Real Wage Growth over the Business Cycle: Contractual versus Spot Markets

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Abstract

We study the wage growth of job stayers over the business cycle, and show that wage adjustments within a job spell display significant history dependence. This is at odds with the spot market model, which implies that the wage *growth* of a worker *within a job spell* depends solely on the change in the economic conditions between two consecutive periods. Instead, we find that workers who were hired during recessions, or those who experienced unfavorable economic conditions since they were hired, receive larger wage raises during expansions, and are subject to smaller wage cuts during downswings. The change in the contemporaneous unemployment rate, on the other hand, is not a significant determinant of wage growth. Our findings are consistent with a model of insurance contracts where neither the employer nor the worker can fully commit to working together in the future.

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The prominent models of the labor market in modern macroeconomics assume that the exchange of labor services with compensation takes place within a short time period as in a spot market (see, for instance, Kydland and Prescott (1982) or Long and Plosser (1983)). Assuming that markets are competitive, a worker's wage, then, equals his marginal product at all times, and, hence, changes in the wage rate are driven solely by contemporaneous changes in economic conditions. A similar prediction comes out of models where workers and firms constantly renegotiate a production surplus (See Mortensen and Pissarides (1994)). Most employment relationships are, however, long in nature. This provides potential welfare gains to decoupling wages from productivity in the short-run, provided that total outlays on a worker equal his expected productivity. For instance, firms may shield workers against arbitrary movements in their marginal product by underpaying them during expansions, and overpaying them during downswings, thereby providing a more stable flow of income. This is the idea behind the models of implicit wage contracts (Azariadis, 1975).[1]

The framework we choose to interpret the labor market data with is crucial for uncovering the structure of preferences and technology. For instance, if measured wage rates do not reflect productivity, as in a contractual market, the standard estimates of the intertemporal labor supply elasticity (see MaCurdy (1981) among others) can be misleading. The contractual model also offers an explanation for the high volatility of hours and employment over the business cycle, relative to the movements in the measured wage (Boldrin, 1995).[2] In this paper we evaluate the two competing modeling approaches that aim to explain the behavior of wages and productivity over the business cycle.

In a contractual market wages carry information about the economic conditions when the contract was (re)negotiated. Consequently, wages are history-dependent unlike in a spot market where wages depend only on current conditions. A growing body of evidence point to the relevance of past labor market conditions for wages. Oreopoulos, Wachter, and Heisz (2006), for instance, finds a persistent negative effect of being hired during a recession.[3] Similarly, Beaudry and DiNardo (1991) finds that workers who expe-

[1] See Rosen (1985) for a survey of the implicit contracts literature.

[2] See also Rudanko (2009, 2010) and Hall (2005) for more recent evaluations of contracts and wage rigidity on unemployment fluctuations.

[3] See also Kahn (2010); Freeman (1981); Oyer (2006); Baker, Gibbs, and Holmstrom (1994) for similar findings on cohort-entry effects in wages.

rienced better economic conditions since they started their jobs have higher wages, and that the contemporaneous conditions are irrelevant.[4] This empirical pattern, apparently inconsistent with a spot market model of wages, was considered as evidence for contractual arrangements between workers and their employers.

Nevertheless, one may be too quick to dismiss the spot market model based on this evidence. It is plausible that jobs that start during recessions are of particularly low quality (Okun, 1973). This argument is somewhat backed up by the finding that the expected duration is shorter for jobs that start in recessions (Bowlus, 1995). Similarly, workers in weak matches may quit their jobs in pursuit of better matches, leading to the selection of more productive employee-employer pairs over time (Topel, 1991). This selection could be especially strong during an upswing when there are plenty of job vacancies. Then the jobs which survived economic expansions would be highly productive, and, perhaps, the findings in Beaudry and DiNardo (1991) simply reflect such selection (Hagedorn and Manovskii, 2010).

In this paper, we propose a novel test of the spot market model against the implicit contracts model. Our identification strategy relies on the implications of the two models for wage growth in response to a change in the economic conditions for workers who do not switch jobs. By focusing exclusively on job stayers, we are able to control for the confounding effect of match quality under the assumption that the latter is time invariant for a given employer-employee pair.

To see the essence of our argument consider two workers of equal productivity who were hired under two different states of the economy: worker B in a boom and worker R in the subsequent recession. If the employment relationship is characterized by implicit insurance contracts, worker B enjoys a higher wage rate than worker R over the recession. This is because he was insured against a downturn when he was hired. As the economy recovers from the recession, worker R is expected to gain more from potential outside offers since he is paid a lower wage conditional on productivity.[5] Consequently, the worker R is more likely to quit given a set of outside wage offers. To retain the worker, the employer, therefore, is more likely to offer a raise to worker R, or, to offer him a larger

[4] See also Grant (2003), and Kudlyak (2010) for similar findings for U.S., McDonald and Worswick (1999) for Canada, and Bellou and Kaymak (2010) for a set of European countries.

[5] We assume that some degree of worker mobility is allowed, and that workers cannot sign a contract that enslaves them to an employer regardless of their outside options.

wage raise relative to worker B. If, on the other hand, the spot market model better describes the wage behavior, both workers should be paid equally at all times since they are equally productive. Hence, there is no reason to believe that the wage adjustments over the business cycle should depend on the economic conditions at the time of the hire.

We test several versions of this argument. Our benchmark null hypothesis is the spot market model with time-invariant heterogeneous match quality. Our aim is to test whether workers who receive a higher insurance premium conditional on productivity, receive lower wage raises or larger wage cuts.[6] To this end, we first focus on self-enforcing wage contracts where the firm can credibly commit to future payments foreseen by the contract, but the worker cannot guarantee to stay with the firm (Harris and Holmstrom, 1982). In this case, the differences in the insurance premiums can be identified by the initial and the best economic conditions since the start of the job. Following Bils (1985) and Beaudry and DiNardo (1991), we use the unemployment rate to approximate the economic conditions.

Our results show that wage growth of job stayers within an employment spell is history dependent. Workers who were hired during expansions, or those who experienced better economic conditions on the job have lower wage growth on average. The contemporaneous change in the unemployment rate, on the other hand, is not a significant determinant of wage growth. This is at odds with the spot market model of wages with time-invariant match quality.

We extend our results in two crucial dimensions. First, we study a contractual market where neither the worker nor the employer can credibly commit to the contract (Thomas and Worrall, 1988). In this case, the optimal contract cannot be summarized by extremum moments, such as the best or the worst unemployment rate. Nevertheless, we develop a general two-step procedure where we first capture the contractual variation in wages due to the differences in the timing of contracts, and then project wage growth on the estimated insurance premium. Workers who receive lower wages conditional on productivity due to differences in contractual terms, have higher subsequent wage growth as foreseen by the implicit contracts model. A one percent difference in the insurance

[6]Technically, an insured worker receives indemnity whenever his wage is higher than his productivity, and pays a premium otherwise. We use the term premium more generally to denote the gap between wage and productivity in contractual markets. It is understood that the premium can be negative.

component of wages is associated with a 0.20% decline in annual wage growth.

