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RIGID WAGES?

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Abstract

How rigid are wages? To answer this question, I empirically investigate the nature of wage rigidity *at the individual level* and compare the results with implications of a variety of approaches to wage rigidity.

The evidence on the frequency of reported wage cuts in panel data reveals remarkable downward flexibility of real wages annually; even nominal wage cuts are not rare. With union and minimum-wage workers excluded, the distribution of wage growth is not skewed away from wage cuts. The high frequency of small wage changes is inconsistent with menu cost models that censor small wage changes. The evidence supporting nominal wage rigidity is (a) a small spike at zero in the nominal wage growth distribution, and (b) incomplete indexing of nominal wage growth to *unanticipated* inflation.

Rigid Wages?⁰

One of the mysterious things is why [employers] do not cut wages.

K. Arrow (1972)

From the Keynesian tradition to modern treatments of implicit contracts and efficiency wages, it is commonplace in economics to model the labor market with a rigid wage. As an alternative, a variety of neoclassical models of job attributes, human capital accumulation, matching, and search employ flexible wages to clear the labor market. The two approaches have squared off in many arenas, but perhaps center stage is the issue of involuntary unemployment and layoffs, which relies on the downward rigidity of wages.

Some arguments can be resolved deductively by logic, but others require evidence. Whether wages are rigid or flexible is an empirical question that has not been answered. Theory has been persuasive: downward rigidity of wages is the foundation for our understanding of involuntary unemployment and layoffs. That union contracts extend for two to three years has been influential as institutional evidence supporting wage rigidity. The direct evidence is from aggregate wage data: the real wage at the aggregate level exhibits Phillips Curve effects or insufficient cyclical variability (e.g., Hall 1975; Gordon 1983). Recent evidence from firm-level data reveals that wage adjustments to output fluctuations are fairly rigid relative to employment adjustments (Holzer and Montgomery 1990), but this is predicted by the price-taking behavior of firms in a competitive labor market.

The principal goal of this paper is to answer a single question: How rigid are

⁰For helpful comments, I thank Joseph Altonji, Gary Becker, Mark Bills, Stephen Cecchetti, Theresa Devine, Bruce Fallick, Alan Krueger, Kevin M. Murphy, Andrew Oswald, Sherwin Rosen, and participants in workshops at the following universities: Rochester, McMaster, Toronto, Penn State, Northwestern, Chicago, and Michigan. I also thank Gordon Crawford and Andre Litster for able research assistance, and Kevin J. Murphy for the data on executive compensation. This research has been supported by the John M. Olin Foundation and the Earhart Foundation through grants to the Center for the Study of the Economy and the State at the University of Chicago, and the National Science Foundation (SES-8821364).

wages *at the individual level?* I focus on the individual level because the foundation for most optimizing models of wage rigidity is consumption insurance or private information, which are likely to be more prominent at the individual level. In the presence of aggregate risk, the insurance motive would generate more smoothing at the individual level than in the aggregate. Private information is also more likely to operate at the individual level where idiosyncratic productivity shocks are important, but these shocks average out in the aggregate.

To answer this question, I empirically investigate the nature of wage rigidity at the individual level and compare the results with implications of a variety of models of wage rigidity. By cataloguing some basic facts about wage variation, the results should be helpful in evaluating the models of the labor economist. Which models fit the facts? Building up from this foundation, the results should also contribute to the debate between Keynesian and neoclassical approaches to macroeconomics.

It is useful to clarify at the outset the relationship among three concepts: wage rigidity, markets clearing, and each worker's wage equaling his marginal product and marginal value of time. First, there exist implicit contract models of wage rigidity in which the market clears with labor allocated efficiently. (See Rosen (1985) for a survey.) Second, each worker's wage might fluctuate and equal his marginal product, but the fluctuations are off the labor supply curve. Third, wages might fluctuate and reflect the opportunity costs of time, but productivities fluctuate more. Although wage data alone cannot be conclusive regarding market clearing, they can be instrumental in guiding the economics of the labor market. It is important to know whether wage rigidity is (a) an essential characteristic and justifiably the focus of our models, or (b) a minor actor from which our models of the labor market can safely abstract.

In Section I, I highlight some preliminary evidence to motivate the analysis. First, the aggregate wage data do reveal historical episodes of declining wages. Second, data on union contract settlements indicate large wage concessions. Third, I introduce the

evidence from the Panel Study of Income Dynamics to highlight the issues.

Section II presents informal implications of wage rigidity for empirical distributions of wage growth. This section also includes an empirical model of the joint determination of productivity and wages. The analysis includes a variance decomposition of wage growth to investigate the effects of various types of measurement error and self-selection in the wage data.

The sample from the Panel Study of Income Dynamics, which is the principal source of evidence for this research, is summarized in Section III. Section IV contains the empirical results on wage variability.

- (a) The wage growth distribution exhibits substantial dispersion: 43 percent of the household heads who do not change employers take real wage cuts annually. For about 17 percent of the sample, the wage cuts are nominal.
- (b) Although the wage growth distribution is more disperse for movers, the wage growth distribution of stayers is also quite disperse.
- (c) Although union workers take real wage cuts in nearly the same proportions as non-union workers, there is strong evidence of union wage compression.
- (d) Dispersion of the wage growth distribution does not appear to be driven by measurement error. The wage data are fairly clean. Also, similar wage cuts are documented using data—on union settlements and corporate executives—that are known to be clean.
- (e) For most workers, the distribution of wage growth is not skewed away from wage cuts. However, the wage growth of union and minimum-wage workers exhibits substantial skewness away from wage cuts.
- (f) Counter to the implications of the simplest menu-cost models, very small wage cuts and raises are the most common wage changes.
- (g) There is no evidence of money illusion. Wage growth moves one-for-one with anticipated inflation, and anticipated inflation has no effect on the frequency of real wage cuts.
- (h) There is some evidence of nominal wage rigidity. Nominal wage growth exhibits a spike at zero as 7 percent of the stayers report exactly zero change in nominal wages. Also, nominal wage growth moves less than one-for-one with *unanticipated* inflation, so wages are not fully indexed to realizations of the price level.

These results paint a sharp picture of wage variability at the individual level and incomplete indexation to the price level at the aggregate level.

I. Motivating Evidence

What is the current evidence on wage rigidity at the individual level? The focus of empirical research on wage behavior at the individual level has been on the position, not the dispersion, of the wage distribution. For instance, Bils (1985) estimates the effect of cyclical fluctuations on real hourly wages, and Raisian (1983) on weekly wages by experience level; Shaw (1989) estimates the effect of oil price shocks on hourly wages.

