Economic Quarterly—Volume 96, Number 2—Second Quarter 2010—Pages 179–199

Are Wages Rigid Over the Business Cycle?

Marianna Kudlyak

The search and matching model of the labor market has become a leading model of unemployment in macroeconomics. Recent work (Shimer 2005) shows that under common parameter values the standard search and matching model cannot account for the cyclical volatilities of vacancies and unemployment observed in the data.[1] This difficulty is related to the flexibility or, alternatively, rigidity of real wages over the business cycle.[2] In this article, I review empirical evidence on wage flexibility as it relates to search and matching models.

The search and matching model introduces frictions into the labor market in the sense that workers and employers cannot costlessly contact each other. In an economy with frictions, market prices are not competitively determined, and the standard search and matching framework assumes that wages are determined by a particular solution to a bargaining problem between workers and employers, the Nash bargaining solution. Under this bargaining, wages increase when productivity is high, thus limiting incentives for job creation. Hall (2005) and Shimer (2005) show that replacing the Nash bargaining solution with an alternative wage determination procedure that makes wages more rigid amplifies the volatility of unemployment and vacancies the model can generate.

I am grateful to Andreas Hornstein, Arantxa Jarque, Damba Lkhagvasuren, Aysegul Sahin, Pierre-Daniel Sarte, Roman Sysuyev, and Antonella Trigari for their generous comments and discussions. All views and errors are mine alone. I thank Nadezhda Malysheva and Devin Reilly for help in editing the earlier draft. The views expressed here are those of the author and do not necessarily reflect those of the Federal Reserve Bank of Richmond or the Federal Reserve System. E-mail: marianna.kudlyak@rich.frb.org.

[1] The "standard search and matching model" refers to the model studied by Shimer (2005) and developed in Mortensen and Pissarides (1994). Pissarides (2000) provides a textbook exposition of the standard search and matching model.

[2] The terms "rigid" and "acyclical" are used interchangeably and imply a lack of response to a cyclical indicator.

This line of research motivates important questions: How flexible, or rigid, are real wages over the business cycle? Is observed wage rigidity consistent with the wage rigidity needed to amplify the fluctuations in the textbook search and matching model?

In the job creation decision, a firm takes into account not only the initial wage in a newly formed match but also the entire expected stream of future wages to be paid in the match. Thus, job creation in frictional labor markets places the focus on the cyclical behavior of the expected present discounted value of wages. The volatility of unemployment in the model depends on the intensity of job creation through changes in the job finding rate. As Shimer (2004) emphasizes, what is relevant for the volatility of job creation, and, thus, of unemployment, is the rigidity of the present discounted value of wages that, at the time of hiring, a firm expects to pay to a worker over the course of the employment relationship.

A large empirical literature exists that studies the behavior of individual wages over the business cycle. The literature finds that the wages of newly hired workers are more cyclical than wages of workers in ongoing employment relationships (for example, Bils [1985] and Carneiro, Guimarães, and Portugal [2009]).

One crucial aspect of the existing empirical literature is that it provides evidence on the cyclical behavior of the current wage, but not on the cyclical behavior of the expected present discounted value of future wages within a match formed in the current period. Emphasizing the importance of the future wages to be paid in the long-term employment relationships, Kudlyak (2007) estimates the cyclicality of the user cost of labor, which is the difference between the expected present discounted value of wages paid to a worker hired in the current period and the value paid to a worker hired the following period. Kudlyak constructs the user cost of labor from the individual wage and turnover data. She finds that the user cost of labor is more cyclical than wages of newly hired workers. Haefke, Sonntag, and van Rens (2009) argue for the importance of the elasticity of the expected present discounted value of wages with respect to the expected present discounted value of productivity in newly formed matches, which they refer to as permanent values of wages and productivity, respectively. They do not estimate the elasticity directly but, using model simulations, conclude that the elasticity of the current period wage of newly hired workers with respect to current period productivity "constitutes a good proxy for the elasticity of the permanent wage with respect to permanent productivity for the case of instantaneously rebargained wages" and "can be seen as a lower bound for [the elasticity of the permanent wage with respect to permanent productivity] in the case of wage rigidity on the job."

Pissarides (2009), Haefke, Sonntag, and van Rens (2009), and Kudlyak (2009) study whether the search and matching model can simultaneously match the empirical wage and unemployment statistics. Pissarides (2009) and Haefke, Sonntag, and van Rens (2009) compare the elasticity of wages in the model to the elasticity of wages of newly hired workers in the data. They conclude that making wages in the model rigid enough to generate the observed volatility of unemployment requires more rigid wages than are found in the data. Kudlyak (2009) shows that the free entry condition in the model ties together match productivity and the user cost of labor. She calibrates the model to match the estimated cyclicality of the user cost of labor and concludes that the model calibrated to wage data cannot generate the empirical volatilities of the vacancy-unemployment ratio.

In summary, in the model, the rigid expected present discounted value of wages in newly formed matches amplifies the response of firm's surplus to productivity shocks. This increases the volatility of job creation and thus of unemployment. The success of the model in generating the empirical volatilities of vacancies and unemployment depends on whether the required rigidity of the relevant measure of wages is consistent with the data. The studies reviewed suggest that wages in the data may not be as rigid as required for generating empirical volatilities of vacancies and unemployment in the standard search and matching model.

The remainder of the paper is structured as follows. Section 1 summarizes the textbook search and matching model and the unemployment volatility puzzle. Using an example, I demonstrate the importance of the expected present discount value of wages for the job creation decision. Section 2 surveys empirical evidence on the cyclicality of individual wages of the newly hired workers and wages of workers in ongoing relationships. Then I review empirical evidence on the cyclicality of a measure of wages that takes into account the expected present discounted value of future wages. Section 3 concludes.

1. SEARCH AND MATCHING MODEL

The Standard Model

An economy is populated by a continuum of firms and a continuum of measure 1 workers. Both firms and workers are risk neutral and infinitely lived. Firms maximize the present discounted value of profits. Workers maximize the present discounted value of wages and do not value leisure. Firms and workers discount the future with a common discount factor β, $0 < \beta < 1$. Time is discrete.