Then we relax our assumption that match quality is constant. One could be concerned that the selection of job stayers over the business cycle may be endogenous to anticipated wage growth. In particular, we define each job by two components: an initial job-specific productivity and an associated wage growth. We analyze the effects of endogenous survival of jobs on the selection of jobs with respect to wage growth and show that our tests are more likely to accept the null hypothesis if such endogeneity in growth rates is ignored. Using workers with several wage observations on the same job, we estimate the extended version of our model, and show that the history dependence in wage growth is indeed stronger. We find that the effect of past labor market conditions on wage growth is large, but less persistent when the selection of job stayers is taken into account.

In the next section, we outline a generic model of implicit insurance contracts and contrast its implications for wages with a spot market model with heterogeneous job quality. We describe our empirical tests in section 2. Section 3 presents our results.

1 Market Structure and the Cyclical Behavior of Wages

1.1 Self-Enforcing Insurance Contracts and the Distribution of Wages

Let y_t be the marginal product of a worker at time t, and $h_t = \{y_t, y_{t-1}, ..., y_{t_0}\}$ denote the history of marginal products on a job that started at $t = t_0$. A contract is a sequence of functions $w_t(h_t)$ for $t \geq t_0$ that assigns a history-dependent stream of wage payments to the worker. Future flows of wages and productivity are discounted geometrically at rate $\delta < 1$.[7] The optimal *self-enforcing* contract solves the following problem:

$$\max \sum_{k=1}^{\infty} \delta^k E_{t_0}[U(w_{t_0+k}(h_{t_0+k}))] \tag{1}$$

[7]The discount rate may reflect the possibility of exogenous termination of the employment relationship as well as the interest rate and time preferences.

subject to

$$\sum_{k=1}^{\infty} \delta^k E_{t_0}[y_{t_0+k} - w_{t_0+k}(h_{t_0+k})] = 0 \tag{2}$$

$$E_t\left[\sum_{k=1}^{\infty} \delta^k U(w_{t+k}(h_{t+k}))\right] \geq v(y_t) \qquad \forall h_t \text{ and } t \geq t_0 \tag{3}$$

$$E_t\left[\sum_{k=1}^{\infty} \delta^k [y_{t+k} - w_{t+k}(h_{t+k})]\right] \geq \pi(y_t) \qquad \forall h_t \text{ and } t \geq t_0 \tag{4}$$

The efficient contract maximizes the welfare of the worker subject to three constraints. Equation (2) is the zero profit condition implied by the free entry assumption. The inequality (3) invokes the worker's incentive compatibility constraint: at any time, the optimal contract is such that the worker prefers to honor the contract, given his outside option $v(y_t)$. The inequality (4) states a similar condition for the firm, where $\pi(y_t)$ denotes the firm's outside option. We assume that the constraint set is non-empty.[8]

The problem above is valid for when neither the worker, nor the firm can commit to honoring the contract in the future. In the other extreme, when both can credibly commit to the conditions of the contract, for instance, when mobility is too costly, the optimal contract solves (1), subject to constraint (2) only. If firms can commit to future payments, but the workers cannot, then the optimal contract maximizes (1), subject to (2) and (3), and so on. The following proposition gives the characterization of the optimal contract when there is two-sided lack of commitment.

Proposition 1 (Thomas and Worrall, 1988) *For any history $h_t = (h_{t-1}, y_t)$, there exist functions $\overline{w}(y_t)$, and $\underline{w}(y_t)$ such that, the optimal contract wage, $w_t(y_t)$ is*

$$w_t(h_{t-1}, y_t) = \begin{cases} \overline{w}(y_t) & \text{if } w_t(h_{t-1}) > \overline{w}(y_t) \\ w_t(h_{t-1}) & \text{if } \overline{w}(y_t) \geq w_t(h_{t-1}) \geq \underline{w}(y_t) \\ \underline{w}(y_t) & \text{if } w_t(h_{t-1}) < \underline{w}(y_t). \end{cases}$$

The optimal contract keeps the contract wage constant from one period to another, as long as the participation constraints of agents do not bind. If the outside option of an agent

[8]The reader is referred to Harris and Holmstrom (1982) or Thomas and Worrall (1988) for the conditions to ensure the existence of an optimal contract in this setting.

changes substantially, so much as to render employment unsustainable at the previously agreed wage rate, the optimal contract calls for an adjustment in the wage payments to prevent separation. If, for instance, the worker receives a better wage offer after a contract is signed, then the firm offers a raise to retain the worker.

1.2 The cross-sectional distribution of wages

When both the worker and the firm can credibly commit, the optimal contract features full insurance, i.e. a constant wage rate. Consequently, by equation (2), the wage rate must be equal to the expected productivity of the worker at t_0. This leads to a cross-sectional dispersion in wages, based only on differences in t_0 across workers, even though the workers have the same current marginal product at time t. Then the economic conditions at the start of a job are sufficient to capture this variation, leaving current economic conditions statistically redundant.

If firms can commit to future payments, but workers cannot, then the optimal contract features a constant wage, that increases only if worker's outside option is sufficiently improved. Since firms commit to payments, wages are never adjusted downward. A worker's wage at time t, therefore, reflects the highest wage he could command since the start of the job. The cross-sectional variation in wages reflect not only the conditions at t_0, but also the best economic conditions since then. These two moments exhaust all the variation in wages. Current economic conditions, on the other hand, remain uninformative.

In the more general case, when neither party can commit, the contracted wage rate moves with marginal productivity, only when the latter is altered substantially, and otherwise remains constant. Current wages are still history dependent, but the form of this dependence cannot be represented by simple moments as above. Nevertheless, an indicator for the start year and the current year pair, (t_0, t), is sufficient to summarize the entire history of economic conditions between t_0 and t, and, hence, the cross-sectional distribution of wages.[9]

[9] A common attempt to capture the two-sided lack of commitment is to include the maximum unemployment rate since the start of the job in the regression, along with the initial and the minimum unemployment rate. This is not theoretically consistent with the two-sided lack of commitment. It is, however, consistent with contracts where workers can be enslaved by employers who cannot credibly commit to keeping them.

In any one of these cases, the current wage distribution displays history-dependence, and current economic conditions do not matter, in sharp contrast to the spot market model of wage determination which we turn to next.

1.3 A Spot Market Model of Wages with Cyclical Selection of Jobs

In a spot market model, wage equals the marginal product. Let productivity worker i in job j be

$$w_{ijt} = \beta_{ij} T_{ij} + \phi_i X_{it} + \epsilon_{ijt} \tag{5}$$

where T_{ij} is job tenure and X_{it} is market experience. The return to seniority is allowed to differ across worker-job pairs, and the return to experience may differ among workers. The unobserved random error component, ϵ_{ijt}, can be decomposed into three:

$$\epsilon_{ijt} = y_t + a_i + m_{ij} + \nu_{ijt}.$$

where a_i is a worker-specific component, m_{ij} is a match specific component and y_t is the cyclical component of productivity. We assume that ν_{ijt} is outside the model and is independent of other components of productivity.