I have found only four papers that investigate whether the wages of individuals fall. First, Mitchell (1985) uses the BLS's survey of wage changes in manufacturing establishments in the 1920s and 1930s. He finds that wage changes were frequently nominal and real wage cuts, and that the frequency of wage cuts varied dramatically year to year. Second, Blinder and Choi (1990) survey compensation and personnel managers in 19 firms in New Jersey and eastern Pennsylvania. They are surprised to find that 26 percent of the firms had recently cut nominal wages. Third, Jensen and Murphy (1990, Table 7) report sizable variation in the compensation of chief executive officers. Using the Forbes executive compensation data from 1974 to 1986, they find that (a) only one-third of the sample receive growth in pay (salary plus bonus in real terms) within the range of zero to ten percent, and (b) one-third receive cuts in pay. Fourth, Mortensen and Neumann (1989, Table 13.4) study inter-firm mobility in the SIME/DIME data from the early 1970s. Their results indicate that approximately 35 percent of the movers took nominal wage cuts in the employment transitions.¹

In this section, I frame the issues by introducing a few pieces of evidence on wage variability. The evidence is presented in three parts: historical wage cuts, union wage

¹Since completing the research reported in this paper, I have discovered a short unpublished paper by Hashimoto and Raisian (1984) with the same theme: wages vary substantially and wage cuts are frequent in panel data. We produced the papers independently. Also, my research predates Farber and Gibbons (1991). In testing their model of learning and wage dynamics, they document that cuts in average hourly earnings in the National Longitudinal Survey of Youth are not rare.

concessions, and wage growth in the Panel Study of Income Dynamics (PSID).

Historical Wage Cuts

A theme of this paper is that aggregate wage data mask substantial underlying wage variability. Nevertheless, a look at historical wage data at various levels of aggregation might remind us that wage cuts have not been rare in the United States.

From the wage tables published in Historical Statistics of the United States (1975), I have compiled the episodes of falling wages, one as far back as 1785.² Whether wages are measured annually, weekly, or hourly, there are clear episodes of nominal and real wage cuts, even large wage cuts. Wage cuts are prominent for aggregates (e.g., all workers, manufacturing production workers, workers in particular industries, etc.), as well as for less aggregated groups (e.g., bituminous coal miners, ministers, artisans in Philadelphia, masons on the Erie Canal, etc.). Overall, there is clear evidence of wage cuts, both real and nominal, despite the concomitant upward trend in wages, productivity, and prices.

Union Wage Concessions

Some evidence on wage variability can be gleaned from union contract settlements. Each month in Current Wage Developments the Bureau of Labor Statistics publishes changes in union wages in bargaining units covering at least 1000 workers; some changes are contract settlements, but others are automatic escalator adjustments and deferred changes from previous settlements. Although union wage concessions in nominal terms are not so frequent to be standard, they do occur.

Consider the wage concessions of the 1980s.³ In the early 1980s, high inflation resulted in only a few nominal wage cuts. But by 1982, wage concessions ranging from

²A lengthy table summarizing the wage cuts present in all the data series reported in Historical Statistics is available from the author.

³A lengthy table summarizing the union wage concessions reported in Current Wage Developments is available from the author.

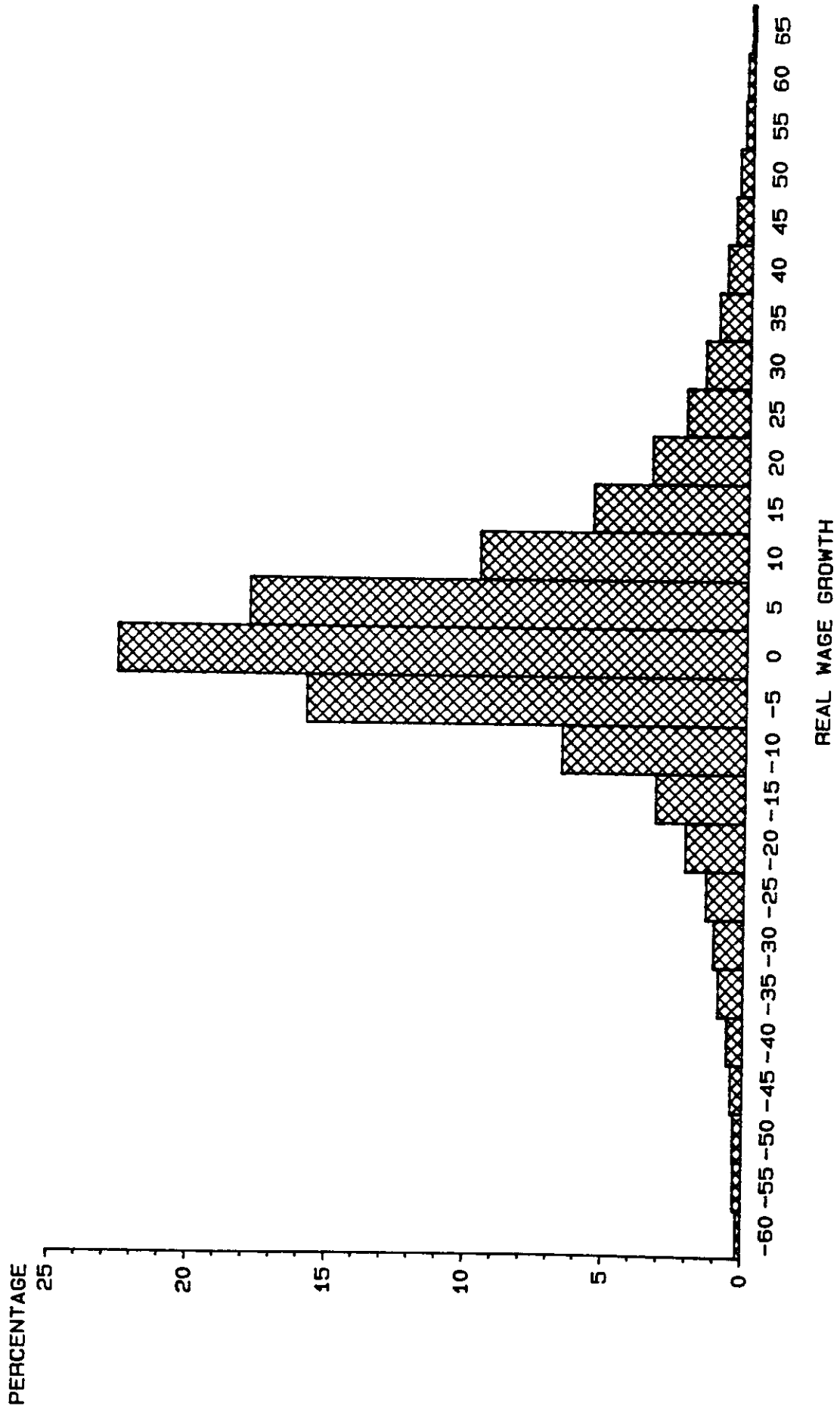
12 cents to \$3.65 per hour were not uncommon. In 1983 and 1984, nominal wage cuts in settlements were frequent, ranging from cuts of 15 cents to \$7.84 per hour. Settled cuts were also frequent in 1986, but tailed off in the late 1980s. In 1983, cost-of-living adjustments in the first half of the year resulted in hourly wage cuts of 1 to 5 cents for 1.4 million workers. COLA wage cuts nearly vanished in 1984, but hourly COLA cuts ranging from 2 cents to 13 cents for nearly one million workers occurred in mid-1986. Deferred decreases in wages were the most common form of wage concessions in 1988 and 1989.

