Match Quality, Contractual Sorting and Wage Cyclicality *

João Alfredo Galindo da Fonseca† Giovanni Gallipoli‡ and Yaniv Yedid-Levi§

July 24, 2017

Abstract

This paper studies the role of match quality for contractual arrangements, wage dynamics and workers' retention. We develop a model in which profit maximizing firms offer a performance-based pay arrangement to retain workers with relatively high match-specific productivity. The key implications of our model hold in data from the NLSY79, where information about job histories and performance pay is available. We relate our findings to the literature on occupation heterogeneity and provide evidence that jobs in "cognitive" occupations have better match quality, exhibit higher prevalence of performance pay, display significant sensitivity of wages to business cycle conditions and last longer.

Keywords: Match Quality, Contracts, Heterogeneity, Occupations, Wages, Cyclicality
JEL Classification: M52, M55, J33, J41, E24

*Financial support from the Social Sciences and Humanities Research Council is gratefully acknowledged. We thank Paul Beaudry, Axel Gottfries, Baris Kaymak, Christos Makridis and Ludo Visschers for helpful discussions.

†UBC, Vancouver School of Economics. E-mail: joaoalfredo.galindodafonseca@alumni.ubc.ca
‡UBC, Vancouver School of Economics. E-mail: gallipol@mail.ubc.ca
§UBC, Vancouver School of Economics. E-mail: yaniv@mail.ubc.ca

1 Introduction

Compensation arrangements influence the evolution of workers' wages. In this paper we examine how profit maximizing firms choose pay arrangements depending on worker-firm match quality, and provide evidence that such arrangements help shape both wage dynamics and employment durations.

We begin by developing a simple model of worker pay based on match quality and worker retention considerations. Our main theoretical result is that firms retain workers in high quality matches by offering compensation that is linked to the performance (production outcome) of the match. Moreover, as production is influenced by an aggregate cyclical component, the model implies that the wage of workers in performance-pay jobs should be more sensitive to cyclical fluctuations.

In the second part of the paper we bring these theoretical predictions to the data. We use detailed information from the NLSY79 to characterize work histories, and resort to specific questions regarding the form of compensation to distinguish between jobs with and without performance pay components. We construct measures of match quality and, following an established literature, we use the unemployment rate as a proxy for business cycle conditions. Our results provide empirical support for the three main theoretical predictions of the model. First, there is a clear positive relationship between match quality and the prevalence of jobs with performance pay. Second, match quality has a direct effect on wages, after controlling for the adoption of performance pay. Third, wages in performance pay jobs exhibit significant sensitivity to cyclical conditions, while wages in jobs with no performance pay components do not. Given our focus on worker retention motives, we also provide evidence that job durations are significantly higher when performance-based pay is adopted.

We relate our results to the growing literature on occupation heterogeneity and show that variation in the way workers are compensated in different occupations is intimately linked to match quality. In fact, we argue that this simple observation can go a long way towards understanding some of the observed differences in the cyclicality of wages, match-specific productivity and job durations across occupations. To this purpose we show that jobs in "cognitive" occupations exhibit higher match quality, are more likely to include performance pay components, have more cyclical wages and last longer.

Our study naturally brings together two branches of the literature on pay arrangements and wage dynamics. The first looks at the choice of compensation mechanisms and their effects on wages.[1] Our theoretical analysis is especially related to the work of Oyer (2004), who was the

[1] A detailed overview of the vast, and growing, literature on personnel and human resource management is presented in Lazear and Oyer (2012).

first to argue that firms may tie employees' pay to firm performance in order to closely match employees' compensation to their outside options. Our theoretical analysis shows that this retention motive becomes extremely salient in the presence of match-specific heterogeneity, leading to interesting patterns of contractual sorting and wage dynamics.

Some of our empirical findings confirm those by Lemieux, Macleod, and Parent (2009, 2012), and Makridis (2014). These studies show that performance pay jobs are concentrated at the upper end of the wage distribution, where most jobs entail relatively high skills and labor returns.[2]

Finally, our results on the cyclicality of wages directly relate to the empirical literature going back to the work of Bils (1985) on the effect of aggregate labor market conditions on employees' wages. This line of research uses the unemployment rate as a proxy for business cycle conditions. One of the most recent contributions in this broad area (Hagedorn and Manovskii, 2013) proposes a theory-based approach to the measurement of match quality, and we adopt this method to generate empirical proxies for match quality.

Our findings highlight the role of aggregate labor market conditions for wages. The idea that contracts play a role in determining the cyclicality of wages is not a new one (see for example the original contribution by Beaudry and DiNardo, 1991). Unlike previous research, however, we focus on the theoretical and empirical linkages between match-specific productivity, pay arrangements and wage cyclicality. By explicitly studying the contract choice of a firm in the presence of heterogeneous match qualities, we closely follow the approach used in organization and personnel economics. In this way we provide novel evidence supporting the view that firms use profit-sharing to retain well-matched workers, and this retention motive helps shape both wage dynamics and job durations.

The remainder of the paper is organized as follows. The model and the theoretical predictions are discussed in Section 2. Section 3 describes the empirical specification and its relation to the model, as well as the measurement of match quality and performance pay. Empirical results and various robustness checks are overviewed in Section 4. Section 5 concludes.

2 A Simple Model of Worker Pay

In what follows we study the problem of a firm that has to decide how to compensate workers, given (i) time-varying aggregate conditions and (ii) match-specific productivity. To simplify the analysis we consider a stylized model with ex-ante identical risk neutral firms and workers. The model highlights the importance of worker retention considerations, a point originally

[2]These studies do not explicitly incorporate match quality in the analysis.

raised by Oyer (2004).

Production. A firm-worker pair produces output using production technology

$$y = Pm, \tag{1}$$

where P is an aggregate (economy-wide) state variable, while m is a match-specific productivity component. The aggregate state is either high (P_H), or low (P_L), where $P_H > P_L$. The match-specific productivity component is drawn once and persists throughout the life of the match.

Timing. We assume that, for all new matches, the first production period is used to learn about match quality. Only at the end of this initial period, after production takes place, match quality m is revealed to the firm and the worker.

To attract a new worker the firm commits to pay some given wage in the initial (learning) period even though match quality is unknown ex-ante. We assume that this wage is a function of the aggregate state P and of the idiosyncratic match quality m in the worker's *previous* job. Specifically, we assume that the wage paid during the learning period is equal to $a(P)m$ and posit that (i) it is increasing in the aggregate state ($a'(P) > 0$); and (ii) that workers compensation is strictly bounded from above by the total value of output in the current match ($a(P) < P$). In the context of our model the firm's commitment to pay $a(P)m$ clearly defines the value of each worker's outside option.[3] The assumptions we make about $a(P)$ imply that workers have better outside options during high productivity periods, when the aggregate state is $P = P_H$.

At the end of the initial period the new match specific productivity is revealed and the firm offers an employment contract to workers.[4] A surviving match lasts for up to two more periods, denoted as 1 and 2. We assume that $P_1 = P_H$ with certainty, while $P_2 = P_H$ with probability q and $P_2 = P_L$ with probability $(1 - q)$.[5]

Some workers might separate from the firm after the initial learning period. This happens when a sufficiently low match quality is revealed. The ex-ante participation constraint of a worker at the start of the period after learning about match quality is

[3]For simplicity we consider the unemployed state as a job with a latent non-zero m value.

[4]Profits or losses incurred during the initial learning period are sunk and the firm does not take them into account when making a new contract offer. This means that the realization of the aggregate state during the learning period has no effect on the contract offer.

[5]In Appendix C we show that the same qualitative results hold if the state in the initial period is low ($P_1 = P_H$).

$$w_1(m|P_H) + E(w_2(m)) \geq a(P_H)m + [qa(P_H) + (1-q)a(P_L)]E(m),$$

where w_1 and w_2 are the wages in period 1 and 2, respectively, and $E(m)$ is the expected match quality for a worker who decides to leave at the end of the learning period. We show in Appendix D that this participation constraint is satisfied for workers who draw match quality m larger than $E(m)$. If m is below $E(m)$ the constraint may be violated. If so, a separation occurs and the worker moves to a different employer, starting a new learning period.

Contractual arrangements. After the learning period, and conditional on match quality, the firm chooses an arrangement to maximize expected profits over the remaining two periods. In what follows we characterize the optimal contract offered by the firm to the workers who did not quit after the learning period. By choosing to remain in the match these workers commit to remain with the same firm in period 1. However they still have the opportunity to find a new job that will pay $a(P)m$ in the following period.

At the beginning of period 1 the firm offers a contract that specifies a wage for period 1 and a state-contingent compensation for period 2 that guarantees the worker's continuous employment (that is, it satisfies the participation constraints). We posit that the firm can offer one of three alternative pay arrangements to the worker. The three arrangements represent very diverse allocations of cyclical risk between worker and firm, encompassing the extreme cases in which either the firm or the worker carry all cyclical risk. The possible pay arrangements are:

1. A fixed wage contract that guarantees the worker's participation (continuous employment within the firm). To retain the worker under this contract the firm must offer a fixed wage that equals the highest possible outside option conditional on x,

$$w(m) = a(P_H)m, \quad \forall P. \tag{2}$$

   This arrangement guarantees worker retention in both periods. The firm subsidizes the worker in bad aggregate states and carries all the production risk.

2. A wage equal to the the worker's outside option, which we call the "spot market" wage. This is a rolling period-by-period arrangement that stipulates that the wage is changed to match the start-of-period outside option of the worker as follows,

$$w(m) = \begin{cases} a(P_H)m & \text{if} \quad P = P_H \\ a(P_L)m & \text{if} \quad P = P_L. \end{cases} \tag{3}$$

If the wage is changed between the two periods, there is a fixed (adjustment) cost $T > 0$ paid by the firm.

3. A performance pay arrangement that stipulates that the worker compensation is a combination of a fixed wage $\hat{w}(m)$ and a fraction b of the match surplus Pm:

$$w(m) = \begin{cases} \hat{w}(m) + bP_H m & \text{if} \quad P = P_H, \\ \hat{w}(m) + bP_L m & \text{if} \quad P = P_L. \end{cases} \tag{4}$$

We assume that the firm has to pay a fixed cost $K > 0$ associated with writing and implementing the performance pay contract.

2.1 Participation Constraints and Contract Choice

To guarantee worker retention each of these contracts must satisfy the workers' participation constraints in period 2, requiring that wage w during that period is at least as high as the available outside option. When aggregate productivity is high the constraint is

$$a(P_H)m \leq w(m). \tag{5}$$

Similarly, the constraint for low productivity periods is

$$a(P_L)m \leq w(m). \tag{6}$$

Both the period-by-period and the fixed wage contractual arrangements trivially satisfy these constraints. For performance pay contracts, however, the firm's offered wage schedule must exhibit parameter values $\hat{w}(m)$ and b such that the contract maximizes expected profits when either one (good times) or both (good and bad times) participation constraints bind. As in Oyer (2004), we consider these cases separately.