1.4 Endogenous separation and cyclical selection

Even though wages depend only on the *current* marginal product of a worker, wages could display history-dependence if the cyclical changes in the composition of jobs or workers are correlated with unobserved productivity characteristics. To see this, suppose, for now, that $w_{ijt} = y_t + a_i + m_{ij}$.[10] Let $\tilde{w}_{it}$ denote the best wage offer that a worker, employed or unemployed, can generate in the market. This offer depends only on the current economic conditions as in the previous section.

A worker decides to quit his existing job if $\tilde{w}_{it} > w_{ijt}$. Since the cyclical and the worker-specific components are equally valuable at all jobs, a better wage offer must come from a better match.[11] The endogenous quit decision leads to destruction of poor matches over

[10] This version of the spot market model is akin to the model considered in Hagedorn and Manovskii (2010).

[11] Otherwise the current employer could retain the worker by outbidding the outside offer.

time, leading to survival of only the best ones. Denoting the match quality corresponding to the best wage offer by $\tilde{m}_{it}$, the average match quality conditional on $T = t - t_0$ years of seniority is

$$E[m_{ij}|m_{ij} > \max\{\tilde{m}(y_{t_0}),\ ...,\ \tilde{m}(y_t)\}]. \tag{6}$$

The number of arguments in the max operator above increases with tenure raising the average quality of surviving matches. When the match quality is not observed, this confounds the estimates of the return to seniority (Topel, 1991).

If the wage offer $\tilde{w}_{it}$ displays cyclical variation, a similar selection argument could also generate a *faux* history-dependence. For instance, if the wage offer $\tilde{w}_{it}$ is pro-cyclical, the selection in (6) applies more stringently to those workers who experienced better economic conditions. This creates a negative relation between the minimum unemployment rate experienced over a worker's tenure and the expected match quality.

Furthermore, the pro-cyclicality of the wage offer, $\tilde{w}_{it}$, transcends to that of the match quality $\tilde{m}_{it}$, implying that the average quality of new matches that are formed during expansions are higher. Therefore, jobs that start during expansions command higher wages, which makes the initial unemployment rate at the start of the job a statistically important determinant of wages, even in a spot market.

1.5 Using wage growth of job stayers to distinguish between models

The cyclical nature of match quality is an empirical matter. On one hand, unemployed workers probably sample more offers during expansions, which raises the quality of matches. On the other hand, during recessions, employers sample more applicants, which also may increase the average quality of new matches. It is plausible, however, that a larger portion of the match surplus is captured by workers during expansions, leading to a pro-cyclical match-specific component in wages. In such a case, the implications of the spot market model are similar to those of the contractual model discussed in the previous section.

Nevertheless, a crucial difference between the two models exists in the wage paths of individual workers. In the contractual markets without commitment, the individual wages are adjusted in response to economic conditions. In the spot market model with selection, on the contrary, it is the composition of workers that are responsive to past

conditions, not individual wages. If panel data on workers and their jobs are available, the two models can be distinguished by studying the wage differences of workers who do not switch their job from one period to another. Let $\Delta x_t = x_t - x_{t-1}$ be the first difference operator. Using (5) to calculate the change in the wages of job stayers:

$$\Delta w_{ijt} = \Delta y_t + \Delta \nu_{ijt} \tag{7}$$

Since the confounding effects of unobserved worker or match quality effects are eliminated in this way, the wage growth of job stayers should not display any history dependence if the labor market is, in fact, characterized only by a spot market model.

In contractual markets, wages are adjusted in response to changes in outside options when at least one party cannot credibly commit to honor the contract forever. The incidence and the extent of a wage adjustment depends crucially on the current wage of the worker, and thereby, on the history of economic conditions. To see this, note that the wage growth along the optimal contract described in Proposition 1 is given by

$$\Delta w_t(h_{t-1}, y_t) = \begin{cases} \overline{w}(y_t) - w_t(h_{t-1}) & \text{if } w_t(h_{t-1}) > \overline{w}(y_t) \\ 0 & \text{if } \overline{w}(y_t) \geq w_t(h_{t-1}) \geq \underline{w}(y_t) \\ \underline{w}(y_t) - w_t(h_{t-1}) & \text{if } w_t(h_{t-1}) < \underline{w}(y_t). \end{cases}$$

Whenever one of the incentive constraints binds, wage is adjusted to reflect the reservation wage of the agent, which is forward looking, and, hence, depends only the current conditions. Differences in wages across workers that arise from differences in market history are annulled when the reservation wage binds. This renders the optimal contract memoryless. Therefore, the wage difference depends negatively on last period's wage whenever there is an adjustment. This generates history dependence in wage differences contrary to the spot market model.The following example illustrates the nature of this dependence.

Consider a labor market where workers do not commit, but employers do, and suppose that the economy can be in one of three states: boom (b), average(a) and recession (r). The wages of two workers, I and II, during a bust cycle are depicted in Figure 1. Worker I was hired during average economic conditions at \$2 an hour. Worker II is hired at \$1 per hour the period after, when the economy was in a recession. When the economy goes

into a recession, the firm's participation constraint in (3) becomes binding for worker I's contract, and the worker's wage is reduced to \$1.5 as part of his contract. That it remains greater than 1\$ indicates the partial insurance embodied in the contract. In period 3, the economy is still in a recession, and wages, therefore, remain constant. In the last period, when the economy goes into a boom, this time the workers' participation constraint in (3) becomes binding, possibly for both workers. Since the worker I already receives a premium over his productivity, he receives a lower wage raise. A similar argument can be made for wage cuts during a recession: workers who are paid a larger insurance premium, for instance those who were hired in booms, are the ones to receive the first or largest wage cuts.

That the insurance premiums received by the two workers converge is implicit in the formulation of the contracting problem. The outside options in inequalities (3) and (4) are forward looking, and, thus, depend only on the current economic conditions. The only difference between wage adjustments come from the existing wage payments, which are predetermined by the contract, and are dependent on the history. We exploit this difference in the predictions of the two models to devise our empirical tests in section 2

1.6 Anticipated wage growth and cyclical selection of job stayers

It may be too restrictive to assume that match quality is constant over time. Investments in job-specific human capital may improve the quality of a match (Becker, 1964). Similarly, concerns about worker efficiency could lead to arrangements where wages increase with seniority (Lazear, 1979). If these seniority premiums were similar across jobs, our argument above would not be changed. However, efficiency and human capital are likely to be more important in some professions than others. Anticipated wage growth affects workers' job choices, creating a potential problem of identification when using wage growth of job stayers to distinguish the two models.

To analyze the effect of endogenous survival of jobs on wage growth, take the first difference of equation (5) to get

$$\Delta w_{ijt} = \phi_i + \beta_{ij} + \Delta y_t + \Delta \nu_{ijt}. \tag{8}$$

Wage growth could display history-dependence if ϕ_i and β_{ij} are correlated with past eco-

nomic conditions. In this section we show that the decision to switch jobs is independent of ϕ_i but not of β_{ij}. However, while expected match quality, m_{ij}, is positively related to having experienced favorable economic conditions in the past, anticipated wage growth β_{ij} is negatively correlated with past conditions, contrary to what one would expect in contractual markets. This, in fact, makes it easier to distinguish between the two models. Next, we provide the details of our result, and then discuss how heterogeneity in returns to tenure and experience can be addressed using panel data.