A firm can choose to remain inactive or to start production, which requires only labor input. To start production, a firm must enter the labor market and hire a worker. Upon entering the labor market, a firm opens a vacancy and searches for a worker. During each period a firm must pay a per vacancy cost, c. An unemployed worker receives a per period unemployment compensation, b, and costlessly searches for a job. Employed workers earn wages and cannot search. 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, thus z is also aggregate productivity. z evolves stochastically according to the first-order Markov process. Every period, a firm-worker pair separates exogenously with probability δ.

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, $m(u, v)$. It is assumed that $m(u, v) = Ku^{\alpha}v^{1-\alpha}$, where $0 < \alpha < 1$ (Petrongolo and Pissarides 2001) and K is a positive constant. Let θ denote labor market tightness, i.e., $\theta \equiv \frac{v}{u}$. Let $q(u, v) \equiv \frac{m(u,v)}{v} = K\theta^{-\alpha}$ denote the probability of filling a vacancy for a firm. Let $\mu(u, v) \equiv \frac{m(u,v)}{u} = K\theta^{1-\alpha}$ denote the probability of finding a job for an unemployed worker. Thus, the unemployment in this economy evolves according to the following equation, given u_0:

$$u_{t+1} = u_t + (1 - u_t)\,\delta - \mu\,(u_t, v_t)\,u_t.$$

Dropping the time subscripts and using $'$ to denote the next period values, I summarize the value functions of a worker and of a firm as follows. The value function of a firm with a worker is

$$J\,(z) = z - w\,(z) + \beta\,(1 - \delta)\,E_z J\left(z'\right), \tag{1}$$

where z' denotes productivity in the next period and E_z is a conditional expectations operator. Equation (1) takes into account that in each period with probability δ, the firm-worker match separates and the firm obtains a value of an inactive firm, which is 0. The value function of an opened vacancy is

$$V\,(z) = -c + q\,(\theta\,(z))\,J\,(z) + (1 - q\,(\theta\,(z)))\,\beta E_z V\left(z'\right). \tag{2}$$

The value function of an employed worker is

$$W\,(z) = w\,(z) + \beta\,(1 - \delta)\,E_z W\left(z'\right) + \beta\delta E_z U\left(z'\right). \tag{3}$$

The value function of an unemployed worker is

$$U(z) = b + \beta E_z\left(\mu(\theta(z'))W(z') + (1 - \mu(\theta(z')))U(z')\right). \tag{4}$$

There are two important conditions in the standard model. First, there is free entry for firms, i.e., firms enter the labor market and post vacancies until the value of an open vacancy, $V(z)$, equals the value of an inactive firm, 0. From (2) free entry implies the following condition:

$$\frac{c}{q\left(\theta\left(z\right)\right)}=J\left(z\right). \tag{5}$$

Second, wages are rebargained every period in new and ongoing matches according to the Nash bargaining rule. The Nash bargaining rule yields the following division of the surplus from the match, $S(z) \equiv J(z) + W(z) - V(z) - U(z)$, in every period:

$$J(z) = (1-\eta)S(z), \tag{6}$$
$$W(z) - U(z) = \eta S(z), \tag{7}$$

where η is a worker's bargaining power, $0 < \eta < 1$. Equations (6)–(7) imply that each party obtains a constant share of the surplus from the match.

Using equations (1)–(5) yields the following equation for the surplus:

$$S(z) = z - b + \beta E_z((1-\delta) - K\theta(z')^{1-\alpha}\eta)S(z'). \tag{8}$$

Combining (5) and (6) yields the job creation condition

$$\frac{c}{K\theta\left(z\right)^{-\alpha}}=\left(1-\eta\right)S\left(z\right). \tag{9}$$

Combining (8) with the job creation condition yields the following equation for the evolution of the vacancy-unemployment ratio:

$$\frac{c}{K\theta(z)^{-\alpha}} = (z-b)(1-\eta) + \beta E_z((1-\delta) - K\theta(z')^{1-\alpha}\eta)\frac{c}{K\theta(z')^{-\alpha}}. \tag{10}$$

Equation (8) links the evolution of the vacancy-unemployment ratio, θ, to the productivity shock, z. Using this equation and common parameter values, Shimer (2005) shows that the standard search and matching model cannot generate the volatilities of vacancies and unemployment observed in the data. In particular, in the U.S. data, the standard deviation of the vacancy-unemployment ratio is 20 times larger than the standard deviation of labor productivity. The standard search and matching model predicts the volatility of the vacancy-unemployment ratio as almost one-to-one to the volatility of the productivity. Since productivity shocks are the driving force in the model, the model is said to lack an internal propagation mechanism.[3] This failure of the standard search and matching model to generate empirical volatilities of vacancies and unemployment is often referred to as the unemployment volatility puzzle (Pissarides 2009).

[3] See Hornstein, Krusell, and Violante (2005) for a detailed inspection of the mechanism. See also Costain and Reiter (2008).

Rigid Wages Within Matches

To understand what measure of wages affects allocations in the search and matching model, consider the following modification of the standard model. In the standard search and matching model, wages in both newly formed and ongoing matches are set in each period using the Nash bargaining rule. In the modified model, wages in newly formed matches are set using the Nash bargaining rule but wages in ongoing matches remain constant and equal to the wage at the time of hiring. We will see that the modified model delivers the same equation for the vacancy-unemployment ratio, thus the same allocations, given the initial conditions, as the standard model despite the fact that in the modified model wages in ongoing matches are rigid. The modified model is a discrete time version of the argument presented in Shimer (2004).[4]

