The Cyclicality of Wages and Match Quality[*]

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November 2018

Abstract

I estimate the cyclicality of real wages for job stayers, hires from employment and from unemployment, using an administrative matched employer-employee dataset from Germany. I find that the wages of new hires appear to be *less* procyclical than the wages of job stayers. I propose an explanation based on countercyclical selection on match quality: when aggregate productivity is low, worker-firm matches have to be unusually productive to warrant job creation. The presence of the match quality selection effect is supported by the relationship between the initial aggregate conditions and subsequent risk of separation: jobs started when unemployment is high are at a decreased risk of ending with a separation to unemployment, which suggests that they are positively selected. Finally, I show that a Diamond-Mortensen-Pissarides search and matching model with match-specific productivity and turnover costs is consistent with empirical findings.

JEL classification: E24, E32, J41, J63, J64

Keywords: Wages, Unemployment, Search and Matching

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1 Introduction

Unemployment is volatile relative to aggregate shocks, as discussed in Shimer (2005) and Pissarides (2009). Since unemployment is driven by fluctuations in job creation and job finding more than by fluctuations in separations, changes in incentives for job creation are an important driver of unemployment. The incentives for job creation depend on the expected cost of labor, which is proxied by the wages of new hires. Consequently, the cyclical behavior of wages is crucial for understanding the cyclical behavior of unemployment.

I provide new evidence on the cyclical behavior of real wages. I argue that the countercyclical cyclical selection with respect to the quality of match between a worker and a firm is reflected in the estimates of the real wage cyclicality: the selection effect makes the wages appear less procyclical. This view is supported by findings from German administrative microdata. I show that the cyclical selection on match quality arises naturally in a Diamond-Mortensen-Pissarides search and matching model with match-specific productivity and turnover costs.

To investigate the cyclicality of wages, I estimate the relationship between the real wages and the unemployment rate using a matched employer-employee administrative dataset from Germany. The dataset allows to differentiate between two types of hires, from employment and unemployment,[1] [2] and to address the potential composition bias due to worker heterogeneity, as discussed in Bils (1985) or Solon, Barsky and Parker (1994), occupational down- or upgrading, and differences between cyclicality of employment at high- and low-paying firms.[3]

Contrary to expectations, the wages of new hires are *less* procyclical than the wages of

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[1] The differentiation between hires from employment and unemployment was neglected in the wage cyclicality literature until recently. Notable recent exceptions are Getler, Huckfeldt and Trigari (2016) who find that the wages of hires from employment are more procyclical and the wages of hires from unemployment are no more cyclical than those of job stayers, and Haefke, Sonntag, and van Rens (2013) who find that the changes in the wages of hires from unemployment closely follow aggregate labor productivity.

[2] Throughout the paper, "unemployment" refers to both unemployment and non-employment.

[3] Recently, Moscarini and Postel-Vinay (2012), Kahn and McEntarfer (2014), Haltiwanger, Hyatt and McEntarfer (2015) investigated the cyclical properties of employment growth at different categories of firms. Their findings raise the possibility that lower-paying firms are responsible for a higher share of employment and hiring during downturns, which would introduce procyclical bias into the estimates of wage cyclicality.

continuing workers. This effect is stronger for hires from employment than for hires from unemployment. This counterintuitive result call for an explanation.

I propose an explanation based on cyclical changes in the quality of firm-worker matches: in bad times, worker-firm pairs have to be unusually productive to warrant job creation. Suppose that output and wages in a firm-worker match depend, positively, on both aggregate and match-specific productivity. A firm-worker contact leads to job creation only if its output is high enough, that is if its idiosyncratic productivity is above a threshold that depends negatively on aggregate productivity. In bad times, only the matches with high idiosyncratic productivity are profitable, in good times, even the low-productivity matches are acceptable. Aggregate productivity has a direct, positive effect on wages as well as an indirect effect. The indirect effect is compositional - average match-specific productivity is inversely related to aggregate productivity, which pushes down wages when aggregate productivity increases.

The presence of the selection effect is empirically validated. As observed in Bowlus (1995), matches of better quality, which I conceptualize as match-specific productivity, should last longer. I investigate the relationship between risk of separation to unemployment, a proxy for match quality, and the unemployment rate at the start of a job. The relationship is negative: higher unemployment at the start of a job is associated with a decreased risk of ending with a separation to unemployment. This association is stronger for hires from employment than for hires from unemployment. The results suggest that matches started during downturns are positively selected, especially when they created by a job-to-job transition.

Finally, I build a stochastic Diamond-Mortensen-Pissarides type model. The key features of the model are match-specific productivity and a cost incurred when a worker is hired. [4] To be consistent with the results on job duration, the model features endogenous separations.

In the model, the selection effect is present for both job stayers and new hires, but is stronger for new hires. Matches with low match-specific productivity can be created and maintained when aggregate productivity is high. When aggregate productivity is low, they

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[4]Hiring costs were added to the search and matching model in Braun (2006), Nagypal (2007), Silva and Toledo (2009) and Yashiv (2006), see also a discussion in Mortensen and Nagypal (2007).

are destroyed. The destruction of matches with low match-specific productivity increases the average match quality for job stayers during downturns, pushing up their observed wages. For new hires, the selection effect is amplified by the presence of a hiring cost. During downturns, surplus from some matches is high enough to prevent their endogenous destruction but not high enough to cover the hiring cost. Consequently, during downturns the lowest match-specific productivity for new hires is higher than the lowest match-specific productivity for job stayers.[5]

I compare the cyclical properties of the model-generated wages and the observed wages. The model-generated wages have similar cyclical properties as the observed wages: the wages of new hires are *less* procyclical than the wages of continuing workers.

2   Related Literature

The main empirical part of the paper belongs to the literature on the cyclical properties of real wages. In the next section, I discuss how the results of the paper relate to previous empirical findings on wage cyclicality.

Bowlus (1995) introduced the idea that the relationship between the conditions at the start of a job and subsequent risk of separation carries information about the cyclical properties of match quality of new hires. To the best of my knowledge, this paper is the first to conduct such analysis controlling for firm heterogeneity and using a large matched sample of firm and workers. I discuss the previous findings and the crucial role of controlling for firm heterogeneity.