Suppose that each job is characterized by a match quality level, m_{ij}, and an anticipated return to tenure β_{ij}.[12] Let $\tilde{W}_{it}$ be the annualized present discounted value of the best offer a worker generates at the beginning of year t. The corresponding expected flow value from the existing job for a worker with T years of tenure is:

$$(1-\delta)\mathbb{E}_t \sum_{k=t}^{\infty} \delta^{k-t} p_{ij} = a_i + m_{ij} + \beta_{ij}(T + \frac{\delta}{1-\delta}) + \phi_i(X_{it} + \frac{\delta}{1-\delta}). \tag{9}$$

A worker quits his job if the value in (9) is less than $\tilde{W}_{it}$. Since all firms reward general skills, a_i and X_{it}, in a competitive market, the decision boils down to the relative match qualities and the anticipated wage growths in the two jobs. Let $\tilde{w}^a_{it} = m_{ij'} + \beta_{ij'}\frac{\delta}{1-\delta}$ be the match-specific component of the best competing offer by firm j'. A worker quits his job if and only if

$$\tilde{w}^a_{it} > m_{ij} + \beta_{ij}(T + \frac{\delta}{1-\delta}).$$

Two points are worth noting. First, the inequality above is more likely to hold if either the current pay or the anticipated wage growth at the existing job are low. Second, it does not depend on ϕ_i, the return to experience.

Figure 2 contrasts the switching decisions during a recession and an expansion. The circles are isodensity curves for the distribution of match quality m_{ij} and the return to tenure β_{ij}. We assume, for the moment, that these are initially independent. The solid line shows the indifference line for switching jobs during a recession. The workers with (m_{ij}, β_{ij}) combinations that are above the line prefer to stay with their current jobs. Therefore, conditional on staying with the current job, both the match level, m_{ij}, and the expected wage growth are higher than their unconditional means. When the economy is in

[12] We do not distinguish between anticipated and realized wage growth. In a more general model, one could also add uncertainty about future pay raises.

an expansion, workers sample more offers, leading to more stringent selection (dashed line) during booms.

That job switches are endogenous implies that the longer the worker has stayed with his job, the more offers must have been sampled, and rejected. Therefore, jobs are selected positively with respect to β_{ij} with tenure. In addition, conditional on tenure, workers that experienced more favorable economic conditions during their tenure faced more stringent selection constraints, and therefore, must be working at jobs with higher β_{ij}'s on average. This is contrary to the predictions of the implicit contracts model: if a worker experienced more favorable conditions, he already receives a larger insurance premium, therefore, experiences a *lower* wage growth during expansions.

Equation (8) could also be estimated directly if there are sufficient observations on each job - worker pair. A fixed effects panel estimation would identify ϕ_i at the worker level and β_{ij} at the job level. Since this estimation requires at least three wage observations for each job - worker pair, it necessarily disregards jobs with short tenure and the workers who have just started their career. Nevertheless, we estimate (8) and address the issues with sample selection in the next section. Next, we lay the details of our empirical strategy.

2 Testing for Contractual Markets: Empirical Implementation

Our purpose is to empirically distinguish between the two models by studying the wage growth of workers who do not switch jobs. We define the spot markets model as our null hypothesis, and test whether the wage growth of stayers display history dependence in a way that is consistent with the implicit contracts model. To this end, we follow two strategies. Our benchmark strategy is to evaluate a version of (7), where we include indicators of past economic performance in the regression along with the changes in current economic conditions. In particular, following Beaudry and DiNardo (1991), we include the unemployment rate at the beginning of a job spell, and the minimum unemployment

rates since the start of the job. The estimated equation is

$$\Delta_k w_{ijt} = \theta \Delta_k u_t + \Delta_k X_{ijt} \Lambda + \gamma_1 u_{t_0} + \gamma_2 u^{min}_{t_0,t-k} + \Delta_k \nu_{ijt} \tag{10}$$

where $u^{min}_{t_0,t-k} = \min\{u_{t_0}, u_{t_0+1}, ..., u_{t-k}\}$, and X_{ijt} denotes worker's productivity characteristics such as tenure, experience etc. Δ_k is the k-period difference operator, where k denotes the number of time periods between two consecutive observations of a worker - job pair.[13] Under the null hypothesis, u_{t_0} and $u^{min}_{t_0,t-k}$ should not carry any statistical significance.

The use of the initial and the minimum unemployment rate, as in the literature, assumes that employers commit to future employment and pay, but workers switch employers at no cost. In more general arrangements where neither side can fully commit, such extremum moments do not capture any sensible variation in wages. We, therefore, develop a second test that is more robust to different contracting schemes.

Our second test draws on the observation that the wage adjustments in a contractual market depend negatively on the insurance premium received by the worker. If a worker already earns a higher premium because he experienced favorable economic conditions while he was on the job, he will be subject to more severe wage cuts during recessions and smaller pay raises during booms relative to a worker of equal productivity. To see whether wage differences are consistent with this prediction, we estimate the following equation.

$$\Delta_k w_{ijt} = I(t \times t - k)\Theta + \Delta_k X_{ijt} \Lambda + \gamma W^p_{t-k} + \Delta_k \nu_{ijt} \tag{11}$$

where W^p_{t-k} denotes the insurance component of wages. To identify this component, we first regress wages on the interactions of job start year and current year indicators controlling for other variables in (11). Given the realized unemployment rates, the combination of start year and current year captures the entire history of economic conditions, and, hence, all possible contracting arrangements defined over the history. This procedure is identical to estimating (11) by replacing W^p_{t-k} with actual wage, W_{t-k}, and using a full set of indicators for all possible $\{t_0, t-k\}$ pairs as instruments for W_{t-k}. We use the TSLS estimate since it has the added advantage of efficiency. $I(t \times t - k)$ contains the full inter-

[13] In the data, k varies across workers, jobs and time. To save on notation, this variation is suppressed throughout the paper.

action of indicators for the current year and the previous year, and captures the changes in the economic conditions between two consecutive interviews. This also ensures that the W^p_{t-k} is identified by indicators pertaining to history strictly prior to year $t-k$.

Note that this strategy is more subtle than simply testing for a negative relationship between wage growth and wage levels. While there are other models that predict such reversion in wages,[14] they do not invalidate the test above unless the nature of this relationship displays a particular cyclical variation. We discuss such possibilities in the next section.

We also estimate more general cases of (10) and (11), where we allow for fixed effects in wage growth by worker and then by job. With our benchmark method, ignoring the potential presence of cyclical selection in growth rates leads to under-rejection of our null hypothesis. This is because only jobs with higher growth rates survive favorable economic conditions, whereas the insurance contracts foresee lower growth rates for workers who experienced favorable conditions. Therefore, we are more likely to reject our null hypothesis when we correct our benchmark test for selection.