In the standard model, given that all matches are equally productive, wages of new hires and existing workers are equal in each period. This implies that when the aggregate productivity is z_t, the value of a firm with a worker in an ongoing match that started in period t_0, $J^{t_0}(z_t)$, equals the value of a firm in the newly formed match, $J^t(z_t)$. Similarly, when the aggregate productivity is z_t, the value of an employed worker in an ongoing match that started in period t_0, $W^{t_0}(z_t)$, equals the value of a newly hired worker in t, $W^t(z_t)$. In the modified model, these values are not necessarily equal. Dropping the time subscripts, using z_0 to denote the aggregate productivity at the time a match is formed and using $'$ to denote the next period values, we can summarize the value functions in the modified model as follows:

$$\begin{aligned}
J^{z_0}(z) &= z - w(z_0) + \beta(1-\delta) E_z J^{z_0}(z'); \\
V(z) &= -c + K\theta(z)^{-\alpha} J^z(z) + \left(1 - K\theta(z)^{-\alpha}\right)\beta E_z V(z'); \\
W^{z_0}(z) &= w(z_0) + \beta(1-\delta) E_z W^{z_0}(z') + \beta\delta E_z U(z'); \\
U(z) &= b + \beta E_z \left[K\theta(z')^{1-\alpha} W^{z'}(z') + \left(1 - K\theta(z')^{1-\alpha}\right) U(z')\right].
\end{aligned}$$

In the modified model the free entry condition, (5), and the surplus division rule, (6)–(7), are required to hold only for the values at the time of hiring, which can be denoted as $J^z(z)$ for a firm and $W^z(z)$ for a worker. Thus, in the modified model, equations corresponding to equations (6), (7), and (9) are as follows:

$$J^z(z) = (1-\eta) S^z(z), \tag{11}$$

[4] See also Haefke, Sonntag, and van Rens (2009) and Pissarides (2009) for insightful discussions of this example and Rudanko (2009) for a model with endogeneous wage rigidity within ongoing matches.

$$W^z(z) - U(z) = \eta S^z(z), \tag{12}$$

$$\frac{c}{q(\theta(z))} = (1-\eta)S^z(z), \tag{13}$$

where $S^z(z)$ is the surplus from a newly formed match when the aggregate productivity is z, $S^z(z) \equiv J^z(z) + W^z(z) - V(z) - U(z)$.

To demonstrate that this modified model delivers exactly the same allocations as the standard model (in which wages are rebargained in all matches every period), it suffices to show that it delivers the same equation for the vacancy-unemployment ratio as the standard model, (10). Using equations for $J^{z_0}(z)$,$W^{z_0}(z)$, and $U(z)$, one can derive the following equation for the total surplus of the newly formed match:

$$S^z(z) = z - b + \beta(1-\delta)E_z S^z(z') + \beta\eta E_z \mu(\theta(z'))S^{z'}(z'), \tag{14}$$

where z' is productivity in the next period.

Note, however, that $J^z(z') = J^{z'}(z') + \left(\frac{1}{1-\beta(1-\delta)}\right)(w(z') - w(z))$, where $\left(\frac{1}{1-\beta(1-\delta)}\right) w(z)$ is a present discounted value of wages paid to a worker hired when the aggregate productivity is z. Similarly, $W^z(z') = W^{z'}(z') - \left(\frac{1}{1-\beta(1-\delta)}\right)(w(z') - w(z))$. Then $S^z(z') = J^z(z') + W^z(z') - U(z') = J^{z'}(z') + W^{z'}(z') - U(z') = S^{z'}(z')$. Substituting $S^z(z')$ for $S^{z'}(z')$ in (14) yields

$$S^z(z) = z - b + \beta E_z((1-\delta) - \mu(\theta(z'))\eta)S^{z'}(z'), \tag{15}$$

where $S^z(z)$ is the surplus from a newly created match when the aggregate productivity is z and $S^{z'}\left(z'\right)$ is the surplus from a newly created match when the aggregate productivity is z'.

Substituting $S^z(z)$ from the job creation condition (13) into (15) yields exactly the same equation for the vacancy-unemployment ratio, θ, as in the standard model, equation (10):

$$\frac{c}{q(\theta(z))} = (z-b)(1-\eta) + \beta E_z((1-\delta) - \mu(\theta(z'))\eta)\frac{c}{q(\theta(z'))}.$$

The two models considered above have important similarities. Both models deliver the same total surplus at the time of hiring, and it is split between a worker and a firm by the same rule. However, they differ in how the wages are determined within ongoing employment relationships. In the standard model, wages are renegotiated for every match in every period. Because all matches are equally productive, this implies that newly hired workers and workers in existing employment relationships receive the same wages. In the modified model, wages of newly hired workers are determined based on the aggregate productivity at the time of hiring. Once set, the wage remains rigid throughout the duration of the match. The modified model generates wages of newly hired workers that are more responsive to the aggregate conditions than wages of the workers in ongoing relationships. However, in the modified model, the rigidity of wages within employment relationships does not affect allocations. Thus, this example shows that the rigidity of wages in ongoing matches is not sufficient to amplify the volatility of the vacancy-unemployment ratio.

To understand what kind of wage rigidity has an effect on allocations in the model, rewrite the job creation (13) using $(1-\eta)S^z(z) = J^z(z)$ and using the expression for $J^z(z)$ in the sequential form. This yields:

$$\frac{c}{q(\theta(z_t))} = E_t \sum_{\tau=t}^{\infty} (\beta(1-\delta))^{\tau-t} z_\tau - E_t \sum_{\tau=t}^{\infty} (\beta(1-\delta))^{\tau-t} w_{t,\tau}(z_t), \quad (16)$$

where $w_{t,\tau}$ is a period τ wage of a worker hired in period t. Equation (16) shows the relationship between the labor market tightness, $\theta(z_t)$, and the expected present discounted value of wages, $E_t \sum_{\tau=t}^{\infty} (\beta(1-\delta))^{\tau-t} w_{t,\tau}(z_t)$, given productivity z_t. Note that $E_t \sum_{\tau=t}^{\infty} (\beta(1-\delta))^{\tau-t} z_\tau$ is a function of z_t alone. Both $\theta(z_t)$ and $E_t \sum_{\tau=t}^{\infty} (\beta(1-\delta))^{\tau-t} w_{t,\tau}(z_t)$ change in response to changes in z_t. The extent of the response of $\theta(z_t)$ to z_t depends on the extent of the response of the expected present discounted value of wages to be paid in a new employment relationship that starts at t. However, it does not depend on the change of wages within the employment relationship if this change does not affect the expected present discounted value of wages to be paid in a new match.