In the 1980s, wage concessions were concentrated in four industries. From March 1981 to June 1984, at least 50,000 workers in the airline industry settled for wage cuts of 10–11 percent. In the 1980s, the steel industry had two episodes of wage concessions. From late 1982 through 1983, wage cuts in 22 settlements covering nearly 300,000 steel workers ranged from 50 cents to \$3.65 per hour. In a second episode, from late 1985 to early 1987, 16 settled concessions resulted in wage cuts of 45 cents to \$3.50 per hour for 115,000 steel workers. Settled wage concessions in the food industry were most frequent in 1984 and 1987. In 1984, more than 20,000 food workers received cuts of 25 cents to \$2.00 per hour. Wage concessions of \$1.00 to \$1.75 per hour resulted from 7 settlements covering nearly 30,000 food workers in 1987. In the food industry, deferred wage cuts of 12 cents to \$1.00 per hour were common in 1988. Construction industry settlements with more than 80,000 workers in the building trades resulted in 37 wage concessions over the period from May 1983 to July 1985. The wage cuts ranged from 5 cents to \$7.84 per hour.

Wage Growth in the PSID

The sample analyzed in the remainder of this paper is drawn from the Panel Study of Income Dynamics (PSID) data on household heads. (The sample is described fully in Section IV below.) Figure 1 illustrates remarkable dispersion in the distribution of annual real wage growth for these workers. The distribution is roughly

Figure 1
Wage Growth Distribution



Annual Differences of Log Real Wage
PSID Data: 1976-1986

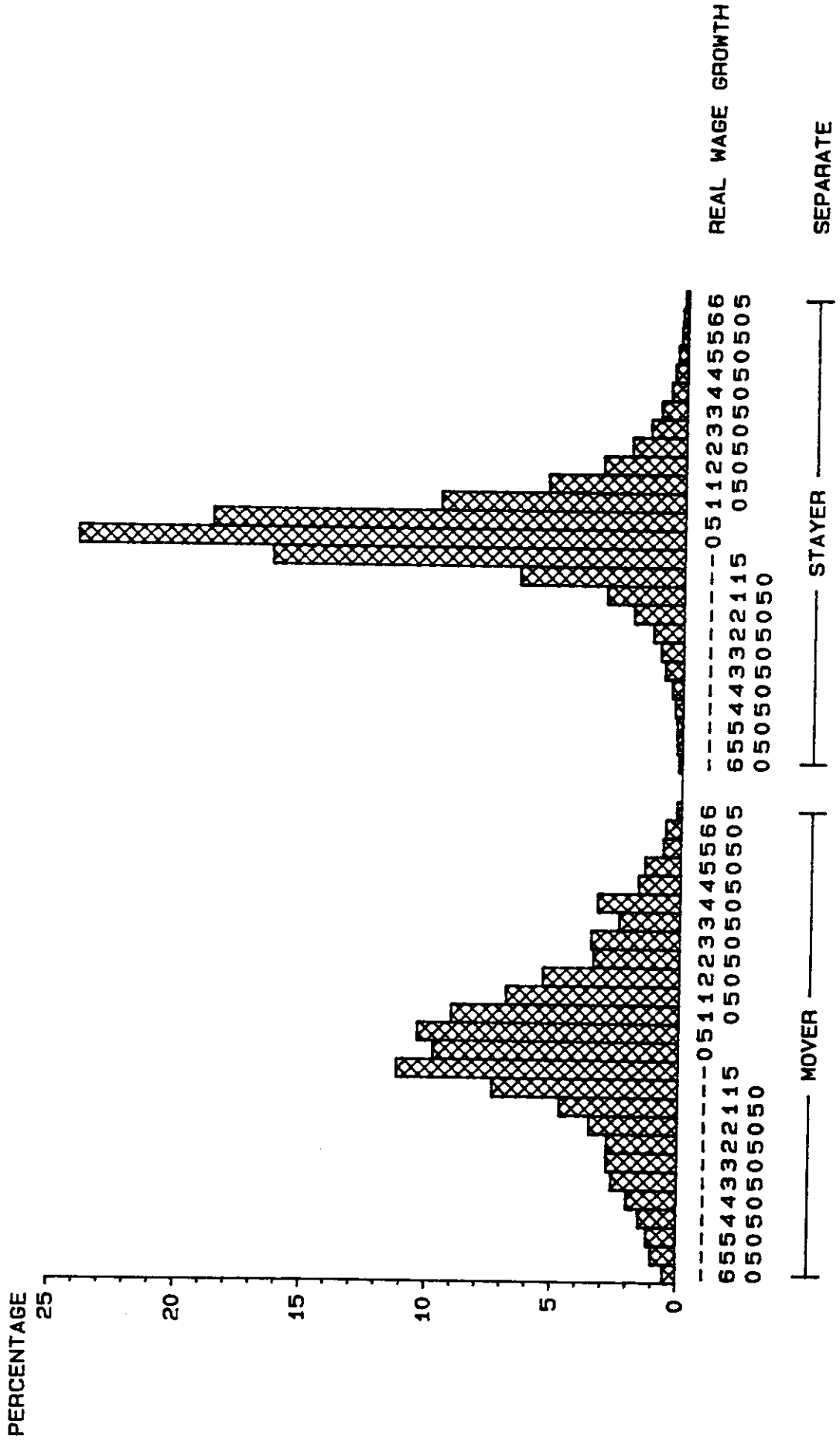
symmetric and exhibits the bell shape characteristic of the normal probability density function. Mean wage growth is 1.9 percent and the standard deviation is 15.4; nearly 65 percent of the sample exhibits real wage growth outside the interval 0 to 10 percent, and 43 percent of the sample receive real wage cuts. Taken at face value, these results are striking. But is the face value accurate?