The same is not necessarily true, however, for our second test. Although jobs are selected positively with respect to wage growth, conditional on the past wage rate, the growth rate could be selected negatively. Since workers compare discounted future wages, a workers's decision to stay when he has a low wage at his current job indicates anticipation of fast wage growth. This could lead to a negative correlation between wage levels and wage growth among surviving matches if m_{ij} and β_{ij} are initially independent as depicted in the figure. If this correlation is sufficiently positive, i.e. workers with higher wages, also have high wage growths, then a potential selection bias goes in the opposite direction. Besides, even when this type of selection predicts lower wage growth conditional on current wage, it is not clear, whether this effect systematically depends on the past economic conditions. If not, then this has no consequence for our test. The effect of cyclical selection in growth rates on the estimate of γ is therefore an empirical question. We test the robustness of our results to cyclical selection in growth rates by explicitly allowing for job-specific fixed effects in wage growth.

[14]For instance, a model of human capital accumulation with on-the-job training, as in (Ben-Porath, 1967), and heterogeneity in the initial capital endowments, would predict that workers with lower wages invest more in their training and enjoy faster wage growth.

3 Data and Estimation Results

3.1 Data

The data comes from the 1979 cohort of the National Longitudinal Survey of Youth (NLSY) for the years 1979 - 2008. NLSY is a panel that closely tracks of workers' jobs, their start dates and end dates, making it ideal for our purposes. Another popular panel used in the literature has been the PSID, however, however it is much harder to identify the job switches in the PSID,[15].

For the purpose of this analysis, we use the nationally representative cross-sectional sample. We restrict our sample to males, between 21 and 60 years of age, working full-time (35+ hours) at the time of the interview in the private sector. We exclude workers with multiple jobs, and those that are enrolled in school. We drop jobs that were started before 1976, and before the respondent was 16 years old. Appendix A provides the details on the construction of variables.

Table 1 shows the summary statistics. Workers in the NLSY are slightly younger than an average US worker, which also explains the slightly lower job tenure. After our restrictions there are 2,550 individual workers with 25,902 valid observations.

Following the literature, we use the national unemployment rate as a proxy for the overall economic conditions. Figure 3 shows the unemployment rate along with official recession dates as announced by the NBER. The sample period starts at the onset of the 1981 recession, and includes three full cycles, providing substantial variation for our estimations.

3.2 Wages and past labor market conditions

We begin our analysis by documenting the history dependence in wages. The variables of interest are the contemporaneous unemployment rate, the unemployment rate when the worker started his current job and the minimum unemployment rate since the beginning of his current job. We include controls for fixed individual effects, cubic polynomials in tenure and experience, and indicators for region and industry. To capture long term correlations between average wages and the unemployment rate, we also include a quadratic

[15] See Kambourov and Manovskii (2008) for a detailed discussion on this issue.

time trend in our regressions.

Table 2 shows the effect of past labor market conditions on wage levels for the entire sample, which includes both stayers and switchers. When wages are regressed only on the contemporaneous unemployment rate, wages appear to be strongly procyclical. An increase in the unemployment rate by 1 percentage point is associated with a 1.33% decline in wages. When the initial unemployment rate is introduced, however, the coefficient on the contemporaneous unemployment rate substantially declines, and eventually becomes statistically insignificant in column 3 when the minimum unemployment rate is included in the regression. The specification in column 4 contrast all three models at once. The past unemployment rates are not only statistically but also quantitatively important. On average, wages decline by 0.93% in response to the unemployment rate at the time of hire, and by a remarkable 2.86% in response to the minimum unemployment rate since then. The contemporaneous unemployment rate, on the other hand, is virtually zero.

Overall, the estimates confirm the marked history-dependence in wages documented in earlier studies. The coefficient on the minimum unemployment rate was estimated as -2.9% in Beaudry and DiNardo (1991), and -2.5% in Grant (2003). The coefficients on other variables are also similar, with the exception that Grant (2003) finds a stronger effect for the contemporaneous unemployment rate in his sample.[16]

3.3 Wage growth and labor market history

Is the history-dependence an indication of self-enforcing contractual arrangements in the labor market, or simply an artifact of unobserved match quality? Next, we turn to wage growth of job stayers to disentangle the two interpretations.

We begin with our benchmark specification where we assume that the wage contracts are characterized by full commitment by the employer, but not by the worker. Table 3 shows the effect of past and contemporaneous unemployment rates on the wage growth of workers who do not change jobs between two consecutive interviews. We start by regressing the wage growth on the initial unemployment rate, and the minimum unemployment rate since the worker started his job until the last wage observation. If wages are

[16]The estimates in Beaudry and DiNardo (1991) come from the PSID (1976 - 1984), and those in Grant (2003) use NLSY (1979 - 1998).

determined on the spot, these variables should be insignificant. We control for differences in cubic polynomials in tenure and experience, a quadratic time trend, and indicators for industry and region.

The results indicate that wages of job stayers are mildly procyclical; a one percent change in the current unemployment rate leads to a 0.35% decline in wages. Nevertheless, the estimate is not statistically significant. By contrast, columns 2 and 3 include the initial and the minimum unemployment rates. Both variables are strong predictors of wage growth. A worker who started his job when the unemployment rate was one percent higher, experiences, on average, 0.48% higher wage growth. similarly, a one percent higher minimum unemployment rate is associated with 1.43% additional wage growth.[17] The change in the current unemployment rate, on the other hand, is irrelevant.

In column 4, we include both the initial and the minimum unemployment rate to compare the two types of contracting models. the initial unemployment rate becomes insignificant, indicating that self-enforcing contracts with one-sided commitment are better descriptions of the reality, than full-commitment contracts. If this is the true model, then the *change* in the minimum unemployment rate is a sufficient statistic for wage adjustments. Now, we set our null hypothesis to be the implicit contracts model with one-sided commitment, and we test it by including the contemporaneous changes in the unemployment rate.

Column 5 shows the estimates. A one percent change in the minimum unemployment rate leads to a 3.15% decline in wages of job stayers, whereas the change in the current unemployment rate is irrelevant. We cannot reject the model of contracts with one-sided commitment. Note, however, that for a worker who was hired during a recovery period, the change in the current unemployment rate and the minimum unemployment rate are not separately identified for several years. Therefore, the coefficient is identified by downward movements in the unemployment rate, and by relatively older workers. This makes it hard to compare it with the coefficient of U^{min} in the previous columns.

Our findings are at odds with a pure spot market model of wage determination. Contemporaneous changes in the economic conditions do not have a significant effect on

[17] Since the number of years between two consecutive wage observations varies, the estimates do not reflect annual changes. Given the actual gaps between two observations, our calculations indicate that the annual change is roughly 80% of the estimated coefficient.

wages of job stayers. Instead, our results are consistent with a contractual market, where wages are adjusted whenever the worker's outside option binds. Furthermore, workers with higher insurance premiums, because they experienced favorable conditions since they have been hired, enjoy smaller wage raises.

