The Cyclicality of the User Cost of Labor with Search and Matching*

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Abstract

I investigate the cyclicality of the cost incentives for job creation in search and matching models distinguishing the user cost of labor from the wage payment. The user cost of labor includes the wage at the time of hiring as well as the expected effect of the economic conditions at the time of hiring on future wages. If wages are smoothed by implicit contracts, then a weak cyclicality of wages can conceal a substantial cyclicality of the user cost of labor incurred by firms. I calculate the cyclicality of the user cost and its components under alternative wage setting mechanisms. I find that in the presence of implicit contracts the wage component of the user cost is more cyclical than the wages of newly hired workers, which in turn are more cyclical than the wages of all workers. The cyclicality of the user cost across economies is approximately the same across settings; however, individual wage cyclicality varies significantly depending on the wage setting mechanism. Recent papers stress rigid wages as an amplification mechanism for the fluctuations in the vacancy-unemployment ratio (Shimer 2005, Hall 2005). This mechanism works by reducing cyclicality of labor's user cost. As found in Kudlyak (2007), the wage component of the user cost is noticeably more procyclical than the individual wages. When the models are calibrated to match the empirical cyclicality of the wage component of the user cost, the models generate approximately half of the empirical volatility of the vacancy-unemployment ratio regardless of the wage setting mechanism.

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1 Introduction

A firm employs a factor up to the point where the marginal benefit of using the factor equals its user cost. For factors hired in a spot market, the user cost is simply the factor's spot market price. If factors are purchased (like capital) or contracted for more than one period, the user cost is an implicit rental price. The rental price is the difference between the purchase price and the expected price that can be recovered from selling the un-depreciated part of the factor.

By analogy, the user cost of labor is the difference between the costs of adding a worker starting from the current period and the expected costs of replacing the worker the next period. If the labor market is a spot market, then the user cost is the wage. But adding a worker is often a long term investment. In the presence of contracts, the economic conditions at the time of hiring might have an impact on the future wage payments within the employment relationship. This impact is captured by the user cost.

In this paper I investigate the cyclicality of the cost incentives of job creation in search and matching models distinguishing the user cost of labor from the wage payment. Shimer (2005) is among the first to show that the standard search and matching model lacks amplification of the productivity shock to generate the empirical volatility of its key endogenous variable, the vacancy-unemployment ratio. Pissarides (2007) labels this failure of the model 'the unemployment volatility puzzle'. The literature suggests rigid wages as a possible amplification mechanism for the fluctuations in the vacancy-unemployment ratio (Shimer 2005, Hall 2005). This mechanism works through making labor's user cost rigid. However, if wages are smoothed by implicit contracts, then rigidity of wages does not imply rigidity of the user cost of labor. In Kudlyak (2007), I construct the user cost from individual wages and find that it is noticeably more cyclical than wages. And, as I show in this paper, the puzzle remains.

To understand how the mild cyclicality of individual wages can conceal a substantial cyclicality of the user cost of labor, consider a contractual arrangement that entails smoothed wages within the employment relationships. When the unemployment rate is high, the wage of new hires is low. In addition, the wages in all subsequent periods in the contract are relatively lower than wages in contracts initiated under more favorable economic conditions. If the unemployment rate is expected to return to lower levels, then hiring wages in the future are expected to rise. By hiring now as opposed to next year, a firm 'locks in' a worker to a relatively low stream of wages. In this case, the wage at the time of hiring overstates the wage component of the user cost of labor incurred by the firm. The user cost is lower by the expected difference between the present value of wages to be paid starting from the next year to a worker hired in the next year and the present value of wages to be paid from that time to a worker hired now.

Empirical support for the importance of accounting for the user cost as opposed to the individual wage is documented in Beaudry and DiNardo (1991). They find evidence of implicit contracts in the individual wages. Additional indirect evidence of 'lock in' to the conditions at the time of hiring can be found in the literature on the cyclicality of individual wages of job changers and job stayers: wages of job changers are 3 to 5 times more cyclical than wages of job stayers, indicating that wages within employment relationships do not respond as readily to changes in economic conditions as wages at the time of hiring.[1] In Kudlyak (2007), I construct the wage cost component of the user cost from individual wages and turnover using NLSY79 data and find that the constructed price of labor is almost three times as cyclical as the individual wages. In particular, one percentage point decrease in unemployment generates approximately 4.5% increase in the price of labor. This cyclicality is also noticeably higher than the cyclicality of the wages of newly hired workers reported in the literature as summarized by Pissarides (2007).

In this paper I consider an economy with search and matching frictions, stochastic productivity, and exogenous separations. In such an economy the user cost of labor can be decomposed into its vacancy and wage cost components. I show that, with free entry, the optimal decision of a firm is to hire labor until the point where a worker's current marginal product equals the user cost of labor, that is, the sum of the vacancy and wage cost components. The vacancy cost component refers to the expected difference in expenses on vacancy creation between the current period and the next. Future expenses are discounted to take into account the real interest rate and turnover. The wage cost component refers to the expected difference in expenses from starting to pay wages in the current period versus the next period, with next period expenses discounted to take into account the real interest rate and turnover. Notice that the wage cost component consists of the difference between two present discounted streams of wages. Therefore, in addition to wages at the time of hiring, the wage cost component includes the effects of economic conditions at the time of hiring on future wages.

To investigate the dynamics of the user cost of labor and its components, I embed alternative wage setting mechanisms in the search and matching model with risk-averse workers. In addition to continuous re-bargaining, I consider the implicit contracts of Thomas and Worrall (1988) with three different modes of commitment: full commitment, lack of commitment on the worker's side, and two-sided lack of commitment.[2] In the quantitative investigation all four economies are hit by the same series of productivity shocks. For each model I calculate the cyclicality of wages and the components of the user cost from the simulated data on individual wages, components of the user cost and unemployment rates.

I find that in the presence of implicit contracts the wage cost component is more cyclical than

[1] See Pissarides (2007) for a review of empirical studies of the cyclicality of individual wages.

[2] Recently Sigouin (2004) and Rudanko (2006) have embedded the wage-setting mechanism of Thomas and Worrall (1988) into a search and matching model. The former investigates the cyclicality of hours worked in the context of a partial equilibrium search model, while the latter investigates the elasticity of aggregate wage with respect to productivity.

the wages of newly hired workers, which in turn are more cyclical than the wages of all workers. The cyclicality of the wage component of the user cost across economies with different wage setting mechanisms is approximately the same. However, individual wage cyclicality varies significantly depending on the individual wage setting mechanism. Wages are only weakly procyclical in the model with implicit contracts with full commitment. Wages are more cyclical in the models with implicit contracts with lack of commitment. In the continuous rebargaining model the individual wage is as cyclical as the wage cost component of the user cost.

I analyze the quantitative behavior of the vacancy-unemployment ratio implied by the four models using the cyclicality of the wage cost found in the companion paper. In particular, the models are calibrated so that the cyclicality of the wage cost component matches its empirical counterpart. I find that the model generates less than the half of the empirical volatility of the vacancy-unemployment ratio regardless of the wage setting mechanism.

This paper contributes to the ongoing discussion on the quantitative behavior of the models with search and matching.

Shimer (2005) calls for rigid wages as a possible amplification mechanism in search and matching model. Although Shimer acknowledges that 'more rigid wages in new jobs, measured in present value terms' should be the solution to look for, the analysis of wages is centered on the analytical expression for wages obtained from continuous rebargaining. Testing the claim for rigidity requires comparing the cyclicality of wage cost in the data with the cyclicality implied by the model. The rigid wage approach generated vast interest in the literature and gave rise to developments of the alternative wage setting mechanisms in a search and matching model. In the original paper Shimer (2005) derives the need for wage rigidity from analytical considerations. Only recently literature turned to contrasting the wage dynamics in the model with the data (Hagedorn and Manovskii 2005; Rudanko 2006; Pissarides 2007; Haefke, Sonntag, and Rens 2007). Although it is acknowledged that the wage is not allocational in the presence of a long term employment relationship, the literature concentrates mostly on individual wage dynamics. The quantitative results in this paper highlight that judging the wage rigidity from the individual wages as opposed to the wage component of the user cost can be misleading.

Contemporaneously, Pissarides (2007) and Haefke, Sonntag and van Rens (2007) examine the dynamics of the wages of newly hired workers in the search and matching model with continuous rebargaining. Under continuous rebargaining wages are the same across all job matches in every period. It implies that the average wage at time t equals the wage of new hires at time t and equals the wage component of user cost. In the data the average wage is less cyclical than the wages of newly hired workers. Hence, the comparison of the dynamics of the wages from the model to the dynamics of the wages of newly hired workers as opposed to the dynamics of the average wage helps to shift away from the rigid wage assumption. However, under continuous rebargaining, the dynamics of wages from the model should be contrasted with the dynamics of the wage component of the user cost in the data. In the data the latter is noticeably more cyclical than the wages of newly hired workers. This implies more negative news for the quantitative behavior of the basic search and matching model.

The concept of user cost was introduced by Keynes and clarified in Scott (1953). Later Jorgenson (1963) applies the term to define the 'shadow' price of capital and Rosen (1969) adopts the term for labor's cost. In Rosen (1969) the user cost of labor refers to the required return to cover the real interest and turnover costs. In addition to Rosen's components, the concept used here encompasses the worker's wage as well as the effect of the economic conditions at the time of hiring on future wages. However, despite a long history, the user cost has not been employed in the recent literature on the quantitative behavior of search and matching models. While the studies acknowledge that what matters for job creation is present value of wages, the literature usually proceeds with the analysis of the individual wage obtained by continuous rebargaining. However, the empirical evidence suggests the importance of the effect of the economic conditions at the time of hiring for future wages.

The paper is organized as follows. Section 2 introduces the user cost of labor and presents the decomposition of the user cost into its vacancy and wage costs components in the context of the search model. Section 3 provides a theoretical description of the models with continuous rebargaining and implicit contacts. Section 4 reviews the existing empirical evidence on the cyclicality of the user cost and wages. Section 5 presents the quantitative results and discussion. Section 6 concludes.

2 The User Cost of Labor

In this section I outline a discrete time search and matching model and introduce the user cost of labor. I will argue that the user cost of labor as opposed to individual wages is a key factor in the job creation decision of firms.

2.1 Environment

The economy is populated by a continuum of infinitely lived risk-neutral homogeneous firms and a continuum of measure 1 of homogeneous infinitely lived workers. Firms maximize the present discounted value of profits. Workers maximize the present discounted value of utility. Firms and workers discount the future with a common discount factor β, $0 < \beta < 1$.

A firm can choose to remain inactive or to start production. Production requires only labor input. To start production, a firm must enter the labor market and hire a worker. There is a free entry; however, due to labor market frictions, the creation of a productive firm-worker match is costly. Upon entering the labor market, a firm opens vacancies and searches for a worker. A firm must pay a per vacancy cost, c, measured in units of the consumption good.

An unemployed worker receives a per period unemployment benefit, b, and costlessly searches for a job. Workers in productive matches earn wages and cannot search while employed. Workers have preferences over consumption and do not value leisure. They do not have access to credit markets and cannot save.

