	Standard deviation of innovation to $\ln x$
ρ_z	0.95	Persistence of aggregate productivity $\ln z$
σ_z	0.37%	Standard deviation of innovation to $\ln z$

3.2. Steady State Results

Some key model steady-state results that determine how our benchmark economy responds to aggregate shocks are presented in Figures 1 and 2. Figure 1 displays the values of the wage, $W - U$ and J as functions of a worker's assets for each of fifteen potential values for match quality x. Higher values of match quality are directly associated with higher wages and capitalized value of employment W, while irrelevant for U. So both $W - U$

and J correspondingly increase with x. Both W and U increase with assets, but having low assets particularly lowers the value of being unemployed, resulting in a lower bargained wage. Figure 1 displays this positive relation between assets and wages. Both $W-U$ and J (reflecting the higher wage) decrease in worker assets.[7]

【Figure 1】 Steady State Value Functions and Wages (Benchmark)



The sharpest positive relation of the wage to assets, and opposite reaction in J, is concentrated at the very low end of assets, near or below zero. But, as we see in Figure 2, there is a very little mass at these very low asset levels.

7) J, equaling $W-U$ times consumption, decreases less than $W-U$ with assets. This is more relevant at low asset levels, where consumption responds more to assets. For instance, for $x=1$, an increase in assets from 0 to 5 yields a 33% smaller drop in J than in $W-U$.

【Figure 2】 Steady State Distributions and Separation Decision Rules (Benchmark)