Case 1: A single binding constraint. If the retention constraint is only binding in good times

(SPC, 'single participation constraint') we have,

$$E[\pi^{SPC}] = \max_b (1+q)(P_H m - \hat{w}(m) - bP_H m) + (1-q)(P_L m - \hat{w}(m) - bP_L m) - K$$
$$\text{s.t.:} \quad a(P_H)m = \hat{w}(m) + bP_H m \tag{7}$$

After rearranging the constraint, substituting $\hat{w}(m)$ in the objective and deriving the first order condition with respect to b, one obtains

$$\frac{\partial E[\pi^{SPC}]}{\partial b} = (1-q)(P_H - P_L)m > 0 \tag{8}$$

Assuming that match quality is never negative, the optimal contract is a corner solution,[6]

$$\begin{aligned} b &= 1 \\ \hat{w}(m) &= (a(P_H) - P_H)m. \end{aligned} \tag{9}$$

Given the maintained assumption that $a(P_H) < P_H$, it follows that $\hat{w}(m) < 0$. Therefore, in the case of a single binding constraint, one can interpret the pay contract as an arrangement in which the worker effectively pays upfront to "buy" the job from the firm. The wage is:

$$w(m) = (a(P_H) - P_H)m + Pm. \tag{10}$$

Under the SPC contract participation is guaranteed in the bad state if $P_H - P_L \leq a(P_H) - a(P_L)$. One can show that, in this case, the "L" constraint holds (even though it does not bind), implying that firms are able to retain workers in both high and low productivity periods.[7]

Case 2: Two binding constraints. If the participation constraint is binding in both good and bad times (DPC, 'double participation constraint'), it must be the case that

$$\begin{aligned} a(P_H)m &= \hat{w}(m) + bP_H m \\ a(P_L)m &= \hat{w}(m) + bP_L m. \end{aligned}$$

The solution for b is derived by subtracting the "L" constraint from the "H" constraint and

[6] We assume that the worker cannot leverage production risk (b is bounded from above at 1).

[7] To see this, substitute the optimal contract into the "L" constraint to obtain:

$$a(P_L)m < (a(P_H) - P_H)m + P_L m.$$

rearranging, which results in

$$b = \frac{a(P_H) - a(P_L)}{P_H - P_L} \tag{11}$$

and

$$\hat{w}(m) = \left[a(P_H) - P_H \frac{a(P_H) - a(P_L)}{P_H - P_L}\right] m. \tag{12}$$

To guarantee that $b < 1$ and the worker does not carry all production risk like in the SPC contract (single participation constraint), it must be the case that $P_H - P_L > a(P_H) - a(P_L)$. That is, the variation in output over time must exceed the variation in workers' outside options.

Performance Pay Contract Specification: DPC or SPC? The discussion above suggests that the set of feasible performance pay contracts depends on the ratio of changes in outside offers to changes in cyclical productivity $\left(\frac{\Delta a(P)}{\Delta P}\right)$.

Specifically, if $[a(P_H) - (a(P_L))] \geq [P_H - P_L]$, it is feasible to have a performance pay contract entailing only one binding participation constraint (SPC). This corresponds to an arrangement in which the worker carries all production risk. Viceversa, if $[a(P_H) - a(P_L)] < [P_H - P_L]$, the performance pay contract must feature two binding participation constraints (DPC) and cyclical production risk is carried by both worker and firm. Hence the value of the ratio $\frac{\Delta a(P)}{\Delta P}$ determines how much of the cyclical production risk is carried by workers in performance pay contracts.

Finally it is useful to note that the DPC performance pay contract results in a wage process identical to the one implied by the rolling period-by-period (spot) arrangement. This is because in both cases we have $w = a(P)m$, with m equal to match quality with the current employer. Hence, one cannot meaningfully distinguish between these two pay mechanisms.[8]

Below we focus on the case in which $\frac{\Delta a(P)}{\Delta P} \geq 1$, so that SPC is the only performance-pay contract offered to workers. This simplifies the analysis by restricting the menu of contracts available to the firm to three: SPC, spot and fixed wage contracts.

2.2 Implications for Wage Cyclicality

The behavior of wages, cross-sectionally and over time, is intimately related to the type of contractual arrangement offered by the firm. Moreover, as we make clear in the following section, match quality plays a key role in determining which contract is offered to workers. This 'contractual sorting' based on match quality has important consequences for the behavior of wages over time, as different contractual arrangements exhibit different cyclical properties.

[8] Of course, if one had a priori information about the relative cost of implementing DPC vs spot contracts, one could argue that the lowest cost option would be the one offered in equilibrium even if they were both feasible.

2.2.1 Which Contract is Offered by the Firm?

Given high aggregate productivity in period 1, we compare the expected profits that firms achieve (over period 1 and 2) by offering each of the three contractual arrangements: fixed wage, spot, or performance pay contract with single participation constraint. First, we conduct a pairwise comparison between any two contracts and show that a simple threshold rule, based on match quality m, can identify the contract preferred by the firm. Then, we rank these thresholds and show that performance pay contracts are consistently preferred for sufficiently high levels of match quality m.

Match-quality thresholds. In what follows we derive the match-quality thresholds that identify which contract is preferred in pairwise comparisons. Substituting the wage functions for the three possible contracts (SPC performance pay, spot, fixed wage) we can write firms' expected profits as,

$$\text{SPC:} \quad E\left[\pi^{SPC}\right] = 2\left(P_H - a(P_H)\right) m - K.$$

$$\text{SPOT:} \quad E\left[\pi^{SPOT}\right] = (1+q)\left(P_H - a(P_H)\right) m + (1-q)\left(P_L - a(P_L)\right) m - (1-q)T$$

$$\text{FW:} \quad E\left[\pi^{FW}\right] = (1+q)P_H m + (1-q)P_L m - 2a(P_H)m.$$

After comparing expected profits, one can characterize the threshold conditions. We do this in Proposition (1).

Proposition 1 *The firm decides which contract to offer depending on observed match-quality.*

1. *The firm prefers a performance pay contract over a spot market contract if*

$$m \geq \frac{K - (1-q)T}{(1-q)\left[(P_H - P_L) - (a(P_H) - a(P_L))\right]} \equiv \underline{m}_1 \tag{13}$$

2. *The firm prefers a performance pay contract over a fixed wage contract if*

$$m \geq \frac{K}{(1-q)(P_H - P_L)} \equiv \underline{m}_2 \tag{14}$$

3. *The firm prefers a spot contract over a fixed wage contract if*

$$m \geq \frac{T}{a(P_H) - a(P_L)} \equiv \underline{m}_3 \tag{15}$$

Proof in Section B.1 of the Appendix.

The numerators in equations (13) to (15) are the expected costs, or cost differentials, between any two contracts. These costs are independent of match quality m. The denominators are, instead, the pairwise differentials in all other profit components, and are monotonic in m. This monotonicity implies the simple threshold rules above.

Ranking the thresholds. The parameters of the problem also determine the ranking of the three thresholds described above. Specifically, as spelled out in Proposition (2), the relative size of contracting costs plays a crucial role in determining the ranking of thresholds.

Proposition 2 *The relative size of the costs of different contracts determines the ranking of the match-quality thresholds and the assignment of workers to different contractual arrangements.*

1. *If* $\frac{K}{T} > \frac{(1-q)(P_H-P_L)}{a(P_H)-a(P_L))}$ *then* $\underline{m}_1 > \underline{m}_2 > \underline{m}_3$.
2. *If* $\frac{K}{T} \leq \frac{(1-q)(P_H-P_L)}{a(P_H)-a(P_L))}$ *then* $\underline{m}_3 \geq \underline{m}_2 \geq \underline{m}_1$.
   Proof in Section B.1 of the Appendix.

To sum up, given Proposition (1) and Proposition (2), the contractual arrangement offered by the firm to the worker can be described as follows.

Corollary 1 ***(a) Sufficiently low K/T.*** *If* $\frac{K}{T} \leq \frac{(1-q)(P_H-P_L)}{a(P_H)-a(P_L))}$ *it must be the case that:*

1. *If* $m \geq \underline{m}_2$*, the firm offers a performance pay contract because in this range* $m > \underline{m}_1$ *and so performance pay is preferable to both fixed wage and spot contracts.*

2. *If* $m < \underline{m}_2$*, the firm offers a fixed wage contract. In this case* $m < \underline{m}_3$ *and therefore fixed wage is preferable to both performance pay and spot contracts.*

(b) Sufficiently high K/T. *If* $\frac{(1-q)(P_H-P_L)}{a(P_H)-a(P_L))} < \frac{K}{T}$ *we have that:*

1. *If* $m \geq \underline{m}_1$*, the firm offers a performance pay contract. In this range* $m > \underline{m}_2$ *and the performance pay contract is preferable to both alternatives.*

2. *If* $\underline{m}_3 \leq m < \underline{m}_1$*, the firm offers a spot contract. In this range spot contracts are preferable to performance pay because* $m < \underline{m}_1$ *and to fixed wage because* $m \geq \underline{m}_3$.

3. *if* $m < \underline{m}_3$*, the firm offers a fixed wage contract.*

One clear implication of these findings is that high productivity matches should more frequently adopt performance pay contracts, while fixed wage arrangements should occur more frequently in jobs where match quality is lower. A second important implication is that match quality should have a direct and positive impact on pay. This positive effect of match quality on wages does not depend on the type of contractual arrangement because all wage mechanisms reflect, in some way, the match specific productivity. A third implication is that the cyclicality of wages depends on the contractual arrangements offered by the firm, and therefore on match quality because of contractual sorting. Our stylized model describes the firm's retention problem over a fictitious three-periods interval, while real work relationships often extend over long horizons. Given enough time, new information may accrue and perturb the original arrangements, possibly leading to renegotiations and separations, about which our model is silent. However, if the the contractual sorting implied by heterogeneous match quality is in fact due to retention motives, one might expect that different contracts have different implications for job durations. For this reason we also consider this possibility in the empirical analysis.

3 Data and Measurement

Our model of pay highlights the relationship between match quality and contract choice. Empirically linking contractual sorting, wage cyclicality and match quality poses several measurement issues. To identify the effects of match-specific heterogeneity on contractual arrangements and wage dynamics one needs to: (i) establish an empirical counterpart of the wage process and control for possible confounding effects; (ii) outline a procedure to approximate match quality using data; (iii) identify jobs in which pay is linked to output through some form of performance-related arrangement.

In this section we describe the key features of our empirical approach. We proceed sequentially. First, we outline the empirical counterpart of the theoretical wage processes. Second, we show how match quality proxies can be constructed using information about labor market tightness. Third, we describe data sources and highlight how theory guides the data organization. Finally, we discuss how we can identify jobs featuring performance-related pay.