When a firm with an open vacancy and an unemployed worker meet, they form a match that immediately becomes productive. While matched, all firm-worker pairs have the same constant return to scale production technology, which uses a unit of labor indivisibly supplied by the worker. Each firm-worker match produces per period output z. Aggregate productivity, z, evolves stochastically. The value of z and its evolution are common knowledge. The firm receives output, z, and pays wage, w, to the worker.

The economy operates according to the following time line: 1) at the beginning of a period a firm decides whether to create a job or to stay inactive; if the decision is to create a job, the firm posts vacancies and incurs the vacancy posting cost; also, workers who were unemployed for at least one period costlessly search for jobs; 2) when firms with open vacancies meet unemployed workers, new matches are created; 3) production takes place in both newly-created matches and matches that were carried over from the previous period; employed workers receive wages and unemployed workers receive their consumption equivalent, b; 4) at the end of a period a fraction δ of productive matches is randomly selected and exogenously destroyed: the workers who were employed in those matches become unemployed and the firms who operated those matches return to the pool of inactive firms; 5) surviving matches are carried over to the next period.

Given the number of unemployed workers, u, and the number of vacancies, v, the number of newly created matches in the economy is determined by a matching function, $m(u, v)$. Let $q(u, v) = \frac{m(u,v)}{v}$ denote the probability of filling a vacancy for a firm. Let $\mu(u, v) = \frac{m(u,v)}{u}$ denote the probability of finding a job for an unemployed worker. Let Ω_t denote a vector of state variables at time t, including the aggregate productivity z_t, and let $\Omega^t \equiv \{\Omega_\tau\}_{\tau=0}^{t}$. The values in the economy can be summarized by the following functions. The option value of an inactive firm is assumed to be equal 0.

The value function of a firm with a worker at time t given that the productive match started at time t_0, $J_{f,t}(t_0, \Omega^t)$, is

$$J_{f,t}(t_0, \Omega^t) = z_t - w_t(t_0, \Omega^t) + \beta E\left[(1-\delta) J_{f,t+1}(t_0, \{\Omega^t, \Omega_{t+1}\}) | \Omega^t\right]. \tag{1}$$

The value function of an opened vacancy, $J_{v,t}(\Omega^t)$, is

$$J_{v,t}(\Omega^t) = -c + q(u_t(\Omega^t), v_t(\Omega^t)) J_{f,t}(t, \Omega^t) + \beta(1 - q(u_t(\Omega^t), v_t(\Omega^t)))\beta E\left[J_{v,t+1}(\{\Omega^t, \Omega_{t+1}\}) | \Omega^t\right]. \tag{2}$$

With free entry, firms enter the labor market and post vacancies until the value of an open vacancy is driven to zero, $J_{v,t}(\Omega^t) = 0 \ \forall t$. Denote by $\varphi(.)$ the worker's utility function. Then the value function of an employed worker at time t given that the productive match started at time t_0, $V_{e,t}(t_0, \Omega^t)$, is

$$V_{e,t}(t_0, \Omega^t) = \varphi(w_t(t_0, \Omega^t)) + \beta E\left[(1-\delta)V_{e,t+1}(t_0, \{\Omega^t, \Omega_{t+1}\}) + \delta V_{u,t+1}(\{\Omega^t, \Omega_{t+1}\})|\Omega^t\right]. \quad (3)$$

The value function of an unemployed worker at time t, $V_{u,t}(\Omega^t)$, is

$$\begin{aligned} V_{u,t}(\Omega^t) &= \varphi(b) + \\ & \beta E\left[\left(\begin{array}{c} \mu(u_{t+1}(\{\Omega^t, \Omega_{t+1}\}), v_{t+1}(\{\Omega^t, \Omega_{t+1}\}))V_{e,t+1}(t+1, \{\Omega^t, \Omega_{t+1}\}) + \\ (1-\mu(u_{t+1}(\{\Omega^t, \Omega_{t+1}\}), v_{t+1}(\{\Omega^t, \Omega_{t+1}\}))V_{u,t+1}(\{\Omega^t, \Omega_{t+1}\}) \end{array}\right)|\Omega^t\right]. \quad (4) \end{aligned}$$

2.2 The Cost of Creating a Firm-Worker Match

Consider a firm facing the decision of creating a productive match in the current period versus postponing the creation until the next. Assuming that the probability of filling one vacancy, $q(u, v)$, is less than 1, to create one match a firm should open just enough vacancies to expect to fill one. The firm's decision involves comparing the marginal benefits and the costs. The costs of such a decision are summarized by the user cost of labor: all the expenses associated with creating a match in the current period that can be avoided if the creation is postponed. Therefore, the user cost does not include the total payments associated with creation of a productive match, but only the part that is expected to be in excess of what a firm will need to pay the next period.

If changes in economic conditions from t to $t+1$ do not have any impact on the hiring cost and future wage payments, then the user cost consists of the wage at the time of hiring and the required return to cover the real interest rate and turnover. The real interest rate is associated with paying the vacancy creation costs at t instead of delaying until $t+1$. The turnover cost is associated with the possibility of separation in period t, which decreases the number of matches surviving until period $t+1$. However, in general, economic conditions may have an impact on future wage payments due to long term employment contracts. Hence, the user cost of labor is calculated as the difference between the expected present discounted value of the costs of hiring and wage payments to the worker in a productive match that starts in period t and the expected present discounted value of the costs of replacing the worker in period $t+1$.

The concept of the user cost of labor is analogous to the implicit rental price of capital: the full costs incurred during the utilization take into account the price at which the factor was acquired at the beginning of the utilization period, expenses on utilization, and the price at which the remaining, un-depreciated part of the factor can be sold. By analogy, the expected reselling price of the employment relationship is the expected discounted value that another firm would be willing to pay in $t+1$ to take over the productive relationship that started in t, which in equilibrium is equal to the cost this firm would have pay to create a match tomorrow.

In the search and matching model the user cost of labor can be decomposed into its two components: the vacancy cost component and the wage cost component. The vacancy cost component is related to the costs of opening vacancies. The expenses of opening a vacancy will be unavoidable even if job creation is postponed until the next period. Hence, the vacancy cost component is the difference between the expected cost of opening enough vacancies to create one productive match in the current period and the discounted expected cost of doing this next period. The wage cost component includes the current period wage as well any possible future costs associated with the effect of the economic conditions at the time of hiring on wage payments.

Let us denote by $C_t(\Omega^t)$ the expected present discounted values of wages paid during employment relationships that start in period t, where

$$C_t(\Omega^t) = w_t(t, \Omega^t) + \sum_{\tau=t+1}^{\infty} (\beta(1-\delta))^{\tau-t} E\left[w_\tau(t, \Omega^\tau)|\Omega^t\right].$$

Given the probability of filling a vacancy in period t, $q(u_t(\Omega^t), v_t(\Omega^t))$, to create one job in period t, a firm opens $1/q(u_t(\Omega^t), v_t(\Omega^t))$ vacancies, each at the cost c, and subsequently pays the worker an expected present discounted stream of wages $C_t(\Omega^t)$. Given a constant exogenous separation rate δ, in period $t+1$ a firm should open $(1-\delta)/q(u_{t+1}(\{\Omega^t, \Omega_{t+1}\}), v_{t+1}(\{\Omega^t, \Omega_{t+1}\}))$ vacancies to keep the number of expected matches in period $t+1$ equal to the number of surviving matches from period t and pay a stream of wages with expected present discounted value $C_{t+1}(\{\Omega^t, \Omega_{t+1}\})$ to each hired worker. Hence, the user cost of labor in period t, $UC_t(\Omega^t)$, is

$$\begin{aligned} UC_t(\Omega^t) &= \left[\frac{c}{q(u_t(\Omega^t), v_t(\Omega^t))} + C_t(\Omega^t)\right] - \\ &\quad \beta(1-\delta)E\left[\left(\frac{c}{q(u_{t+1}(\{\Omega^t, \Omega_{t+1}\}), v_{t+1}(\{\Omega^t, \Omega_{t+1}\}))} + C_{t+1}(\{\Omega^t, \Omega_{t+1}\})\right)|\Omega^t\right]. \quad (5) \end{aligned}$$

Define the vacancy component of user cost, $UC_t^V(\Omega^t)$, as

$$UC_t^V(\Omega^t) = \frac{c}{q(u_t(\Omega^t), v_t(\Omega^t))} - \beta(1-\delta)E\left[\frac{c}{q(u_{t+1}(\{\Omega^t, \Omega_{t+1}\}), v_{t+1}(\{\Omega^t, \Omega_{t+1}\}))}|\Omega^t\right].$$

Define the wage component of user cost, $UC_t^W(\Omega^t)$, as

$$UC_t^W(\Omega^t) = C_t(\Omega^t) - \beta(1-\delta)E\left[C_{t+1}(\{\Omega^t, \Omega_{t+1}\})|\Omega^t\right].$$

Rearranging the expression for $UC_t(\Omega^t)$ yields a decomposition of the user cost of labor into its two components:

$$UC_t(\Omega^t) = UC_t^V(\Omega^t) + UC_t^W(\Omega^t).$$

The two components in the decomposition of user cost are treated differently from the perspective of the firm. The wage cost component is based on the wages offered by a firm to a worker. The vacancy cost component is taken as given and depends on the aggregates in the economy.

Given free entry for firms, the following proposition obtains.

Proposition 1. *Given free entry for firms, the marginal productivity of a match equals the period user cost of labor, $z_t = UC_t(\Omega^t)$ $\forall t$.*

Proof.

Consider a value of a firm with a worker at time t given that the productive match starts at time t:

$$J_{f,t}(t,\Omega^t) = z_t - w_t(t,\Omega^t) + \beta(1-\delta)E\left[J_{f,t+1}(t,\{\Omega^t,\Omega_{t+1}\})|\Omega^t\right] =$$
$$z_t - w_t(t,\Omega^t) + \sum_{\tau=t+1}^{\infty}(\beta(1-\delta))^{\tau-t}E\left[(z_\tau - w_\tau(t,\Omega^\tau))|\Omega^t\right].$$

Then the expected difference between the value of a firm at time t from the match that starts at time t and the expected present discounted value from the match at time $t+1$ that starts at $t+1$, is

$$J_{f,t}(t,\Omega^t) - \beta(1-\delta)E\left[J_{f,t+1}(t+1,\{\Omega^t,\Omega_{t+1}\})|\Omega^t\right] =$$
$$z_t - \left[w_t(t,\Omega^t) + \sum_{\tau=t+1}^{\infty}(\beta(1-\delta))^{\tau-t}E\left[(w_\tau(t,\Omega^\tau) - w_\tau(t+1,\Omega^\tau)|\Omega^t\right]\right] = z_t - UC_t^W(\Omega^t).$$

Substituting the free entry condition, $J_{f,t}(t,\Omega^t) = \frac{c}{q(u_t(\Omega^t),v_t(\Omega^t))}$, into the left-hand side of the above equation allows it to be rewritten as follows:

$$\frac{c}{q(u_t(\Omega^t),v_t(\Omega^t))} - \beta(1-\delta)E\left[\frac{c}{q(u_{t+1}(\{\Omega^t,\Omega_{t+1}\}),v_{t+1}(\{\Omega^t,\Omega_{t+1}\}))}|\Omega^t\right] = UC_t^W(z^t,\Omega^t).$$

Using $UC_t^V(\Omega^t) = \frac{c}{q(u_t(\Omega^t),v_t(\Omega^t))} - \beta(1-\delta)E\left[\frac{c}{q(u_{t+1}(\{\Omega^t,\Omega_{t+1}\}),v_{t+1}(\{\Omega^t,\Omega_{t+1}\}))}|\Omega^t\right]$, the following equality obtains:

$$z_t = UC_t^V(\Omega^t) + UC_t^W(\Omega^t).\blacksquare$$

Firms create jobs in period t as long as the marginal benefit from adding a worker exceeds the user cost of labor. Due to free entry, the firms will enter the labor market until the net benefit is driven to 0. At that point the decision to add a worker exactly balances the current value of the benefit with both the current cost and the current value of the expected future cost resulting from the current decision. If the user cost exceeds the marginal benefit and firm decides to create a match, then this decision is executed at the expense of the future expected uses of resources.