The key elements of the model I use are match-specific productivity and hiring costs. I discuss the related papers.

2.1   Cyclicality of Wages

How do real wages react to the business cycle conditions? At least since the Dunlop-Tarshis-Keynes exchange, this simple question was a subject of a large body of research and is still not

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[5]The presence of a firing cost would have the same effect. When firing workers is costly, during downturns some surviving matches generate negative surplus, while all new matches have to generate positive surplus.

fully answered. In recent years, the interest in the question was renewed after Shimer (2005) argued that the Diamond-Mortensen-Pissarides search and matching model had difficulty reconciling fluctuations in unemployment and productivity. As emphasized in Pissarides (2009), information about the cyclical behavior of real wages is crucial for understanding fluctuations in unemployment. This paper belongs to a recent wave of papers that use microdata to investigate the cyclicality of wages.

Up to the early 1990s, the consensus, based on studies using aggregate data, was that real wages in the US were acyclical or, at best, weakly procyclical. These studies were suspected to suffer from various forms of composition bias. As Stockman (1983) surmised, the composition of the labor force changes over the cycle. More pronounced procyclicality of hours and employment of low-wage workers induces a countercyclical bias in an aggregate measure of wages. An opposite procyclical effect was identified in Chirinko (1980) as arising from high cyclical sensitive of high-wage industries such as durables manufacturing and construction.

The use of individual level data shattered the previous consensus, starting with Bils (1985) and Solon, Barsky and Parker (1994). The wages were usually found to be procyclical.

Newer paper differentiate not only between job stayers and new hires, but also hires from unemployment and employment. A recent example is Haefke, Sonntag and van Rens (2013) which uses the CPS cross-sectional data to find the elasticity of wages with respect to labor productivity is higher for hires from unemployment than for job stayers, and even higher for hires from employment, although standard errors are large. A different conclusion is reached by Gertler, Huckfeldt and Trigari (2016) which uses the SIPP panel data to find that the wages of job stayers are slightly procyclical, the wages of hires from unemployment are acyclical and the wages of hires from employment are procyclical.

The studies of the US labor market suffer from data limitations. Suitable datasets are, at best, panels. They contain scanty information on employers and often unsatisfactory information on workers and are plagued by measurement error. The use of administrative datasets reduces measurement error issues and, more importantly, allows to control for various potential sources of composition bias. Recent examples are Carneiro, Guimaraes and Portugal (2012) and Martins, Solon and Thomas (2012) use Portuguese Quadros de

Pessoal matched employeremployee dataset. In the first paper, the cyclicality of wages is estimated with controls for worker, job and occupation fixed effects. The wages of new hires are found to be more procyclical than wages of job stayers. The second paper concentrates on hiring wages for a set of entry jobs which are found to be quite procyclical. Due to limitations of the dataset, these papers cannot differentiate between hires from employment and from unemployment.

For Germany, Stueber (2017) used a similar source of data as my paper, the employment biographies generated by the German social security system, but for the period 1977-2009 at yearly frequency. The wages of new hires were found to be no more procyclical, controlling for worker and employer-occupation fixed effects, than the wages of job stayers.

2.2 Match Quality

Is match quality higher or lower in jobs started in periods of high unemployment than in periods of low unemployment? Match quality, however understood, is not directly observable. A traditional proxy for job quality is job duration - a better match should last longer. Using job duration until transition to different employment or unemployment as a proxy is equivalent to investigating the probability of separation, or the instantaneous probability of separation conditional on previous survival (hazard rate). The sign and strength of the relationship between job duration or risk of separation and unemployment at the start of a job provides information about the cyclical behavior of match quality.

Bowlus (1995) found that the higher initial unemployment rate increased risk of subsequent separation. This finding, suggestive of procyclical match quality, motivated Barlevy (2002) to formulate a theory of sullying recessions. Baydur and Mukoyama (2018) use the competing risks model to estimate that the higher initial unemployment rate increases the risk of job-to-job transition but decreases the risk of separation into nonemployment.

These papers used panel data from the National Longitudinal Survey of Youth, which precluded controlling for firm heterogeneity. Kahn (2008) exploited a small matched dataset of Fortune 500 firms and their employees to show that controlling for firm heterogeneity switches the sign of the relationship between separation risk and the initial unemployment rate from positive to negative.

As I discuss later, the results of this paper taken together with the previous results for the US suggest that average match quality for new hires might be countercyclical in the US as well as in Germany.

2.3   Match-Specific Productivity

The presence of match-specific productivity, or equivalently idiosyncratic price of output, is common in the search and matching literature. The standard assumption is that new matches start with the same match-specific productivity, which later evolves, as in Mortensen and Pissarides (1994), Pissarides (2009), Fujita and Ramey (2012). The matches were allowed to start with randomly drawn productivity in Mortensen (1982) and Mortensen and Nagypal (2007a). However, the consequences of the presence of match-specific productivity for the cyclical properties of wages were not investigated.

A paper closely related to mine is Gertler, Huckfeldt and Trigari (2018). They build a model with match-specific productivity and endogenous on-the-job search that generates a procyclical selection effect for new hires from employment. An interesting implication of the model is that jobs created by a job-to-job transition during downturns should be at an increased risk of ending with a subsequent job-to-job transition. The implication was not investigated in the paper.

The consequences of match quality selection for wages appear in a different context in Hagedorn and Manovskii (2013). They argue that when wages depend on current conditions and match-specific productivity, past selection over match quality makes wages appear to depend on past labor market conditions summarized by the lowest unemployment rate during a job spell. Their preferred proxies for match quality are based on the labor market tightness during a job spell and an employment cycle.

2.4   Turnover Costs

Turnover (hiring or firing) costs are added to the search and matching model in Braun (2006), Nagypal (2007), Silva and Toledo (2009) and Yashiv (2006). Turnover costs improve the performance of the model by making firms' net profits more responsive to changes in productivity.

Muehlemann and Pfeifer (2016) use a German firmlevel survey from the 2000s to assess recruitment and adaptation costs of new hires. The average total hiring costs in Germany was equal to more than 2 months of wage payments, with two thirds incurred when a worker was hired. I use the provided ratio of the hiring cost to calibrate my model. For the US, Dube et al. (2010) assess the average total hiring costs to be around 1.1 of monthly wages in California, which suggests that the hiring cost should be twice as high in Germany as in the US.