3.1 Empirical Wage Processes

One can show that the empirical counterparts of the different pay arrangements examined above can all be nested within one general wage representation. This wage representation is obtained through simple log-linear approximations. We begin by noting that, in addition to the specific mechanism outlined in the theoretical section, wages obviously are affected by other individual and job characteristics. Hence, allowing for an additively separable vector of characteristics X, the following proposition holds.

Proposition 3 *Let workers be paid according to one of the three possible contractual arrangements (SPC, FW, or Spot). Assume that: (a) X_t is a log additive component to the wage that captures observable worker characteristics; (b) z_{ijt} is an approximation error. Then the conditional expectation of the wage, under any of the contracts, can be generally represented as*

$$E[\log(w_{ijt})|P_t, m_ij, X_t] = \beta_0 + \beta_1 \log(m_{ij}) + \beta_2 \log(P_t) + \beta_3 \log(X_t) + E[z_{ijt}] \quad (16)$$

where i identifies a worker, j identifies a job, t denotes the time period and $E[z_{ijt}]$ is the expectation of the unobserved residual implied by the approximation error. In the case of a fixed wage contract $\beta_2 = 0$, while $\beta_2 > 0$ for other contracts. Under all contracts $\beta_1 > 0$.

The proof is obtained by log-linearization of the various wage functions. Details are in Appendix B.

We consider a simple representation of the unobserved residual productivity z_{ijt}. Specifically, we assume that z_{ijt} consists of an individual fixed effect a_i and an i.i.d. shock η_{ijt}. In our empirical specification we explicitly account for observable heterogeneity, for time effects and for worker fixed effects. As a result, the empirical specification for the wage processes is

$$log(w_{ijt}) = \beta_0 + \beta_1 log(m_{ij}) + \beta_2 log(P_t) + \beta_3 log(V_{ijt}) + z_{ijt}, \quad (17)$$

with $\beta_2 = 0$ in the case of a fixed wage contract.

Following Bils (1985), and a large subsequent literature, we focus on the sensitivity of wages to fluctuations in aggregate unemployment to capture wage cyclicality.

The theoretical analysis suggests that match quality plays a key role for the cross-sectional distribution of wages and their cyclicality. Match quality influences wages directly and through contractual sorting effects. In particular, wage sensitivity to contemporaneous aggregate conditions depends on the type of pay arrangement in place and, therefore, on match quality. In the next section we describe how we approximate match-specific quality.

3.2 Measuring Match Quality

The match quality proxies are constructed following the approach of Hagedorn and Manovskii (2013) and build on the idea that changes in labor market tightness have a direct bearing on the match quality distribution. The two proxies (respectively denoted as q^{eh} and q^{hm}) rely on the assumption that the number of offers a worker receives is positively correlated with match quality. If an employed worker receives a job offer and accepts it, then it must be the case that match quality has a good chance of being weakly improved. Similarly, if a worker receives a job offer and rejects it, then current match quality is more likely to be preferable to the alternative. Hence a worker who receives many offers has, on average, better match quality, whether these offers were accepted or rejected. The basic empirical challenge is how to measure the number of offers a worker receives. The reasoning above suggests that labor market tightness, measured before and during a particular job, conveys information about the number of offers. As an example consider a worker i employed in the same job between periods T_{begin} and T_{end}, with $T_{end} > T_{begin}$. If the sum of labor market tightness between T_{begin} and T_{end} is high, and we observe i staying at her job, then i received and rejected relatively many job offers. Therefore i's job must have high match quality. Following this logic, the variable $q^{hm}_{i,j}$ is defined as

$$q^{hm} = \sum_{t=T_{begin}}^{T_{end}} \left(\frac{V_t}{U_t} \right), \tag{18}$$

where V_t is an index of vacancies and U_t is the unemployment rate in period t.

The same line of reasoning implies that match quality in the current job is also sensitive to market tightness during employment periods preceding the current job. In the example above suppose that worker i had a different job prior to the current one. Moreover, while working on the previous job the labor market was tight and she received many offers. The fact that she received many offers before accepting the current job suggests that the quality of the current match is likely to be relatively high. Hence past labor market tightness conveys information about current match quality. The variable $q^{eh}_{i,j}$ is meant to capture past labor market conditions and is defined as,

$$q^{eh} = \sum_{t=T_1}^{T_{begin}} \left(\frac{V_t}{U_t} \right), \tag{19}$$

where $T_1 < T_{begin}$ denotes the first period of the employment cycle, that is, the first period of work after involuntary unemployment.[9]

[9] The interval between T_1 and T_{end} must not be interrupted by involuntary unemployment spells, as this would make it hard to argue for sequential on-the-job renegotiations.

3.3 Data on Work Histories

The data source for wages is the National Longitudinal Survey of Youth (NLSY79). We construct the (weekly) job history for each worker and identify an observation as the wage of a worker at the current job.[10] We construct the current unemployment rate using the seasonally adjusted unemployment series from the Current Population Survey (CPS). We use the Composite Help Wanted Index constructed by Barnichon (2010) as a measure of vacancies. Details about data are in Appendix A. All of the analysis focuses on men between 25 to 55 years old.

Key to the analysis is the concept of employment cycles. An employment cycle is defined as a continuous spell of employment, possibly entailing a sequence of jobs and employers. The cycle begins in the period when the worker transitions from non-employment to employment, and ends when the worker transitions back to involuntary non-employment.[11]

To measure individual employment cycles, and job spells within each cycle, we follow Wolpin (1992), Barlevy (2008), and Hagedorn and Manovskii (2013). At each interview date the NLSY provides a complete description of jobs held since the last interview, including start and stop dates (week), wage, hours worked, and occupation. In addition one can link employers across interviews and identify a job as a worker's spell with a given employer.

In the NLSY79 the information related to a specific job is only recorded once per interview. Therefore wage changes within a job are recorded only if an individual works at the same job for a period covered by two or more interviews, implying that within-job wage variation is identified using jobs that extend over at least two NLSY interview dates. If a job appeared for the first time in the year T interview, and again in the year $T+1$ interview, then this job counts as two observations within the same employment cycle. Each observation is a wage-job pair. The wage refers to a job that was active at any time between the current and the previous interview date. Thus we view an observation (a wage-job pair) as the wage prevailing over the period between two successive interviews while employed at a particular job, or in any subset of that period during which the job was active.

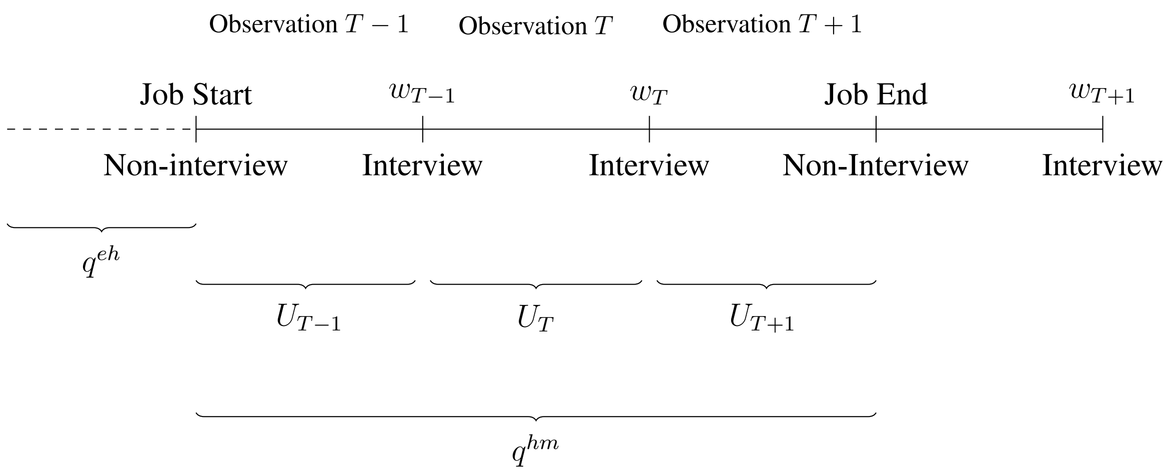
For illustration consider the example in Figure 1. A worker is interviewed at date $T-2$, begins to work for a specific employer between $T-2$ and $T-1$, is interviewed again at $T-1$, T, and $T+1$, but eventually stops working for this employer at some point between T and $T+1$. Given this sequence of events, we use the wage w_{T-1}, recorded during the first interview, as the wage applying to the period between the start of the job and $T-1$. Similarly,

[10] For each week we define the 'main job' as the one with the highest mode of reported hours worked. Past research focuses on male workers. For comparability we follow this convention.

[11] As in Barlevy (2008) and Hagedorn and Manovskii (2013) a separation is considered voluntary if (i) the worker reports a quit, rather than a layoff; and (ii) the interval between the end of the previous job and the beginning of the next is shorter than 8 weeks. Employment cycles may include short periods of non-employment.

we use the wage w_T for the period between $T-1$ and T, and the wage w_{T+1} for the period between T and the end of the job.

Figure 1: Employment Cycles: an Example.



Partitioning the data into employment cycles and job spells allows us to construct the match quality proxies described in Section 3.2. We use data on aggregate vacancies and unemployment to calculate tightness ratios $\frac{V_t}{U_t}$ and define: (i) q^{eh} as the sum of tightness ratios from the beginning of the employment cycle to the period preceding the start of the current job; (ii) q^{hm} as the sum of market tightness ratios during a job spell. The latter captures past, current and future tightness over the current job spell and reflects the expected match quality of that particular job.

Next, we assign to each observation a contemporaneous unemployment rate, measured as the average unemployment recorded over the period in which a job is active between consecutive interview dates. Figure 1 illustrates how match quality proxies and unemployment rates are assigned to different observations w_{T-1}, w_T and w_{T+1}: q^{eh} is the sum of labor market tightness from the start of the employment cycle until the start of the current job; q^{hm} is the sum of labor market tightness from the start to the end of the current job. A different contemporaneous unemployment rate applies to each relevant time interval.

3.4 Performance Pay in the NLSY79

The NLSY79 reports partial information about performance pay for the years 1988 to 1990, 1996, 1998 and 2000. For years $1988-1990$ individuals were asked whether, in their most current job, earnings were partly based on performance. For years $1996, 1998, 2000$, individuals were asked for each of their jobs if earnings featured any of the following types of compensation: piece rate, commission, bonuses, stock options and/or tips. Therefore in $1996, 1998, 2000$, for each job-individual pair we generate a binary variable indicating if that particular type of compensation was used in determining the pay received for that job. A performance pay observation is then a job-year-individual triplet for which one of following conditions is satisfied:

- The year is $1988, 1989$ or 1990, and the individual reports being paid based on performance;
- The year is $1996, 1998$ or 2000 and the individual reports having earnings based on at least one among tips, commission, bonuses or piece rate.
- It is a job-year-individual triplet pertaining to a job/individual pair that satisfies one of the above two conditions for at least one of the interviews. This imposes the restriction that the performance pay status is constant within a job, adding observations for the years in which the performance pay variables are not available.