2.3 The Wage Component of the User Cost of Labor

The wage component of the user cost is:

$$UC_t^W(\Omega^t) = w_t(t,\Omega^t) + \sum_{\tau=t+1}^{\infty}(\beta(1-\delta))^{\tau-t}E\left[(w_t(t,\Omega^\tau) - w_{t+1}(t+1,\Omega^\tau))|\Omega^t\right]. \tag{6}$$

The wage cost at time t consists of two parts: the hiring wage at time t and the expected present discounted value of the differences between wages paid from the next period onward in the employment relationship that started in period t and the employment relationship that started in period $t+1$. Unless the second term is 0, the wage cost component is not equal to the wage at the time of hiring.

Consider the conditions under which the second term in (6) vanishes. An example is the case where the wage is reset each period and is not history-dependent. Then wages across all matches are equal in every period. Hence, the wage component of the user cost of labor equals the wage at the time of hiring. The wage cost will also include only the wage at the time of hiring if the wage is rigid and is not responsive to changes in economic conditions. Finally, if the aggregate shock in the economy is perfectly autocorrelated, then there is no expected change in productivity. In that case, depending on the nature of the contract, the expected wages may remain constant due to the unchanged economic conditions.

However, in general wages are history dependent. For example, if workers are risk-averse and cannot save, firms that have access to asset markets can provide insurance against fluctuations in productivity. In this case, the wage at the time of hiring is part of a contractual scheme. Contracts are designed to deliver promised utility to the worker. Firms choose the wage stream to minimize the expected cost of delivery of the promised value. Hence, the wage may not reflect the total wage commitment that the firm takes on at the time of hiring. The wage component of the user cost of labor summarizes the future value of this commitment in current terms. Depending on the process for individual wage determination, the second term in (6) can dampen or amplify the fluctuations of the wage costs relative to the hiring wages.

Now consider the result of Proposition 1: in the model the dynamics of the wage component of the user cost and vacancies and unemployment are tied together by the following equation:

$$z_t = \left(\frac{c}{q(u_t(\Omega^t),v_t(\Omega^t))} - \beta(1-\delta)E\left[\frac{c}{q(u_{t+1}(\{\Omega^t,\Omega_{t+1}\}),v_{t+1}(\{\Omega^t,\Omega_{t+1}\}))}|\Omega^t\right]\right) + UC_t^W(\Omega^t). \tag{7}$$

Given the dynamics of the wage component of the user cost, the dynamics of individual wages do not have a direct impact on the dynamics of vacancies and unemployment. The dynamics of the wage component of the user cost are what matter for the dynamics of firms' job creation activity.

The dynamics of individual wages are determined by the individual wage setting mechanism and can vary considerably. The question I pose regards the relationship between the cyclicality of individual wages and the cyclicality of the wage component of the user cost. In particular, how cyclical can the wage component of the user cost be if wages are smoothed by contractual arrangements?

In the next section I consider four different wage setting mechanisms in models with search and matching and risk-averse workers. In addition to continuous rebargaining, I consider three mechanisms with implicit contracts distinguished by the abilities of the parties to commit to the contract. The implicit contracts are designed so that firms shield risk-averse workers from fluctuations in productivity. As the results of the quantitative investigation reveal, the weak cyclicality of individual wages may conceal a substantial cyclicality of the wage costs associated with job creation.

2.4 Reinterpreting Rigidity in Wages as an Amplification Mechanism

Shimer (2005) calibrates the standard search and matching model and finds that it does not generate the empirical magnitudes of the fluctuations in vacancies and unemployment. In the standard model there are two assumptions in addition to the environment described above. First, workers are risk neutral. Second, upon meeting a firm and a worker divide a total surplus from the match according to the Nash bargaining rule. Under this rule a worker gets a constant share of the surplus. Hence, fluctuations in productivity are almost entirely mirrored by the change in wages. Consequently, productivity shocks do not bring large changes in firms' job creation activity. In particular, Shimer (2005) shows that both vacancies and unemployment are 10 times less volatile in the model than in the data. Shimer (2005) and Hall (2005) suggest that the surplus sharing rule may be the source of the model's failure to amplify the propagation of the productivity shock. A surplus sharing rule that makes the worker's share less responsive to changes in productivity at the time of hiring will generate larger response of firms to shock.

To understand the required rigidity in wages for the amplification mechanism, consider Proposition 1 and the decomposition of the user cost of labor as summarized in equation (7). It demonstrates the trade-off between the volatility of the vacancy cost component and the wage cost component. Both wage cost component and vacancy cost component are positively related to productivity (are procyclical).[3] Hence, the weaker the response of the wage component of user cost to changes

[3] To see why the vacancy cost component must be procyclical, suppose that the productivity process is stationary and positively autocorrelated. Given the stationarity, the elasticity of the expected present discounted value of the productivity with respect to the initial productivity, in general, is less than 1. In the data, firm's profits, which is the difference between the expected present discounted values of productivity and wages, are procyclical as well. Hence, the elasticity of the expected present discounted value of wages is at most 1. The wage cost is the expected

in productivity, the stronger the response of the vacancy cost component, which is a function of the number of vacancies and unemployed. If the wage cost component is rigid, then the vacancy cost component absorbs all the fluctuations in productivity.

Equation (7) provides intuition behind the test of the quantitative behavior of the search and matching model that I conduct in the paper. It allows bringing together the data on unemployment and the statistics from wage data that are relevant for the job creation decision. This test is feasible if there is an empirical counterpart of the dynamics of the wage component of the user cost. The empirical counterpart is obtained from Kudlyak (2007), where I construct a measure of the wage component of the user cost and calculate its cyclicality. In this paper I calibrate the models with different wage setting mechanisms to match this cyclicality. Then, given the dynamics of productivity shocks, I obtain the dynamics of vacancies and unemployment implied by the models.

As mentioned above, given the dynamics of the wage component of the user cost, individual wage dynamics do not have a direct effect on the dynamics of unemployment and vacancies. As the results show (Table 5), once the cyclicality of the wage component of the user cost is calibrated across different models to its empirical counterpart, then the economies that are hit by the same sequence of productivity shocks generate very similar dynamics of vacancies and unemployment regardless of the individual wage setting mechanism. Furthermore, in the case where both firms and workers are risk neutral the individual path of wages does not affect the total surplus from job creation, provided the present discounted value of wages at the time of hiring is held constant. In that case the economies with different wage settings exactly share the user cost and the issue of the wage setting mechanism is sidestepped all together.

3 Model

In this Section I describe four search and matching models with alternative wage-setting mechanisms. The purpose is to examine wage setting mechanisms that allow for different cyclicality of the individual wages and, in the quantitative results section, to investigate the implications for the cyclicality of the user cost of labor and its components.

First, I consider contractual arrangements. In this case, individual wages may depend on the history of economic conditions from the start of an employment relationship. Consequently, under this kind of wage setting mechanism, the wage cost in (6) has a non-zero second term. In addition, I consider a conventional continuous rebargaining wage setting mechanism. In this case, the wage cost equals the wage at the time of hiring.

The contractual arrangements I consider are implicit contracts as introduced by Thomas and

difference between the expected present discounted values of wages between two consecutive periods. Given positive autocorrelation and stationarity of the process for productivity, the elasticity of wage cost with respect to productivity is nonnegative and at most 1. Hence, the elasticity of the vacancy cost component is nonnegative.

Worrall (1988). They study an environment where firms are risk-neutral and workers are risk-averse. Absent workers' access to capital markets, workers' aversion to fluctuations in consumption due to fluctuations in earnings provides a scope for the provision of insurance by firms.

3.1 Implicit Self-Enforcing Contracts

In this subsection implicit self-enforcing contracts as in Thomas and Worrall (1988) are embedded into the search and matching model with risk-averse workers. The exposition below follows Rudanko (2006).

3.1.1 Environment, Workers and Firms

Consider the same economic environment as introduced in Section 2.1. Here I additionally specify the search and matching technology, the mechanism for wage determination, workers' utility function, and the stochastic process for productivity shocks.

Firms are risk neutral and maximize the expected present discounted value of profits. Workers are risk-averse and maximize the expected present discounted value of utility:

$$E_t \sum_{\tau=t}^{\infty} \beta^{\tau} \varphi(c_{\tau}),\ \varphi'(c_{\tau}) > 0, \varphi''(c_{\tau}) < 0,$$

where c_τ is consumption in period τ, which is equal to the wage for employed workers and to the consumption equivalent, b, for unemployed agents.

I model the search technology using the competitive search framework of Moen (1997). Firms open vacancies with associated employment contracts and workers direct their search to employment contracts. The vacancies opened with the associated contract σ and the unemployed workers searching for contract σ constitute a labor market with an associated market tightness θ_σ. A contract is a state-contingent sequence of wages that delivers a certain promised value to the worker. The contracts considered here insure workers against fluctuations in wages caused by fluctuations in productivity. However, they do not insure against the drop in consumption caused by the termination of the employment relationship.

The matching function has a conventional Cobb-Douglas specification (Petrongolo and Pissarides 2001), $m(u,v) = Ku^{\alpha}v^{1-\alpha}$, where $\alpha \in [0,1]$, is the elasticity of matching function with respect to the number of unemployed. Given $\theta = \frac{v}{u}$, a labor market tightness, the probability of filling a vacancy for a firm is $q(\theta) = \frac{m(v,u)}{v} = K\theta^{-\alpha}$ and the probability of finding a job for an unemployed worker is $\mu(\theta) = \frac{m(v,u)}{u} = K\theta^{1-\alpha}$.

The stochastic process for aggregate productivity, z, is governed by a stationary first-order Markov process with transition probabilities $\pi(z_{t+1}|z_t)$ and a set of possible states $Z = \{z_1, ..., z_K\}$ such that $z_i < z_{i+1}$, $1 \leq i < K$. All agents in the economy can observe the aggregate state.

I distinguish three types of contracts based on different degrees of commitment: full commitment contracts, contracts with lack of commitment from the worker's side and full commitment from the firm's side, and contracts with lack of commitment from both the worker's and firm's sides. If there is a lack of commitment from any side of the contract, the contract should be self-enforcing for that side to prevent reneging. A contract is self-enforcing for a worker if in any period the value a worker receives from a contract σ is not less than the value a worker receives upon reneging on the contract. A contract is self-enforcing for a firm if in any period the value the firm obtains from the contract σ is not less than the value the firm can obtain from severing an employment relationship and entering a pool of inactive firms, which have option value 0.