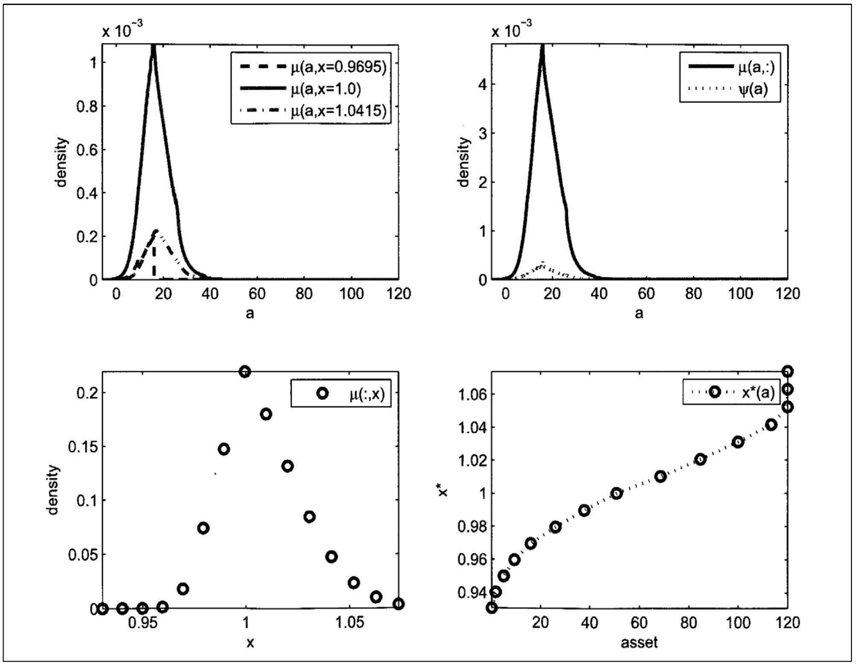


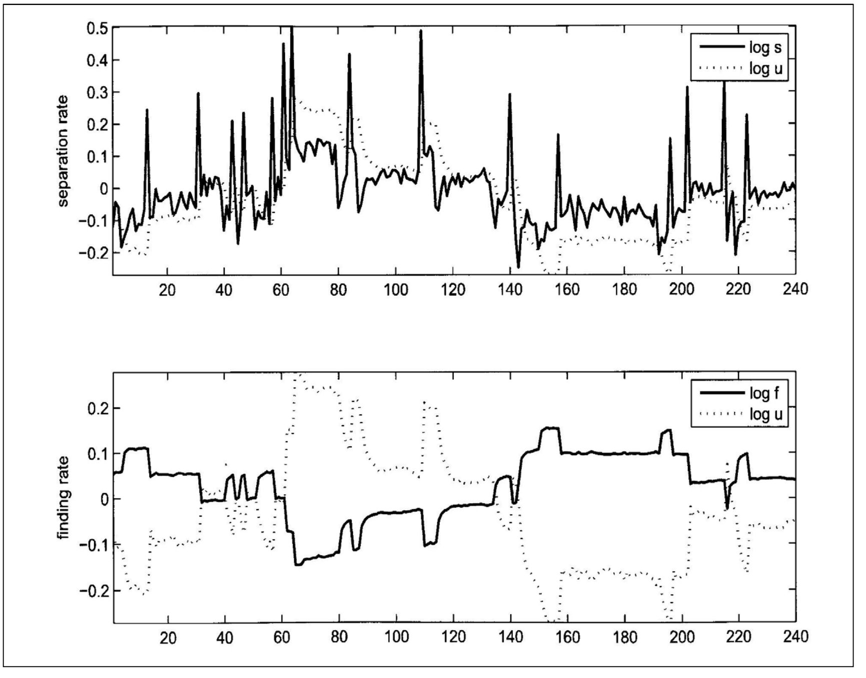
Figure 2, top left, shows the density of assets for workers at each of three levels for match quality $\mu(a,x)$. For low match qualities, the distribution of assets is sharply truncated---only matches with workers with low assets survive match qualities that low. Complementing this result, endogenous separations skew the distribution of match qualities toward higher values of match quality. This is shown in the lower-left panel of Figure 2. In particular, virtually no workers remain in matches where x has fallen below 0.97. Combining these first two panels yields the distribution of assets across all workers. This is shown in the upper-right panel together with the density of assets for the unemployed, $\psi(a)$. The dispersion in assets is fairly small---both densities are largely contained between asset levels of 5 and 30 months of earnings. The final panel of Figure 2 displays how a worker's critical value for match quality x^* depends on assets. This threshold for separating increases notably with assets at all asset values; but the key for the response of separations to aggregate shocks is its responsiveness for assets from 5 to 30 months earnings where the density is concentrated.

3.3. Business Cycles

We next characterize the business cycles properties of the model in response to shocks to aggregate productivity. With aggregate fluctuations, the measures of workers, μ and ψ become state variables for agents' optimization problems, as separation decisions depend on subsequent matching probabilities. These, in turn, depend on the next period's measures of workers. Because it is not possible to keep track of the evolution of these measures, we employ Krusell-Smith's (1998) "Bounded Rationality" method which approximates the distribution of workers by a limited number of its moments. In particular, we assume that agents make use of the average asset holdings of the economy and the fraction of workers who are employed. To produce business cycle statistics, we generate 12,000 monthly periods for a model economy. After dropping the first 3,000 observations, we log and HP filter the data (with smoothing parameter 900,000 to be comparable to Shimer, 2005) and generate business cycle statistics.

A sample portion of the cyclical simulation is displayed in Figure 3. Separations are countercyclical. They also clearly lead the cycle, which is consistent with findings by Fujita and Ramey (2006). We see that, consistent with the data, the model generates strikingly opposite movements in unemployment and the job finding rate.

【Figure 3】 Separation and Finding Rates (Benchmark)



Some key statistics are highlighted in Table 2. In addition to results for our benchmark model with endogenous separations (shown in Column 1), for comparison, Column 2 reports model statistics when we shut down all endogenous separations, i.e., innovations to match quality are eliminated, while the exogenous separation rate is doubled to 2%.[8)]

Our benchmark model with endogenous turnover (Column 1) generates observed volatility. In fact, its standard deviation of ln(unemployment), 10.5%, actually exceeds that in the data, 9.5 %.[9)]

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8) Slight changes in some parameters are inevitable for the exogenous separation model to generate a comparable steady state with our benchmark, specifically, the labor market tightness of 1 and the average assets of 18 months of earnings. Those changes are $\kappa = 0.0736$ and $\beta = 0.99472$.