Is the illustrated variability of wages driven by workers who change employers (movers), with stayers' wages rigid? That movers comprise only 12 percent of the sample suggests this is not the case. Comparison of the wage growth distributions of movers and stayers is illustrated in Figure 2. Although movers exhibit more variability of wages than stayers, nevertheless, the stayers' distribution of wage growth is quite disperse. Forty-three percent of the stayers take real wage cuts annually, and the cuts average 9 percent.

A second question is whether inflation is the source of the real wage cuts. Perhaps nominal wages are downwardly rigid, but Figure 1 misses the mark by plotting the distribution of *real* wage growth. That inflation averaged less than 7 percent per year over the sample period 1976–1986, and real wage cuts of 10–15 percent were not uncommon suggests that inflation is not the culprit. Indeed, the results in Section V below establish that (a) 17 percent of the stayers receive *nominal* wage cuts, and (b) inflation does not systematically fool workers into taking real wage cuts.

Two more issues require a formal treatment and more structured analysis of the data. The first is whether variation in wages is induced by measurement error in reported wages. From wage equation estimates on these data, we know there is a clear systematic component; however a sizable measurement–error component might be producing the dispersion of the wage growth distribution. Second, although the empirical wage growth distribution is quite disperse, it might be much less disperse than the productivity growth distribution. I address these issues in the next section.

Figure 2
Wage Growth Distribution
Movers and Stayers



Annual Differences of Log Real Wage
 PSID DATA: 1976-1986

II. Productivity, Wages, and Wage Rigidity

To guide the empirical work, in this section I investigate the affect wage rigidity would have on the observed distribution of wage growth. The analysis begins by considering the effect of wage rigidity in compressing the distribution of wage growth relative to the distribution of productivity growth. After briefly exploring downward rigidities, menu costs, and nominal rigidities, the analysis turns to more formal results on the effects of measurement error and self-selection.

Wage rigidity is about how frequently wages change, how much they change, and how disperse is the distribution of wage changes or wage growth. The wage could be rigid with respect to some shocks and flexible with respect to others, smoothed through time, or rigid within firms and flexible across firms, etc. But a key feature is that wage rigidity compresses the distribution of wage growth relative to the distribution of productivity growth. Consequently, the grip of the rigid wage approach weakens with intertemporal variation in the reported wages of stayers. Empirically, if the variance of wage growth were small, large wage changes were rare, and lots of unchanged wages were frequent, then the evidence of wage rigidity would be fairly strong. But if the stayers' variance of wage growth were large, large wage changes and some wage cuts were common, and unchanged wages were rare, then this would be some evidence of fairly flexible wages. Productivity might fluctuate more, but at least there would be evidence that wages vary substantially.

If more structure were imposed on the specification of wage rigidity, detecting its presence would be easier. Downward rigidities, menu costs, and nominal rigidities add more empirical content to the rigid wage hypothesis.

The fascination of economists since Keynes with involuntary unemployment has lead to an emphasis on downward rigidities. If wages were upwardly flexible and downwardly rigid, then the observed wage growth distribution of stayers would exhibit a spike at zero (from the censored wage cuts), few wage cuts, and positive skewness.

Alternatively, if menu costs were the source of wage rigidity, then small wage changes would be censored. A spike at zero wage growth, holes around zero wage growth, and fat tails would be properties of the wage growth distribution.

Within the wage-rigidity literature, there is not a consensus on whether nominal or real wages are rigid. The new micro-foundations of Keynesian macroeconomics,⁴ such as efficiency wage and segmented labor-market models, are primarily real. However, in nominal-contracting models (e.g., Fischer 1977; Taylor 1980), nominal wages or prices are rigid. So the idea of inflation as the manager's best friend in orchestrating real wage cuts warrants attention.

How does nominal wage growth respond to the inflation rate? One possibility is that nominal wage growth moves one for one with the inflation rate, so the probability of receiving a real wage cut is invariant to inflation. Another possibility is that nominal wage growth responds fully to anticipated inflation, but is rigid with respect to unanticipated inflation; therefore, unanticipated inflation would increase the frequency of real wage cuts. A third possibility allows for money illusion: nominal wage growth is rigid with respect to the inflation rate, so real wage cuts are more frequent the higher is inflation. Consequently, by estimating the effects of anticipated and unanticipated inflation on nominal wage growth and the frequency of real wage cuts, we can detect and quantify the severity of nominal wage rigidity.

Model

To identify the degree of wage rigidity and the effects of measurement error and self-selection in wage data, it is useful to sketch a model of the relationship between

⁴Keynes (1936) proposed a policy of fixing or stabilizing nominal wages: "To suppose that a flexible wage policy is a right and proper adjunct of a system which on the whole is one of laissez-faire, is the opposite of the truth. ... I am now of the opinion that the maintenance of a stable general level of money-wages is, on a balance of considerations, the most advisable policy..." (pp. 269-70). While modern Keynesian models employ wage or price rigidity to generate excessive fluctuations, Keynes himself argued for a policy of nominal wage rigidity to stabilize the economy.

productivity and wages. To do so, I model the joint determination of productivity and wages in the regression context with i indexing workers, j firms, and t time.

Productivity (in logs), denoted by M , is related to observable skills X and fixed effects for individuals, job matches, and time periods.

$$\begin{aligned} M_{ijt} &= \alpha_i + \mu_{ij} + \delta_t + X_{it}\beta_j + \epsilon_{ijt}^M \\ &= \alpha_i + \mu_{ij} + \delta_t + X_{it}\beta_j + u_{ijt} + \nu_{ijt}^T, \end{aligned} \quad (1)$$

where u_{ijt} follows a random walk: $u_{ijt} = u_{ijt-1} + \nu_{ijt}^P$. The permanent shocks ν_{ijt}^P and transitory shocks ν_{ijt}^T are independent draws from two distributions with mean zero and variances σ_P^2 and σ_T^2 . Thus the stochastic component of productivity incorporates both permanent and transitory components. The structure of the productivity process excludes worker-specific and firm-specific time effects, but is otherwise quite general.⁵

For simplicity, let the wage (in logs), denoted W , be linearly related to productivity.⁶

$$W_{ijt} \equiv \gamma_0 + \gamma_1 M_{ijt} + \epsilon_{ijt}^W, \quad (2)$$

⁵Aside from changing skills and time effects, why would a worker's productivity vary through time? Equation (1) is consistent with an equilibrium model that blends neoclassical marginal analysis and matching features to generate stochastic productivity values (McLaughlin 1991). In equilibrium, the productivity of worker i in firm j at time t depends on *all* firms' product demands, production functions, and mappings from skills into units of labor input, as well as the skill composition of the labor market. Consequently, the stochastic components of productivity result from shocks to product demands, production functions, skill mappings, and skill supplies.