A characteristic feature of the German labor market are high firing costs. Unlike in the US, an employee on permanent contract that is dismissed on operational grounds is entitled to severance pay equal to half a months wage for each year of tenure, of up to 12 monthly wages for most workers, and even more for older workers with long tenure.

3 Data

I use a German matched employer-employee dataset data provided by the Research Data Centre of the Federal Employment Agency at the Institute for Employment Research (IAB). The Linked Employer-Employee Data Longitudinal Model 1993-2010 (LIAB LM 9310) contains administrative data on all workers that were employed at any time between 1999 and 2009 in one of the establishments of the 2000-2008 panel of the IAB Establishment Panel. The sample of establishments is drawn from the population of all establishments with employees covered by social security, and stratified with respect to industry, size and federal state.

For each worker, I have information on all employment spells covered by social security between 1993 and 2010: establishment identifier, sex, education, working hours (full-time or part-time), employment status (indicators for special status such as traineeship, partial retirement and others), daily earnings, occupation, with 120 occupational categories, and other information. Tenure can be precisely calculated.

I briefly describe origin, structure, contents, sample selection of the dataset and construction of monthly panel used for my analysis in Appendix A. A detailed description is provided in Klosterhuber, Heining and Seth (2014).

The dataset lacks precise information on working hours, but I observe whether a worker works full-time or part-time. A worker is classified as full-time if their contracted hours are the usual working hours in the establishment. Consequently, when I restrict the sample to full-time workers, I can control for differences in working hours across workers by the addition of firm fixed effects.

The observations with daily earnings above the legally mandated contribution assessment ceiling (Beitragsbemessungsgrenze) are topcoded. More than 10% of observations are affected. Using the Tobit regression with the same fixed effects as for the censored sample is computationally infeasible. Instead, to establish that it is implausible that my results are affected by censoring, I use a robustness check the replaces worker and firm fixed effects with the CHK estimates from Card, Heining, Kline (2013). They estimate a Mincer-type wage model with additive fixed effects for workers and establishments for all West German workers covered by social security. The estimated worker fixed effects represent a component of a wage that a worker receives wherever he works, controlling for his observable characteristics. The estimated firm fixed effects proxy a wage component common to all workers in a firm, controlling for their observable and unobservable characteristics. The IAB provided a supplementary dataset containing the CHK effects for workers and establishments of the LIAB LM 9310.

The main sample is restricted to the spells of employment in West German establishments that are the 2000-2008 panel cases of the IAB Establishment Panel. I restrict the sample to men aged 20-60. The restriction is adopted for comparability with earlier studies.

4   Empirical Results

In this section, I discuss the specification and the results for the estimation of the cyclicality of wages, and for the estimation of the relationship between risk of separation and initial conditions.

4.1 Wages: Specification

The specification for estimating the cyclicality of wages is the same as in Gertler, Huckfeldt and Trigari (2016). Data are at monthly frequency. Let w_{it} denote the real wage paid in period t to individual i. The wage equation is

$$log\, w_{it} = \pi u_t + \pi_E NH_E(i,t)u_t + \pi_U NH_U(i,t)u_t + \alpha_i + \beta_{j(i)} + \boldsymbol{\gamma}'_x \boldsymbol{x}_{it} + \epsilon_{it} \qquad (1)$$

where u_t is the unemployment rate, $NH_E(i,t)$ and $NH_U(i,t)$ are indicator variables that take value one for new hires from employment and from unemployment, respectively. Controls are fixed effects α_i, worker fixed effects, $\beta_{j(i)}$, firm fixed effects where $j(i)$ denotes i's employer and additional variables contained in vector $\boldsymbol{x}_{it}$: indicators for both types of new hires, a time trend (calendar-month dummies and a quadratic polynomial in time), an education-specific cubic polynomial in age, a cubic polynomial in tenure when applicable, and occupation fixed effects.

Hires from employment are identified as workers that started their current job no more than 14 days after the end of their previous employment and without registering with the BA as an unemployed or a jobseeker, while hires from unemployment are identified as workers that started their current job more than 14 days after the end of their previous employment or after registering with the BA. The results are robust to changing the cutoff for differentiation between hires from employment and unemployment to 31 days and to 7 days.

In Table 4, I present the estimates of the wage cyclicality with different controls added. The results with all controls added are in column 7. The results of the Tobit regression on an uncensored sample, with the CHK effects replacing worker and firm fixed effects, are in column 5 of Table 5. The estimates for a sample that includes part-time workers are in column 6 of 5.

The coefficients of interest are π, the semielasticity of wages with respect to the unemployment rate u_t, the incremental effects for hires from employment and from unemployment, π_E and π_U. The cyclicality of wages is captured by u_t, $u_t + \pi_E$ and $u_t + \pi_U$ for job stayers, new hires from unemployment and employment, respectively.

4.2   Wages: Results

The results in first four columns on Table 4 show the estimates of π, π_E, π_U for specifications that sequentially add more controls for worker heterogeneity: observable workers' characteristics in column (2), worker fixed effects in column (3), and occupation fixed effects in column (4). With more controls for worker observables and worker fixed effects are added, the estimates of wage cyclicality decrease substantially. The addition of occupation fixed effects leaves the estimates essentially unchanged.

These results are consistent with both job stayers and new hires having better observable and unobservable characteristics when unemployment is higher. Cyclical occupational up- or down-grading seems to be unimportant.

The addition of firm fixed effects lowers the estimates in the comparison with the specification without any controls, as the comparison of columns (5) and (1) reveals. On its own, these results suggest countercyclical changes in the quality of firms that retain and hire workers, although firm fixed effects are difficult to interpret on their own since they might pick up differences in workforce characteristics across firms.

The estimates from the specifications without and with firm fixed effects in the addition to full worker controls, presented in columns (3)-(4) and (6)-(7), reveal that the addition of firm fixed effects is unimportant for job stayers but lowers the cyclicality of wages for new hires, in particular hires from unemployment, which suggests countercyclical changes in the quality of hiring firms.