9) The model also generates highly persistent fluctuations in unemployment and the finding rate with respective autocorrelations, even after the series

【Table 2】 Model Comparison: Endogenous vs. Exogenous Separations

	Endogenous Separations	Exogenous Separations	U.S. data
$\sigma(u)$	10.5	3.7	9.5
$\sigma(v)$	3.9	6.4	10.1
$\sigma(s)$	11.2	0.0	3.8
$\sigma(f)$	5.6	4.3	5.9
$\sigma(E[a_u]/E[a_e])$	1.6	0.7	
$cor(u,v)$	-0.16	-0.61	-0.89
$cor(u,s)$	0.32	0.0	0.71
$cor(u,f)$	-0.99	-0.85	-0.95
$cor(u, E[a_u]/E[a_e])$	0.77	-0.48	

Notes: All variables are logged before applying HP filter with smoothing parameter of 900,000 except for $E[a_u]/E[a_e]$. Standard deviation of variables are relative to that of HP filtered productivity of 1%. U.S. statistics are based on Shimer (2005, 2007).

Shimer points out that the natural log of unemployment series exhibits volatility, measured by standard deviation, that is 9.5 times that in labor productivity, whereas in his calibrated model with constant exogenous separations the unemployment series displays lower volatility by a factor of about one half. By contrast the version of our calibrated model with only exogenous separations generates a standard deviation of unemployment that is 3.7 times that in productivity. The considerably greater volatility for unemployment here largely reflects a lower surplus value of employment for our model. Thus it is important to frame any contributions to unemployment volatility from the mechanisms in our model relative to the results with exogenous separations, rather than the larger disparities framed by Shimer's calibration.

Our model with endogenous separations generate much more cyclical volatility than the model with exogenous separations for

are HP filtered, of 0.94 and 0.93. The predicted separation rate is much less persistent, with autocorrelation of 0.26.

the following two reasons. First, the model generates countercyclical separations, correlation of 0.32 with unemployment, that are quite volatile with a standard deviation slightly larger than that for $\ln(\text{unemployment})$. Second, the model generates considerable cyclical selection into separating to unemployment by worker assets. In Column 2, the correlation between the unemployment rate and the assets of unemployed relative to employed is -0.48, reflecting the drop in assets with longer unemployment durations during recessions. In our benchmark model with endogenous sorting, this correlation is 0.77. This shift toward workers with higher assets and higher reservation wages in recessions drives down the value of vacancy creation.[10)]

Cyclical sorting into unemployment also serves to generate realistic cyclicality in the finding rate. Our model with endogenous separations exhibits a standard deviation of the finding rate (5.6%) that is greater than either that for the model with constant separations (4.3%), and much closer in line with the data. Our model, like the data, also displays a much stronger negative correlation between unemployment and the finding rate than the model with constant exogenous separations. Our model does generate a negative correlation, though at -0.16 it is far weaker than observed in the data. It also generates a negative correlation of the separation and finding rates (-0.35), though not as negative

10) The volatility of separation rate in our benchmark model critically depend on the distribution of workers over the idiosyncratic match specific productivity which is governed by σ_x. As σ_x increases workers are more dispersed so that fewer workers transit between employment and unemployment as aggregate productivity shifts and the steady state unemployment rate increases. We calibrated σ_x so that it can replicate the volatility of unemployment while maintaining the steady state unemployment rate of 6%, which required quite small σ_x. It is hard to reconcile low volatility of separation rate and high volatility of unemployment rate. For more discussion about this difficulty, see Bils, Chang and Kim (forthcoming).

as reported by Shimer (-0.57). A particular empirical shortcoming to note for our model of endogenous separations is that it generates less volatility in vacancies than observed for unemployment, whereas empirical measures for vacancies appear to suggest a time series as volatile as unemployment.

3.4. Cyclicality of Wages and Separations

Lastly we take the model simulations and generate a panel of 2,000 individual worker histories of 360 months of wages, asset, and separation outcomes. We anticipate cyclicality in wages and separations to differ by workers' labor supply (reservation match quality)---workers with higher reservation match quality should exhibit less cyclical wages, but more cyclical separations. The artificial panel data allows us to estimate regressions of wages and separations on the unemployment rate interacted with the worker's reservation match quality or assets.