2. EMPIRICAL EVIDENCE ON CYCLICAL BEHAVIOR OF WAGES

This section reviews the empirical evidence on wage cyclicality. First, I present the empirical evidence on the behavior of individual wages over the business cycle, distinguishing wages of new hires from wages of workers in ongoing employment relationships (often referred to as job stayers). Second, I present the empirical evidence on the history dependence of wages. Then, I present the evidence on the cyclical behavior of a measure of wages that takes into account both the initial wage and the expected value of future wages paid in the newly formed matches. Finally, I summarize the quantitative implications of the evidence for the volatility of vacancies and unemployment in the standard search and matching model.

Cyclicality of Wages of New Hires and Wages of Existing Workers

Below I provide a statistical model of individual wages with a particular emphasis on how wages depend on the unemployment rate. Then I survey results from the empirical studies that include information on individual workers and from the studies that include information on workers and their employers.[5] The findings show that wages of newly hired workers are more procyclical than wages of job stayers. All of these studies refer to current wages and not to the expected present discounted value of future wages.

General Framework

In labor economics the standard statistical model for wages is Mincer regression, which attributes variation in the logarithm of wages to the observable characteristics of a worker—years of schooling, a quadratic polynomial in labor market experience, and other factors (Mincer 1974). These variables are supposed to reflect productivity (or human capital) differences. The literature that studies the behavior of individual wages over the business cycle includes the contemporaneous unemployment rate as a business cycle indicator. What is of interest for the questions in this article are the differences, if any, of the responses of wages of workers in ongoing matches (job stayers) and wages of new hires to changes in the unemployment rate.

The individual wage equation that distinguishes between the cyclical response of wages of job stayers and wages of new hires is specified as follows:

$$\ln w_{it} = X_i\alpha + X_{it}\gamma + \beta U_t + \beta^{nh} U_t * I_{it}^{nh} + \delta I_{it}^{nh} + \eta_i + v_{it}, \qquad (17)$$

where w_{it} is a real wage of worker i in t, X_i is a vector of observable individual-specific explanatory variables that remain fixed over time, X_{it} is a vector of individual controls that vary with time, U_t is a measure of the unemployment rate, and η_i and v_{it} are the unobservable error terms. I_{it}^{nh} is a dummy variable that takes value 1 if an individual is a new hire, and 0 otherwise. The new hire is defined as a worker who has been employed at a firm for less than a specified period, usually one year. Error terms are assumed independent of each other and of all explanatory variables in X. The variables commonly included in X_{it} are a quadratic in worker labor market experience and a quadratic in tenure (for job stayers). Because of the structure of the survey data, the time period is typically one year.

[5] Given a large literature, this survey does not aim to summarize all works on the real wage cyclicality. An interested reader is referred to the surveys in Abraham and Haltiwanger (1995) and Brandolini (1995).

The coefficient on the unemployment rate is interpreted as a semi-elasticity, which indicates a percent change in wage in response to a one percentage point increase in the unemployment rate. If the semi-elasticity is positive, the wage is called procyclical, i.e., it moves positively with the business cycle. For job stayers the cyclicality is measured by β. If the cyclicality of wages of new hires differs from the cyclicality of job stayers, then the coefficient on the interaction term, β^{nh}, is statistically significantly different from zero and the cyclicality of new hires is measured by $\beta + \beta^{nh}$.

Evidence from Worker Survey Data

Most of the existing evidence on the cyclicality of individual wages comes from studies that use individual level survey data: the National Longitudinal Survey (NLS), the Panel Study of Income Dynamics (PSID), and the National Longitudinal Study of Youth (NLSY). These data allow tracking individual workers' histories across time and contain information on individual workers' characteristics, including education, age, sex, and job characteristics such as industry and occupation.[6]

Bils (1985) is the first study that examines the cyclicality of individual wages while separating the wages of job stayers from the wages of new hires. He also distinguishes between new hires who are hired from another job and new hires who are hired from unemployment. Using the individual data on men from NLS for the period 1966–1980, Bils finds that as the unemployment rate increases by one percentage point, individual wages of white male workers on average decrease by 1.59 percent. Once the job changers are explicitly accounted for, the results show that wages of job changers are much more procyclical than wages of job stayers. In particular, wages of job stayers decrease by 0.64 percent while wages of job changers decrease by 3.69 percent in response to one percentage point increase in the unemployment rate. Similarly, wages of workers who move in and out of employment are also more procyclical than wages of workers who do not change jobs.

Shin (1994), using a different estimation procedure for the NLS data on men's wages from 1966–1981, estimates separate equations for workers who remain with the same employer from $t - 1$ to t and for workers who change their employer. Similarly to Bils, Shin finds substantially procyclical wages for workers who change employers and much less procyclical wages for job stayers. Solon, Barsky, and Parker (1994) estimate wage cyclicality using data from the PSID for the period 1967–1987. They find that the point estimate of the cyclicality of men's real wages is between -1.35 percent and -1.40 percent. In the sample restricted to workers who did not change employers,

[6] The type of data set, which contains information on the cross section of individuals over time, is called panel data.

the coefficient reduces to -1.24 percent. Consistent with Bils (1985), Solon, Barsky, and Parker find that wages of job stayers are less procyclical than wages of all workers.