When employed, a worker produces output z_t and consumes the wage, $w_\sigma(t_0, z^t)$, specified under the contract accepted at the beginning of the employment relationship. An employed worker becomes unemployed when the employment relationship is terminated due to the exogenous separation shock or when either of the parties reneges on the contract. Given that the contract is self-enforcing or the agent is assumed fully committed, a worker will never quit.

In the original Thomas and Worrall (1988) environment without labor market frictions, workers who renege on the contract are prohibited from entering any contractual arrangements in the future and are bound to trade their labor services at the spot market wage. In the current environment, once unemployed, workers search and enter contractual arrangements as soon as they find a new match. However, both firms and workers face search and matching frictions. Those frictions influence the value of the outside option through the probability of finding a new match. The job finding probability in the economy depends on the aggregate productivity and the number of unemployed workers searching for a job, which are the two state variables in the economy. However, as is customary in the literature (Shimer 2005), I consider only those equilibria in which all endogenous variables depend only on the history of aggregate productivity, z^t. Once unemployed and searching, all workers are identical: there are no savings and no stigma attached to being unemployed.

The value an employed worker receives in period t from a contract that started in period t_0, $V_{e,\sigma}(t_0, z^t)$, is

$$V_{e,\sigma}(t_0, z^t) = \varphi(w_\sigma(t_0, z^t)) + E_t \sum_{\tau=t+1}^{\infty} \beta^{\tau-t}(1-\delta)^{\tau-(t+1)} \left[(1-\delta)\varphi(w_\sigma(t_0, \{z^{\tau-1}, z_\tau\})) + \delta V_u(z_\tau)\right].$$

The value of a newly unemployed worker or a worker who did not find a match in the current period is a sum of the current utility, obtained from consuming an unemployment benefit, b, and the expected discounted value from searching:

$$V_u(z_t) = \varphi(b) + \beta E_t \left[\mu(\theta_\sigma(\{z^{t+1}, z_t\}))V_{e,\sigma}(t+1, \{z^t, z_{t+1}\}) + (1 - \mu(\theta_\sigma(\{z^{t+1}, z_t\})))V_u(z_{t+1})\right].$$

The value a firm obtains in period t given the aggregate state z_t from a contract σ that started in period t_0 is

$$J_{f,\sigma}(t_0, z^t) = z_t - w_\sigma(t_0, z^t) + E_t \sum_{\tau=t+1}^{\infty} (\beta(1-\delta))^{\tau-t}(z_\tau - w_\sigma(t_0, \{z^{\tau-1}, z_\tau\})).$$

3.1.2 Efficient Equilibrium Contracts in a Search and Matching Environment

Equilibrium contracts are limited to efficient optimal contracts. A contract is efficient if there exists no other contract that offers each party at least as much expected utility and one party strictly more. A contract is optimal if it maximizes the total welfare given the initial promise of a value to one of the parties. An efficient contract cannot be Pareto dominated after any history. Hence, after any history it can be rewritten as a maximization problem. The Pareto frontier is traced by varying the value promised by the contract to the worker and maximizing the value of the firm given the worker's promised value. As in Thomas and Worrall (1988), the history of the productivity realizations from the start of the match can be summarized by the worker's promised value. Given the assumption that z_t follows a first order Markov process, it is sufficient to keep track of the current value of z to determine the expectations. In the presentation that follows the time subscripts are suppressed: z denotes the current value of productivity and z' denotes the value next period.

Let V be the value promised to a worker under the contract. Let $V_u(z)$ be the value of an unemployed worker given aggregate state z and let $f(z, V, V_u(z))$ denote a value of a firm from a contract on a Pareto frontier given z, V, $V_u(z)$, and the evolution of $V_u(z)$. Then $f(z, V, V_u(z))$ solves the following dynamic programming optimization problem for all $z \in Z$:

$$f(z, V, V_u(z)) = \max_{w, \{V(z')\}_{z' \in Z}} \quad z - w + \beta E_z (1-\delta) f(z', V(z'), V_u(z')) \tag{8}$$

s. t.

$$V = \varphi(w) + \beta E_z \left[(1-\delta)V(z') + \delta V_u(z')\right] \tag{9}$$

$$V(z') \geq V_u(z') \ \forall \ z' \in Z \tag{10}$$

$$f(z', V(z'), V_u(z')) \geq 0 \ \forall \ z' \in Z. \tag{11}$$

An efficient contract maximizes the value of a firm, f, given the aggregate state, z, the promised value for the worker, V, and the worker's outside option, $V_u(z)$. The first constraint is a promise-keeping constraint that specifies that a worker gets exactly value V from the contract that pays wage w and promises values $V(z')$ for all states $z' \in Z$ where there is no exogenous separation. The second and third constraints are self-enforcing constraints for the worker and the firm, respectively. By omitting self-enforcing constraints, contracts with different degrees of commitment are obtained:

1) full commitment (by omitting (10) and (11)); 2) lack of commitment from the worker's side and full commitment from the firm's side (by omitting (11)); and 3) two-sided lack of commitment (when both (10) and (11) are present).

I study equilibria of this economy which consist of a contract $\sigma(z)$, value functions for the firm from a contract $\sigma(z)$, f_σ, values promised to the worker at the time of hiring, $V_{h,\sigma}(z)$, values of an unemployed worker, $V_u(z)$, and a market tightness, $\theta_\sigma(z)$, associated with the contract $\sigma(z)$ for each $z \in Z$, such that

1. (Optimization) Given a vector V_u, the list of functions $f(z, V_{h,\sigma}(z), V_u(z))$ solves the dynamic programming problem (8)-(11).

2. (Free entry) Firms enter a labor market and post vacancies with the associated contract σ until the value of posting a vacancy is driven to 0:

$$q(\theta_\sigma(z))f(z, V_{h,\sigma}(z), V_u(z)) = c. \tag{12}$$

3. The value of an unemployed worker evolves according to the following rule:

$$V_u(z) = \varphi(b) + \beta E_z \left[\mu(\theta_\sigma(z'))V_{h,\sigma}(z') + (1 - \mu(\theta_\sigma(z')))V_u(z')\right]. \tag{13}$$

In addition, I impose the following equilibrium refinement:

4. (Pareto efficiency) There does not exist an efficient self-enforcing contract $\sigma'(z)$ and an associated labor market with tightness $\theta_{\sigma'}(z)$ such that the net surpluses from search for a worker, $\mu(\theta_{\sigma'}(z))(V_{h,\sigma'}(z) - V_u(z))$,and for a firm, $-c + q(\theta_\sigma(z))f(z, V_h(z), V_u(z))$, are at least as much as under $\sigma(z)$ and $\theta_\sigma(z)$ and for one party it is strictly more.

This refinement of the set of equilibrium contracts follows Rudanko (2006), who motivates it from the competitive search formalism of Moen (1997), in which competitive market-makers specify the set of the efficient self-enforcing contracts that can be posted in the economy. Each contract is offered in a separate market with an associated labor-market tightness, and in equilibrium each market must offer the same surplus from search for firms and the same surplus for workers. Because of competition between market-makers, only markets in which the offered contract is on the Pareto frontier will be opened in equilibrium. Condition 2 combined with Condition 3 determines equilibrium values of the promised value for the worker at the time of hiring, $V_{h,\sigma}(z)$, and an equilibrium value of the market tightness in the market with σ, $\theta_\sigma(z)$.

In this economy unemployment evolves according to the following law, given $u(z_{t_0})$:

$$u(\{z^t, z_{t+1}\}) = u(z^t) + (1 - u(z^t))\delta - \mu(\theta(\{z^t, z_{t+1}\}))u(z^t). \tag{14}$$

The pool of unemployed in the current period consists of unemployed workers from the previous period and those who became unemployed because of the exogenous separations in the previous period, net of the unemployed workers who find jobs in the current period.

Thomas and Worrall (1988) and Rudanko (2006) prove that the optimization problem described above is a concave problem, so the first-order conditions are necessary and sufficient. The first-order conditions for an arbitrary z read:

$$-\lambda_z = -\frac{1}{\varphi'(w)}. \tag{15}$$

$$-\lambda_z = (1 + \zeta(z'))f_V(z', V(z'), V_u(z')) + \phi(z') \; \forall z' \in Z, \tag{16}$$

where λ_z is the Langrange multiplier on the promise-keeping constraint; $\beta\pi(z'|z)\phi(z')$, are Langrange multipliers on the self-enforcing constraints for a worker, and $\beta\pi(z'|z)\zeta(z')$ are Langrange multipliers on self-enforcing constraints for a firm $\forall z' \in Z$. Complimentary slackness conditions: $\lambda_z \geq 0$, $\zeta(z'), \phi(z') \geq 0 \; \forall z'$, and (10) and (11). The envelope condition:

$$f_V(z, V(z), V_u(z)) = -\lambda_z. \tag{17}$$

Combining the envelope condition, (17), with the first order conditions, gives the following condition which links current and next period wage:

$$\frac{1}{\varphi'(w(z, V, V_u(z)))} = (1 + \zeta(z'))\frac{1}{\varphi'(w(z', V(z'), V_u(z')))} + \phi(z') \; \forall z' \in Z$$

The following proposition obtains.

Proposition 2. (Thomas and Worrall 1988, Rudanko 2006). *For any history (z^t, z_{t+1}), there exists a $w_{\min}(z_{t+1})$ and $w_{\max}(z_{t+1})$, $w_{\min}(z_{t+1}) \leq w_{\max}(z_{t+1})$, such that the contract wage at $t+1$ is*

1) in the contract with full commitment: $w(z^t, z_{t+1}) = w(z^t)$;

2) in the contract with lack of commitment from the worker and full commitment from the firm:

$$w(z^t, z_{t+1}) = \begin{cases} w(z^t) & \text{if } w_{\min}(z_{t+1}) \leq w(z^t) \\ w_{\min}(z_{t+1}) & \text{if } w(z^t) < w_{\min}(z_{t+1}) \end{cases};$$

3) in the contract with two-sided lack of commitment:

$$w(z^t, z_{t+1}) = \begin{cases} w_{\max}(z_{t+1}) & \text{if } w(z^t) > w_{\max}(z_{t+1}) \\ w(z^t) & \text{if } w_{\min}(z_{t+1}) \leq w(z^t) \leq w_{\max}(z_{t+1}) \\ w_{\min}(z_{t+1}) & \text{if } w(z^t) < w_{\min}(z_{t+1}) \end{cases}.$$

The reader is referred to the original papers for proof. Proposition 2 states that whenever possible, the optimal contract offers a constant wage. However, in the contracts with lack of commitment, if the value of the outside option exceeds the value under the contract, the wage is adjusted to prevent reneging.