4 Empirical Results

In this section we report our main empirical findings. Specifically, we present results documenting that (i) a significant relationship exists between match quality and contractual arrangements; (ii) contractual arrangements play a key role in determining wage cyclicality; (iii) employment durations vary with contractual arrangements (and match quality) as predicted by theory; (iv) occupations that exhibit higher average match quality tend to adopt performance-pay more frequently; wages in such occupations appear to be more cyclical, as predicted by our model. Finally, we discuss some extensions and robustness checks.

4.1 Match Quality and Performance Pay Adoption

An immediate implication of our theoretical analysis is that firms offer different pay arrangements depending on match quality. Propositions (1) and (2) imply that high quality matches should exhibit a higher adoption of performance-related pay schemes.

Given the information available in our sample, we can directly estimate the empirical relationship linking each job's PPJ status to its match quality proxies. We do this by using a set of Logit models. The unit of observation for this analysis is the job-worker pair, with the dependent variable being a binary indicator for whether the job uses any performance related compensation and the key right-hand side variables being measures of match quality. We estimate a fixed effect specification to control for worker unobserved heterogeneity and restrict the sample to men between ages 25 and 55.[12] We also control for a variety of observable job-worker characteristics.[13]

In Table 1 we report the results of this analysis for three alternative specifications in which we control for each measure of match quality, both separately and together.

Table 1: Performance Pay and Match Quality: Fixed Effects Logits

	Specification		
Variables	(1)	(2)	(3)
$log(q^{eh})$	18.4***	-	19.9***
	[7.68]	-	[7.73]
$log(q^{hm})$	-	52.9***	54.6***
	-	[1.84]	[1.85]
Observations	2,028	2,058	2,028

Note a. The notation $\ln q^x$, with $x = \{hm, eh\}$, denotes the natural logarithm of the sum of market tightness
Note b. Estimated coefficients and associated standard errors are multiplied by 100. All standard errors are clustered by observation start-date and end-date. Results are robust to clustering by individual. Significance: *** 1%, ** 5%, * 10%.
Note c. The sample includes male workers between age 25 and 55. We include controls for year, job tenure with current employer, work experience, geographic and SMSA region, industry, marital status, education, age (maximum in the employment spell), union status.

The results clearly indicate the presence of a significant, and sizeable, relationship between match quality and performance pay adoption. Both proxies of match quality are highly significant, and the magnitudes of their effects remain unchanged when they are both included.

To gauge the magnitude of the match quality effects we compute the change in the probability of being PPJ implied by a one standard deviation increase in match quality. To this purpose, we generate a random subsample of worker-job pairs such that each worker is sampled only once, and use it to measure the baseline probability that an individual-job pair exhibits performance pay. This exercise returns an average probability of 38.7%. Then, we perturb each individual match quality and make it larger by one standard deviation. This results in an average likelihood of PPJ equal to 54.6%. Hence, our results suggest that a one-standard-deviation change in match quality is associated to an increase of over 40% in the probability

[12]The sampling restrictions implicit in the fixed-effect Logit estimator imply that our sample only includes workers who are observed at least once in both PPJ and non-PPJ, at different points in time.

[13]We include controls for year, geographic and SMSA region, job tenure with current employer, work experience, industry, marital status, education, age (maximum in the employment spell), union status.

of being in a performance pay job. Replicating this analysis for the median probability of PPJ suggests an increase from a baseline value of 26.4% to 44.5%. These are large effects, and clearly indicate that match quality and performance pay are strongly associated. We confirm the robustness of this association in Section 4.5.

As we discuss below, this strong association between match quality and contractual choice has important implications for wage cyclicality and job durations.

4.2 Match Quality and Wage Cyclicality

A second, crucial implication of our theoretical analysis is that selection into different contractual arrangements has an indirect effect on the cyclicality of wages. As mentioned above, we follow an extensive literature and measure the cyclicality of wages with respect to labor market conditions by gauging wage responses to aggregate unemployment.

We use the baseline (log-linearized) approximation derived in Section 3.1 to estimate how the sensitivity of log wages depends on the current unemployment rate, and on both match quality proxies. The unit of observation for this analysis is the wage observed for a job-worker pair at a point in time. We use a fixed effect specification and, as before, also control for a full set of observable job and worker characteristics.[14] The model suggests that there should be a direct effect of match quality proxies on wages. Moreover, as shown above, match quality also has a strong, indirect effect on wages by determining the contractual arrangement in the job-worker relationship. This contractual selection effect has a variety of testable implications. Namely, we use our general empirical specification (equation 17, derived in Section 3.1) to test the following theoretical predictions:

(i) Do performance pay jobs (PPJ) exhibit positive cyclicality?
(ii) Is any cyclicality detected among non-PPJ?[15]
(iii) Does match-quality have a direct effect on wages after controlling for PPJ status?

We begin by documenting the properties of the pooled sample of jobs (both PPJ and non-PPJ). Table (2) reports results from the analysis of such pooled data. The first column reports results for a specification in which wages depend on unemployment, without controlling for match quality (this is the kind of regression originally suggested by Bils, 1985). In the second column we add controls for match quality as well as cyclical responses to the unemployment

[14]We control for all variables used in the linear probability model. For workers we use current age, rather than maximum age, to allow for within job age profiles.

[15]Such cyclicality could occur if the cost T of implementing spot contracts is sufficiently small that firms offer them to a large enough share of workers.

rate. In the third column we extend the model by allowing for different cyclical responses depending on PPJ status.

Table 2: Pooled wage regression

Dependent Variable: Log Wage			
Variables	(1) (Bils specification)	(2) (add match quality)	(3) (add match quality)
U	-0.0164***	-0.0167***	-0.004
	[0.0043]	[0.0042]	[0.005]
$log(q^{eh})$	-	7.59***	7.47***
	-	[0.66]	[0.66]
$log(q^{hm})$	-	6.81***	6.70***
	-	[0.66]	[0.68]
$U \cdot PPJ$	-	-	-0.0298***
	-	-	[0.0064]
Observations	17.995	17,434	17,434
R-squared	0.642	0.646	0.646

Note a. The notation $\ln q^x$, with $x = \{hm, eh\}$, denotes the natural logarithm of the sum of market tightness. The explanatory variable $U \cdot PPJ$ is the interaction between current unemployment rate and an indicator function taking value equal to one if the job includes performance-related compensation.

Note b. Estimated coefficients for $\ln q^{eh}$ and $\ln q^{hm}$, and associated standard errors, are multiplied by 100. All standard errors are clustered by observation start-date and end-date. Results are robust to clustering by individual. Significance: *** 1%, ** 5%, * 10%.

Note c. The sample includes male workers between age 25 and 55. We include controls for year, job tenure with current employer, work experience, geographic and SMSA region, industry, marital status, education, age and union status.

Results suggest that match quality has a direct effect (level shift) on wages, as predicted by the model and illustrated in Section 3.1. The sensitivity of wages to cyclical unemployment is however similar with or without quality controls, with a gradient of roughly 1.6%. Yet, our results also indicate that all the cyclical sensitivity of wages is due to PPJ status: column 3 shows that only wages in performance-pay jobs exhibit cyclical responses to the unemployment rate. Moreover, these responses are much stronger than in the pooled sample. A 1% increase in the unemployment rate is associated to a 3% increase in average wages for PPJ, and to no significant wage change in non-PPJ.

Taken together, these results are consistent with the view that match quality has a strong indirect effect on pay by selecting workers into different contractual arrangements, indirectly affecting wage cyclicality. To explicitly test this hypothesis, we perform the same analysis separately on PPJ and non-PPJ jobs. This allows to flexibly control for observables in the two groups. Table (3) reports estimation results for different PPJ status.

Table 3: Wage regressions: PPJ vs non-PPJ.

Variables	(1) $PPJ = 1$ (Bils specification)	(2) $PPJ = 0$ (Bils specification)	(3) $PPJ = 1$ (add match quality)	(4) $PPJ = 0$ (add match quality)
U	-0.0283***	-0.0089	-0.0282***	-0.0096
	[0.0056]	[0.0063]	[0.0056]	[0.0064]
$\ln q^{eh}$	-	-	9.88***	6.12***
			[1.43]	[0.974]
$\ln q^{hm}$	-	-	8.79***	5.94***
			[1.50]	[0.892]
Observations	7,280	10,715	7,065	10,369
R-squared	0.719	0.613	0.723	0.614

Note a. The notation $\ln q^x$, with $x = \{hm, eh\}$, denotes the natural logarithm of the sum of labour market tightness

Note b. Estimated coefficients for $\ln q^{eh}$ and $\ln q^{hm}$, and associated standard errors, are multiplied by 100 for $\ln q^x$. All standard errors are clustered by observation start-date and end-date. Results are robust to clustering by individual. Significance: *** 1%, ** 5%, * 10%.

Note c. The sample includes male workers between age 25 and 55. We include controls for year, geographic and SMSA region, industry, marital status, education, age and union status.

The findings confirm that strong and significant wage cyclicality is present in jobs where performance-related pay is used. In fact, the magnitudes of the cyclical response of PPJ wages is almost identical to the one estimated from the pooled sample (-.0282 vs -0.0298 in column 3 of Table 2). As before, wages seem not to respond to cyclical unemployment in jobs with no performance related pay. When we test for the significance of the difference between the cyclical gradient of PPJ and non-PPJ we reject the null hypothesis of equal coefficients at the 5% confidence level.

These results document that match quality has a direct effect on wages even after we control for contractual arrangements (PPJ status). The match quality effect is positive as expected in all cases. Hence, higher match quality is associated to higher wages and, on average, to stronger cyclical sensitivity.

4.3 Evidence from Occupation Groups

As highlighted in our discussion of match quality, we expect tighter labour markets to be associated to a higher frequency of job offers to workers, which in turn translates into higher average match quality.

This line of reasoning has an interesting implication: the adoption of performance pay should be more widespread in occupations which are in high demand. The reason for this is that retention considerations (participation constraints) induce firms to use variable compensation as a way to keep workers when they are most in demand. This argument suggests that employee profit-sharing or other forms of performance-related pay should be relatively more attractive in occupations which are in strong demand. This is clearly the case of cognitive and non-routine jobs over the past few decades, as documented for example by Autor and Dorn (2013) and Cortes, Jaimovich, Nekarda, and Siu (2015).

In this section we document that occupations that are in higher demand exhibit larger frequency of performance pay jobs and better match quality.

Table 4: Occupation heterogeneity: share of jobs with (i) above median match quality and (ii) performance pay, by occupation group.