The usual measure of wages used in the studies is the average hourly wage, which is constructed by dividing total annual earnings by total annual hours worked. However, if workers are more likely to hold more than one job in expansions, then the constructed average hourly wage may be more procyclical than actual wages within employment relationships. Devereux (2001) conducts a detailed examination of the cyclicality of wages of job stayers and, in contrast to the earlier studies, focuses on the wages of workers who have only one job at a time. Using PSID data from 1970–1992 on men's earnings, Devereux finds that the cyclicality of the average wage of these workers is -0.54 percent. These findings confirm that wages of job stayers are less procyclical than wages of job changers.[7]

Evidence from Matched Firm-Worker Data

Controlling for a firm fixed effect is important if there are changes in the composition of firms over the business cycle with respect to the level of wages they offer. For example, if the firms that hire in economic booms are predominantly high-wage firms and the firms that hire in economic busts are low-wage firms, then the failure to control for the firm's fixed effect may lead to biasing the estimates of the cyclicality away from zero even when wages are acyclical. Researchers often use occupation and industry fixed effects to control for changes in the composition of jobs over the business cycle, which is readily available from worker survey data. Most of the studies employ individual worker survey data that do not allow identification of the firm's fixed effect. To allow identification of a firm fixed effect, the data must contain information on more than one worker from the same firm and on firm identifiers. Only recently have longitudinal firm-worker data for the U.S. economy become available; however, to my knowledge, there are no studies of wage cyclicality using these data yet.

Carneiro, Guimarães, and Portugal (2009) use administrative firm-worker data from Portugal. They estimate a model in levels similar to (17), controlling for an individual worker's qualification, education, age, and a quadratic in time trend. Their findings are very similar to the findings by Bils (1985). In particular, controlling for a worker and a firm fixed effects, they find that the cyclicality of wages of workers who have been with their employer for less than a year is -2.77 percent. The cyclicality of wages of workers who have been with an employer for more than a year, job stayers, is -1.41 percent. Importantly, accounting for both firm and worker fixed effects delivers results

[7] Shin and Solon (2007) find similar evidence in the NLSY data.

very similar to the results from accounting only for worker fixed effect. In particular, the cyclicality of wages of new hires from the regression with only a worker fixed effect is -2.73 percent, while with only a firm fixed effect it is -3.53 percent. The cyclicality of wages of job stayers from the regressions with only a worker fixed effect is -1.50 percent, while from the regression with only a firm fixed effect it is -2.94 percent. Using the same data set, Martins, Solon, and Thomas (2010) investigate the cyclicality of wages of newly hired workers in a subset of occupations into which firms frequently hire new workers. The estimated cyclicality of the wages of newly hired workers in these entry jobs is -1.8 percent. The authors conclude that the wages of new hires in the entry jobs are substantially procyclical.[8]

The results from the studies that allow controlling for firm fixed effects confirm the earlier findings that wages of newly hired workers are more cyclical than wages of existing workers.

Cyclicality of Wages of Job Stayers and Job Changers and Match Quality

Gertler and Trigari (2009) suggest that the difference in the cyclicality of wages of new hires and existing workers can be explained by the differences in the quality (or, alternatively, productivity) of newly formed and ongoing matches. In particular, Gertler and Trigari argue that separately controlling for firm and worker fixed effects cannot account for match quality, which must be controlled for by the interaction term—a worker-job fixed effect. Gertler and Trigari use individual male worker data from the Survey of Income and Program Participation over the period 1990–1996. The data consists of four panels from 1990, 1991, 1992, and 1993, each lasting approximately three years and containing information from interviews conducted every four months. The data allow for identifying if a worker changes employer. Gertler and Trigari estimate a wage equation similar to equation (17) except that, instead of controlling for a worker fixed effect, η_i, they control for the unobserved firm-worker effect, which simultaneously captures two effects: a worker fixed effect that does not change from job to job and a joint worker-firm effect. After the authors control for a worker-firm fixed effect, the coefficient on the interaction term between the unemployment rate and the dummy for new hire becomes small and statistically insignificant. Gertler and Trigari interpret the results as evidence of an omitted variable, a worker-firm specific fixed effect. If a job change is systematically associated with the movement from low to high quality match, then the omitted variable is negatively correlated with the interaction term, biasing the estimates. They conclude that a large part of the

8 Martins, Solon, and Thomas (2010) conclude that the cyclicality is of the similar magnitude as the cyclical elasticity of employment.

higher procyclicality of wages of new hires is probably due to the comparatively higher quality of these matches. Gertler and Trigari suggest that the existing literature does not provide conclusive evidence that the newly hired workers have more cyclical wages than the existing workers in the same firm.

This finding raises questions, which I discuss at the end of this section, about what heterogeneity in the data should be controlled for when calculating the statistics and how to bring the model to match these statistics.

Dependence of Wages on the Past Labor Market Conditions

Literature surveyed so far finds evidence that the wages of new hires are more sensitive to the aggregate labor market conditions than the wages of workers in ongoing employment relationships. A closer look at workers in ongoing employment relationships shows that their wages depend not only on current labor market conditions, but also on the history of labor market conditions during the entire employment relationship.

Beaudry and DiNardo Regressions

Beaudry and DiNardo (1991) estimate the following equation for individual wages:

$$\ln\left(w_{jt_0t}\right) = X_{jt_0t}\alpha + \gamma_{start}U_{t_0} + \gamma_c U_t + \gamma_{\min}\min\{U_\tau\}_{\tau=t_0}^{t} + \eta_j + \nu_{jt}, \quad (18)$$

where w_{jt_0t} is an hourly wage of a worker j in year t who was hired in year t_0, X_{jt_0t} is a vector of the individual- and job-specific characteristics, U_τ is the unemployment rate in year τ, η_j is an individual-specific fixed effect, and ν_{jt} is an individual- and time-varying error term. ν_{jt} is assumed to be serially uncorrelated as well as uncorrelated across individuals. The vector of individual- and job-specific characteristics, X_{jt_0t}, includes a quadratic in experience, a quadratic in tenure, years of schooling, and dummies for industry, region, race, union status, marriage, and standard metropolitan statistical area. The equation is estimated using the individual data on men's wages from PSID, 1976–1984, and two cross-sectional samples from the Current Population Survey (CPS).