Because of free entry and Pareto optimality, $V_h(z)$ and $\theta(z)$ solve the following maximization problem given $V_u(z)$:[4]

$$\max_{\{\theta(z)\},\{V_h(z)\}} \left\{ \ \mu(\theta(z))(V_h(z) - V_u(z)) \ \right\} \tag{18}$$
$$\text{s.t. } q(\theta(z)f(z, V_h(z), V_u(z)) = c$$

Combining the first order condition for Pareto optimality problem, (18), the free entry condition, (12), the envelope condition, (17), the first order condition for wages, (15), and the law of motion for the value of unemployed workers, the following system of equations characterizes the equilibrium objects f, $V_u(z)$, $V_h(z)$ and $\theta(z)$ $\forall z \in Z$, given the optimal contract described in Proposition 2.

$$\frac{\alpha}{1-\alpha} f(z, V_h(z), V_u(z)) = \frac{V_h(z) - V_u(z)}{\varphi'(w(z, V_h(z), V_u(z)))}. \tag{19}$$

$$\theta(z) = \left(\frac{c}{f(z, V_h(z), V_u(z))} \frac{1}{K} \right)^{-\frac{1}{\alpha}}. \tag{20}$$

$$V_u(z) = \varphi(b) + \beta E_z \left[\mu(\theta_\sigma(z'))V_{h,\sigma}(z') + (1 - \mu(\theta_\sigma(z')))V_u(z') \right]. \tag{21}$$

3.2 Continuous Rebargaining

In addition to the contracting environments considered in Section 3.1, I also consider the possibility that wages are determined by continuous rebargaining. This assumption is the benchmark case in the literature. When an unemployed worker and a firm with an open vacancy meet, they bargain over the total surplus from the match. Wages in this case are determined by the Nash bargaining every period. All other details of the economy remain the same as in Section 3.1.[5]

An equilibrium in this economy with continuous rebargaining consists of the set of the value functions for a firm, $J_f(z)$, (1), and $J_v(z)$, (2), and a worker, $V_e(z)$, (3) and $V_u(z)$, (4), and a market tightness $\theta(z)$, such that

1. (Free entry) The value of a vacancy is 0:

$$q(\theta(z))J_f(z) = c.$$

2. (Surplus division) Each period during an employment relationship, the firm and the worker bargaining over the match surplus. At the time of bargaining the outside option value for a worker is

[4] Rudanko (2006) proves that given fairly mild conditions there is a unique Pareto-efficient contract offered in equilibrium.

[5] As in Section 3.1, I consider equilibria that depend on aggregate productivity only.

the value of unemployment, while the outside option for a firm is 0 (the value of an inactive firm). A matched worker-firm pair divides the total surplus from the match by solving the following maximization problem:

$$\max_{V_e(z)-V_u(z),J_F(z)} (V_e(z)-V_u(z))^{\eta}\, J_f(z)^{1-\eta}$$
$$\text{s.t. } \frac{V_e(z)-V_u(z)}{\varphi'(w(z))}+J_f(z)=S(z) \tag{22}$$

where η is a bargaining power of the worker, $\varphi'(w)$ is the marginal utility of income, and $S(z)$ is a total surplus.

3. The value of an unemployed worker evolves according to the following rule:

$$V_u(z)=\varphi(b)+\beta E_z\left[\mu(\theta(z'))V_e(z')+(1-\mu(\theta(z')))V_u(z')\right].$$

The first order condition for the bargaining problem (22) is

$$\frac{\frac{V_e(z)-V_u(z)}{u'(w(z))}}{J_f(z)}=\frac{\eta}{1-\eta}\forall z\in Z. \tag{23}$$

This condition is familiar from the literature: the share of the surplus that agent obtains from a productive match corresponds to her bargaining power. As opposed to the implicit contracts described above, continuous rebargaining does not entail risk sharing and will not be optimal if workers are risk averse.

4 Empirical Evidence on the Cyclicality of the Wage Cost and Individual Wages

Empirical studies of the cyclicality of individual wages provide both direct and indirect evidence for the relevance of implicit contracts for individual wage dynamics over the business cycle.

The cyclical behavior of individual wages distinguishing wages of newly hired workers was first examined by Bils (1985). Using NLS data, 1966-80, he concludes that there are substantial differences in the cyclicality of wages of workers continuously employed at the same job and those of workers who are newly employed. The cyclicality of wages is measured as the percent change in wages due to a one percentage point increase in the unemployment rate. In his study a percentage point increase in the unemployment rate is associated with a 0.64% decrease in real wages of job stayers and with a 3.69% decrease in the wages of job changers. The corresponding figure for the cyclicality of wages of all workers is -1.59. Numerous studies since, using different data sets, also find that the cyclicality of job changers is substantially higher than that of job stayers (among them

Solon, Barsky, and Parker (1994) using the PSID and Shin (1994) using the NLS).

The empirical evidence on the cyclicality of individual wages is summarized in Pissarides (2007). He reports that the general consensus in the literature on the cyclicality of the wages of newly hired workers is -3.0%, while the cyclicality of the wages of job stayers is approximately -1%. This evidence suggests that the wages of newly hired workers are adjusted to reflect the economic conditions at the time of hiring. However, within employment relationships wages are smoothed and only respond weakly to changes in economic conditions. The substantial cyclicality of the wages of newly hired workers as compared to the wages of continuously employed workers suggests the existence of contractual arrangements that smooth wages over the course of employment.

More direct evidence of implicit contracts in wages is presented in Beaudry and DiNardo (1991). They test whether a contractual wage model is more consistent with the formation of wages than a spot market model. In addition to the contemporaneous unemployment rate in the regressions of real wages on unemployment, they also include the unemployment rate at the start of the job and the minimum unemployment rate since the start of the job. Using PSID data for 1976-84 and CPS data for 1979 and 1983, they find that the effect of the minimum unemployment rate since the start of the job dominates the effects of the other two unemployment rates. Grant (2003) replicates the Beaudry and DiNardo regressions using the NLS up to 1998 and concludes that the minimum unemployment rate from the start of the job as well as the contemporaneous unemployment rate are significant for the determination of the real wage.

Motivated by the evidence of implicit contracts, in Kudlyak (2007) I conduct an empirical investigation of the cyclicality of the wage component of the user cost of labor using the NLSY79 data.

Since the user cost of labor is not directly observed in the data, it is constructed based on the behavior of individual wages and turnover. First, I estimate an empirical model of the response of individual wages to the labor market conditions, controlling for individual-specific effects. The labor market conditions are proxied by the history of unemployment rates. As in Beaudry and DiNardo (1991), I consider the initial unemployment rate, the minimum unemployment rate from the start of the job and the current unemployment rate. Next, using the estimated empirical model for wages, the empirical separation rate, and the forecasting equation for unemployment, I construct the series of the user cost of labor. In the construction future payments are discounted to take into account the separation rate and the real interest rate. Finally, the constructed series of the logarithm of the user costs is projected on the unemployment rate.

I find that the wage component of the user cost of labor so constructed is almost three times as cyclical as the individual wages. In particular, one percentage point decrease in unemployment generates approximately 4.5% increase in the price of labor. This cyclicality is also noticeably higher than the cyclicality of the wages of newly hired workers reported in the literature (see Pissarides

(2007)). The relatively high cyclicality of the price of labor uncovers a substantial amplification of the cost incentives for job creation over the business cycle relative to the observed wages.

5 Quantitative Results

The purpose of the quantitative results section is twofold. First, it is to demonstrate that, given conventional parameter values, in the implicit contracts models the wage component of the user cost is much more cyclical than the individual wages. Second, when the model is calibrated to match the empirical cyclicality of the wage component of the user cost, the standard deviation of the vacancy-unemployment ratio is approximately half of its empirical counterpart.

5.1 Parameterization

For the first part of the quantitative results I adopt the conventional parameter values from the literature. The idea is to show that, for a broad ranges of parameter values, the contractual models deliver a cyclicality of the wage component of the user cost of labor higher than the cyclicality of individual wages. The parameters of the stochastic process for productivity shocks can be calibrated outside of the model as shown below. Then, the only parameter that requires calibration within a model is the cost of posting a vacancy, c. It is calibrated to match the mean monthly job finding rate, $E(\mu(\theta)) = 0.45$.

For the second part of the quantitative results, in addition to calibrating $E(\mu(\theta))$, I calibrate the model to match the cyclicality of the wage component of the user cost found in Kudlyak (2007). Hence, an additional free parameter is needed. When the model is calibrated to two targets – the mean expected job finding rate and the cyclicality of the wage cost (or the standard deviation of v-u ratio), it is done via the cost of posting a vacancy, c, and the consumption of unemployed, b.

The value of the consumption of unemployed has been documented to have an important impact on the quantitative behavior of such models (Hagedorn and Manovskii 2005, Rudanko 2006). In a model with risk neutral workers and continuous rebargaining, Hagedorn and Manovskii show that a high value of b, $b > 0.95E(z)$, combined with low bargaining power of workers, can deliver the empirical volatility of the vacancy-unemployment ratio. A high value of the consumption of unemployed increases the value of unemployment relative to the value of employment. With high b, the worker's wage is close to productivity and its response to productivity is limited by the low bargaining power. In the continuous rebargaining model wage equals the wage component of the user cost. Given the rigid and large wage component of the user cost, the vacancy cost is very responsive to changes in productivity. However, the general consensus in the literature is that the consumption of a worker who becomes unemployed drops much more than 5%. Shimer (2005) uses $b = 0.40$ in a model with linear utility, which is a replacement rate of unemployment benefits

($E(z) = 1$). Hall (2005), Pissarides (2007) and Mortensen and Nagypal (2006) use a higher value of 0.70, also in a model with risk neutral workers. In this paper workers are risk averse. This implies that the consumption equivalent of the unemployed is not directly comparable to b in the models with linear utility. Hence, in this paper I present results for different values of b, except for the cases when the model has two calibration targets; then b is one of the calibrated parameters.

The model period is one month. The adopted parameters are reported in Table 1. The discount factor is .9960, that corresponds to the annual discount rate of 4.88%. The monthly separation rate is set to 0.034 (Shimer 2005). The existing literature reports a matching function parameter α in the range $0.5 - 0.7$ (Petrongolo and Pissarides 2001). In all parameterizations below the bargaining power of workers is set to equal α to preserve the mathematical equivalence of the competitive search and random search equilibria (Rudanko 2006).[6] Later on I perform the sensitivity analysis with respect to α.

The calibration of the production process is carried outside of the computation of the solution to the models. To calibrate a stochastic process for productivity, I consider a three-state symmetric Markov process, $\mathbf{z} = [z_0 - \Delta, z_0, z_0 + \Delta]$, $\Delta > 0$, with the transition matrix, where

$$\mathbf{\Pi}_z = \begin{bmatrix} \lambda & 1-\lambda & 0 \\ \frac{1}{2}(1-\lambda) & \lambda & \frac{1}{2}(1-\lambda) \\ 0 & 1-\lambda & \lambda \end{bmatrix}.$$

The variance of this process, σ_z^2, is $\frac{\Delta^2}{2}$ and the autocorrelation, ρ, is λ. The expected value, $E(z)$, is normalized to 1. The parameters Δ and λ are calibrated to match the quarterly standard deviation, 0.02, and quarterly autocorrelation, 0.878, of productivity per worker as reported by BLS. The empirical targets are obtained from Shimer (2005), Table 1, which are the statistics from the deviations in logarithms at quarterly frequency from an HP trend with smoothing parameter 10^5.To find Δ and λ, I draw the initial shock from a stationary distribution of z and, using the initial values for Δ and λ, generate monthly series of length $12T$, where T is the length of the time series in the data in years (from 1951 to 2003), aggregate by summing to obtain quarterly data, calculate the standard deviation and the autocorrelation of the logged quarterly series, and iterate until meeting the calibration targets.