	Occupation Groups			
	COG	MAN	NR	R
Share PPJ	40.7%	23.91%	33.15%	29.21%
	(49.13%)	(42.66%)	(47.09%)	(45.48%)
q^{eh} above median	54.54%	46.82%	51.93%	48.67%
	(49.8%)	(49.9%)	(50%)	(50%)
q^{hm} above median	57.67%	43.57%	55.41%	45.21%
	(49.42%)	(49.59%)	(49.72%)	(49.78%)
Observations	2,433	3,475	2,413	3,495

Note a. Top panel: share of jobs with performance pay arrangements (Share PPJ) for coarse occupation groups: cognitive vs manual jobs (COG vs MAN); routine vs non-routine jobs (R vs NR). Standard deviations in parentheses (also as shares).

Note b. Bottom panel: share of jobs with match quality above the unconditional median for coarse occupation groups: cognitive vs manual jobs (COG vs MAN); routine vs non-routine jobs (R vs NR). First line based on q^{eh} match quality proxy; second line based on q^{hm} match quality proxy.

Table 4 reports two important dimensions of heterogeneity across occupation groups: (i) the relative frequency of PPJ; (ii) the relative share of above-median match qualities. Cognitive occupations have a considerably higher occurrence of both PPJ and of above-median match quality, when compared to manual occupations. A similar, but less marked difference, is present when comparing non-routine and routine occupations.

These differences are highly significant and lend direct support to the view that, especially in cognitive occupations, stronger demand is associated to relatively higher match qualities and more frequent recourse to performance pay. Of course, contractual sorting across occupation might have direct effects on the cyclicality of wages in different occupations, an implication that we investigate in the next section.

4.3.1 Wage Cyclicality across Occupations

Our theory suggests that compensation arrangements are key for the sensitivity of wages to current unemployment. For this reason we re-estimate the general wage specification (equation 17) for different occupation groups. To retain reasonably large, and comparable, sample sizes we focus on broad occupation categories (cognitive vs manual jobs; non-routine vs routine jobs).

Table 5: Wage Regressions: Cyclicality by Occupation Group.

	Dependent Variable: Log Wage			
	(1)	(2)	(3)	(4)
Variables	COG	MAN	NR	R
U	-0.0245**	-0.0041	-0.0204*	-0.0098
	[0.0110]	[0.0059]	[0.0118]	[0.0066]
$\ln q^{eh}$	5.43***	6.51***	4.49***	5.57***
	[1.34]	[1.0]	[1.50]	[0.943]
$\ln q^{hm}$	6.68***	8.16***	7.44***	6.60***
	[1.23]	[0.842]	[1.34]	[0.860]
Observations	7,495	6,123	6,978	6,640
R-squared	0.611	0.705	0.650	0.709

Note a. The notation $\ln q^x$, with $x = \{hm, eh\}$, denotes the natural logarithm of the sum of labour market tightness

Note b. Estimated coefficients and associated standard errors are multiplied by 100 for $\ln q^x$. All standard errors are clustered by observation start-date and end-date. Results are robust to clustering by individual. Significance: *** 1%, ** 5%, * 10%.

Note c. The sample includes male workers between age 25 and 55. We include controls for year, geographic and SMSA region, industry, marital status, education, age and union status.

Columns (1) and (2) in Table 5 report results obtained for, respectively, the samples of cognitive (Cog) and manual (Man) occupations. While we detect positive, strong and significant responses of wages to current unemployment in cognitive occupations, no significant effect can be detected for manual jobs. Columns (3) and (4) in Table 5 report results of the same regressions for an alternative occupation grouping in which jobs are split between non-routine (NR) and routine occupations (R). For non-routine jobs we find weaker evidence (at the 10% confidence level) of wage cyclicality. Results for routine jobs indicate that current labor market conditions have no detectable effect on wages.

Taking stock of all these results, we conclude that there are visible discrepancies in the wage-unemployment relationship across occupation groups. In manual and routine jobs the current labor market conditions (as captured by the current unemployment rate) have no gradient on wages. However we find evidence that wages in cognitive occupations are strongly cyclical, while non-routine jobs exhibit a somewhat weaker and less significant cyclicality. To the extent that match quality is higher, and performance pay more widespread, among cognitive and non-routine occupations, these results offer further evidence that contractual sorting may have an important role in determining the cyclical behavior of wages.

4.4 Performance Pay and Job Durations

Our model highlights the role of worker retention for the adoption of performance pay. However, given its stylized nature, it has no direct implications for the duration of jobs, as all pay arrangements satisfy the participation constraints when a contract is offered. Nonetheless, if the retention motive is, in fact, one of the main reasons for introducing performance-related pay, one might suppose that a relationship exists between PPJ and job durations. We examine this possibility by checking whether: (i) job durations are higher in PPJ than in non-PPJ; (ii) job durations are higher in occupations in higher demand.

These relationships are fairly easy to test using job histories from the NLSY79, as we can construct the duration of each worker's tenure with a given employer. In Table (6) we report the mean and standard deviation of job durations for different groups in our NLSY79 sample. We find that all duration differences are well above one year (five quarters or more).[16] All differences (PPJ vs. non PPJ, cognitive vs. manual, routine vs. non-routine) are extremely significant at levels well below 1%.

These findings confirm that PPJ jobs, or occupations in higher demand (in which PPJ is more prevalent), exhibit higher job durations. Hence they provide direct evidence that the adoption of alternative contractual arrangements is closely linked to retention outcomes.

[16]Durations in Table (6) refer to a sample of workers with relatively strong labor market attachment and are higher than durations for the overall population.

Table 6: Summary statistics of job durations in different occupation groups.

	Mean	S.D.	Observations
PPJ=1	26.4	27.7	2,738
PPJ=0	18.4	23.3	5,823
COG	22.8	24.3	2,492
MAN	17.4	21.8	3,570
NR	22.3	24.3	2,460
R	17.8	21.9	3,602

Job durations are measured in quarters. Cog = cognitive, MAN = manual, NR = non-routine, R = routine. Unit of observation is a job/year pair.

4.5 Extensions and Robustness

In what follows we replicate the analysis for some alternative specifications to gauge the robustness of our findings. First, we verify that the key predictions of the model, and baseline empirical results, are robust to the inclusion of working women in our samples. Second, we estimate a simple linear probability model linking PPJ status to match quality proxies, and show that a positive relationship continues to hold. Third, we document that the main result about wage cyclicality remains intact even when we use GDP variation, rather than unemployment, to proxy for cyclical conditions. Finally, we split workers into different education groups to assess whether the cyclicality of wages across education groups lines up with the relative frequency of PPJ across these groups.

Extending the sample to include women. Our baseline results are based on a sample of male workers. This restriction was introduced to facilitate comparisons to previous work on the cyclicality of wages. In what follows we extend the sample by adding women. We maintain all the sampling restrictions described in Section 3.3 and Appendix A, which guarantee a sample with fairly strong labor market attachment.

We begin by replicating the Logit analysis linking PPJ status to match quality proxies. Table (7) shows that also in the expanded sample there exists a strong, positive and significant relationship between probability of being in a performance pay job and match quality. Both men and women exhibit an increased likelihood of performance-related pay when match quality is higher. Magnitudes are broadly comparable to the ones estimated for the sample on male workers and reported in Table (1).

Table 7: Performance Pay and Match Quality: Fixed Effects Logits (men and women)

	Specification		
Variables	(1)	(2)	(3)
$log(q^{eh})$	14.6***	-	15.7***
	[5.55]	-	[5.59]
$log(q^{hm})$	-	67.3***	66.0***
	-	[1.36]	[1.37]
Observations	3,635	3,691	3,635

Note a. The notation $\ln q^x$, with $x = \{hm, eh\}$, denotes the natural logarithm of the sum of market tightness
Note b. Estimated coefficients and associated standard errors are multiplied by 100. All standard errors are clustered by observation start-date and end-date. Results are robust to clustering by individual. Significance: *** 1%, ** 5%, * 10%.
Note c. The sample includes female and male workers between age 25 and 55. We include controls for year, geographic and SMSA region, industry, marital status, education, age and union status.

Next, having verified the significance of this positive relationship, we move on to replicate the wage cyclicality analysis presented in Tables (2-3) using the extended sample. Table (8) reports the regression results for a fixed effect specification based on the pooled sample of all jobs, whether PPJ or not. Then, Table (9) shows the estimation results when the estimator is run separately in PPJ and non-PPJ jobs.

Table 8: Pooled wage regression (men and women)

Dependent Variable: Log Wage			
Variables	(1)	(2)	(3)
	(Bils specification)	(add match quality)	(add match quality)
U	-0.0120***	-0.0121***	-0.0026
	[0.0045]	[0.0044]	[0.0051]
$log(q^{eh})$	-	6.15***	6.06***
	-	[0.56]	[0.509]
$log(q^{hm})$	-	6.62***	6.44***
	-	[0.47]	[0.483]
$U \cdot PPJ$	-	-	-0.0298***
	-	-	[0.0064]
Observations	34,050	33,043	33,043
R-squared	0.625	0.627	0.627

Note a. The notation $\ln q^x$, with $x = \{hm, eh\}$, denotes the natural logarithm of the sum of market tightness. The explanatory variable $U \cdot PPJ$ is the interaction between current unemployment rate and an indicator function taking value equal to one if the job includes performance-related compensation.

Note b. Estimated coefficients for $\ln q^{eh}$ and $\ln q^{hm}$, and associated standard errors, are multiplied by 100. All standard errors are clustered by observation start-date and end-date. Results are robust to clustering by individual. Significance: *** 1%, ** 5%, * 10%.

Note c. The sample includes female and male workers between age 25 and 55. We include controls for year, job tenure with current employer, work experience, geographic and SMSA region, industry, marital status, education, age and union status.

While cyclicality is slightly less pronounced, all these robustness checks confirm the baseline findings. The cyclical responses of wages in PPJ are highly significant, whether we pool all observations or split them by PPJ status. In contrast, no evidence of cyclicality is detected for non-PPJ. These findings provide further support to the theoretical model's predictions.

Table 9: Wage regressions: PPJ vs non-PPJ (men and women)

Variables	(1) $PPJ = 1$ (Bils specification)	(2) $PPJ = 0$ (Bils specification)	(3) $PPJ = 1$ (add match quality)	(4) $PPJ = 0$ (add match quality)
U	-0.0187***	-0.0093	-0.0201***	-0.0092
	[0.0044]	[0.0065]	[0.0043]	[0.0066]
$\ln q^{eh}$	-	-	8.82***	4.54***
			[1.18]	[0.734]
$\ln q^{hm}$	-	-	9.04***	5.47***
			[1.25]	[0.59]
Observations	12,002	22,048	11,588	21,455
R-squared	0.72	0.593	0.723	0.592

Note a. The notation $\ln q^x$, with $x = \{hm, eh\}$, denotes the natural logarithm of the sum of labour market tightness

Note b. Estimated coefficients for $\ln q^{eh}$ and $\ln q^{hm}$, and associated standard errors, are multiplied by 100 for $\ln q^x$. All standard errors are clustered by observation start-date and end-date. Results are robust to clustering by individual. Significance: *** 1%, ** 5%, * 10%.