⁶The conclusions that follow are quite robust to altering the specification of wage rigidity. For instance, an alternative specification lets wages vary fully with some components of productivity, but forces wages to be rigid with respect to other components. A second alternative uses a partial adjustment process to update tomorrow's wages in response to today's realization of productivity. The following results on compression, identification, and effects of measurement error and self-selection hold for these alternatives, as well as several others I have analyzed.

where the disturbance ϵ_{ijt}^W is measurement or reporting error. Let ϵ_{ijt}^W be generated as the sum of permanent, classical, and "smoothing" components.

$$\epsilon_{ijt}^W \equiv \phi_{ij} + \nu_{ijt}^C + \nu_{ijt}^S. \quad (3)$$

The permanent component of measurement error ϕ_{ij} is a "lying" factor; e.g., individual i when employed by firm j always inflates his wage by 12 percent. The classical component ν_{ijt}^C , which is uncorrelated with productivity, is designed to capture errors of knowledge and coding errors. Classical measurement error has mean zero and variance σ_C^2 . The third component of measurement error, the smoothing factor ν_{ijt}^S , is not classical; ν_{ijt}^S is assumed to be negatively correlated with the transitory component of productivity ν_{ijt}^T : $E(\nu_{ijt}^T \cdot \nu_{ijt}^S) < 0$. This captures the smoothing or mean-reverting element of survey responses (Bound and Krueger 1991). Individual i reports what he usually would be paid or his best forecast of his wage with firm j . In particular, I assume that ν_{ijt}^S is proportional to the difference between the true wage and the wage if ν_{ijt}^T were to equal zero: $\nu_{ijt}^S \equiv -\eta\gamma_1\nu_{ijt}^T$, with $\eta \geq 0$.

The productivity and structural wage equations combine to produce the commonly used wage equation.

$$W_{ijt} = \alpha_i^* + \mu_{ij}^* + \delta_t^* + X_{it}\beta_j^* + \epsilon_{ijt}, \quad (4)$$

with $\alpha_i^* \equiv \gamma_0 + \gamma_1\alpha_i$, $\mu_{ij}^* \equiv \gamma_1\mu_{ij}$, $\delta_t^* \equiv \gamma_1\delta_t$, $\beta_j^* \equiv \gamma_1\beta_j$, and $\epsilon_{ijt} \equiv \gamma_1\epsilon_{ijt}^M + \epsilon_{ijt}^W \equiv \gamma_1[u_{ijt} + (1 - \eta)\nu_{ijt}^T] + \phi_{ij} + \nu_{ijt}^C$. The disturbance ϵ_{ijt} is a mixture of random walk, time-invariant permanent, and transitory components. The specification is consistent with wage equation estimates from the PSID (Topel 1990).

The wage growth of a worker who remains with his incumbent employer is

$$\begin{aligned}\Delta W_{ijt} &\equiv \Delta \delta_t^* + \beta_j^* \Delta x_{it} + \Delta \epsilon_{ijt} \\ &\equiv \gamma_1 \left[\Delta \delta_t + \beta_j \Delta x_{it} + \nu_{ijt}^P + \Delta \nu_{ijt}^T \right] + \Delta \nu_{ijt}^C + \Delta \nu_{ijt}^S,\end{aligned}\quad (5)$$

where Δ denotes the time difference. (For notational ease, I have reduced the vector X_{it} to a scalar measure of skill x_{it} .) The variance of wage growth $\sigma_{\Delta W}^2$ is

$$\sigma_{\Delta W}^2 \equiv \gamma_1^2 \left[\sigma_{\Delta \delta}^2 + \beta_j^2 \sigma_{\Delta x}^2 + \sigma_P^2 + 2(1 - \eta)^2 \sigma_T^2 \right] + 2\sigma_C^2. \quad (6)$$

Consequently, the variance of reported wage growth is an additive function of the variances of fluctuations in productivity—both permanent and transitory— and transitory measurement error in wages, as well as the variances of changes in time effects and skills.

The expression for the variance of wage growth of movers is similar, but there are two differences. First is the addition of the variance of the change (across firms) of the match effect. The second is that the variance of $\Delta(x_{it}\beta_j)$ —with Δ representing differences across both time and firms—replaces $\beta_j^2 \sigma_{\Delta x}^2$. Each modification is expected to induce a higher variance of wage growth of movers than of stayers.⁷

Identification

For the question of wage rigidity, much of the interest turns on whether wages are less variable than productivities. Or, within the context of the model, how big is γ_1 ? The following result serves to focus the empirical exercise.

RESULT 1. The parameter γ_1 is not generally identified without productivity data.

⁷Moving cost is also a factor inducing a more disperse wage growth distribution of movers. Due to the cost of mobility, efficient mobility censors separations with small wage changes.

With observations on productivity M_{ijt} , an estimate of γ_1 could be generated directly from equation (2). Without a productivity variable, equations (2) – (6) are not useful in estimating γ_1 . That γ_1 is unidentified limits the potential of the empirical analysis. The degree of wage flexibility must be established absolutely, not relative to productivity.

The empirical literature on cyclical wage patterns also does not identify the degree of wage rigidity. Whether one follows equation (6)—as I do below—in analyzing the variance of wage growth or one follows equation (5)—as others have done—in regressing wage growth on a cyclical indicator such as unemployment rate changes, oil price shocks, or monetary growth, γ_1 is not identified without marginal productivity data. (The regression coefficient is an estimate of $\beta^* \equiv \gamma_1\beta$, but β is not known unless the regressor is marginal productivity.) Thus what is a big or small regression coefficient in terms of wage rigidity is not known. We do know that the regression coefficient is predicted to be smaller the more important is wage rigidity. Similarly, the more rigid are wages, the smaller is the variance of reported wage growth. Consequently, neither the variance approach nor the regression approach has an advantage in identifying γ_1 . However, analyzing the variance of wage growth might uncover substantial underlying wage variability that is masked by the regression approach.

Measurement Error

The specified process of wages can be used to determine the effects of measurement error components on the variance of wage growth. Four results are immediate:

RESULT 2. Permanent measurement error ϕ_{ij} has no effect on the variance of wage growth.

RESULT 3. Classical measurement error ν_{ijt}^C , which is uncorrelated with productivity, increases the variance of reported wage growth relative to the variance of true wage growth; that is, $\sigma_{\Delta W}^2$ increases with σ_C^2 .