【Table 3】 Cyclicality of Wages and Separations

	Wages		Separations	
	(1)	(2)	(3)	(4)
Unemployment Rate	-1.37 (0.03)	-1.38 (0.03)	0.22 (0.02)	0.22 (0.02)
$UR^{*}\ln x^{*}$		6.0 (0.07)		7.17 (1.10)

Notes: Estimation of wage cyclicality allows for individual fixed effects. Estimation of cyclicality in separations controls for worker's assets as well as the reported cyclical variables. Standard errors (in parenthesis) correct for clustering by the 360 months.

Column 1 of Table 3 reports the results of regressing a worker's log real wage on the unemployment rate in percentage points. Estimation allows for an individual worker fixed-effect. The wage, not surprisingly, is markedly procyclical, with a one percentage point increase in the unemployment rate associated with a drop in real wage of 1.4%. More relevant to our model, Column 2 adds an interaction of the unemployment rate with the worker's reservation match quality which is critically affected by asset holdings. The interaction effect is clearly significantly positively---higher x^* predicts a smaller negative wage response to the unemployment rate. The magnitude of this effect on wages is not so large. The standard deviation of the reservation match quality, x^*, in the artificial panel is about 1.5%. So increasing x^* by this standard deviation reduces the predicted wage drop in response to a percentage point increase in the unemployment rate from 1.4% to 1.3%.

Columns 3 to 4 of the table conduct the same exercise but for the separation rate, entering as a zero/one dummy, as the dependent variable. Separations are countercyclical. A one percentage point increase in unemployment rate increases the rate of separations by 0.22% points (Column 3). Mirroring the results for wages, separations are significantly more cyclical for workers with lower labor supply, as captured by a higher reservation match quality (Column 4). This effect is fairly sizable: Increasing x^* by its standard deviation increases the magnitude of the effect of unemployment on separations by 50%.

Ⅳ. Cyclicality in Wage and Separations in the SIPP Data

Our model predicts that workers with higher desired labor supply will exhibit more cyclical wages and thereby less cyclical separations. We compare these predictions here to findings in the SIPP data. We first stratify workers based on how much they work during their approximately three years in the SIPP panel. We also examine how cyclicality differs based on a measure of their asset position.

We pool the 12 panels of the SIPP (1984 through 1993, 1996 and 2001). We restrict our sample to individuals between the ages of 20 and 60. Individuals must not be in the armed forces, not disabled, not be attending school full-time, and must have remained in the survey for at least a year. We further restrict the analysis to those who worked at least two separate months with reported hours and earnings during their interview panel. Our resulting pooled sample consists of 153,322 separate individuals, representing 1,175,945 interviews, with data on employment status for 4,368,272 monthly observations. Wage rates reflect an hourly rate of pay on the main job. More than 60% report a wage in this form. For the rest we construct an hourly rate from hours and earnings information for that month based on how the hourly wage projects on these variables for those reporting an hourly wage. The statistics on employment and wages do not reflect self employment.

For each worker we sum the fraction of weeks worked during their panel of observations and the average log of hours worked when employed. To put variations in fraction of weeks worked in percent terms, we divide the individual's value by the mean for their sample. We stratify workers based on the amount of net worth and unsecured debt they report. We define a worker as a low-asset worker if either (a) they have non-positive net worth or (b) they have unsecured debt greater than 1,000 hours of earnings based on their average wage. About one-sixth of the male sample and one-fifth of female sample fall under this category.

4.1. Cyclicality in Wages

Table 4 examines the response of individual hourly wages to the unemployment rate. We report this separately for new hires and other workers. New hires are those who were hired at that employer within the last year. Wages for new hires are clearly procyclical. For men a 1% point increase in the unemployment rate is associated with a 1.8% lower wage; for women it is associated with a 1.2% lower wage. By contrast Columns 2 and 4 report that, for workers not identified as new hires, the wage is not cyclical.[11)]

【Table 4】 Cyclicality of Wages: SIPP Data

	Men		Women	
	New Hires	Other Workers	New Hires	Other Workers
Unemployment Rate	-1.78 (0.21)	-0.29 (0.15)	-1.23 (0.19)	-0.10 (0.14)
UR*Relative Labor Supply	-1.93 (0.69)	-1.65 (0.51)	-1.47 (0.32)	-0.86 (0.29)
UR*Low Assets	-0.78 (0.33)	-0.53 (0.17)	-0.68 (0.28)	-0.13 (0.14)