I obtain corresponding statistics for the models by simulating economies with each of the four different wage setting mechanisms as follows. First, a vector of aggregate shocks, z, is generated„ which is common to the four model economies. For the panel of 10,000 individuals an initial employment status is drawn. Then, each period, the separation shock is drawn for each employed

[6] Rudanko (2006) shows the mathematical equivalence of the competitive search and random search equilibria if $\eta = \alpha$ in the environment with risk averse workers. This result has been known as the Hosios condition (Hosios 1990) in the models with risk neutral wokers.

individual and his employment status is updated, and for each unemployed agent the job finding shock is drawn and his unemployment status is updated. Given the employment histories of individuals, individual wages are generated according to the wage setting mechanism. The first $4,000$ periods of the simulated series are discarded; the statistics are based on the series from the last 636 periods. The results that follow are based on the simulations of the four economies with the different wage setting mechanisms, but hit by the exact same sequence of productivity shocks.[7]

5.2 The Cyclicality of the Components of the User Cost of Labor and Individual Wages

In this section I investigate the cyclicality of wages and the components of the user cost of labor in the search and matching models with the different wage setting mechanisms. The cyclicality of the series x is measured as a projection of the logarithm of the series on the unemployment rate, $\frac{cov(\ln(x),u)}{var(u)} * 100$, which is the semi-elasticity of the series with respect to unemployment. It indicates the percentage change in the variable as the unemployment rate increases by one percentage point. I report the cyclicality of the individual wages of all workers, wages of newly hired workers, and of the components of the user cost of labor.

Table 2 reports the cyclicality of wages and the user cost of labor for the models where workers have logarithmic utility. As can be seen from Table 2, the cyclicality of individual wages varies across wage setting mechanisms with the wages being only mildly procyclical in the implicit contract models and as cyclical as the wage component of the user cost in continuous rebargaining.

In the continuous rebargaining model wages of all workers are rebargained every period. Consequently, every period wages across all matches are the same. The wage upon hiring reflects the cost of labor (sans vacancy costs). Hence, the wages of newly hired workers and the wage component of the user cost are as cyclical as the wages of all workers.

This is not the case in the implicit contract models. As can be seen from Table 2, the wage cost component in those models is more than twice as cyclical as the wages of newly hired workers. And the wages of newly hired workers are approximately 3 times as cyclical as the wages of all workers.

The cyclicality of the wages in the model with implicit contracts and full two-sided commitment obtains due to new hires entering employment relationship, constant separation rate and a positive autocorrelation in the productivity process. In the model with full commitment on the firm's side and lack of commitment on the worker's side, in addition to the composition effect, the wages in the existing employment relationships are bid up whenever the worker's outside option value becomes more attractive than the value from the contract. In the model with lack of commitment on both firm's and worker's sides the wages can also be bid down whenever the value from the match for a

[7] Since the model is stationary, I do not HP-filter series simulated from the model.

firm falls below 0.[8]

To understand why the cyclicality of the wage component of the user cost in the implicit contract models is higher than the cyclicality of wages at the time of hiring recall the workings of the wage setting mechanism. The implicit contracts offer individual wages that are rigid during employment relationship to insure workers, who cannot save, against fluctuations in consumption. The wages of new hires adjust to reflect the worker's outside option value. Consequently, the wages of newly hired workers are more cyclical than the wages of all workers. For example, when the job finding rate is low, the hiring wage is relatively low. In addition, the wages in all subsequent periods in the employment relationship are relatively lower than the wages in the contracts, initiated under the more favorable economic conditions. If the labor market is expected to tighten, by hiring now the firm commits to a comparatively lower stream of wages. The wage component of the user cost takes into account both the lower hiring wage and lower future wage payments. Hence, the wage component of the user cost is more procyclical than the wages of newly hired workers.

I obtain similar results from the models, where workers' coefficient of relative risk aversion is 3 (Table 3). As workers' risk aversion increases, they are willing to accept lower wages in exchange for less variability in the hiring wage. Hence, the individual wages are less responsive to the changes in economic conditions. Lower wages bring down the wage component of the user cost and firms increase job creation. To preserve the expected job finding rate, the cost of opening a vacancy, c, goes up. As a result, the increase in risk aversion from 1 to 3 slightly lowers the cyclicality of individual wages and the wage cost component in the implicit contracts models. However, the main lesson remains.

In summary, the quantitative results show that in the presence of implicit contracts the wage cost component is more cyclical than the wages of newly hired workers, which in turn are more cyclical than the wages of all workers. Individual wage cyclicality varies significantly depending on the individual wage setting mechanism. Wages are only weakly procyclical in the model with implicit contracts with full commitment. They are more cyclical in the models with implicit contracts with lack of commitment. In the continuous rebargaining models the individual wage is as cyclical as the wage cost component of the user cost.

The quantitative results demonstrate that, when wages are smoothed by implicit contracts, the dynamics of individual wages are not directly related to the dynamics of the user cost of labor, which constitutes the cost incentives for job creation. In that case a weak cyclicality of the wages can conceal a substantial cyclicality of the wage component of the user cost of labor. Furthermore, focusing on the cyclicality of individual wages gives a misleading assessment of the quantitative behavior of the model if the wage setting mechanism, which is not a central feature of the model,

[8] The cyclicality of individual wages in the models with contracts and lack of commitment also depends on the number of states of the productivity process. However, qualitatively or quantitatively it does not have an impact on the main results.

is specified incorrectly.

Given the consumption equivalent of unemployed of 0.70, the implicit contract models generate a standard deviation of the vacancy-unemployment ratio of approximately 0.0620 and only slightly higher in continuous rebargaining, while the empirical counterpart is 0.3820 (Shimer 2005). At the same time, the wage component of the user cost is almost twice as cyclical as its empirical counterpart. In the next subsection I calibrate the models to match the empirical cyclicality of the wage component of the user cost.

5.3 Quantitative Behavior of the Search and Matching Model

As reported in Tables 2 – 3, given conventional parameter values, the model generates a wage component of the user cost that is too cyclical as compared to the data. At the same time the vacancy-unemployment ratio is not volatile enough. In this section I calibrate the models to match the cyclicality of the wage cost component of the user cost of labor found in Kudlyak (2007). This exercise tests the quantitative implications of the search and matching model for the volatility of the vacancy-unemployment ratio given the empirical cyclicality of the wage component of the user cost which is relevant for the job creation decisions of the firms.

Shimer (2005) and Hall (2005) are among the first to draw attention to the lack of an amplification mechanism in the basic search and matching model. In particular, Shimer shows that the model generates the elasticity of the vacancy-unemployment ratio with respect to productivity only slightly in excess of 1. In the data the vacancy-unemployment ratio is 20 times as volatile as productivity. In the standard search and matching model (Pissarides 1985, Mortensen and Pissarides 1994) with risk neutral agents the surplus at the time of hiring is divided according to Nash bargaining. Shimer (2005) argues that more rigid wages in present value terms can amplify the cyclical fluctuations job creation. In Shimer's paper the rigid wage assumption was derived from analytical considerations and was not tested in the data.

In Table 4 the cost of opening a vacancy, c, and the consumption of unemployed agents, b, are calibrated to match the expected value of the job finding rate, $E(\mu(\theta)) = 0.45$, and the cyclicality of the wage component of the user cost, $cov(\ln(UC^W), u)/var(u) = -0.045$ (Kudlyak 2007). In order to generate the empirical cyclicality of wages, the value of the consumption of unemployed must rise to more than 80% of the wage. Regardless of the wage setting mechanism, the model generates approximately $1/3 - 1/2$ of the empirical volatility of the vacancy-unemployment ratio, 0.3820, reported in Shimer (2005).[9]

The strong procyclicality of the wage component of the user cost dampens the effect of economic conditions on the job creation decision of firms over the business cycle. As a result, the model

[9] Alternatively, to match the empirical volatility of the vacancy-unemployment ratio, the model generates the wage component of the user cost that is more rigid as compared to the empirical counterpart (See Table 6).

generates too little volatility in job creation. The reasons for the mitigation lie in the nature of the implicit contracts which tie future wages within an employment relationship to its initial conditions, and in the mean reversion of unemployment fluctuations. As the elasticity of the matching function increases, the empirical cyclicality of the wage cost is associated with somewhat higher volatility of the vacancy-unemployment ratio. However, at $a = 0.72$, the volatility is still not more than half of its empirical counterpart (Table 4).

As shown in Table 4, there are substantial differences in individual wage cyclicality across the wage setting mechanisms. However, there is no significant difference in the volatility of the vacancy-unemployment ratio across wage setting mechanisms once the cyclicality of the wage component of the user cost is calibrated. Hence, the wage cost component allows for quantitative analysis of the model, sidestepping the direct effect of the individual wage setting mechanism.

In the case when both firms and workers are risk neutral and the elasticity of the matching function, α, equals the worker's bargaining power, η, the individual wage setting mechanism does not have any impact on job creation (Table 5, the linear utility case). If both firms and workers are risk neutral, then the individual path of wages does not have affect the total surplus from job creation as long as the present discounted value of wages at the time of hiring remains the same. The implicit contracts do not have a micro-foundation in this context. However, one can think about the wage paths in Proposition 2 as the examples of the different individual wage dynamics. The economies with different wage settings that are hit with the same productivity shock are observationally equivalent except for the dynamics of individual wages. Hence, the job finding rate and the components of the user cost are equal state by state across the economies. All four economies share the same cyclicality of the wage component of the user cost. However, individual wages, and hence the cyclicality of the individual wages and even the wages of newly hired workers differ substantially across all four economies.

Subsequent to Shimer, the literature has turned to contrasting the wage dynamics in the model with the data (Hagedorn and Manovskii 2005, Rudanko 2006, Pissarides 2007, Haefke, Sonntag and Rens 2007). Although it is acknowledged that the wage is not allocational in the presence of a long term employment relationship, the literature concentrates mostly on individual wage dynamics. Pissarides (2007) and Haefke, Sonntag and van Rens (2007) emphasize the importance of the dynamics of individual wages as opposed to the aggregate wage to the job creation decisions of firms and examine the dynamics of wages of newly hired workers obtained from the model with continuous rebargaining. Under continuous rebargaining wages are the same across all job matches in every period. This implies that the average wage at time t equals the wage of new hires at time t and equals the wage component of user cost. In the data the average wage is less cyclical than the wages of newly hired workers. Hence, the comparison of the dynamics of the wages from the model to the dynamics of the wages of newly hired workers as opposed to the dynamics of the average wage already helps to shift away from the wage rigidity. However, under continuous rebargaining, the dynamics of wages from the model should be contrasted with the dynamics of the wage component of the user cost in the data. In the data the latter is noticeably more cyclical than the wages of newly hired workers. This implies more negative news for the quantitative behavior of the basic search and matching model.

While testing for the individual wage setting mechanism is not the main focus of this paper, the magnitudes of the cyclicality of individual wages in Table 4 provide some insight for the relevance of implicit contracts for individual wage dynamics. In particular, as discussed above the empirical studies report the cyclicality with respect to unemployment in the range -1 to -1.5% for wages of all workers and -3% for wages of newly hired workers. In Table 4, the model with implicit contracts and two-sided lack of commitment generates individual wage dynamics with cyclicality comparable to their empirical counterpart. However, in the continuous rebargaining model the cyclicality of wages of new hires and all workers are the same. Hence, the data reject continuous rebargaining in favor of the models with contracts.