The main results in column (7) of Table 4 indicate procyclicality of wages of job stayers and countercyclicality for new hires. The wages of hires from employment are more counter-cyclical than wages of hires from unemployment. The addition of controls for occupations is again unimportant, as shown by the similarity of the results in columns (7) and (6) which are obtained for the specifications with and without occupation fixed effects.

The check of problems that censoring might cause yields reassuring results, presented in Table 5. I compare the results of the Tobit estimation on the uncensored sample, column (5), to the analogous results in column (1) from the estimation on the censored sample. Both specifications use the CHK estimates as controls for worker and firm heterogeneity. The estimated wage cyclicality is similar. In turn, the estimates in column (1) are similar

to the estimates in column (2), with occupation fixed effects, and the estimates in columns (1) and (2) are to the fixed-effects results in columns (3) and (4).

I estimate the wage equation on a sample that includes part-time workers, adding fixed effects for working hours and employment status. The results in column 6 of Table 5 are, again, qualitatively similar to the results in column (4), although the coefficients of the cyclicality of wages job stayers and the incremental effect for hires from unemployment lose significance.

4.3 Separation Risk: Specification

Separation risk can be captured by the hazard defined as the instantaneous probability that worker i experiences an event (separation) conditional on the event not happening up to time t and information set captured as a vector $\boldsymbol{w}_{it}$:

$$h_{it} = lim_{\Delta t \to 0} \frac{P(t \leq T_{event} < t + \Delta t | T_{event} \geq t, \; \boldsymbol{w}_{it})}{\Delta t}.$$

I impose a functional form on the hazard using the Cox (1972) model. The hazard function takes the form

$$h_{it} = \tilde{h}_{jt} exp(\boldsymbol{\beta}' \boldsymbol{w}_{it} + \epsilon_{it})$$

where β is a vector of parameters common for all observations, and $\tilde{h}_{jt}$ is the baseline hazard, which might differ across subsets (strata) of observations, in this case firms $j = j(i)$. For comparisons with previous papers, I estimate two versions of the Cox model: unstratified, with $\tilde{h}_{jt} = \tilde{h}_t$, and stratified, with $\tilde{h}_{jt}$ allowed to differ across firms.

The stratified Cox model is a modification of the Cox proportional hazards model that allows the baseline hazard to differ across strata. Stratification in the Cox model is a counterpart of adding fixed effects to linear models. The strata in my estimation are firms, which allows for differences in the baseline hazard across firms.

The information set for worker i at time t is captured by vector $\boldsymbol{w}_{it}$, which includes the unemployment rate at the start of a job, $u_{ij}^{initial}$, the indicator for hires from unemployment, H_{ij}^U, the indicator interacted with the initial unemployment rate, a time trend, initial wage, current unemployment rate and its square and other controls for observable worker heterogeneity.

The main estimation equation is

$$h_{it} = \tilde{h}_{jt} exp(\alpha u_{ij}^{initial} + \alpha_U H_{ij}^U u_{ij}^{initial} + \boldsymbol{\gamma}_x' \boldsymbol{x}_{it} + \epsilon_{it}), \tag{2}$$

which is startified to control for firm heteregeneity.

For comparisons with previous papers, I additionally estimate the non-stratified version of 2

$$h_{it} = \tilde{h}_t exp(\alpha u_{ij}^{initial} + \alpha_U H_{ij}^U u_{ij}^{initial} + \boldsymbol{\gamma}_x' \boldsymbol{x}_{it} + \epsilon_{it}), \tag{3}$$

and pool together 2 types of hires in the startified and non-stratified estimation of

$$h_{it} = \tilde{h}_{jt} exp(\alpha u_{ij}^{initial} + \boldsymbol{\gamma}_x' \boldsymbol{x}_{it} + \epsilon_{it}), \tag{4}$$

and

$$h_{it} = \tilde{h}_t exp(\alpha u_{ij}^{initial} + \boldsymbol{\gamma}_x' \boldsymbol{x}_{it} + \epsilon_{it}), \tag{5}$$

The results for 2 and and 3, with and without stratification across firms, are in Tables 6 and 7. The results for 4 and and 5, are in Tables 8 and 9. Columns (1) present the results for separations pooled together, columns (2) for separations to employment, columns (3) for separations to unemployment.

For 2 and and 3, the coefficients of interest are α, which captures the relationship between the initial unemployment rate and subsequent risk of separation for hires from employment, and incremental effect α_U for hires from unemployment. For hires from unemployment, the relationship between the initial unemployment rate and subsequent risk of separation is captured by $\alpha + \alpha_U$. For 4 and and 5, the coefficient of interest is α.

4.4 Separation Risk: Results

The main results from the stratified Cox model with the incremental effect for hires from unemployment, presented in Table 6, suggest that a higher initial unemployment rate decreases subsequent risk of separation into unemployment but not to different employment. This cyclical property is attenuated for hires from unemployment. When both types of separations are considered together, as in some previous papers, the relationship between the initial unemployment rate and risk of separation is negative.

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The unstratified Cox model yields different results, presented in Table 7. A higher initial unemployment rate decreases subsequent risk of separation to employment. When both types of separations are considered together, the relationship between the initial unemployment rate and risk of separation is positive for hires from employment, although not significant for both types of hires considered together, as shown in column (1) of Table 9.

Controlling for firm heterogeneity has similar effects as in Kahn (2008), which uses a small sample of data on large US firms and their employees. This raises a possibility that the estimates of the relationship between the initial unemployment rate and subsequent hazard of separations that neglect firm heterogeneity are biased.

I conclude that firm-worker matches established in times of higher unemployment appear to be of better quality. In the next section, I conceptualize match quality as match-specific productivity, randomly drawn when a worker and firm meet and fixed for the duration of employment.

5 Selection Effect: Stylized Example

I illustrate the match selection effect using a minimal example.

There are 2 values off aggregate productivity, low y_1 and high y_2, and 3 match-specific productivities z_1, z_2 z_3, such that $z_1 < z_2 < z_3$. Workers and firms are myopic, discounting with factor 0.

A worker in a match with match-specific productivity z_i produces $z_i y_k$ when aggregate productivity is y_k, receiving a fraction τ of his output. His employer earns $(1 - \tau)z_i y_k$. The worker quits if his wage $\tau z_i y_k$ would fall below unemployment benefit b otherwise.[6] An exogenous separation happens with probability δ.