3.4 Testing for contracts with no commitment

We now generalize our test to contracts where neither the worker nor the employer can fully commit to the contract. We examine whether the subsequent wage growth depends negatively on the insurance premium that worker receives (or pays). We identify the the variation in premiums due the timing of contracts by first projecting the lagged wage on a full set of interactions of indicators for the start year, t_0, and the last interview year $t-k$, where k is the time interval between two consecutive wage observations. If, in fact, wages are determined by contracts, then the insurance premiums across workers are dispensable when the participation constraints of either the employer or the worker binds. Then, we test if the subsequent wage growth is negatively related to the estimated insurance premium. This is essentially a test of mean-reversion in the insurance premium, where workers who start in a disadvantaged position catch up with other workers over time, or the workers with initial wage advantages lose them in severe downswings.

To implement our idea, we regress wage growth on the lagged wage rate and use the full set of history indicators as instruments for the lagged wage rate. To control for changes in the economic conditions between two consecutive interviews, we control for a full set of interactions of indicators for the current year, t, and the last interview year $t-k$. This insures that the identification of the insurance premium comes entirely from different histories of economic conditions across job spells. The main advantage of this method is that it is robust to any contractual arrangement that can be defined over the history of economic conditions. It therefore encompasses the case where neither the employer nor the worker can commit to honoring the contract.[18] Another advantage is that we do not need to rely on proxies, such as the unemployment rate or the market tightness, to capture the economic conditions. These proxies may perform poorly especially when the average

[18] A similar strategy was employed in Beaudry and DiNardo (1995) to estimate the intertemporal elasticity of labor supply in contractual markets

wages are non-stationary.

The last two columns in Table 3 shows our results. As before, we also control for differences in cubic polynomials of experience and tenure, a quadratic time trend, and indicators for industry and region. The results indicate that a worker who enjoys a 1% lower wage rate, for instance, because he was hired in a recession, enjoys a 0.12% larger wage growth on average. The last column uses the initial unemployment rate and the minimum unemployment rate as instruments to capture the variation in wages that are due to differential timing of contracts. This yields a coefficient of 0.18%.

These findings confirm our earlier conclusion. If the wages were described by a spot market model, the variation in wages predicted by the history indicators would correspond to real, match-specific productivity differences between jobs that were selected differently over the business cycle. There is, however, no reason to believe that workers with higher match qualities should be subject to larger cuts in downswings, and small raises during upswings. On the contrary, one would expect larger wage raises in good matches, for instance due to increased investment in job specific capital Becker (1964). In addition, given that average wage growth is positively related to observed productivity characteristics, such as education or ability, one would expect the unobserved match quality to be also positively related with wage growth.

Two additional remarks are in order. First, the two estimates are close. This shows that the market is not much different than a contractual market with one-sided commitment. Second, given the distribution of time lags in our sample between two consecutive interviews, the estimates correspond to annual differences of -0.10, and -0.15. Based on the effects of past labor market conditions in wages, these estimates indicate that the contractual variation in wages can last 6 to 10 years, once the time invariant match-quality is controlled for. Neither of these conclusions are, however, robust to selection of job stayers with respect to anticipated wage growth as we show next.

3.5 Anticipated wage growth

Our benchmark results abstracted from potential match-specific variation in the growth rate of wages. Significant variation in wage growth was documented nonetheless at the worker level (Guvenen, 2007; Haider, 2001). Such variation may arise from differences in

training contents of various career paths, or differences in ability to accumulate human capital. Variation in growth rates could also be specific to worker-employer matches due to, for instance, differences in the scopes of job specific capital or varying degrees of moral hazard problems across jobs.

If workers sort into different jobs based not only the current wage offer, but also on expected wage growth, cyclical selection of stayers could lead to a bias in our estimations above. Ignoring this endogeneity leads to selection of high-growth-paths over time. Furthermore, those who experience more favorable market conditions over his career, hold, on average, jobs with steeper wage profiles. Thus, one would expect our results in Table 3 to be stronger if the endogeneity job duration is accounted for. In this section, we address the selection in wage growth by including worker and job fixed effects.

We first address the selection of job stayers over the business cycle by including worker fixed effects in wage differences. This requires that we have at least three wage observations on the same job, or at least four observations on two different jobs to allow us to calculate two wage growth observations. Table 4 shows our estimation results. When fixed worker effects are included in the regression, the coefficients on measures of past economic activity are slightly stronger. When both the initial and the minimum unemployment rate are included, the coefficient on the minimum unemployment rate is 1.48%, compared to 1.30% in our benchmark specification. The coefficient on the change in the minimum unemployment rate remains effectively the same. This is consistent with our findings in section 1.6. Since market experience is rewarded equally at all jobs, endogenous survival of jobs does not predict a particular selection effect worker-specific wage growth.

The following columns in Table 4 control for job fixed effects. The coefficient on the minimum unemployment rate further increases from 1.48% to 2.12%. This is consistent with the hypothesis that jobs with higher anticipated growth rates are more likely to survive expansions. Then, our benchmark estimates were biased towards zero. The coefficient on the change in the minimum unemployment rate, on the other hand, remains similar. Since this coefficient is not identified during recovery periods, it suggest that the selection of job stayers is particularly important during downturns.

Note that the contemporaneous change in the unemployment rate is close to zero and insignificant in all of the specifications in Table 4.

Table 5 repeats our robust test with worker fixed effects. The first column uses the initial and the minimum unemployment rates on a job as instruments for last period's wage. The second column generalizes this test to contracts with two-sided lack of commitment. The coefficient on the lagged wage rate remains the same in the one sided commitment model. Our estimate for the two-sided lack of commitment declines substantially to -32%. This is consistent with positive selection of job stayers along the business cycle. The cyclical composition of the labor force consists of workers with particularly steeper wage profiles during expansions. It could be that employment in jobs with flatter wage profiles is more cyclical in general, or that employers prefer to hire relatively inexperienced workers during expansions rather than recessions.

When we add fixed effects for jobs, the coefficient on lagged wage further declines to -0.51. This implies that a worker who was paid a one percent higher premium because of the history of economic conditions on the job, enjoys a 41% less wage growth on average per year. In contrast to our earlier findings, when the cyclical selection of job stayers are taken into account, the effect of past labor market conditions disappears in a few years. These findings are consistent with the hypothesis that high match quality jobs are those with higher potential for wage growth.

4 Conclusion

We study the wage growth of job stayers and show that wage adjustments over the business cycle show significant dependence on the past economic conditions. On the contrary, the changes in the contemporaneous conditions do not have a significant effect on wage growth when past labor market conditions are controlled for. This is at odds with the spot market model of the labor market where wages equal marginal product at all times, and, hence, wage growth depends only on the contemporaneous economic conditions.

We find that workers who were hired in booms, and those who experienced favorable economic conditions during their tenure on the job, have lower wage raises during expansions, and larger wage cuts during recessions. This pattern of wage adjustments is instead consistent with a contractual labor market, where employers and workers partake in an implicit agreement to shield the wage payments from fluctuations in the workers' marginal product, without fully committing themselves to future payments and work.

Our results, therefore, indicate a decoupling of the marginal product from wage payments providing a potential explanation for the low elasticity of wages over the business cycle. If workers are paid under their marginal product during booms, and overpaid during recessions, than the cyclicality of wages will be much lower than the underlying fluctuations in the marginal product.