Notes: Estimation allows for individual fixed effects. Standard errors (in parenthesis) correct for clustering by 224 to 232 months. Regressions control for age, age2, and seasonals. In addition to reported variables, regressions include interactions of age and age2 with the unemployment rate. Estimates employ sampling weights. The relative labor supply reflects the worker′s measured fixed effect in labor, which excludes the prior two months, current, and subsequent three months to the month determining the dependent variables. The relative wage reflects the workers fixed effect in ln(wage). Low assets equals one if net wealth is not positive or unsecured debt is greater than 1,000 hours of wages, zero otherwise. 16.7% of the sample for men and 21.1% of the sample for women has low assets by this measure.

For men the modest effect of a 1% point increase in the

11) Workers returning to an employer are not treated as new hires. Other workers may include workers who joined the employer at a date 4 to 11 months prior, if that date is prior to the worker joining the data panel.

unemployment rate, a fall of 0.3% in the wage, is only marginally significant; for women it is insignificant. The finding of greater wage cyclicality for new hires is consistent with earlier findings from other data sets by Bils (1985) and Beaudry and DiNardo (1991). Models incorporating wage rigidity into cyclical matching models (e.g., Hall, 2005) stress the wage setting of new hires, as the discounted value of wages is central to the value of vacancy creation. But we find wages of new hires are very cyclical. When aggregating all workers, wages are only modestly cyclical for both men and women. With one percent point increase in the unemployment rate is associated with drops in the real wages by 0.5% for men and 0.3% for women.

We next ask if the cyclicality in wages differs for workers by their longer-run labor supplied to confirm the prediction of our model that workers with high desired labor supply (low reservation match quality) should exhibit more cyclical wages and less cyclical separations.

The second line of Table 4 reports the interaction the unemployment rate with a worker's fixed effect in labor supplied. Workers who typically work more show much more cyclical wages. This is true both for new hires and other workers. The standard deviation in this measure of long-run labor supplied is 0.22 for men and 0.33 for women. A one-standard deviation increase in hours worked implies that one percentage point increase in the unemployment rate is associated with a wage decline that is 0.36% points larger for men and 0.28% larger for women. Among new hires, Columns 1 and 3, wages are even more strikingly cyclical for those who work more, especially among women.

Our model relates cyclicality of a worker's reservation wage to that worker's asset position. Workers with lower assets are predicted to show more cyclical wages and less cyclical separations. We examine these predictions in the third line of Table 4. Wages are more cyclical for workers with lower assets. Wage are much more cyclical for new hires with relatively low assets for both men and women. Consider two new hires with comparable long-term wage, but only one with low assets. The regression implies that, among men, the man with low assets will show a decline in real wage that is 0.78% points larger for a 1% point increase in the unemployment rate. Among female new hires the differential is similar, 0.68% points. For other workers the effects of assets on wage cyclicality is qualitatively similar, but weaker. Among men greater cyclicality of wages for workers with low assets is statistically significant, but the estimated interaction with wage cyclicality is only 70% as large as its estimate among new hires. For women excluding new hires, the interaction of having low assets is smaller in magnitude and not statistically significant.

4.2. Cyclicality in Separations: SIPP Data

We last examine how cyclicality in separations differs across workers by labor supply and by assets. We focus on separations out of employment, both those with and without return to the employer.

The first line of Table 5 shows the effect of interacting the unemployment rate with the worker's long-term labor supply. From columns 1 and 3, we see that workers who typically work more are much less likely to exhibit temporary separations when unemployment is high. Increasing labor by one standard deviation (0.22 for men and 0.33 for women) decreases the response of these separations to the unemployment rate by more than 0.5% points for men and by 0.8% points for women. These differences are large as well as statistically significant.12)

Workers who work longer hours, both for men and for women, are also less likely to exhibit non-temporary separations out of employment during recessions (columns 2 and 4). We view these results as very supportive of the central tenet of our model---workers with higher desired labor supply will separate less during recessions.13)