The main finding of Beaudry and DiNardo (1991) is that when all three measures of the unemployment rate are included, the effect of the minimum unemployment rate is the most significant, both statistically and economically. Thus, whenever the labor market conditions improve, wages increase. In particular, controlling for worker fixed effect in the PSID sample, the coefficient on the minimum unemployment rate is −2.9 percent, the coefficient on the unemployment rate at the start of the job is −0.6 percent and insignificant, and the coefficient on the contemporaneous unemployment rate is −0.7 percent.

If, however, only the contemporaneous unemployment rate is included, then the results are consistent with earlier studies—the coefficient on the contemporaneous unemployment rate is -1.4 percent.

Subsequent studies replicate the findings of Beaudry and DiNardo (1991) for different time periods and using different data sets. McDonald and Worswick (1999) find support in Canadian data. Grant (2003) estimates an equation similar to (18) and adds the maximum unemployment rate experienced by a worker from the start of the job. Grant finds that both the minimum unemployment rate and the contemporaneous unemployment rate have an effect on wages. In particular, in the sample of young men from NLS from 1966–1983, when all three unemployment rates are included, the coefficient on the minimum unemployment rate is -2.29 percent while the coefficient on the contemporaneous unemployment rate is -2.37 percent. This finding leads Grant to conclude that wages depend both on the past and on the contemporaneous labor market conditions.

Devereux and Hart (2007) study the history dependence in wages in British data, the New Earnings Survey Panel, for the period 1976–2001. They estimate a model similar to (18) that also includes the maximum unemployment rate but employ a different estimation procedure from the studies above. They find that both the minimum unemployment rate and the contemporaneous unemployment rate are statistically significant and negative. The authors conclude that the British real wage data exhibit both the history dependence as described in Beaudry and DiNardo (1991) and the dependence on the contemporaneous labor market conditions.

Hagedorn and Manovskii (2009) find that the dependence on the past unemployment rates in model (18) disappears if one controls for the quality of a match. They argue that the quality of a match can be learned from the number of job offers a worker receives throughout the total duration of the job, which can be approximated by the sum of the aggregate vacancy-unemployment ratios experienced by a worker throughout the job. In addition, if a worker switches job-to-job, then the sum of labor market tightnesses experienced during a previous job also helps predict the quality of the current match. Using the NLSY, the authors find that if these controls are included in Beaudry and DiNardo's (1991) equation, (18), the coefficients on the past unemployment rates are insignificant both economically and statistically, while the new controls have a large positive effect.

Evidence from Matched Firm-Worker Data

Baker, Gibbs, and Holmstrom (1994) provide compelling evidence on the history dependence of wages in the study of the wage policy of a large firm over the period 1969–1988. The authors find that there is a substantial cohort effect in wages, where the cohort is defined as the employees who enter the sample in a given year.[9] That is, much of the variation in wages between cohorts comes from the differences in starting wages, which implies that wages depend on the history of the labor market conditions from the start of the job. The authors investigate whether the differences in the starting wage can be driven by observable or unobservable worker characteristics. To check for the possible impact of unobservable characteristics, they examine whether cohorts that entered with lower starting wages are promoted less and exit more. They find no evidence of this and no evidence that composition effect can fully account for either the differences in starting wages or the persistent effect of external labor market conditions from the start of the job on wages.

Using a large matched employer-employee data set from Northern Italy, Macis (2006) provides a detailed empirical investigation of the dependence of wages on the unemployment rates from the start of the job, controlling for both firm and worker fixed effects. Using a model similar to (18), Macis finds that wages are correlated with both the best and the worst labor market conditions from the start of the job, as well as with the contemporaneous unemployment rate.

Cyclicality of a Measure of Wages that Takes into Account Future Wages

The studies reviewed above estimate the cyclicality of the *current* wage. These studies find that wages of newly hired workers are more procyclical than wages of workers in ongoing employment relationships, and wages depend on the history of labor market conditions from the start of the job. As discussed earlier, what is relevant for job creation is the expected present discounted value of wages paid in a newly formed match. Nevertheless, from the evidence presented so far we can form some intuition about the cyclical behavior of the measure of wages that takes into account both the initial wage and the expected value of future wages.

Consider a firm that decides whether to hire a worker in the current period or to hire in the following period. In addition, suppose that in the current period unemployment is high but is expected to return back to its lower level in the following period. Since wages of newly hired workers are procyclical, the hiring wage in the employment relationship that starts in the current period is low. Because of the history dependence of wages, the future wages in this relationship are also expected to be lower than the wages in the matches formed in the future periods. Thus, by hiring now a firm locks in a worker to a stream

[9] In the study, the authors cannot identify whether the entrants are the new hires at the firm or are internally promoted. They argue that it is plausible that both categories of workers are treated in the same way by the firm. Their comparison of wage patterns of these workers with industry wages supports this view.

of wages that is lower as compared to a stream of wages to be paid to a worker hired the following period. Consequently, the wage costs associated with hiring in the current period are comparatively lower because the initial wage is low and because of the future wage savings. Similarly, if in the current period the unemployment rate is low and is expected to increase in the following period, the total wage costs associated with hiring in the current period are comparatively higher than the total wage costs associated with hiring in the following period. This argument, developed in Kudlyak (2009), suggests that the relevant measure of wages that a firm takes into account at the time of hiring is low when unemployment is high and high when unemployment is low, which is the opposite of being rigid. To gauge the quantitative importance, we need empirical estimates of this cyclical volatility.