When an unemployed worker and a vacancy-posting firm meet, they draw value z_i of match-specific productivity from a given probability distribution. The firm has to incur sunk cost h when hiring the worker. It wants to convert the meeting into a job if its per-period earnings would cover the cost, $(1 - \tau)z_i y_k \geq h$. The worker wants the job if his wage would be no less than the unemployment benefit, $\tau z_i y_k \geq b$.

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[6] For clarity of exposition, I assume that a firm and a worker split the match output $z_i y_k$, not surplus $z_i y_k - b$. The reasoning goes through when they split the surplus instead.

Figure 1 illustrates the selection mechanism. When aggregate productivity is high, all matches produce enough output to be preferable to unemployment for workers and justify job creation for firms. When aggregate productivity is low, output from the lowest-productivity match is so low that being unemployed is preferable to being employed in the match. The medium-productivity match is productive enough to survive if it was established earlier, but not to be created.[7]

It is easily shown that wages and job durations generated by a model with properties depicted in Figure 1 would have the same cyclical properties as found in data. The key observation is that match-specific productivity for new hires is, on average, lower than for job stayers when aggregate productivity is high, and higher when aggregate productivity is low.

The mean match-specific productivity for new hires if $\mathbb{E}z$ when aggregate productivity is high, and z_3 when aggregate productivity is low. The mean wages of new hires are, respectively, $\overline{w}_2^H = \tau y_2 \mathbb{E}z$ and $\overline{w}_1^H = \tau y_1 z_3$.

When aggregate productivity is high, job stayers belong to 3 groups: workers that were hired during the current boom, with mean match-specific productivity $\mathbb{E}z$, workers that were hired during a previous boom and remained employed during a downturn, with mean match-specific productivity $\mathbb{E}z|z > z_1$, and workers that were hired during a previous recession, with mean match-specific productivity z_3. Let the fractions of the second and third group be γ and γ'. The mean wage of job stayers is

$$\overline{w}_2^S(\gamma, \gamma') = (1 - \gamma - \gamma')\tau y_2 \mathbb{E}z + \gamma \tau y_2 \mathbb{E}z|z > z_1 + \gamma' \tau y_2 z_3$$

where γ, $\gamma' \in [0, 1]$, such that $\gamma + \gamma' \in [0, 1]$, depend on the rate of exegenous separations, vacancy creation and history.

When aggregate productivity is low, job stayers belong to 3 groups: workers that were hired during the current recession, with mean match-specific productivity z_3; workers that were hired during a previous boom and remain employed during the current recession, with
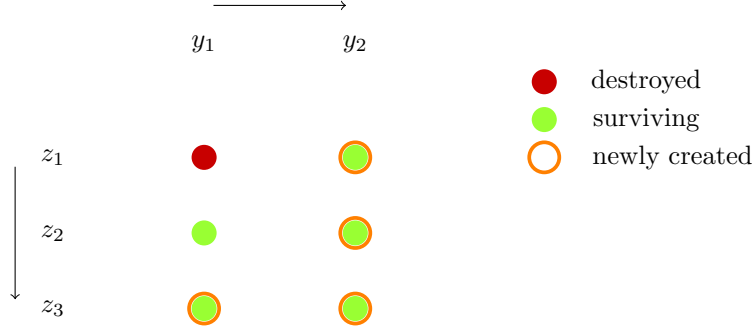
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[7] The parameters have to satisfy the inequalities

$$z_3 \geq \frac{h}{(1 - \tau)y_1} > z_2 \geq \frac{b}{\tau y_1} > z_1 \geq \frac{h}{(1 - \tau)y_2}$$

which is always possible.

Figure 1: Selection Effect

mean match-specific productivity $\mathbb{E}z|z > z_1$, workers that were hired during a previous recession, with mean match-specific productivity z_3. Let the fraction of the second and third group be ψ. The mean wage of job stayers is

$$\overline{w}_1^S(\psi) = (1 - \psi)\tau y_1 z_3 + \psi \tau y_1 \mathbb{E}z|z > z_1$$

where $\psi \in [0,1]$ depend on the rate of exegenous separations, vacancy creation and history.

The mean wage of new hires is higher than the mean wage of job stayers during recessions, but lower during booms, $\overline{w}_1^S(\psi) < \overline{w}_1^H$ and $\overline{w}_2^H < \overline{w}_2^S(\gamma, \gamma')$ for ψ, $\gamma + \gamma' > 0$, from which follows that

$$\frac{\overline{w}_1^S(\psi) - \overline{w}_2^S(\gamma, \gamma')}{\overline{w}_2^S(\gamma, \gamma')} < \frac{\overline{w}_1^H - \overline{w}_2^H}{\overline{w}_2^H} < 0 < \frac{\overline{w}_2^H - \overline{w}_1^H}{\overline{w}_1^H} < \frac{\overline{w}_2^S(\gamma, \gamma') - \overline{w}_1^S(\psi)}{\overline{w}_1^S(\psi)}. \tag{6}$$

In percentage terms, the mean wages of new hires are less responsive to aggregate productivity than the mean wages of job stayers, as (6) shows. Consequently, regressing the logarithms of wages on aggregate productivity or unemployment, as in (1), would lead to the conclusion that the wages of new hires are less procyclical than the wages of job stayers, even though all wages are equally and fully responsive to aggregate conditions.

The matches created during recessions are of the highest match-specific productivity and never end with an endogenous separation. Some of the matches created during booms are of the lowest match-specific productivity and end with an endogenous separation when aggregate productivity drps. Consequently, the relationship between risk of separation to unemployment and the unemployment rate at the start of a job is negative.

6   Model

I build a variant of the Diamond-Mortensen-Pissarides search and matching model. The two crucial elements of the model are match-specific productivity and a hiring cost.

6.1   Model Outline

There is a continuum of workers with measure one and a continuum of firms. Each firm turns one unit of labor into $r(y, z)$ units of output, where r is an increasing function of aggregate productivity y and match-specific productivity z. I use the standard production function $r(y, z) = yz$. The unemployed workers receive flow benefit b.