Note c. The sample includes female and male workers between age 25 and 55. We include controls for year, geographic and SMSA region, industry, marital status, education, age and union status.

Performance pay and match quality: a linear probability model. The linear probability specification provides a simple and relatively unrestrcited test of the statistical relationship between PPJ and match quality proxies. As for the Logit analysis, we estimate a fixed effect specification to control for additively separable heterogeneity and control for a variety of observable characteristics.

The findings confirm that match quality and PPJ are positively and significantly linked. A ten percent increase in the q^{eh} match quality proxy is associated to an average thirty percent increase in the prevalence of performance-related pay. The effect is even stronger for the q^{hm} measure of match quality: in this case a ten percent increase in match quality is associated to a sixty percent change in the prevalence of performance pay. Interestingly, including both measures of match quality in the right-hand side of the linear probability model does not change their gradient or significance, suggesting that both measures capture relevant and independent aspects of match quality. When both measures are included, a ten percentage points change in match quality is associated to a doubling of the probability that performance pay is adopted.

Table 10: Performance Pay and Match Quality: Linear Probability Regressions

	Dependent Variable: Performance Pay Indicator		
Variables	(1)	(2)	(3)
$log(q^{eh})$	2.89**	-	3.09***
	[1.13]	-	[1.13]
$log(q^{hm})$	-	6.00***	6.33***
	-	[2.04]	[2.03]
Observations	4,704	4,810	4,704
R-squared	0.630	0.632	0.631

Note a. The notation $\ln q^x$, with $x = \{hm, eh\}$, denotes the natural logarithm of the sum of market tightness
Note b. Estimated coefficients and associated standard errors are multiplied by 100. All standard errors are clustered by observation start-date and end-date. Results are robust to clustering by individual. Significance: *** 1%, ** 5%, * 10%.
Note c. The sample includes male workers between age 25 and 55. We include controls for year, job tenure with current employer, work experience, geographic and SMSA region, industry, marital status, education, age (maximum in the employment spell), union status.

Using GDP to gauge cyclicality. In our baseline specification we follow the literature and estimate the cyclical responsiveness of wages to unemployment. Here we verify the robustness of our results to using GDP as an alternative measure of cyclicality. Specifically, we approximate cyclical fluctuations using the log deviations of quarterly GDP from its linear trend.

Our findings suggest that the key results about wage cyclicality and performance-related pay remain intact. Column (1) of Table (11) shows that the GDP gradient is positive and significant only when interacted with the PPJ dummy, indicating that only wages for PPJ=1 exhibit cyclical fluctuations. In columns (2) and (3) we replicate the analysis separately for $PPJ = 1$ and $PPJ = 0$. We find that only performance pay jobs exhibit cyclical responses to GDP fluctuations, just as we did when using unemployment rate to approximate for cyclical labor market conditions. A 1% upward deviation of GDP from trend is associated to a 1.3% increase in wages.[17]

[17]The magnitude of the cyclical wage responses in performance-pay jobs is in fact comparable to the one estimated using the unemployment rate. Assuming that an extra 1% of GDP is associated with a decline in the aggregate unemployment rate of between 0.3% and 0.5%, a back of the envelope calculation (and our estimates in Table 3) suggest that a 1% deviation of GDP from trend should be associated to a wage change between 0.85% and 1.4%.

Table 11: Wage regressions using GDP as a cyclical proxy.

	Dependent Variable: Log Wage		
	(1)	(2)	(3)
Variables	All	$PPJ = 1$	$PPJ = 0$
GDP	0.158	1.33***	-0.00514
	[0.253]	[0.279]	[0.298]
$GDP \cdot PPJ$	0.797**	-	-
	[0.348]	-	-
$log(q^{eh})$	6.61**	8.67***	5.90***
	[0.678]	[1.50]	[0.893]
$log(q^{hm})$	7.53***	9.81***	6.16***
	[0.667]	[1.43]	[0.972]
Observations	17,434	7,065	10,369
R-squared	0.646	0.723	0.614

Note a. The notation $\ln q^x$, with $x = \{hm, eh\}$, denotes the natural logarithm of the sum of market tightness

Note b. Estimated coefficients and associated standard errors are multiplied by 100. All standard errors are clustered by observation start-date and end-date. Results are robust to clustering by individual. Significance: *** 1%, ** 5%, * 10%.

Note c. The sample includes male workers between age 25 and 55. We include controls for year, job tenure with current employer, work experience, geographic and SMSA region, industry, marital status, education, age (maximum in the employment spell), union status.

Evidence from Education Groups. Next, we split workers into three groups (high school dropouts, high school graduates including those with some college, and college graduates) and document significant differences in the prevalence of performance pay across different education groups. As shown in Table (12) the prevalence of performance-related pay is higher among more educated workers.

Table 12: Proportion of performance pay jobs (PPJ) by education group.

	COL	HSG	HSD
Share PPJ	43.56%	30.66%	25.04%
	(49.6%)	(46.11%)	(43.33%)
q^{eh} above median	39.43%	35.46%	31.28%
	(48.88%)	(47.85%)	(46.37%)
q^{hm} above median	41.47%	34.24%	30.07%
	(49.27%)	(47.46%)	(45.86%)
Observations	2,011	3,832	2,564

Note a. Top panel: share of jobs with performance pay arrangements (Share PPJ) for coarse education groups: college versus high school graduates versus high school dropouts (COL vs HSG vs HSD). Standard deviations in parentheses (also as shares).

Note b. Bottom panel: share of jobs with match quality above the unconditional median for coarse education groups: college versus high school graduates versus high school dropouts (COL vs HSG vs HSD). First line based on q^{eh} match quality proxy; second line based on q^{hm} match quality proxy.

Table 13: Wage Regressions: Cyclicality by Education Group.

Dependent Variable: Log Wage			
	(1)	(2)	(3)
Variables	HSD	HSG	CG
U	0.001	-0.0084	-0.0266***
	[0.0125]	[0.0055]	[0.0103]
$\ln q^{eh}$	5.55***	7.01***	6.57***
	[1.74]	[0.792]	[1.34]
$\ln q^{hm}$	8.88***	6.75***	5.84***
	[1.91]	[0.80]	[1.25]
Observations	1,884	9,367	6,183
R-squared	0.666	0.652	0.572

Note a. The notation $\ln q^x$, with $x = \{hm, eh\}$, denotes the natural logarithm of the sum of labour market tightness

Note b. Estimated coefficients and associated standard errors are multiplied by 100 for $\ln q^x$. All standard errors are clustered by observation start-date and end-date. Results are robust to clustering by individual. Significance: *** 1%, ** 5%, * 10%.

Note c. We exclude women and individuals with less than 25 years old.

When we re-estimate our wage specification for different education groups, results (in Table 13) suggest that patterns by education mirror those found for occupations. While wages of workers with no college degrees appear to be insensitive to aggregate labor market fluctuations, those for college grads respond strongly and significantly. In fact, both the sign and magnitude of the responses for college-graduates are similar to those estimated for workers in cognitive occupations or in performance pay jobs.

5 Conclusions

Heterogeneity in match-specific productivity has been the object of much attention in recent theoretical and applied studies of labor markets. This paper investigates the implications of match quality heterogeneity for the choice of pay arrangements, and examines how differences in these arrangements influence wage dynamics and workers' retention.

Several interesting and empirically relevant implications become apparent when one explicitly considers the heterogeneity of contractual arrangements. Our theoretical and empirical results clearly point towards a strong association between match-specific productivity, pay arrangements, and wage cyclicality. We provide evidence that employers tend to adopt performance-based pay when match quality is higher. In turn, this is associated to better retention and longer job durations.

We also find that this type of contractual sorting has implications for wage cyclicality: wages in jobs with higher match quality exhibit significant and sizeable responses to aggregate cyclical conditions whereas lower match quality jobs exhibit no such cyclicality.

These findings have implications for the behavior of wages across occupations. Retention considerations should induce firms to use variable compensation as a way to retain workers whenever they are most in demand. Hence, employee profit-sharing (or other forms of performance-related pay) should be relatively more attractive in occupations which are in high demand. We are able to document that jobs in cognitive occupations exhibit strong wage cyclicality and longer durations, while routine and non-cognitive jobs do not. These features are consistent with better average match quality and higher prevalence of performance pay jobs, observations that we are able to confirm using micro data.

A Data

In this section we describe the data sources, as well as how we construct work histories and other relevant variables.

A.1 Data Sources

The main data source is the National Longitudinal Survey of Youth (NLSY79). The NLSY79 is a nationally representative sample of individuals aged 14 to 22 in 1979. The sample period is 1979 to 2010, which makes the maximum age in the sample equal to 53. The NLSY79 consists of three samples: a main representative sample, a military sample, and a supplemental sample designed to over-represent minorities. We only use the main representative sample. Throughout the baseline analysis we focus on males 25 year or older. To gauge robustness we also extend the sample to women who satisfy the sampling restrictions.

Observations for which the reported stop date of the job precedes the reported start date, as well as jobs that last less than 4 weeks, are dropped. Following Hagedorn and Manovskii (2013) we impose some basic sampling restrictions: (i) all observations for which the reported hours worked are below 15 hours are excluded; (ii) the education variable is forced to be non-decreasing over the life cycle. Wages are deflated using the CPI. Following Barlevy (2008) we only consider observations with reported hourly wages above $\$0.10$ and below $\$1,000$. Only observations for individuals that have completed a long-term transition to full time labor market attachment are used in the analysis. As in Yamaguchi (2010), an individual is considered to have made this transition starting from the first employment cycle that lasts 6 or more quarters. Finally, for each job we assign the mode of hours worked as the relevant value for that job. The reorganized NLSY79 data consists of 34,860 job-wage observations, for a sample of 5,712 individuals. Not all of these observations can be used in the estimation because some control variables may be missing in certain years.

A.2 Jobs and Employment Cycles

We define each job as one subset of an employment cycle during which the employer does not change. Each wage observation in the NLSY79 is linked to a measure of the current unemployment rate. To construct the current unemployment rates, we use the seasonally adjusted unemployment series from the Current Population Survey (CPS). We use the Composite Help Wanted Index constructed by Barnichon (2010) as a measure of vacancies.[18] We use the crosswalk provided by Autor and Dorn (2013) to link Census occupation codes with Dorn's 'standardized' occupation codes.[19] We classify occupations into four categories: non-routine

[18]https://sites.google.com/site/regisbarnichon/research.
[19]David Dorn's crosswalks are available at http://www.cemfi.es/dorn/data.htm.

cognitive, non-routine manual, routine cognitive, and routine manual.[20] Furthermore, as in Yamaguchi (2012), if a worker reports having the same job between period t and $t+2$, with occupation i in year t, occupation B in year $t+1$, and again occupation i in $t+2$, then we assume that occupation B is misclassified and we correct it to be A. To minimize the effects of other coding errors, we follow Neal (1998) and Pavan (2011) and disregard observations that report a change in occupation within a job (during a spell with the same employer). Industry codes are aggregated up to 15 major categories to make them comparable over time. In order to reduce the effects of industry coding error, and similar to the treatment of occupations, we only consider observations for which there are no industry changes within the job.