RESULT 4. Measurement error that smooths reported wages relative to productivity, ν_{ijt}^S , decreases the variance of reported wage growth relative to the variance of true wage growth; that is, $\sigma_{\Delta W}^2$ decreases with η .

RESULT 5. The variances of transitory productivity shocks and measurement error are not separately identified with wage data alone. That is, time series properties are sufficient to identify $\gamma_1^2 \sigma_P^2$ and $\gamma_1^2 (1-\eta)^2 \sigma_T^2 + \sigma_C^2$, but σ_T^2 , σ_C^2 , and η are not identified separately.

The empirical results of Section IV use the sample variance of reported wage growth to assess the degree of wage variability. Results 1–3 establish that the effect of measurement error depends on the type of measurement error. Result 4 is important: the i.i.d. component of wages should not be used to estimate the variance of measurement error because productivity is also likely to have an i.i.d. component.

Selection Effects

The equations that generate productivities and wages, equations (1) – (4), embed population regression functions. In expressing the variance of wage growth for stayers, equation (6), I implicitly assume random sampling and ignore potentially important effects of self-selection. Self-selection can affect both the variance and skewness of empirical wage growth distributions.

Does the wage growth distribution of stayers duplicate the wage growth distribution of movers *had they stayed*? In particular, would the process generating turnover imply that the variance of stayers' wage growth overstates the movers' variance had they stayed? Consider two cases. First, perhaps the movers would face exactly zero wage growth if they were to stay, which is why they choose (or are forced) to move. Second, the stayers' variance could understate the movers' variance had they stayed. The movers might have higher variances of the productivity shocks, σ_P^2 and σ_T^2 . As long as the productivity shocks are not perfectly correlated across firms in a standard model of efficient turnover, the separation rate increases with the

variance of productivity shocks. Stayers tend to be low-variance observations. Both cases rely on heterogeneity, the first in γ_1 and the second in the variances of the stochastic components of productivity. Overall, the effect of self-selection on the stayers' variance of wage growth is ambiguous.

Self-selection can induce positive skewness of the wage growth distribution even if the underlying productivity growth distribution were symmetric and wages equaled marginal productivities (Weiss and Landau 1984). A worker with a high draw for productivity growth with his incumbent employer would be unlikely to move, but a large negative draw would generate an efficient separation. That is, draws in the left tail of the wage growth distribution are more likely to be truncated by turnover. Thus, even in the absence of downward rigidities, self-selection could produce a wage growth distribution that is skewed away from wage cuts.

III. Data

The motivating evidence in Figures 1 and 2 and the more formal evidence presented in Section IV on the dispersion of wage growth distributions rely on a sample drawn from the Panel Study of Income Dynamics (PSID). The PSID has followed more than 5,000 families since 1968, a long enough span to determine the effect of inflation on real wage growth.

The precise form of the wage data in the PSID is also well suited for studying the variability of wages. An employed household head is asked the mode of pay on his (or her) main job. An hourly worker is asked his straight-time hourly wage at the time of the annual interview; a salaried worker is asked his salary. (Nonresponses are not assigned or imputed.) I do not convert the salary to an hourly wage as variation in hours worked might induce "wage" variability where salary rigidity exists. In addition, the replication studies of Duncan and Hill (1985) and Bound, Brown, Duncan, and Rodgers (1989) conclude that large errors are introduced in wage data by dividing labor

income by hours worked even for a holder of a single job. Nevertheless, for comparison, I also present results for both earnings and hourly earnings growth distributions.

Some information is available on the pay of other workers (piece rate and commission workers, etc.), and on the overtime pay of hourly and salaried workers. The analysis is limited to hourly and salaried workers as only 56 observations on the wage growth of piece-rate and commission workers could be computed. (Preliminary analysis of the piece rate and commission workers revealed that the distribution of wage growth of these workers is substantially more disperse.) In my sample, 62 percent of the hourly and salaried workers report overtime pay. Consequently, I can compare the variabilities in straight-time pay and overtime pay.

Wage⁸ growth in year t is computed as the first difference of log wages: $\log W_t - \log W_{t-1}$. I prefer "differences in logs" to "percentage changes" based on the substantial empirical foundation of log wage equations. Also, "differences in logs" supports a test of normality. If the wage were log normally distributed, the "differences in logs" would be normally distributed. The method of computing wage growth does not affect the frequencies of negative, zero, and positive wage growth, but empirically "percentage changes" produces substantial positive skewness.

The GNP Deflator (base year 1982) converts the nominal wage to a real wage. The inflation rate is also computed as a difference in the logs, so the inflation rate is the difference between nominal and real wage growth.

In each interview year from 1976 to 1986, the sample is limited to employed⁹

⁸Hereafter, "wage" refers to the wage rate of hourly workers *and* a commensurate wage for salaried workers. The PSID reports the salary of a salaried worker in units comparable to the wage of hourly workers: annual salaries are divided by 2000 and weekly salaries are divided by 40. Division by these constants does not affect wage growth.

⁹Individuals on temporary layoffs are excluded from the sample although they do report wages on the jobs from which they are laid off. Self-employed workers are also excluded.

household heads aged 21 to 65 who report wages or salaries. Prior to 1976, the PSID's wage data are less rich. (In the early years of the PSID, straight-time pay on the main job was reported for only hourly paid workers.) Excluded from the wage growth computations are 1 percent of the observations in each tail of the wage growth distribution. This exclusion is a fairly robust method to mitigate the effects of extreme measurement error.

Table 1 displays the summary statistics for the sample, as well as subsamples by turnover status.

IV. Results

Table 2 contains the main results in the form of wage growth statistics for a variety of samples. The first results quantify the degree of wage variability illustrated in Figures 1 and 2. The wage growth statistics reported in lines 1–3 are the basis for mover–stayer comparisons. For the combined sample of movers and stayers in line 1, the standard deviation of real wage growth is 15.35, 43.1 percent of the sample take real wage cuts, and the real wage cuts average nearly 10 percent. Comparison of lines 2 and 3 reveals that movers exhibit substantially more wage growth variability than stayers. The standard deviation of wage growth is much higher for movers (23.49 for movers and 14.18 for stayers);¹⁰ 3 percentage points more movers receive wage cuts; and the average wage cut is twice as large for movers (18 percent for movers and 9 percent for stayers). The extra dispersion of the movers' distribution is consistent with either approach to wage determination.