The workers and firms are risk-neutral. They maximize the expected sum of periodical incomes, discounting with factor $\beta \in (0, 1)$.

The aggregate productivity, y, is the same for all firms, with values in set $Y = \{y_1, y_2, .., y_{N_Y}\}$, where $y_1 < y_2 < ... < y_{N_Y}$ and $N_Y \geq 2$. The aggregate productivity y is updated to $\hat{y}$ at the beginning of the next period with probability $f_Y(y, \hat{y})$, where $f_Y : Y^2 \to [0, 1]$.

The match-specific productivity, z, with values in set $Z = \{z_1, z_2, .., z_{N_Z}\}$, where $z_1 < z_2 < ... < z_{N_Z}$ and $N_Z \geq 2$, is fixed for each match after being drawn from the probability distribution $f_Z : Z \to [0, 1]$ with the cumulative distribution function F_Z when a worker and a firm meet. The match-specific productivity is drawn when a worker and a firm meet, but before a worker is hired.

The notation for value functions is standard. The value of match to the firm, the value of match to the worker, the value of unemployment, the match surplus denoted, respectively, as $J(y, z)$, $W(y, z)$, $U(y)$, $S(y, z) = J(y, z) + W(y, z) - U(y)$. The contract between a firm and its employee specifies wage $w(y, z)$. The wage equalizes the worker's surplus $W(y, z) - U(y)$ with $\tau S(y, z)$, where $\tau \in [0, 1]$ is the workers' bargaining power parameter.

There is a hiring cost $h \geq 0$ that has to paid in the first period of employment. The cost is sunk, incurred when a worker is hired.

The firms create vacancies which meet workers through a frictional meeting process. The number of meeting is determined by a CRS matching $M(u, v)$, which depends on the number of created vacancies, v, and the number of workers looking for jobs, u. The probabilities that

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the workers and the vacancies meet are $M(u,v)/u$ for workers and $M(u,v)/v$ for vacancies, which can be written as functions of the labor market tightness $\theta = v/u$. An unemployed worker meets a vacancy with probability $p(\theta)$, where $p : [0, \infty) \to [0, 1]$ is a differentiable function with a bounded derivative. A vacancy meets a worker with probability $q(\theta)$, where $q : [0, \infty) \to [0, 1]$ is an invertible and differentiable function with a derivative that is bounded away from zero for any $[0, A]$, where $A < \infty$, and $q(0) = 1$. For the calibration exercise I use the standard matching function $M(u, v) = \kappa u^{\eta} v^{(1-\eta)}$.

The zero profit condition determines vacancy creation. The firms' expected profit from vacancy creation depends on the probability of meeting a worker and the expected value of meeting a worker, $\tilde{J}(y)$. If the expected value exceeds the cost of vacancy creation, $c > 0$, vacancies are created until the expected profit is driven to zero. If the expected value is less than the cost of vacancy creation, no vacancies are created. The market tightness is determined as

$$\theta(y) = \begin{cases} q^{-1}(c/\tilde{J}(y)), & \text{if } \tilde{J}(y) \geq c \\ 0. & \text{if } \tilde{J}(y) < c. \end{cases} \tag{7}$$

Matches are destroyed if surplus $S(y, z)$ is negative and with the exogenous separation probability $\delta \in (0, 1)$. For simplicity, I assume that workers who lose a job cannot find a new one in the same period.

6.2 Value Functions

The match surplus S is a sum of the firm's surplus, J, and the worker's surplus, $W - U$, where W, U are the value of employment and unemployment. The Nash bargaining leads to the condition

$$\frac{J(y, z)}{1 - \tau} = S(y, z) = \frac{W(y, z) - U(y, z)}{\tau}.$$

The value accruing to an unemployed worker is

$$U(y) = b + \beta \mathbb{E}\Big[\big(1 - p(\theta(\hat{y}))\big)U(\hat{y})$$
$$+ p(\theta(\hat{y})) \int \mathbb{1}\{(1-\tau)S(\hat{y}, z) < h\}dF_Z(z)U(\hat{y})$$
$$+ p(\theta(\hat{y})) \int \mathbb{1}\{(1-\tau)S(\hat{y}, z) \geq h\}W(\hat{y}, z)dF_Z(z)\Big]$$

which can be rewritten as

$$U(y) = b + \beta \mathbb{E}\left[U(\hat{y}) + p(\theta(\hat{y}))\int \mathbb{1}\{(1-\tau)S(\hat{y},z) \geq h\}\tau S(\hat{y},z)dF_Z(z)\right].$$

The value accruing to an employed worker is

$$W(y,z) = w(y,z) + \beta\mathbb{E}\Big[\delta U(\hat{y})$$
$$+ (1-\delta)\mathbb{1}\{S(\hat{y},z) < 0\}U(\hat{y})$$
$$+ (1-\delta)\mathbb{1}\{S(\hat{y},z) \geq 0\}W(\hat{y},z)\Big]$$

which can be rewritten as

$$W(y,z) = w(y,z) + \beta\mathbb{E}\Big[U(\hat{y}) + (1-\delta)\mathbb{1}\{S(\hat{y},z) \geq 0\}\tau S(\hat{y},z)\Big].$$

The value accruing to a firm employing a continuing worker is

$$J(y,z) = r(y,z) - w(y,z) + \beta\mathbb{E}(1-\delta)\mathbb{1}\{S(\hat{y},z) \geq 0\}J(\hat{y},z)$$

which can be rewritten as

$$J(y,z) = r(y,z) - w(y,z) + \beta\mathbb{E}(1-\delta)\mathbb{1}\{S(\hat{y},z) \geq 0\}(1-\tau)S(\hat{y},z).$$

The surplus S can be rewritten as

$$S(y,z) = r(y,z) - b + \beta\mathbb{E}\Big[(1-\delta)\mathbb{1}\{S(\hat{y},z) \geq 0\}S(\hat{y},z)-$$
$$p(\theta(\hat{y}))\int \mathbb{1}\{(1-\tau)S(\hat{y},\hat{z}) \geq h\}\tau S(\hat{y},\hat{z})dF_Z(\hat{z})\Big]. \tag{8}$$

The expected value of meeting a worker is

$$\tilde{J}(y) = \int \mathbb{1}\{(1-\tau)S(\hat{y},z) \geq h\}((1-\tau)S(y,z) - h)dF_Z(z). \tag{9}$$

6.3   Equilibrium

An equilibrium is a surplus function S satisfying equation (8), where a market tigthness function θ is dictated by equations (9) and (7).