B Proofs

B.1 Proofs for Model Section

Proof of Proposition 1. Derivation of $\underline{m}_1$:

$$E[\pi^{SPC}] = 2(P_H - a(P_H))m - K \geq E[\pi^{spot}] = (1+q)(P_H - a(P_H)m + (1-q)(P_L - a(P_L))m - (1-q)T \tag{A-1}$$

Rearrange to have m on the left hand side:

$$m \geq \frac{K - (1-q)T}{(1-q)[(P_H - P_L) - (a(P_H) - a(P_L))]} \equiv \underline{m}_1 \tag{A-2}$$

Derivation of $\underline{m}_2$:

$$E[\pi^{SPC}] = 2(P_H - a(P_H))m - K \geq E[\pi^{FW}] = (1+q)P_H m + (1-q)P_L m - 2a(P_H)m \tag{A-3}$$

Rearrange to have m on the left hand side:

$$m \geq \frac{K}{(1-q)(P_H - P_L)} \equiv \underline{m}_2 \tag{A-4}$$

[20]This classification replicates the one presented in Cortes and Gallipoli (2014), Table A.1.

Derivation of $\underline{m}_3$:

$$E[\pi^{spot}] = (1+q)(P_H - a(P_H)m + (1-q)(P_L - a(P_L))m - (1-q)T$$
$$\geq E[\pi^{FW}] = (1+q)P_H m + (1-q)P_L m - 2a(P_H)m \quad \text{(A-5)}$$

Rearrange to have m on the left hand side:

$$m \geq \frac{T}{a(P_H) - a(P_L)} \equiv \underline{m}_3 \quad \text{(A-6)}$$

■

Proof of Proposition 2.

Using the treshholds from the Proof of Proposition 1, if $\frac{K}{T} > \frac{(1-q)(P_H - P_L)}{a(P_H) - a(P_L)}$

$$\underline{m}_2 \equiv \frac{K}{(1-q)(P_H - P_L)} > \underline{m}_3 \equiv \frac{T}{a(P_H) - a(P_L)} \quad \text{(A-7)}$$

and

$$\frac{K}{T} > \frac{(1-q)(P_H - P_L)}{a(P_H) - a(P_L)} \Rightarrow$$
$$K(1-q)(P_H - P_L) - (1-q)^2 T(P_H - P_L) > K(1-q)(P_H - P_L) - K(1-q)(a(P_H) - a(P_L)) \quad \text{(A-8)}$$

which implies

$$\underline{m}_1 \equiv \frac{K - (1-q)T}{(1-q)[(P_H - P_L) - (a(P_H) - a(P_L))]} > \underline{m}_2 \equiv \frac{K}{(1-q)(P_H - P_L)}. \quad \text{(A-9)}$$

Prooceding in a similar fashion for the proof in the opposite direction if $\frac{K}{T} \leq \frac{(1-q)(P_H - P_L)}{a(P_H) - a(P_L)}$

$$\underline{m}_2 \equiv \frac{K}{(1-q)(P_H - P_L)} \leq \underline{m}_3 \equiv \frac{T}{a(P_H) - a(P_L)} \quad \text{(A-10)}$$

and

$$\frac{K}{T} \leq \frac{(1-q)(P_H - P_L)}{a(P_H) - a(P_L)} \Rightarrow$$
$$K(1-q)(P_H - P_L) - (1-q)^2 T(P_H - P_L) \leq K(1-q)(P_H - P_L) - K(1-q)(a(P_H) - a(P_L)) \quad \text{(A-11)}$$

which implies

$$\underline{m}_1 \equiv \frac{K-(1-q)T}{(1-q)[(P_H-P_L)-(a(P_H)-a(P_L))]} \leq \underline{m}_2 \equiv \frac{K}{(1-q)(P_H-P_L)}. \qquad \text{(A-12)}$$

■

B.2 Proof for Empirical Wage Processes section

Proof of Proposition 3.

Proof. Log-linearize (w, m, P, X) around (w^*, m^*, P^*, X^*) for the SPC and spot contract wage expressions and (w, m, X) around (w^*, m^*, X^*) for the fixed wage contract, where

$$P^* = \frac{P_h + P_l}{2} \quad w^* = E[w], \quad m^* = E[m], \quad X^* = E[X] \qquad \text{(A-13)}$$

Log-linearization results in:

1. For SPC : $w^*(log(w) - log(w^*)) = (\frac{P_h+P_l}{2} + a(P_h) - P_h)m^*(log(m) - log(m^*)) + P^*m^*(log(P) - log(P^*)) + X^*\gamma(log(X) - log(X^*))$
2. For Fixed wage : $w^*(log(w)-log(w^*)) = a(P_h)m^*(log(m)-log(m^*))+X^*\gamma(log(X)-log(X^*))$
3. For Spot : $w^*(log(w)-log(w^*)) = \frac{da(P)}{dP}|_{P=P^*}P^*m^*(log(P)-log(P^*))+a(P^*)m^*(log(m)-log(m^*)) + X^*\gamma(log(X) - log(X^*))$

After rearranging, and keeping only $log(w)$ on the left hand side, we obtain:

1. For SPC : $log(w) = \frac{-(log(X^*)-log(w^*)w^*+log(m^*)+log(P^*))}{w^*} + \frac{(\frac{P_h+P_l}{2}+a(P_h)-P_h)m^*}{w^*}log(m) + \frac{P^*m^*}{w^*}log(P) + \frac{X^*\gamma}{w^*}log(X)$
2. For Fixed wage : $log(w) = \frac{-(log(m^*)+log(X^*)-log(w^*)w^*)}{w^*} + \frac{a(P_h)m^*}{w^*}log(m) + \frac{X^*\gamma}{w^*}log(X)$
3. For Spot : $log(w) = \frac{-(log(P^*)+log(m^*)+log(X^*)-log(w^*)w^*)}{w^*} + \frac{a(P^*)m^*}{w^*}log(m) + \frac{\frac{da(P)}{dP}|_{P=P^*}P^*m^*}{w^*}log(P) + \frac{X^*\gamma}{w^*}log(X)$

Denote the by β_1 and β_2 the coefficients multiplying $\log(m)$ and $\log(P)$, respectively. Then:

1. $\beta_1^{SPC} > 0, \beta_1^{FW} > 0, \beta_1^{Spot} > 0$
2. $\beta_2^{SPC} > 0, \beta_2^{Spot} > 0$ and $\beta_2^{FW} = 0$

In particular, to see that $\beta_2^{SPC} > 0$, note that

$$\begin{aligned} a(P_h) - a(P_l) &> P_h - P_l \\ \Rightarrow \quad & a(P_h) > P_h - P_l \\ \Rightarrow \quad & \frac{P_h + P_l}{2} > P_l > P_h - a(P_h) \\ \Rightarrow \quad & \frac{P_h + P_l}{2} + a(P_h) - P_h > 0 \end{aligned}$$

where $a(P_h) - a(P_l) > P_h - P_l$ is just the necessary condition for the SPC contract to be feasible.

■

C Model Thresholds Derivation: Case of $P_1 = P_L$.

In the main text we assume that in period 1 of a job (i.e. after the learning period), the aggregate state is $P = P_H$. In this section, we repeat the analysis for the case where the aggregate state in period 1 is $P = P_L$. While some technical details change, the main arguments remain in tact.

C.1 Optimal b and expected profits under SPC

The firm's problem is:

$$\begin{aligned} \max_b \{E\left[\pi^{SPC}\right]\} &= \max_b \{q\left[P_H m - \hat{w}(m) - bP_H m\right] + (2-q)\left[P_L m - \hat{w}(m) - bP_L m\right] - K\} \\ \text{s.t.:} \quad & a(P_H)m = \hat{w}(m) + bP_H m \end{aligned}$$

rearrange the constraint and substitute: $\hat{w}(m) = a(P_H)m - bP_H m$

$$\begin{aligned} \max_b \{E\left[\pi^{SPC}\right]\} &= \max_b \{q\left[P_H m - a(P_H)m + bP_H m - bP_H m\right] \\ & \quad +(2-q)\left[P_L m - a(P_H)m + bP_H m - bP_L m\right] - K\} \\ &= \max_b \{q\left[P_H m - a(P_H)m\right] + (2-q)\left[P_L m - a(P_H)m + bP_H m - bP_L m\right] - K\} \end{aligned}$$

First order condition with respect to b:

$$\frac{\partial E\left[\pi^{SPC}\right]}{\partial b} = (2-q)m\left(P_H - P_L\right) > 0$$

and therefore $b = 1$ as before.

With $b = 1$ we have expected profits:

$$\begin{aligned} E\left[\pi^{SPC}\right] &= q\left[P_H m - a(P_H)m\right] + (2-q)\left[P_L m - a(P_H)m + P_H m - P_L m\right] - K\} \\ \\ &= q\left[P_H m - a(P_H)m\right] + (2-q)\left[-a(P_H)m + P_H m\right] - K\} \\ &= q\left[P_H m - a(P_H)m\right] + (2-q)\left[P_H m - a(P_H)m\right] - K\} \\ &= 2\left[P_H m - a(P_H)m\right] - K \end{aligned}$$

C.2 Spot wages

Assume that wages follow the outside option as before. Because workers are hired at a low state, we assume here that the cost T is paid if the aggregate state changes to H:

$$E\left[\pi^{SPOT}\right] = q\left[P_H m - a(P_H)m - T\right] + (2-q)\left[P_L m - a(P_L)m\right]$$

C.3 Fixed wages

As before, assume that a fixed wage is paid to match the outside option of the H state:

$$E\left[\pi^{FW}\right] = q\left[P_H x - a(P_H)x\right] + (2-q)\left[P_L x - a(P_H)x\right] = qP_H x + (2-q)P_L x - 2a(P_H)x$$

C.4 Deriving cutoff conditions

C.4.1 SPC>SPOT

$$\begin{aligned} &2\left[P_H m - a(P_H)m\right] - K > q\left[P_H m - a(P_H)m - T\right] + (2-q)\left[P_L m - a(P_L)m\right] \\ &(2-q)\left[P_H m - a(P_H)m\right] - K > -qT + (2-q)\left[P_L m - a(P_L)m\right] \\ &(2-q)\left[(P_H - a(P_H)) - (P_L - a(P_L))\right] m > K - qT \\ &m > \frac{K - qT}{(2-q)\left[(P_H - a(P_H)) - (P_L - a(P_L))\right]} \equiv \hat{m}_1 \end{aligned}$$