Our results also draw attention to significant cohort entry effects in wages. Workers that are hired during recessions enjoy a lower wage rate in general. Nevertheless, our estimates indicate that these effects are relatively short-lived and they disappear in a few years on average.

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A Data

The analysis focuses on male respondents in the cross-sectional sample, who at the time of the interview were not enrolled in school and were employed.

Wages: The wage is the hourly rate of pay constructed by the NLSY. Nominal wages are deflated using the annual CPI index (All Urban Consumers, U.S City Average, All Items) from the Bureau of Labor Statistics (base period 1982-84). I deflate wages using the CPI of the year when the worker last worked for the job as reported at the time of the interview. Observations with missing wage information or real wages below $1 and above $100 are dropped. Hours: These are the usual weekly hours worked. Observations with missing information on hours were dropped. The sample includes only full-time workers (usual weekly hours âL'ě 35). Class of the job: The sample includes workers in the private sector only, thus dropping government employees, self-employed and those working without pay.

Industry Classification: The NLSY has employed the 3-digit 1970 and 1980 Census classification system in the 1979-2000 surveys in order to code all jobs into industry groups. Beginning 2002, the 3-digit 2000 Census codes were used to classify industries of all jobs reported by the respondents. To minimize potential inconsistencies or the effect of coding changes due to switching from the 1970/1980 to 2000 classification system for respondents who did not change jobs between consecutive interviews, 9 broader industry groups are defined based on the reported industry classification. The groups are: Agriculture, Forestry and Fisheries; Mining; Construction; Manufacturing; Utilities, Transportation and Warehousing; Wholesale and Retail Trade; Finance, Insurance, Real Estate, Rental and Leasing; Professional, Scientific, Technical Services, Management, Administrative and Waste Management Services, Educational Services, Health Services, Accom-

modation and Food Services, Arts, Entertainment and Recreation, Other Services; Public Administration

Job start date: The starting date of the job is identified by subtracting tenure (constructed by the NLSY and measured in weeks) from the date the worker last worked for the job as reported at the interview date. Jobs that started prior to 1976 are disregarded.

Current age: The current age corresponding to each job observation is constructed as the difference between the year the worker last worked at the job as reported at the time of the interview and the birth year. The age at the start of the job is calculated as the difference between the start year of the job and the birth year of the respondent. We only consider jobs that started when the respondent was 16 or older. Moreover, we restrict attention to workers with current age 21 years old and above.

Experience: This is actual experience measure in weeks constructed by adding for consecutive interviews the "total number of weeks the respondent worked since the last interview". This variable is constructed by the NLSY for all respondents of ages 16 years old and above. The results are very similar to the usage of current age at each job observation as a measure of potential experience.

Unemployment rate: The unemployment rate is the quarterly, seasonally adjusted, civilian unemployment rate for ages 16+ obtained from the Bureau of Labor Statistics. The contemporaneous unemployment rate is the unemployment rate at the date (quarter, calendar year) when the respondent reported last working for the job. The initial unemployment rate corresponds to the unemployment rate at the date (quarter, calendar year) the job started. The minimum quarterly unemployment rate in the wage growth specifications is calculated as the historical minimum unemployment rate recorded between the date (quarter, calendar year) the job started and the last interview date (quarter, calendar year) before the contemporaneous year. All specifications are robust to the usage of annual instead of quarterly unemployment.