Using the free entry condition for firms, Haefke, Sonntag, and van Rens (2009) argue for the importance of the elasticity of the expected present discounted value of wages with respect to the expected present discounted value of productivity in newly formed matches, which they refer to as permanent values of wages and productivity, respectively. They do not estimate the elasticity directly but aim at providing the empirical bounds for this statistic. Using simulations of the standard model, Haefke, Sonntag, and van Rens conclude that "the elasticity of the current period wage of newly hired workers with respect to current period productivity . . . constitutes a good proxy for the elasticity of the permanent wage with respect to permanent productivity for the case of instantaneously rebargained wages." Using the simulations of a model, similar to the modified model presented in Section 1 above, they argue that "the elasticity of the current period wage of newly hired workers with respect to current period productivity . . . can be seen as a lower bound for [the elasticity of the permanent wage with respect to permanent productivity] in the case of wage rigidity on the job." Haefke, Sonntag, and van Rens (2009) proceed to estimate the elasticity of wages of newly hired workers with respect to productivity using a large data set on wages of newly hired workers from nonemployment from the CPS. The estimated model for wages is similar to the models presented above except that, instead of using the series of unemployment, they use the series of labor productivity as a cyclical indicator. They find that the elasticity of wages of newly hired workers from nonemployment, 0.8, is substantially larger than the elasticity of wages of all workers, 0.2.[10]

Kudlyak (2009) provides an estimate of the cyclical behavior of the measure of wages that takes into account the initial wage and the expected present value of future wages to be paid in a newly formed match. The firm's hiring decision can be thought of as a decision to hire in the current period versus

---

[10] Haefke, Sonntag, and van Rens (2009) document that the elasticity of wages of job-to-job movers is similar to the elasticity of wages of newly hired workers from nonemployment or even larger.

waiting one more period and hiring then. In equilibrium, the marginal productivity of an additional worker equals the user cost of labor, which is the difference between the expected present discounted values of the costs associated with creating a match with a worker in the current period and the costs associated with creating a match the following period. In a model with search and matching, these costs consist of expenses on hiring a worker, i.e., costs associated with vacancy posting, and wage payments to a worker.

Using individual wage data from the NLSY, Kudlyak (2009) estimates the cyclicality of the wage component of the user cost of labor, which equals the wage at the time of hiring plus the expected present discounted value of the differences from the next period onwards between the wages paid to the worker hired in the current period and the worker hired the following period.[11] The estimated cyclicality of the wage component of the user cost of labor is -4.5 percent as compared to the cyclicality of wages of newly hired workers of -3 percent. The greater cyclicality obtains because at the time of hiring, a firm to some degree locks in a worker to a stream of wages that depends on the economic conditions from the start of the job. Thus, the rigidity of wages within employment relationships actually amplifies the fluctuations of the expected present discounted value of wages to be paid to a newly hired worker as compared to the fluctuations in the initial wage in newly formed matches.

Discussion

To gauge whether the wage data exhibit enough rigidity to amplify fluctuations in the standard search and matching model, the empirical estimates from wage data must be contrasted with the statistics obtained from the model. This task is conducted in Pissarides (2009), Haefke, Sonntag, and van Rens (2009), and Kudlyak (2009).

Pissarides (2009) compares the elasticity of wages with respect to productivity obtained from the standard search and matching model using common parameter values to the elasticity of wages of newly hired workers with respect to productivity in the data. He finds that the elasticity of wages of new hires with respect to productivity in the data is close to 1. This is consistent with the elasticity of wages generated by the standard search and matching model with Nash bargaining. He concludes that any solution to the unemployment volatility puzzle should be able to generate this near-proportionality of wages of new hires and productivity. Thus, a model with more rigid wages will not be able to match the data. The same conclusion is reached by Haefke, Sonntag, and van Rens (2009), who compare their estimates of the elasticity of wages

[11] See Kudlyak (2007) for more details on the estimation.

of newly hired workers with respect to productivity to the statistics from the standard search and matching model.

Kudlyak (2009) calibrates the elasticity of the wage component of the user cost of labor in the model to the empirical estimate and examines how much volatility of vacancies and unemployment the calibrated model can generate. She concludes that the data lack required rigidity to amplify the fluctuations of vacancies and unemployment in the model.

Statistics Conditional on Match Quality

Gertler and Trigari (2009) find that, conditional on match quality, there is no difference between the cyclicality of wages of new hires and existing workers. They argue that their finding implies that assuming the same cyclicality for new hires' and existing workers' wages within each firm in the standard search and matching model is consistent with the existing micropanel data evidence on new hires' wages once the empirical evidence controls for match quality, i.e., match productivity. Their finding that, conditional on match quality, there is no difference between the cyclicality of wages of new hires and existing workers is consistent with the evidence that the wages that firms pay to newly hired workers are (unconditionally) more procyclical than the wages of workers in ongoing matches. Note, however, that if the conditional statistics are used for calibrating the model, i.e., if the wage statistics from the model are compared to the conditional wage statistics in the data, then the driving force of the model—productivity—as well as other statistics in the model should also be conditioned accordingly.

Gertler and Trigari's evidence suggests a possible source of the difference between the cyclicality of wages of new hires and wages of the existing workers—the difference between the quality of a newly formed match and of an existing match. It implies that there is economically significant cyclical heterogeneity in match quality between newly formed and ongoing matches. In contrast, in the standard search and matching model, newly formed and ongoing matches are homogeneous, i.e., they are equally productive in every period. Thus, for the model to generate cyclical volatilities, the finding calls for a modification of the model to incorporate the cyclical heterogeneity.

3. CONCLUSION

What matters for the hiring decision of a firm over the business cycle is the cyclicality of the expected value of wages paid in newly formed matches. Most of the existing studies are concerned with the cyclicality of the current wage. The evidence on the cyclicality of the expected present value of future wages to be paid in a newly formed match is scarce.

The data provide evidence of the difference between the cyclicality of wages of newly hired workers and of wages of workers in ongoing matches.

In particular, the studies document that a one percentage point increase of the unemployment rate is associated with approximately a 3 percent decrease in wages of newly hired workers. Wages of workers in ongoing matches are less responsive to the contemporaneous labor market conditions and depend on the history of the labor market conditions from the start of the job, i.e., they are more rigid as compared with the wages of newly hired workers. This wage rigidity within employment relationships may, in fact, make the expected present value of wages to be paid in newly formed matches more cyclically volatile than the wage of new hires.

Haefke, Sonntag, and van Rens (2009), using simulations from the model, argue that the wage measure that takes into account future wages in a match is likely more volatile than wages of new hires. Kudlyak (2009) provides an estimate of the cyclicality of the user cost of labor, which takes into account hiring wage and the expected future wages to be paid in the employment relationship. She finds that a one percentage point increase in the unemployment rate is associated with a 4.5 percent decrease in the expected difference between the present value of wages to be paid in a match created in the current period and in a match created in the following period.