For stayers, a comparison of real and nominal wage growth is displayed in lines 3 and 4 of Table 2. Fully 17 percent of the stayers report nominal cuts to straight-time pay annually; and the nominal cuts average nearly 12 percent. The 6.2 percent

¹⁰In lines 5 and 6 of Table 3, I have divided stayers into job stayers and job changers within the firm. Even workers who stay on the same job within the firm have a standard deviation of real wage growth as large as 13.7.

TABLE 1
SUMMARY STATISTICS
PSID, 1976-1986^a

Variables	Stayers and Movers	Stayers	Movers
Real Wages	9.06 (4.71)	9.24 (4.73)	7.70 (4.25)
Real Hourly Earnings ^b	9.84 (8.59)	10.09 (8.91)	7.98 (5.11)
Real Overtime Pay	12.04 (5.46)	12.30 (5.46)	10.11 (5.07)
Nominal Wage Growth	7.71 (15.47)	7.72 (14.31)	7.64 (23.56)
Real Wage Growth	1.90 (15.35)	1.90 (14.18)	1.91 (23.49)
Real Hourly Earnings ^b Growth	2.83 (23.45)	2.92 (22.42)	2.03 (31.14)
Real Overtime Growth	2.51 (22.96)	2.71 (20.84)	0.52 (38.04)
Age	37.66 (11.38)	38.40 (11.43)	32.09 (9.27)
Education	12.30 (2.84)	12.28 (2.87)	12.48 (2.53)
Male ^c	0.80 (0.40)	0.80 (0.40)	0.80 (0.40)
White ^c	0.64 (0.48)	0.63 (0.48)	0.68 (0.47)
Union ^c	0.32 (0.47)	0.33 (0.47)	0.20 (0.40)
Hourly ^c	0.56 (0.50)	0.55 (0.50)	0.64 (0.48)
Separation ^c	0.12 (0.32)	0.00 —	1.00 —
Number of Observations	26,985	23,844	3,141

^aThe sample contains observations on household heads reporting wages on their main jobs. After time differencing, the remaining observations on wage, hourly-earnings, and overtime-pay growth are respectively: 21,471, 21,113, and 10,706.

^bPrevious year's annual earnings and hourly earnings.

^cDummy variable.

TABLE 2

WAGE GROWTH STATISTICS^a
PSID, 1976-86

Growth Variable	Sample	Number of Obs.	Mean	Standard Deviation	Skewness	Kurtosis	Kolmogorov D	F(0) ^b	Ave Wage Cut (%)	
<i>A. Turnover Status</i>										
(1)	Real Wages	Stayers & Movers	21,471	1.90	15.35	0.04	2.94	0.103	43.1	9.8
(2)	Real Wages	Movers	2,107	1.91	23.49	-0.10	0.07	0.056	45.8	17.6
(3)	Real Wages	Stayers	19,364	1.90	14.18	0.11	3.52	0.102	42.9	8.9
(4)	Nominal Wages	Stayers	19,364	7.72	14.31	0.09	3.43	0.121	17.3 ^c	11.9
(5)	Real Wages	Stayer, Same Job	16,837	1.31	13.69	0.06	3.87	0.106	44.5	8.7
(6)	Real Wages	Stayer, Diff. Job	1,972	6.18	16.72	-0.01	2.10	0.083	31.4	10.6
<i>B. Demographic Groups^d</i>										
(7)	Real Wages	Non-Union	12,216	1.88	14.95	0.05	2.97	0.098	43.5	9.6
(8)	Real Wages	Union	6,079	1.85	11.79	0.29	4.99	0.114	41.7	7.1
(9)	Real Wages	Minimum Wage	207	2.14	14.00	0.70	4.30	0.179	52.2	6.1
(10)	Nominal Wages	Minimum Wage	207	8.39	13.93	0.70	3.78	0.196	7.7 ^c	14.2
(11)	Real Wages	Non-Union and Non-Min.-Wage	12,019	1.88	14.97	0.04	2.95	0.096	43.3	9.7
(12)	Real Wages	Regr'n Residual	19,364	0.00	14.08	0.09	3.60	0.100	52.8	8.9
(13)	Real Wages	Stable Hours	4,109	1.96	12.87	0.17	4.07	0.102	42.5	7.9

TABLE 2 (cont.)

Growth Variable	Sample	Number of Obs.	Mean	Standard Deviation	Skewness	Kurtosis	Kolmogorov D	F(0) ^b	Ave Wage Cut (%)
<i>C. CEOs^e</i>									
(14)	R. Salary+Bonus Stayers	6,647	6.99	20.33	0.85	14.17	0.108	29.5	12.08
(15)	N. Salary+Bonus Stayers	6,647	12.99	20.22	0.80	13.98	0.120	14.0	16.03
(16)	R. Salary+Bonus Regr'n Residual	6,647	0.00	20.03	0.82	14.49	0.107	54.5	11.74
<i>D. Type of Compensation</i>									
(17)	Real Wages Stayers, Hourly	9,962	1.87	11.03	0.30	5.38	0.105	42.2	6.5
(18)	Real Wages Stayers, Salaried	7,866	1.64	16.23	0.05	2.22	0.086	44.1	11.0
(19)	Real Earnings Stayers	21,259	3.27	20.74	0.11	3.62	0.101	42.8	12.7
(20)	R. Hrly Earn. Stayers	21,113	2.85	22.09	0.005	2.29	0.067	43.4	15.0
(21)	Real Overtime Stayers	10,706	2.52	16.13	0.29	3.24	0.122	42.0	9.6

^aWage growth is computed as the annual time difference of log wage.

^bF(0) is the empirical cumulative distribution function of wage growth evaluated at zero (and expressed as a percentage). It is the percentage of observations taking wage cuts.

^cIn line (4), an additional 7.2 percent of the observations report exactly zero nominal wage growth. In lines (10) and (15), the frequencies of zero nominal wage growth are 24.6 percent and 3.1 percent respectively.

^dThe statistics in this panel are computed on the sample of stayers.

^eThe CEO sample, which is not part of the PSID, is drawn from Jensen and Murphy (1990) and is described in the text.

average annual inflation rate over the sample period generates 26 percentage points more real wage cuts than nominal wage cuts. Should the empirical analysis focus on real or nominal wage cuts? Estimates reported at the end of this section imply that the 26 percentage point difference is attributable to fully indexed anticipated inflation. Consequently, in characterizing the distribution of wage growth, I focus on real wage growth.