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7 Calibration

The key features of the model are match-specific productivity and the hiring cost.

I follow the literature and assume that match-specific productivity has a lognormal distribution with standard deviation σ, $z \sim Lognormal(0, \sigma^2)$. The data moment used to calibrate σ is standard deviation of residual log wages, taken from Card, Heining, and Kline (2013), which estimate the Mincer equation for log wages using the whole universe of German labor market biographies.

The hiring cost h is calibrated to be around 1.3 of mean monthly labor income, as calculated Muehlemann and Pfeifer (2016) from a survey of German firms.

The exogenous separation rate $\delta = 0.95$ is equal to the lower values of the monthly separation rate in the 2000s calculated in Nordmeier (2014), and consistent with previous calculations in Elsby et al. (2013). The flow benefit parameter b is calibrated to be around 0.4 of mean monthly labor income, as in Krause and Uhlig (2012) for the post-Hartz period.

The parameters β, η, τ and ρ have values standard in the literature. The aggregate productivity is either low, $1 - \sigma_y$, or high, $1 + \sigma_y$. Tha parameter σ targets standard deviation 0.02 of log labor productivity, as in Shimer(2005).

The vacancy creation cost c and the matching function efficiency parameter κ are chosen to match the mean monthly job finding rate calculated in Nordmeier (2014) and Elsby et al. (2013), around $0.055 - 0.07$, and the mean monthly unemployment rate 0.09.

The model-generated wages have the key cyclical property matching the empirical findings: the estimated incremental effect $\hat{\pi}_U = 0.54$ is positive and significant.

Table 1: Model Parameters

Value	Description	Target/Source
$\sigma = 3$	log match productivity sd	residual log wages sd 0.14, Card, Heining, and Kline (2013)
$h = 1.9$	hiring cost	$h = 1.3\overline{w}$, Muehlemann and Pfeifer (2016)
$\delta = 0.0095$	exogenous separation rate	Elsby et al. (2013), Nordmeier (2014)
$b = 0.55$	flow benefit	$b = 0.4\overline{w}$, Krause and Uhlig (2012)
$\beta = 0.9966$	discount factor	annual interest rate 4.17%
$\eta = 0.5$	matching function elasticity	micro studies, Pissarides and Petrongolo (2001)
$\tau = 0.5$	workers' bargaining power	Hosios' condition, $\tau = \eta$
$\sigma_y = 0.02$	aggregate productivity sd	labor productivity sd 0.02, Shimer (2005)
$\rho = 1/24$	transition probabilities	2-year long recessions, Krussell and Smith (1998)
$c = 0.425$	vacancy creation cost	mean unemployment 0.09
$\kappa = 0.35$	matching function efficiency	job finding rate = 0.3, Nordmeier (2014)

Notes:

$\overline{w}$ denotes mean labor income.

Table 2: Model Fit

Outcome	Target	Description
0.11	0.14	residual log wages sd
1.29	1.3	hiring cost relative to $\overline{w}$
0.37	0.4	flow benefit relative to $\overline{w}$
0.019	0.02	log labor productivity sd
0.11	0.09	unemployment rate
0.01	0.01	separation rate
0.7	0.06	job finding rate

Notes:

Results from simulations of 2400 monthly observations on 10000 workers with 51 possible match-specific productivities, $\overline{w}$ denotes mean labor income.

Table 3: Wage Cyclicality Estimates for Model-Generated Wages

	coef	std err	t-stat	P>|t|	[0.025	0.975]
$\hat{\pi}$	-1.5823	0.002	-726.088	0.000	-1.587	-1.578
$\hat{\pi}_U$	0.5387	0.022	24.082	0.000	0.495	0.583

Notes:

+ p< .1, * p<.05, ** p<.01; 42106825 observations from simulations of 2400 monthly observations on 10000 workers with 51 possible match-specific productivities.

8 Conclusions

The relationship between the business cycle and the real wages is one of the oldest topics in macroeconomics. I explored the previously neglected possibility that the cyclical selection on match quality makes wages of new hires appear less procyclical than they really are. Using German administrative microdata, I found evidence of the presence of countercyclical selection on match quality. The estimates of both the real wage cyclicality and the relationship between the initial conditions and subsequent risk of separation support my hypothesis of the countercyclical selection effect for new hires.

I showed that the cyclical selection on match quality arises naturally in a standard Diamond-Mortensen-Pissarides search and matching model with two additional features: match-specific productivity and turnover costs. More generally, these two fairly realistic features could generate the same selection effect in models with different wage-setting mechanisms, dampening the observed procyclicality of wages of new hires. An example would be a model with staggered multiperiod Nash bargaining in which workers' wages are negotiated for the first time when they are hired.[8] Without the selection effect, the wages of new hires would be more procyclical than weakly procyclical wages of job stayers. With the selection effect induced by match-specific productivities and turnover costs, the observed

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[8] Unlike Gertler and Trigari (2009), where workers hired in-between wage renegotiations receive the ongoing wage.

procyclicality of wages of new hires relative to job stayers would be smaller. The estimation of the cyclicality of model-generated wages would lead an observer to conclude that the wages of new hires were relatively unresponsive to aggregate conditions.

My empirical results suggest that the selection effect is stronger for hires from employment than from unemployment. In future work, I will incorporate on-the-job search to account for job-to-job transitions. In the present form, my model would not generate the stronger selection effect for hires from employment than for hires from unemployment. However, a conceptually easy modification should resolve this issue. For simplicity, I made match-specific productivity an inspection good, known to workers and firms immediately upon meeting. I could relax this assumption, making match-specific productivity partially an experience good. Then, worker-firm pairs receive a signal about match-specific productivity upon meeting. If they decide to create a job, the underlying productivity is revealed during first few months of its duration.[9] For hires from unemployment, the same force driving the selection effect in the baseline model appears in the generalized model. For hires from employment, the selection effect should be enhanced: during recessions, the employed workers would be unenthused about accepting a new job of unknown quality, fearing a job loss in times of high unemployment, and would require a higher signal about match quality to accept a new offer.