5.4 Sensitivity Analysis

For the broad set of the parameter values adopted in the literature I find that the implicit contracts models generate substantially more cyclicality of the wage component of the user cost than the cyclicality of the individual wages or even the cyclicality of the wages of newly hired workers. In this subsection I present model-generated results for different parameter values of the consumption of the unemployed, b, and the elasticity of the matching function, a.

Table 7 presents results from economies that differ only in the level of consumption of unemployed agents. As the consumption of the unemployed, b, increases, individual wages and the wage component of the user cost increase towards productivity. As the wage component constitutes a larger share of the user cost and its coefficient of variation decreases, the volatility of the vacancy cost component, and, therefore, of the vacancy-unemployment ratio, increases to absorb fluctuations in productivity. However, even for $b = 0.90$, the model produces a volatility of the vacancy-unemployment ratio of only half of its empirical magnitude. In fact, to reach the empirical volatility of 0.3820, b should increase to 0.94 (Table 6). Notice that at $b = 0.90$, despite the volatility of the vacancy-unemployment ratio being only slightly above half of its empirical magnitude, the wage component of the user cost is more rigid than its empirical cyclicality. Table 8 shows the case in which workers have log utility, but similar results hold for the case when workers' risk aversion coefficient 3.

As the elasticity of the matching function increases the surplus from the match for the firm falls. To keep the expected value of the job finding rate constant, the vacancy creation cost falls as well. However, overall the volatility of the vacancy-unemployment ratio decreases. It reduces the volatility of unemployment and increases the cyclicality of wages and the user costs Table 8. However, the main lesson endures.

6 Conclusion

Empirical evidence suggests that the labor market is characterized by contractual arrangements as opposed to a spot market (Beaudry and DiNardo 1991, Kudlyak 2007). This implies that the wage at the time of hiring may not reflect the user cost of labor incurred by firms upon hiring. The user cost of labor summarizes the hiring wage as well as the current value of the expected future savings or losses associated with hiring a worker in the current period.

In this paper I have investigated the cyclicality of the components of the user cost of labor and wages in models with search and matching. I have considered four economies with different wage setting mechanisms: implicit contracts with full commitment, implicit contracts with lack of commitment on the worker's side and full commitment on the firm's side, implicit contracts with lack of commitment on both the worker's and the firm's sides, and continuous rebargaining. I show that firms create jobs up to the point where the worker's marginal product equals the labor's user cost.

I show that in the presence of contractual arrangements a weak cyclicality of individual wages can conceal a substantial cyclicality of the wage component of the user cost. Under the conventional parameter values the wage component of the user cost is more than 2 times as cyclical as even the wages of newly hired workers. This implies that the possibility to 'lock in' a worker to a stream of wages at the time of hiring and the mean reversion of the productivity process create expected future gains or losses from adding a worker today as opposed to next period. Consequently, the substantially procyclical wage component of the user cost of labor mitigates the effect of productivity shocks on the firms' job creation activity.

In particular, when I calibrate the four models to match the empirical cyclicality of the wage component of the user cost of labor as found in Kudlyak (2007), I find that the models produce approximately half of the empirical volatility of the vacancy-unemployment ratio, regardless of the wage setting mechanism. In addition, given the cyclicality of the wage component of the user cost, individual wage dynamics are irrelevant for the volatility of the vacancy unemployment ratio: the same process for the wage component of the user cost can be associated with individual wage dynamics ranging from very weakly procyclical (as in full commitment contracts) to as cyclical as the wage component of the user cost (as in continuous rebargaining).

In conclusion, the fact that firms do not rush to create vacancies in recessions despite substantial cost incentives in terms of relatively lower future wages may imply that there is some other element of costs associated with job creation that is countercyclical and that should be taken into account to counteract the low wage cost. Alternatively, unemployed workers in a recession may be of a lower value to an employer, so that employers do not benefit from hiring them; or the employment duration of the workers hired in recession is not long enough to reap the benefits from wage lock-in.[10] All these topics are potentially productive directions for future research.

[10] Heterogeneity of the unemployed is recently studied in Bils, Chang and Kim (2007).

Table 1: PARAMETERS

Parameter	Value	Comment
Discount rate, β	.9960	
Separation rate, δ	.0340	Shimer (2005)
Matching function elasticity $(Ku^{\alpha}v^{1-\alpha})$, α	0.5 - 0.7	Petrongolo and Pissarides (2001)
Matching function constant $(Ku^{\alpha}v^{1-\alpha})$, K	0.5	Normalization
Worker's bargaining power, η	α	Hosios (1990), Rudanko (2006)

Table 2: CYCLICALITY OF THE USER COST OF LABOR AND ITS COMPONENTS.

Log utility, $\alpha = 0.60$, $b = 0.70$

		Commitment Models			Re-
		Full	1-sided lack of	2-sided lack of	bargain
1	Individual wages (all)	-1.47	-1.47	-1.73	-9.47
2	Individual wages (new hires only)	-4.77	-4.77	-4.99	-9.41
3	Wage component of user cost	-11.15	-11.15	-11.07	-9.47
4	Vacancy component of user cost	-55.06	-55.06	-54.96	-55.14
5	User cost of labor	-11.89	-11.89	-11.82	-10.24
		θ statistics			
6	$\sigma_{\ln(\theta)}$, quarterly	0.0622	0.0622	0.0611	0.0704
		Calibrated parameters			
7	Vacancy creation cost, c	0.2675	0.2675	0.2676	0.2674

Results from simulating the models with risk averse workers (log utility). The vacancy creation cost, c, is calibrated to match $E(\mu(\theta)) = 0.45$. All statistics are calculated from the monthly series unless mentioned otherwise. The cyclicality of the series is calculated as $\frac{cov((\ln(x),u)}{var(u)} * 100$, which is the semi-elasticity of x with respect to unemployment, u: it indicates the % change in x for a unit increase in u (measured in percentage points). The corresponding quarterly statistics for the cyclicality of the wage component of the user cost for the four models are -11.15, -11.15, -11.08, and -9.4723, respectively. The statistics, corresponding to $\sigma_{\ln(\theta)}$, from the deviations in logarithms of the vacancy-unemployment ratio at quarterly frequency from an HP trend with smoothing parameter 10^5 for the four models are 0.0516, 0.0516, 0.0519, and 0.0599, respectively.

Table 3: CYCLICALITY OF THE USER COST OF LABOR AND ITS COMPONENTS.

CRRA $\gamma = 3$ utility, $\alpha = 0.60$, $b = 0.70$

		Commitment Models			Re-
		Full	1-sided lack of	2-sided lack of	bargain
1	Individual wages (all)	-1.44	-1.44	-1.45	-7.18
2	Individual wages (new hires only)	-4.67	-4.67	-4.68	-7.15
3	Wage component of user cost	-10.92	-10.92	-10.90	-7.18
4	Vacancy component of user cost	-54.98	-54.98	-54.96	-55.23
5	User cost of labor	-11.95	-11.95	-11.93	-8.29
		θ statistics			
6	$\sigma_{\ln(\theta)}$, quarterly	0.0604	0.0604	0.0605	0.0868
		Calibrated parameters			
7	Vacancy creation cost, c	0.3700	0.3700	0.3701	0.3699

Note - Results from simulating the models with risk averse workers (CRRA coefficient $\gamma = 3$). The vacancy creation cost, c, is calibrated to match $E(\mu(\theta)) = 0.45$. All statistics are calculated from the monthly series unless mentioned otherwise. The cyclicality of the series is calculated as $\frac{cov((\ln(x),u)}{var(u)} * 100$, which is the semi-elasticity of x with respect to unemployment, u: it indicates the % change in x for a unit increase in u (measured in percentage points). The corresponding quarterly statistics for the cyclicality of the wage component of the user cost for the four models are equal with respect to the precision in the tables. The statistics, corresponding to $\sigma_{\ln(\theta)}$, from the deviations in logarithms of the vacancy-unemployment ratio at quarterly frequency from an HP trend with smoothing parameter 10^5 for the four models are 0.0514, 0.0514, 0.0514, and 0.0738, respectively.

Table 4: CYCLICALITY OF THE USER COST OF LABOR AND ITS COMPONENTS AND THE VOLATILITY OF THE V-U RATIO.
Two calibrated targets: expectation of the job finding rate and the cyclicality of the wage component of the user cost.

	Log utility											
	$a = 0.50$				$a = 0.60$				$a = 0.72$			
	Commitment Models			Re-	Commitment Models			Re-	Commitment Models			Re-
	Full	1-sided lack of	2-sided lack of	bargain	Full	1-sided lack of	2-sided lack of	bargain	Full	1-sided lack of	2-sided lack of	bargain
	Cyclicality indicator											
Wages (all)	-0.59	-0.78	-0.95	-4.50	-0.58	-0.86	-1.56	-4.50	-0.58	-1.13	-2.24	-4.50
Wages (new hires only)	-1.94	-2.18	-2.34	-4.49	-1.94	-2.24	-2.77	-4.49	-1.94	-2.56	-3.51	-4.49
Wage component of user cost	-4.50				-4.50				-4.50			
Vacancy component of user cost	-37.09	-37.14	-37.07	-37.00	-57.20	-57.29	-57.25	-57.02	-107.64	-107.79	-107.57	-107.10
User cost of labor	-4.90	-4.90	-4.90	-4.94	-4.82	-4.83	-4.83	-4.85	-4.73	-4.73	-4.74	-4.74
	θ statistics											
$\sigma_{\ln(\theta)}$, quarterly	0.1164	0.1163	0.1163	0.1156	0.1475	0.1473	0.1472	0.1468	0.2140	0.2138	0.2136	0.2136
	Calibrated parameters											
Consumption of unemployed, b	0.8350	0.8335	0.8327	0.8193	0.8710	0.8698	0.8681	0.8616	0.9100	0.9088	0.9075	0.9056
Vacancy creation cost, c	0.1883	0.1901	0.1912	0.2079	0.1041	0.1051	0.1069	0.1123	0.0471	0.0476	0.0486	0.0495

Note - Results from simulating the models with risk averse workers (log utility). The vacancy creation cost, c, is calibrated to match $E(\mu(\theta)) = 0.45$ and the cyclicality of the wage cost component of the user cost. All statistics are calculated from the monthly series unless mentioned otherwise. The cyclicality of the series is calculated as $\frac{cov((\ln(x),u)}{var(u)} * 100$, which is the semi-elasticity of x with respect to unemployment, u: it indicates the % change in x for a unit increase in u (measured in percentage points). The corresponding quarterly statistics for the cyclicality of the wage component of the user cost for the four models and different values of α are equal with respect to the precision in the tables. The statistics, corresponding to $\sigma_{\ln(\theta)}$, from the deviations in logarithms of the vacancy-unemployment ratio at quarterly frequency from an HP trend with smoothing parameter 10^5 for the four models with $\alpha = 0.50$ are 0.0990, 0.0989, 0.0989, and 0.0983, respectively; for $\alpha = 0.60$: 0.1254, 0.1253, 0.1252, 0.1249; for $\alpha = 0.72$: 0.1821, 0.1820, 0.1819, 0.1818.

Table 5: Cyclicality of the user cost and its components and the volatility of the v-u ratio, $a = 0.60$.