C.4.2 SPC>FW

$$\begin{aligned} &2\left[P_H m - a(P_H)m\right] - K > qP_H m + (2-q)P_L m - 2a(P_H)m \\ &2P_H m - 2a(P_H)m - qP_H m - (2-q)P_L m + 2a(P_H)m > K \\ &(2-q)\left(P_H m - P_L m\right) > K \\ &m > \frac{K}{(2-q)(P_H - P_L)} \equiv \hat{m}_2 \end{aligned}$$

C.4.3 SPOT>FW

$$
\begin{aligned}
&qP_H m + (2-q)P_L m - 2a(P_H)m < q\left[P_H m - a(P_H)m - T\right] + (2-q)\left[P_L m - a(P_L)m\right] \\
&-2a(P_H)m < -qa(P_H)m - qT + (2-q)a(P_L)m \\
&qT < (2-q)a(P_L)m + 2a(P_H)m - qa(P_H)m \\
&qT < (2-q)m\left[a(P_H) - a(P_L)\right] \\
&m > \frac{qT}{(2-q)\left[a(P_H) - a(P_L)\right]} \equiv \hat{m}_3
\end{aligned}
$$

C.5 Ranking the cutoff levels

Condition for $\hat{m}_1 > \hat{m}_2$.

$$
\begin{aligned}
&\frac{K - qT}{(2-q)\left[(P_H - a(P_H)) - (P_L - aP_L)\right]} > \frac{K}{(2-q)(P_H - P_L)} \\
&\frac{K - qT}{(2-q)\left[P_H - P_L\right] - (2-q)\left[a(P_H) - a(P_L)\right]} > \frac{K}{(2-q)(P_H - P_L)} \\
&K(2-q)(P_H - P_L) - qT(2-q)(P_H - P_L) > K(2-q)(P_H - P_L) - K(2-q)\left[a(P_H) - a(P_L)\right] \\
&-qT(2-q)(P_H - P_L) > -K(2-q)\left[a(P_H) - a(P_L)\right] \\
&qT(P_H - P_L) < K\left[a(P_H) - a(P_L)\right] \\
&\frac{K}{T} > \frac{q(P_H - P_L)}{a(P_H) - a(P_L)}
\end{aligned}
$$

Condition for $\hat{m}_1 > \hat{m}_3$.

$$
\begin{aligned}
&\frac{K - qT}{(2-q)\left[(P_H - a(P_H)) - (P_L - aP_L)\right]} > \frac{qT}{(2-q)\left[a(P_H) - a(P_L)\right]} \\
&\frac{K - qT}{(2-q)\left[P_H - P_L\right] - (2-q)\left[a(P_H) - a(P_L)\right]} > \frac{qT}{(2-q)\left[a(P_H) - a(P_L)\right]} \\
&K(2-q)\left[a(P_H) - a(P_L)\right] - qT(2-q)\left[a(P_H) - a(P_L)\right] > \\
&\qquad qT(2-q)\left[P_H - P_L\right] - qT(2-q)\left[a(P_H) - a(P_L)\right] \\
&K(2-q)\left[a(P_H) - a(P_L)\right] > qT(2-q)\left[P_H - P_L\right] \\
&\frac{K}{T} > \frac{q(P_H - P_L)}{a(P_H) - a(P_L)}
\end{aligned}
$$

Condition for $\hat{m}_3 > \hat{m}_2$.

$$
\begin{aligned}
&\frac{qT}{(2-q)\left[a(P_H) - a(P_L)\right]} > \frac{K}{(2-q)(P_H - P_L)} \\
&\frac{K}{T} < \frac{q(P_H - P_L)}{a(P_H) - a(P_L)}
\end{aligned}
$$

Note that while $\hat{m}_1$, $\hat{m}_2$, and $\hat{m}_3$ are not equal to $\underline{\mathrm{m}}_1$, $\underline{\mathrm{m}}_2$, and $\underline{\mathrm{m}}_3$, their ranking follows a similar line of argument as in Proposition (2) and implies similar qualitative implications as in Corollary (1). Hence, we can write:

- if $\frac{K}{T} > \frac{q(P_H - P_L)}{a(P_H) - a(P_L)}$ then $\hat{m}_1 > \hat{m}_2 > \hat{m}_3$
  - SPC for any $m > \hat{m}_1$
  - SPOT for $\hat{m}_3 < m < \hat{m}_1$
  - FW for $m < \hat{m}_3$
- if $\frac{K}{T} < \frac{q(P_H - P_L)}{a(P_H) - a(P_L)}$ then $\hat{m}_3 > \hat{m}_2 > \hat{m}_1$
  - SPC for any $m > \hat{m}_2$
  - FW for $m < \hat{m}_2$

Proof.

D Period 1 participation constraint (after learning period)

In the main text we explain that an ex-ante participation constraint must hold for workers who choose to stay with their employer:

$$w_1(m|P_H) + E(w_2(m)) \geq a(P_H)m + [qa(P_H) + (1-q)a(P_L)]\, E(m)$$

Fixed wage contract: in this case $w_1(m) = w_2(m) = a(P_H)m$. Therefore:

$$\begin{aligned}
&2a(P_H)m \geq a(P_H)m + [qa(P_H) + (1-q)a(P_L)]\, E(m) \\
&a(P_H)m \geq [qa(P_H) + (1-q)a(P_L)]\, E(m) \\
&m \geq \frac{[qa(P_H) + (1-q)a(P_L)]}{a(P_H)} E(m)
\end{aligned}$$

Since $\frac{[qa(P_H)+(1-q)a(P_L)]}{a(P_H)} < 1$ it implies that for any $m > E(m)$ the match does not separate.
Spot contract: in this case $w_1(m) = a(P_H)m$ and $E(w_2(m)) = qa(P_H)m + (1-q)a(P_L)m$. Therefore:

$$\begin{aligned}
&a(P_H)m + qa(P_H)m + (1-q)a(P_L)m \geq a(P_H)m + [qa(P_H) + (1-q)a(P_L)]\, E(m) \\
&[qa(P_H) + (1-q)a(P_L)]\, m \geq [qa(P_H) + (1-q)a(P_L)]\, E(m) \\
&m \geq E(m)
\end{aligned}$$

Which trivially implies that under spot contract matches survive if $m > E(m)$.

SPC: in this case equation (12) implies that the wages are $w_1(m) = a(P_H)m$ and $E(w_2(m)) = (a(P_H) - P_H)m + qP_Hm + (1-q)P_Lm$. Substitute:

$$a(P_H)m + (a(P_H) - P_H)m + qP_Hm + (1-q)P_Lm \geq a(P_H)m + [qa(P_H) + (1-q)a(P_L)]\, E(m)$$
$$a(P_H)m + (1-q)\,[P_L - P_H]\, m \geq [qa(P_H) + (1-q)a(P_L)]\, E(m)$$
$$\frac{m}{E(m)} > \frac{qa(P_H) + (1-q)a(P_L)}{a(P_H) + (1-q)\,[P_L - P_H]}$$

Note that the last condition implies a threshold for m such that matches do not separate. In addition, it can be shown that given the assumption that $a(P_H) - a(P_L) \geq P_H - P_L$, which is required for SPC, the right hand side of this condition is smaller than 1. Therefore, it must be that the threshold is lower than $E(m)$ and therefore every match with $m > E(m)$ does not separate before period 1. To see this, check the conditions such that the right hand side is smaller than 1:

$$\frac{qa(P_H) + (1-q)a(P_L)}{a(P_H) + (1-q)\,[P_L - P_H]} < 1$$
$$qa(P_H) + (1-q)a(P_L) < a(P_H) + (1-q)\,[P_L - P_H]$$
$$0 < (1-q)\,[a(P_H) - a(P_L) - (P_H - P_L)]$$
$$P_H - P_L < a(P_H) - a(P_L)$$

■

References

AUTOR, D., AND D. DORN (2013): "The growth of low-skill service jobs and the polarization of the US labor market," *The American Economic Review*, 103(5), 1553–1597.

BARLEVY, G. (2008): "Identification of Search Models Using Record Statistics," *Review of Economic Studies*, 75(1), 29–64.

BARNICHON, R. (2010): "Building a composite help-wanted index," *Economics Letters*, 109(3), 175–178.

BEAUDRY, P., AND J. DINARDO (1991): "The effect of implicit contracts on the movement of wages over the business cycle: Evidence from micro data," *Journal of Political Economy*, pp. 665–688.

BILS, M. J. (1985): "Real wages over the business cycle: evidence from panel data," *The Journal of Political Economy*, pp. 666–689.

CORTES, G. M., AND G. GALLIPOLI (2014): "The costs of occupational mobility: An aggregate analysis," Discussion paper, University of Chicago, Working Paper, HCEO.

CORTES, M., N. JAIMOVICH, C. NEKARDA, AND H. SIU (2015): "The Micro and Macro of Disappearing Routine Jobs: a Flows Approach," Discussion paper, UBC, Vancouver School of Economics, Working Paper.

HAGEDORN, M., AND I. MANOVSKII (2013): "Job selection and wages over the business cycle," *The American Economic Review*, 103(2), 771–803.

LAZEAR, E. P., AND P. OYER (2012): "Personnel Economics," in *The Handbook of Organizational Economics*, ed. by R. Gibbons, and J. Roberts. Princeton University Press.

LEMIEUX, T., W. B. MACLEOD, AND D. PARENT (2009): "Performance Pay and Wage Inequality," *Quarterly Journal of Economics*, 124(1).

LEMIEUX, T., W. B. MACLEOD, AND D. PARENT (2012): "Contract form, wage flexibility, and employment," *The American Economic Review*, pp. 526–531.

MAKRIDIS, C. (2014): "The Performance Pay Premium, Human Capital and Inequality: Evidence from Over Forty Years of Microdata," Discussion paper, Working paper.

NEAL, D. (1998): "The complexity of job mobility among young men," Discussion paper, National bureau of economic research.

OYER, P. (2004): "Why do firms use incentives that have no incentive effects?," *The Journal of Finance*, LIX(4), 1619–1649.

Pavan, R. (2011): “Career choice and wage growth,” *Journal of Labor Economics*, 29(3), 549–587.

Wolpin, K. I. (1992): “The determinants of black-white differences in early employment careers: Search, layoffs, quits, and endogenous wage growth,” *Journal of Political Economy*, 100(3), 535–60.

Yamaguchi, S. (2010): “Job search, bargaining, and wage dynamics,” *Journal of Labor Economics*, 28(3), 595–631.

——— (2012): “Tasks and heterogeneous human capital,” *Journal of Labor Economics*, 30(1), 1–53.