The evidence suggests that the measure of wages relevant for job creation is rather procyclical. In fact, using the existing empirical evidence and also providing new estimates, recent studies find that, quantitatively, the data may not exhibit the required rigidity necessary to generate the empirical volatility of unemployment in the standard search and matching model.

REFERENCES

Abraham, Katharine G., and John C. Haltiwanger. 1995. "Real Wages and the Business Cycle." *Journal of Economic Literature* 33 (September): 1,215–64.

Baker, George, Michael Gibbs, and Bengt Holmstrom. 1994. "The Wage Policy of a Firm." *Quarterly Journal of Economics* 109 (November): 921–55.

Beaudry, Paul, and John DiNardo. 1991. "The Effect of Implicit Contracts on the Movement of Wages over the Business Cycle: Evidence from Micro Data." *Journal of Political Economy* 99 (August): 665–88.

Bils, Mark J.. 1985. "Real Wages over the Business Cycle: Evidence from Panel Data." *Journal of Political Economy* 93 (August): 666–89.

Brandolini, Andrea. 1995. "In Search of a Stylized Fact: Do Real Wages Exhibit a Consistent Pattern of Cyclical Variability?" *Journal of Economic Surveys* 9: 103–61.

Carneiro, Anabela, Paulo Guimarães, and Pedro Portugal. 2009. "Real Wages and the Business Cycle: Accounting for Worker and Firm Heterogeneity." Banco de Portugal Working Paper 10/2009 (July).

Costain, James S., and Michael Reiter. 2008. "Business Cycles, Unemployment Insurance, and the Calibration of Matching Models." *Journal of Economic Dynamics and Control* 32 (April): 1,120–55.

Devereux, Paul J. 2001. "The Cyclicality of Real Wages within Employer-Employee Matches." *Industrial and Labor Relations Review* 54 (July): 835–50.

Devereux, Paul J., and Robert A. Hart. 2007. "The Spot Market Matters: Evidence on Implicit Contracts from Britain." *Scottish Journal of Political Economy* 54 (November): 661–83.

Gertler, Mark, and Antonella Trigari. 2009. "Unemployment Fluctuations with Staggered Nash Wage Bargaining." *Journal of Political Economy* 117 (February): 38–86.

Grant, Darren. 2003. "The Effect of Implicit Contracts on the Movement of Wages over the Business Cycle: Evidence from the National Longitudinal Surveys." *Industrial and Labor Relations Review* 56 (April): 393–408.

Haefke, Christian, Marcus Sonntag, and Thijs van Rens. 2009. "Wage Rigidity and Job Creation." IZA Discussion Paper 3714.

Hagedorn, Marcus, and Iourii Manovskii. 2009. "Spot Wages Over the Business Cycle?" Unpublished manuscript.

Hall, Robert E. 2005. "Employment Fluctuations with Equilibrium Wage Stickiness." *American Economic Review* 95 (March): 50–65.

Hornstein, Andreas, Per Krusell, and Giovanni L. Violante. 2005. "Unemployment and Vacancy Fluctuations in the Matching Model: Inspecting the Mechanism." Federal Reserve Bank of Richmond *Economic Quarterly* 91 (Summer): 19–51.

Kudlyak, Marianna. 2007. "The Cyclical Price of Labor When Wages Are Smoothed." Unpublished manuscript, University of Rochester.

Kudlyak, Marianna. 2009. "The Cyclicality of the User Cost of Labor with Search and Matching." Federal Reserve Bank of Richmond Working Paper 09-12 (September).

Macis, Mario. 2006. "Wage Dynamics and Insurance." Unpublished manuscript, University of Chicago.

Martins, Pedro S., Gary Solon, and Jonathan Thomas. 2010. "Measuring What Employers Really Do about Entry Wages over the Business Cycle." Working Paper 15767. Cambridge, Mass.: National Bureau of Economic Research (February).

McDonald, James Ted, and Christopher Worswick. 1999. "Wages, Implicit Contracts, and the Business Cycle: Evidence from Canadian Micro Data." *Journal of Political Economy* 107 (August): 884–913.

Mincer, Jacob A. 1974. *Schooling, Experience and Earnings*. New York: Columbia University Press.

Mortensen, Dale T. and Christopher A. Pissarides. 1994. "Job Creation and Job Destruction in the Theory of Unemployment." *Review of Economic Studies* 61 (July): 397–415.

Petrongolo, Barbara, and Christopher A. Pissarides. 2001. "Looking into the Black Box: A Survey of the Matching Function." *Journal of Economic Literature* 39 (June): 390–431.

Pissarides, Christopher A. 2000. *Equilibrium Unemployment Theory*, 2nd ed. Cambridge, Mass.: MIT Press.

Pissarides, Christopher A. 2009. "The Unemployment Volatility Puzzle: Is Wage Stickiness the Answer?" *Econometrica* 77: 1,339–69.

Rudanko, Leena. 2009. "Labor Market Dynamics under Long-Term Wage Contracting." *Journal of Monetary Economics* 56 (March): 170–83.

Shimer, Robert. 2004. "The Consequences of Rigid Wages in Search Models." *Journal of the European Economic Association* 2: 469–79.

Shimer, Robert. 2005. "The Cyclical Behavior of Equilibrium Unemployment and Vacancies." *American Economic Review* 95 (March): 25–49.

Shin, Donggyun. 1994. "Cyclicality of Real Wages among Young Men." *Economics Letters* 46 (October): 137–42.

Shin, Donggyun, and Gary Solon. 2007. "New Evidence on Real Wage Cyclicality within Employer-Employee Matches." *Scottish Journal of Political Economy* 54 (November): 648–60.

Solon, Gary, Robert Barsky, and Jonathan A. Parker. 1994. "Measuring the Cyclicality of Real Wages: How Important Is Composition Bias?" *Quarterly Journal of Economics* 109 (February): 1–25.