Figure 1: Behavior of wages in a model of insurance contracts without commitment

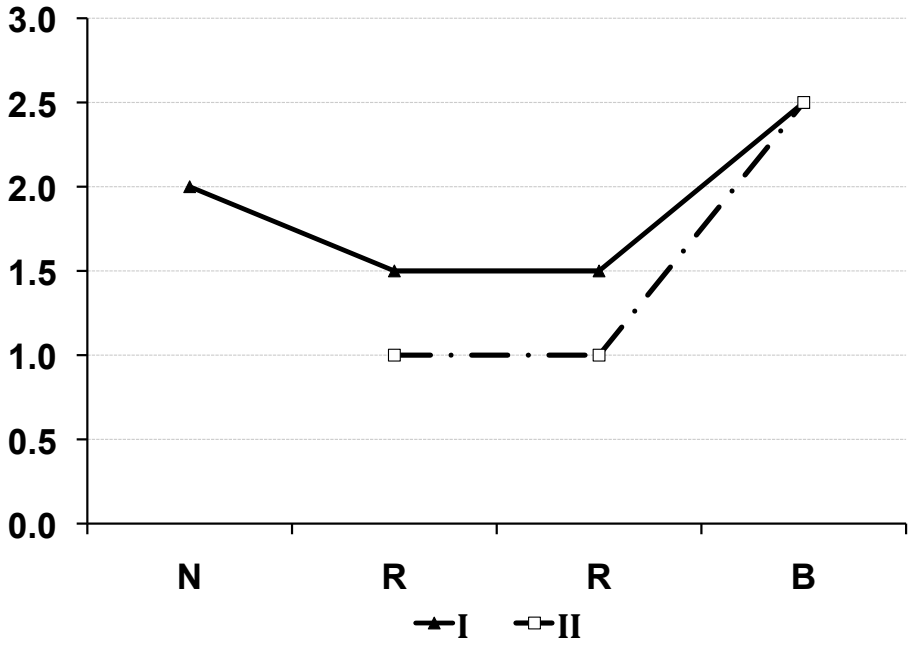

Figure 2: Cyclical selection and wage growth

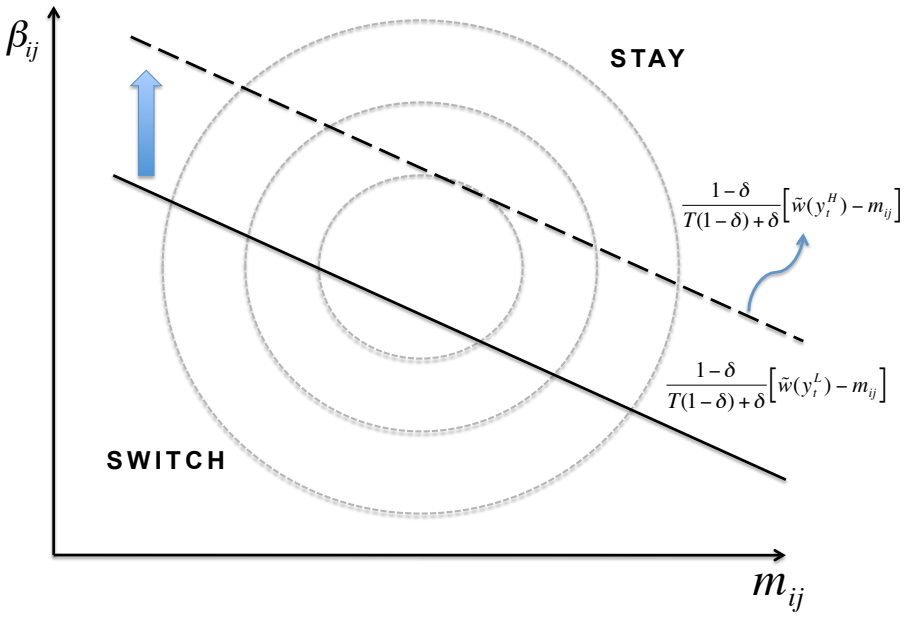

Figure 3: The unemployment rate: 1979 - 2008

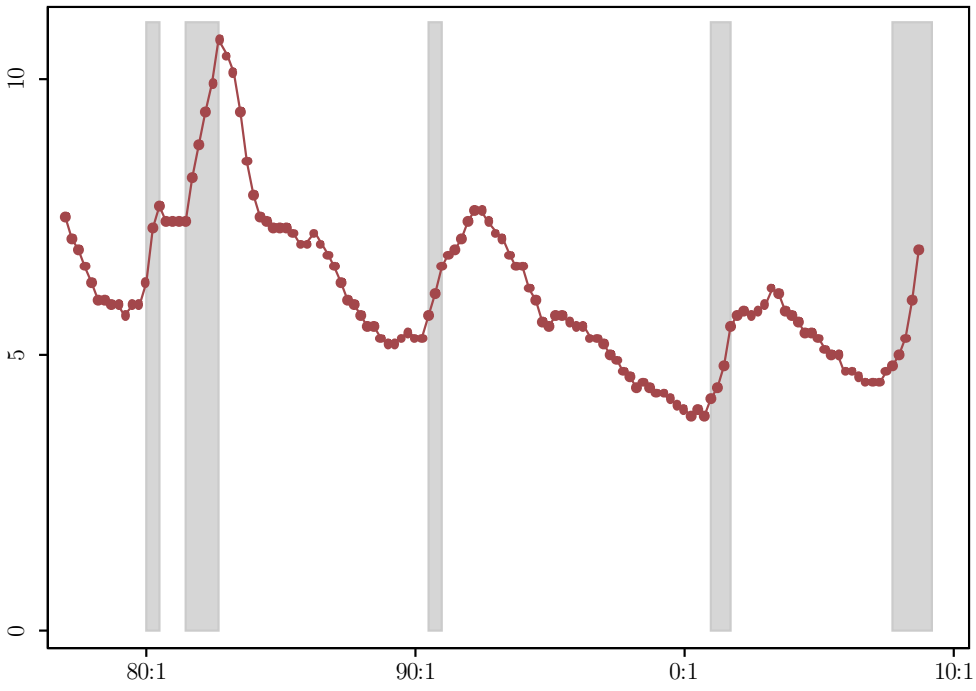

Table 1: Descriptive Statistics

	Mean	Standard Deviation
Age	31.7	7.3
Tenure	4.8	5.2
Income (log)	2.1	0.5
Weekly hours	45.6	8.8
Number of workers	2,550	
Number of observations	25,902	

Note.— Data comes from the 1979 cohort of the NLSY (1979 - 2008). Men of ages 21 to 64 who work full time in the private sector.

Table 2: Real Wages and Unemployment History

Dependent Variable: hourly wage rate (logs)				
U_t	-1.33**	-0.97**	0.08	-0.11
	(0.26)	*(0.23)*	*(0.25)*	*(0.26)*
U_{t_0}		-2.18**		-0.93**
		(0.27)		*(0.32)*
$U^{min}_{t_0,t}$			-3.8**	-2.86**
			(0.47)	*(0.55)*
Sample size	24,342	24,342	24,342	24,342

Note .—All specifications control for individual fixed effects, cubic polynomials in experience and tenure, a quadratic time trend, and indicators for industry and region. Data comes from the 1979 cohort of the NLSY (1979 - 2008). Sample includes men of ages 21 to 64 who work full time in the private sector. Standard errors are clustered by start year and current year interactions.
$*$, $**$indicate statistical significance at 5%, 1%.

Table 3: Real Wage Growth and Unemployment History: Job Stayers

Dependent Variable: $\Delta_k \ln w_{ijt}$							
$\Delta_k U_t$	-0.38	-0.27	0.08	0.07	0.15		
	(0.25)	*(0.26)*	*(0.28)*	*(0.28)*	*(0.29)*		
$\Delta_k U^{min}$					-3.15**		
					(0.85)		
U_{t_0}		0.48**		0.13			
		(0.18)		*(0.20)*			
$U^{min}_{t_0,t-k}$			1.43**	1.30**			
			(0.39)	*(0.44)*			
$\log W^p_{t-k}$						-0.12**	-0.18**
						(0.02)	*(0.06)*
Sample size	15,520	15,520	15,520	15,520	15,520	15,520	15,520

Note.– All specifications control for differences in cubic polynomials of experience and tenure, differences in a quadratic time trend, and indicators for industry and region. Data comes from the 1979 cohort of the NLSY (1979 - 2008). Sample includes men of ages 21 to 64 who work full time in the private sector. Standard errors are clustered by start year and current year interactions.
$*$, $**$indicate statistical significance at 5%, 1%.

Table 4: Real Wage Growth and Unemployment History with Profile Heterogeneity

Dependent Variable: log-real hourly wage							
$\Delta_k U_t$	-0.19	-0.07	0.26	0.25	0.30	0.4	0.34
	(0.25)	*(0.25)*	*(0.27)*	*(0.27)*	*(0.29)*	*(0.3)*	*(0.3)*
$\Delta_k U^{min}$					-3.19**		-3.12**
				(0.88)			*(0.98)*
U_{t_0}		0.77*		0.14			
		(0.32)		*(0.37)*			
$U^{min}_{t_0,t-k}$			1.58**	1.48**		2.12**	
			(0.46)	*(0.53)*		*(0.6)*	
Worker Fixed Effects	Yes	Yes	Yes	Yes	Yes	–	–
Job Fixed Effects	No	No	No	No	No	Yes	Yes
Obs.	15,520	15,520	15,520	15,520	15,520	15,520	15,520

Note.— All specifications also control differences in cubic polynomials of experience and tenure, indicators for region and industry. Data comes from the 1979 cohort of the NLSY (1979 - 2008). Sample includes men of ages 21 to 64 who work full time in the private sector. Standard errors are clustered by start year and current year interactions.
$*$, $**$indicate statistical significance at 5%, 1% .

Table 5: Real Wage Growth and Lagged Wage with Profile Heterogeneity

Dependent Variable: $\Delta_k \ln w_{ijt}$			
	I	II	III
$\log W^p_{t-k}$	-0.18*	-0.32**	-0.51**
	(0.08)	*(0.03)*	*(0.04)*
Worker Fixed Effects	Yes	Yes	No
Job Fixed Effects	No	No	Yes
Sample Size	15,520	15,520	15,520

Note.— TSLS estimates where the last observed wage,log W_{t-k}, is instrumented by a full interaction of start year and last year indicators, $I(t_0 \times t - k)$. All specifications also control differences in cubic polynomials of tenure and age, indicators for region and industry. Data comes from the 1979 cohort of the NLSY (1979 - 2008). Sample includes men of ages 21 to 64 who work full time in the private sector. Standard errors are clustered by start year and current year interactions.
* and **indicate statistical significance at 5% and 1%.