In future empirical work, I plan to use information on past and future labor market conditions[10] as controls for match quality. This methodology could be applied to data on wages from Germany as well from the US. My results on risk of separation, taken together with the previous results for the US, raise an interesting possibility that the countercyclical selection effect for new hires is present in the US labor market.

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[9] Which is consistent with the observation that risk of separation is elevated during first few months on job, and drops dramatically later.

[10] Along the lines of Beaudry and DiNardo (1991) and Hagedorn and Manovskii (2013), but with the addition of information about the most adverse labor market conditions which a job survives.

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A Wage Cyclicality

Table 4: Wage Cyclicality Estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\hat{\pi}$	0.634**	0.350**	−0.097*	−0.091*	0.392**	−0.097*	−0.091*
	(0.058)	(0.057)	(0.042)	(0.041)	(0.052)	(0.042)	(0.042)
$\hat{\pi}_E$	1.543*	1.598*	0.769**	0.773**	1.553**	0.706**	0.718**
	(0.671)	(0.737)	(0.223)	(0.238)	(0.379)	(0.161)	(0.178)
$\hat{\pi}_U$	3.167**	2.783*	0.410*	0.450*	1.086*	0.338*	0.384*
	(1.149)	(1.086)	(0.201)	(0.201)	(0.500)	(0.169)	(0.172)
adj. R-sq	0.014	0.227	0.866	0.866	0.396	0.867	0.867
No of Obs.	24751079	24751079	24736866	24663419	24751073	24736866	24663419
No of Firms	3434	3434	3427	3421	3428	3427	3421
No of Workers	443987	443987	429774	426886	443981	429774	426886
Worker Controls	No	Yes	Yes	Yes	No	Yes	Yes
Occupation FE	No	No	No	Yes	No	No	Yes
Worker FE	No	No	Yes	Yes	No	Yes	Yes
Firm FE	No	No	No	No	Yes	Yes	Yes

Notes:

+ p< .1, * p<.05, ** p<.01; time-clustered standard errors in parentheses; uncensored observations for full-time non-trainee workers.

Table 5: Wage Cyclicality Estimates - Robustness

	(1)	(2)	(3)	(4)	(5)	(6)
$\hat{\pi}$	-0.121^{**}	-0.123^{**}	-0.097^{*}	-0.091^{*}	-0.228^{**}	-0.018
	(0.043)	(0.043)	(0.042)	(0.042)	(0.042)	(0.044)
$\hat{\pi}_E$	0.922^{**}	0.911^{**}	0.706^{**}	0.718^{**}	0.916^{**}	0.718^{**}
	(0.250)	(0.242)	(0.161)	(0.178)	(0.215)	(0.160)
$\hat{\pi}_U$	0.389	0.544^{+}	0.338^{*}	0.384^{*}	0.306	0.121
	(0.327)	(0.305)	(0.169)	(0.172)	(0.291)	(0.121)
adj. R-sq	0.765	0.774	0.867	0.867	-	0.935
No of Obs.	24751079	24677279	24736866	24663419	29221597	26703724
No of Firms	3434	3428	3427	3421	3439	3433
No of Workers	443987	440746	429774	426886	474070	479089
Worker Controls	Yes	Yes	Yes	Yes	Yes	Yes
Occupation FE	No	Yes	No	Yes	No	Yes
Worker FE	No	No	Yes	Yes	No	Yes
Worker CHK	Yes	Yes	No	No	Yes	No
Firm FE	No	No	Yes	Yes	No	Yes
Firm CHK	Yes	Yes	No	No	Yes	No
Only Uncensored	Yes	Yes	Yes	Yes	No	Yes
Only Full-Time	Yes	Yes	Yes	Yes	Yes	No

Notes:
+ p< .1, * p<.05, ** p<.01; time-clustered standard errors in parentheses.

B   Separation Risk

Table 6: Estimates for Job Duration, Stratification

	All Separations	EE Separations	EU Separations
	(1)	(2)	(3)
$\hat{\alpha}$	-4.532^{**}	-0.211	-13.18^{**}
	(1.693)	(2.122)	(1.509)
$\hat{\alpha}_U$	0.412	2.366	5.037^{**}
	(1.031)	(1.556)	(1.093)
No of Observations	8465856	8465856	8465856
No of Firms	4137	4137	4137
No of Workers	269334	269334	269334

Notes:

+ p< .1, * p<.05, ** p<.01; time-clustered standard errors in parentheses; stratification by establishment.

Table 7: Estimates for Job Duration, No Stratification

	All Separations	EE Separations	EU Separations
	(1)	(2)	(3)
$\hat{\alpha}$	4.170^+	11.91^{**}	-9.941^{**}
	(2.254)	(3.286)	(1.710)
$\hat{\alpha}_U$	-4.910^*	-5.862^+	4.389^{**}
	(2.111)	(3.032)	(1.658)
No of Observations	8465856	8465856	8465856
No of Firms	4137	4137	4137
No of Workers	269334	269334	269334

Notes:

+ p< .1, * p<.05, ** p<.01; time-clustered standard errors in parentheses; stratification by establishment.

Table 8: Estimates for Job Duration, All Hires, Stratification

	All Separations	EE Separations	EU Separations
	(1)	(2)	(3)
$\hat{\alpha}$	-3.959^{**}	0.731	-9.044^{**}
	(1.397)	(1.726)	(1.270)
No of Observations	8465856	8465856	8465856
No of Firms	4137	4137	4137
No of Workers	269334	269334	269334

Notes:

+ p< .1, * p<.05, ** p<.01; time-clustered standard errors in parentheses; stratification by establishment.

Table 9: Estimates for Job Duration, All Hires, No Stratification

	All Separations	EE Separations	EU Separations
	(1)	(2)	(3)
$\hat{\alpha}$	1.467	9.872**	-7.623**
	(1.528)	(2.435)	(1.424)
No of Observations	8465856	8465856	8465856
No of Firms	4137	4137	4137
No of Workers	269334	269334	269334

Notes:

+ p< .1, * p<.05, ** p<.01; time-clustered standard errors in parentheses.