【Table 5】 Cyclicality of Separations: SIPP Data

	Men		Women	
	Return to employer	No return to employer	Return to employer	No return to employer
UR*Relative Labor Supply	-1.93 (0.69)	-1.65 (0.51)	-1.47 (0.32)	-0.86 (0.29)
UR*Low Assets	-0.78 (0.33)	-0.53 (0.17)	-0.68 (0.28)	-0.13 (0.14)

Notes: Standard errors correct for clustering by 208 to 216 months. Regressions additionally include the unemployment rate and controls for years of schooling, marital status, age, age2, individual fixed effect in wage, dummy for low assets, monthly seasonals, linear and quadratic time trends, and dummies variables for early, mid, and late segments of SIPP panels. Also included are interactions of each reported variable with linear and quadratic trends and interactions of age and age2 with time trends and the unemployment rate. Also see notes to Table 4.

The second line of Table 5 examines how cyclicality in separations projects on a worker's asset position. As predicted by

12) Recall that, in determining separations in any month, the worker's weeks worked and hours in that, the two preceding, and three following months, do not enter into the measure of long-term labor supply. Since temporary separations are those who return at least by the interview four months later, the period of temporary separation is not reflected in the measure of long-term labor supplied.

13) We focus on separations out of employment, as job-to-job separations are not readily related to our model. We can point out, however, that job-to-job separations display a shift toward workers with higher labor supply and workers with higher wages with increases in the unemployment rate.

the model, for both men and women permanent separations are lower in recessions for workers with low assets. The estimated magnitude of this effect is economically important; but it is not statistically quite significant. By contrast, temporary separations, with return to the employer, are more cyclical for those workers with greater assets. But this effect is also only marginally statistically significant.

Ⅴ. Conclusions

We introduced worker heterogeneity in worker's asset holdings into a model of separations, matching, and unemployment over the business cycle. We have focused on heterogeneity associated with a worker's labor supply because it yields sharp, rich, testable predictions for a model with flexible wages. Most notably, it predicts that workers with high labor supply, those with low assets and therefore low reservation wages, will avoid separating in recessions when unemployment duration is long. In turn this predicts these workers will show greater cyclicality of wages, but less (counter)cyclical separations. When separations shift toward workers with high reservation wages in downturns, because these workers yield lower rents to employers, this acts to discourage creating vacancies, exacerbating the cyclicality of unemployment.

We examine employment separations and wage cyclicality over the past twenty years for workers in the SIPP data. Workers who typically work longer hours do display much greater cyclicality of wages and less cyclicality of separations. We also find that workers with low assets or high debts show more cyclical wages and less cyclical separations into unemployment, though the latter effect is not so empirically significant.

We conclude that heterogeneity, particularly sorting by unemployment tolerance, may help to explain why unemployment durations are so cyclical. A related conclusion is that, in one way, wage flexibility exacerbates cyclical volatility---it is through flexible wage setting that workers with tolerance for unemployment sort into that pool during recessions.

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임금, 실직률, 실업률의 경기동행성

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논문초록

본 연구는 매칭모형을 확장하여 노동자들의 자산보유 상태의 차이로 인한 노동공급에 관한 이질적인 성향을 명시적으로 고려한다. 실업기간이 긴 시기에 직장을 잃는 것은 장시간 근로를 희망하는 노동자들에게는 특히 불리할 것이다. 노동자들의 희망 노동시간의 차이로 인해 다음과 같은 이론적 예측이 도출될 수 있으며 이들은 자료를 통해 증명가능하다. 즉, 자산이 많지 않아서 장시간 근로를 희망하는 노동자들의 경우, 임금은 상당히 경기동행적이지만 실직률은 덜 경기동행적일 것이다. 결과적으로 경기하강기에는 실업자들 중에서 희망 노동시간이 적은 노동자들이 증가할 것이다. 이런 성향의 노동자들은 취업상태에서도 적은 경제적 지대 밖에 생성하지 못하므로, 기업의 일자리 창출의지가 더욱 약화될 것이고, 이는 다시 실업기간을 장기화시키는 악순환을 일으킬 것이다. 미국의 SIPP 자료를 관찰한 결과, 이러한 이론적 예측이 대체로 현실적으로 일어나고 있음을 발견할 수 있었다.

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