Two calibrated targets: expectation of the job finding rate and the cyclicality of the wage component of the user cost.

	Linear utility				Logarithmic utility				CRRA 3 utility			
	Commitment Models			Re-	Commitment Models			Re-	Commitment Models			Re-
	Full	1-sided lack of	2-sided lack of	bargain	Full	1-sided lack of	2-sided lack of	bargain	Full	1-sided lack of	2-sided lack of	bargain
					Cyclicality indicator							
Individual wages (all)	-0.58	-0.90	-1.65	-4.50	-0.58	-0.86	-1.56	-4.50	-0.58	-0.80	-1.36	-4.50
Individual wages (new hires only)	-1.94	-2.25	-2.85	-4.49	-1.94	-2.24	-2.77	-4.49	-1.94	-2.21	-2.59	-4.49
Wage component of user cost	-4.50				-4.50				-4.50			
Vacancy component of user cost	-57.26				-57.20	-57.29	-57.25	-57.02	-57.06	-57.32	-57.25	-56.53
User cost of labor	-4.81				-4.82	-4.83	-4.83	-4.85	-4.87	-4.88	-4.89	-4.99
					θ statistics							
$\sigma_{\ln(\theta)}$, quarterly	0.1480				0.1475	0.1473	0.1472	0.1468	0.1463	0.1458	0.1453	0.1431
					Calibrated parameters							
Consumption of unemployed, b	0.8702				0.8710	0.8698	0.8681	0.8616	0.8715	0.8683	0.8644	0.8381
Vacancy creation cost, c	0.0984				0.1041	0.1051	0.1069	0.1123	0.1176	0.1211	0.1262	0.1565

Note - Results from simulating the models with workers with different utility functions as indicated. The vacancy creation cost, c, is calibrated to match $E(\mu(\theta)) = 0.45$ and the cyclicality of the wage cost component of the user cost. All statistics are calculated from the monthly series unless mentioned otherwise. The cyclicality of the series is calculated as $\frac{cov((\ln(x),u)}{var(u)} * 100$, which is the semi-elasticity of x with respect to unemployment, u: it indicates the % change in x for a unit increase in u (measured in percentage points). The corresponding quarterly statistics for the cyclicality of the wage component of the user cost for the four models and different utilities are equal with respect to the precision in the tables. The statistics, corresponding to $\sigma_{\ln(\theta)}$, from the deviations in logarithms of the vacancy-unemployment ratio at quarterly frequency from an HP trend with smoothing parameter 10^5 for the four models with linear utility are 0.1259; the four models with CRRA $\gamma = 3$: 0.1244, 0.1240, 0.1236, 0.1217; for the four models with log utility see Table 4.

Table 6: CYCLICALITY OF THE USER COST AND ITS COMPONENTS AND THE VOLATILITY OF THE V-U RATIO.

Two calibrated targets: expectation of the job finding rate and the volatility of the v-u ratio.

	$\alpha = 0.60$											
	Linear utility				Logarithmic utility				CRRA 3 utility			
	Commitment Models			Re-	Commitment Models			Re-	Commitment Models			Re-
	Full	1-sided lack of	2-sided lack of	bargain	Full	1-sided lack of	2-sided lack of	bargain	Full	1-sided lack of	2-sided lack of	bargain
	Cyclicality indicator											
Individual wages (all)	-0.21	-0.51	-1.09	-1.62	-0.21	-0.51	-1.06	-1.62	-0.21	-0.50	-1.01	-1.61
Individual wages (new hires only)	-0.70	-1.05	-1.39	-1.62	-0.70	-1.04	-1.38	-1.62	-0.70	-1.03	-1.35	-1.61
Wage component of user cost	-1.63				-1.62	-1.62	-1.62	-1.62	-1.62	-1.62	-1.61	-1.62
Vacancy component of user cost	-76.89				-76.76	-76.80	-76.57	-76.24	-76.47	-76.60	-75.98	-74.98
User cost of labor	-1.75				-1.75	-1.75	-1.75	-1.75	-1.75	-1.75	-1.75	-1.76
	Calibration targets											
$\sigma_{\ln(\theta)}$, quarterly	0.3820											
$E(\mu(\theta))$	0.4500											
	Calibrated parameters											
Consumption of unemployed, b	0.9434				0.9438	0.9432	0.9428	0.9424	0.9444	0.9427	0.9417	0.9402
Vacancy creation cost, c	0.0415				0.0424	0.0427	0.0432	0.0435	0.0443	0.0454	0.0471	0.0481

Note - Results from simulating the models with workers with different utility functions as indicated. The vacancy creation cost, c, is calibrated to match $E(\mu(\theta)) = 0.45$ and $\sigma_{\ln(\theta)} = 0.3820$. All statistics are calculated from the monthly series unless mentioned otherwise. The cyclicality of the series is calculated as $\frac{cov((\ln(x),u)}{var(u)} * 100$, which is the semi-elasticity of x with respect to unemployment, u: it indicates the % change in x for a unit increase in u (measured in percentage points). The corresponding quarterly statistics for the cyclicality of the wage component of the user cost for the four models and different utility functions are equal with respect to the precision in the tables, except for the log utility, where the statistics are -1.63 for all four models. The statistics, corresponding to $\sigma_{\ln(\theta)}$, from the deviations in logarithms of the vacancy-unemployment ratio at quarterly frequency from an HP trend with smoothing parameter 10^5 for the four models with linear, log or CRRA $\gamma = 3$ utility are 0.3257.

Table 7: CYCLICALITY OF THE USER COST OF LABOR AND ITS COMPONENTS. COMPARISON ACROSS DIFFERENT VALUES OF THE CONSUMPTION OF UNEMPLOYED AGENTS.

	Log utility, $\alpha = 0.50$											
	$b = 0.40$				$b = 0.70$				$b = 0.90$			
	Commitment Models			Re-bargain	Commitment Models			Re-bargain	Commitment Models			Re-bargain
	Full	1-sided lack of	2-sided lack of		Full	1-sided lack of	2-sided lack of		Full	1-sided lack of	2-sided lack of	
	Cyclicality indicator											
Individual wages (all)	-2.44	-2.44	-2.44	-13.49	-1.13	-1.13	-1.13	-7.29	-0.33	-0.61	-0.98	-2.42
Individual wages (new hires only)	-7.78	-7.78	-7.78	-13.30	-3.69	-3.69	-3.69	-7.28	-1.11	-1.39	-1.64	-2.42
Wage component of user cost	-18.48	-18.48	-18.48	-13.49	-8.56	-8.56	-8.56	-7.29	-2.56	-2.53	-2.51	-2.42
Vacancy component of user cost	-36.37	-36.37	-36.37	-36.39	-36.57	-36.57	-36.57	-36.59	-38.36	-38.43	-38.46	-38.44
User cost of labor	-19.59	-19.59	-19.59	-14.91	-9.25	-9.25	-9.25	-8.01	-2.80	-2.77	-2.75	-2.66
	θ statistics											
$\sigma_{\ln(\theta)}$, quarterly	0.0296	0.0296	0.0296	0.0388	0.0623	0.0623	0.0623	0.0719	0.1991	0.2015	0.2030	0.2093
	Calibrated parameters											
Vacancy creation cost, c	0.9131	0.9131	0.9131	0.9131	0.3688	0.3688	0.3688	0.3687	0.1099	0.1097	0.1100	0.1099

Note - Results from simulating the models with risk averse workers (log utility). The vacancy creation cost, c, is calibrated to match $E(\mu(\theta)) = 0.45$ and the cyclicality of the wage cost component of the user cost. All statistics are calculated from the monthly series unless mentioned otherwise. The cyclicality of the series is calculated as $\frac{cov((\ln(x),u)}{var(u)} * 100$, which is the semi-elasticity of x with respect to unemployment, u: it indicates the % change in x for a unit increase in u (measured in percentage points). The corresponding quarterly statistics for the cyclicality of the wage component of the user cost for the four models and different values of b are equal with respect to the precision in the tables. The statistics, corresponding to $\sigma_{\ln(\theta)}$, from the deviations in logarithms of the vacancy-unemployment ratio at quarterly frequency from an HP trend with smoothing parameter 10^5 for the four models with $b = 0.40$ are 0.0251, 0.0251, 0.0251, and 0.0330, respectively; for $b = 0.70$: 0.0530, 0.0530, 0.0530, 0.0611; for $b = 0.90$: 0.1695, 0.1714, 0.1728, 0.1781.

Table 8: Cyclicality of the user cost of labor and its components. Comparison across a.
One calibrated target: expectation of the job finding rate.

	Log utility, $b = 0.70$											
	$a = 0.235$				$a = 0.50$				$a = 0.72$			
	Commitment Models			Re-	Commitment Models			Re-	Commitment Models			Re-
	Full	1-sided lack of	2-sided lack of	bargain	Full	1-sided lack of	2-sided lack of	bargain	Full	1-sided lack of	2-sided lack of	bargain
	Cyclicality indicator											
Individual wages (all)	-0.61	-0.63	-0.63	-4.01	-1.13	-1.13	-1.13	-7.29	-2.18	-2.18	-3.36	-14.07
Individual wages (new hires only)	-2.00	-2.02	-2.02	-4.00	-3.69	-3.69	-3.69	-7.28	-7.03	-7.03	-7.82	-13.87
Wage component of user cost	-4.63	-4.62	-4.62	-4.01	-8.56	-8.56	-8.56	-7.29	-16.60	-16.60	-16.33	-14.07
Vacancy component of user cost	-11.11	-11.11	-11.11	-11.09	-36.57	-36.57	-36.57	-36.59	-94.82	-94.82	-94.75	-95.07
User cost of labor	-5.07	-5.06	-5.06	-4.49	-9.25	-9.25	-9.25	-8.01	-17.39	-17.39	-17.12	-14.88
	θ statistics											
$\sigma_{\ln(\theta)}$, quarterly	0.0738	0.0739	0.0739	0.0832	0.0623	0.0623	0.0623	0.0719	0.0594	0.0594	0.0604	0.0694
	Calibrated parameters											
Vacancy creation cost, c	0.9238	0.9238	0.9238	0.9239	0.3688	0.3688	0.3688	0.3687	0.1795	0.1795	0.1798	0.1795

Note - Results from simulating the models with risk averse workers (log utility). The vacancy creation cost, c, is calibrated to match $E(\mu(\theta)) = 0.45$ and the cyclicality of the wage cost component of the user cost. All statistics are calculated from the monthly series unless mentioned otherwise. The cyclicality of the series is calculated as $\frac{cov((\ln(x),u)}{var(u)} * 100$, which is the semi-elasticity of x with respect to unemployment, u: it indicates the % change in x for a unit increase in u (measured in percentage points). The corresponding quarterly statistics for the cyclicality of the wage component of the user cost for the four models and different values of α are equal with respect to the precision in the tables. The statistics, corresponding to $\sigma_{\ln(\theta)}$, from the deviations in logarithms of the vacancy-unemployment ratio at quarterly frequency from an HP trend with smoothing parameter 10^5 for the four models with $a = 0.235$ are 0.0627, 0.0628, 0.0628, and 0.0707, respectively; for $a = 0.50$: 0.0530, 0.0530, 0.0530, 0.0611; for $\alpha = 0.72$: 0.0505 0.0505 0.0513 0.0590

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