Normality

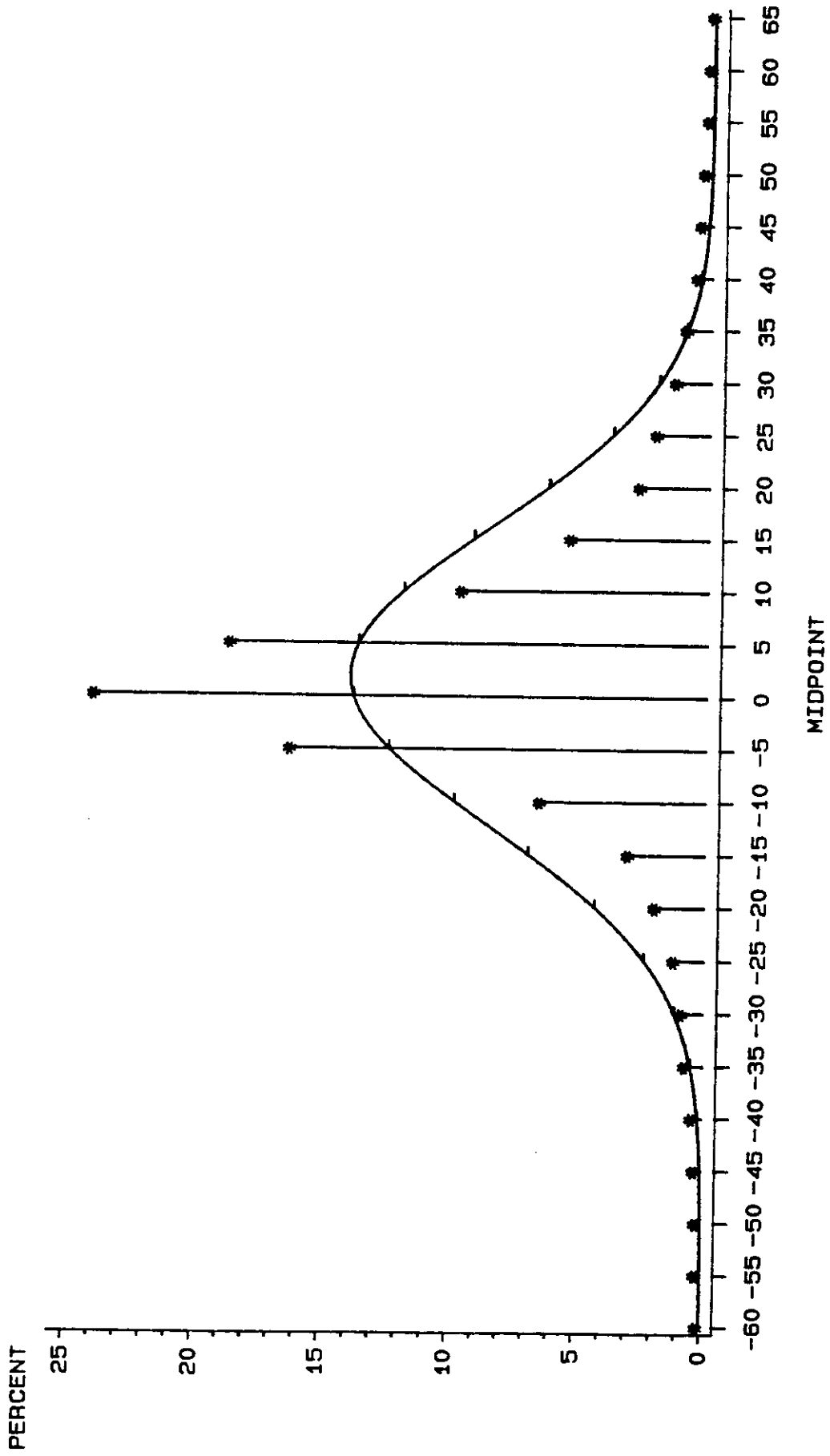
If log wages follow the normal distribution, then analysis of the dispersion of wage growth would be fully summarized by the standard deviation. For each of the 17 lines in Table 2, I present the Kolmogorov D statistic for goodness of fit as a test of normality (Bickel and Doksum 1977, 378–81; Mood, Graybill, and Boes 1974, 508–11; Stephens 1974). Consider the case of real wage growth of stayers in line 3. A D statistic of .102 is sufficient at the 1 percent level to reject the null hypothesis of normality.

The nature of the rejection is illustrated in Figure 3. The normal probability density function with mean 1.90 and standard deviation 14.18 is superimposed over the empirical distribution of stayers' real wage growth. The empirical distribution reaches a higher peak at the mode, has fatter tails, and is shallower over intermediate positive and negative values of wage growth. The kurtosis coefficient of 3.52, which is significantly different from zero at the 1 percent level, also indicates heavy tails. Like the distribution of stock returns, the distribution of wage growth is leptokurtic.¹¹

A less dramatic feature of Figure 3 is the positive (or right) skew of the empirical wage growth distribution. A value of 0.11 for the skewness coefficient is sufficiently large to reject symmetry at the 1 percent level. Substantial positive skewness is

¹¹The wage growth distribution is well approximated by the generalized- t distribution, a 4-parameter class of symmetric distributions that includes the normal as a member (McDonald and Newey 1988). Maximum-likelihood estimates of the 4 distributional parameters are available on request.

Figure 3
 Wage Growth Distribution and Normal PDF
 Stayers



Annual Differences of Log Real Wage
 PSID Data: 1978-1986

present in the wage growth distributions of union (line 8) and minimum-wage (line 9) workers, but a test of symmetry is not rejected on the sample of non-union and non-minimum-wage workers in line 11.¹²

Despite the rejection of normality, I focus on the standard deviation to gauge the degree of wage flexibility.

Intergroup Comparisons

Several intergroup comparisons of wage growth are presented in panel B of Table 2. Evidence of union wage compression is presented in lines 7 and 8. The standard deviations of wage growth of union and non-union workers are 11.79 and 14.95, respectively. Also, the wage growth of union workers exhibits substantially more skewness and kurtosis than the wage growth of non-union workers. Although, union workers take real wage cuts in nearly the same proportion as non-union workers, the wage cuts are on average 2.5 percent smaller for union workers.¹³

Other comparisons are fairly standard. In unreported results, I find that the old, experienced, and less educated take wage cuts more frequently than the young, inexperienced, and educated. How much of the dispersion of the wage growth distribution is accountable to changes in these observables and time effects? On the sample of stayers, I estimate a wage growth regression using education, experience, employment tenure, union status, and sex as observables. The residuals from this

¹²Carlton (1986) investigates the rigidity of industrial prices among individual buyer-seller pairs. He finds "no evidence to support asymmetric price changes" (p. 649).

¹³Who are the people who take nominal wage cuts? The nominal cuts are not focused on any particular group. There are some systematic differences between those with and without nominal wage cuts; however, most of the detectable differences are dominated by the variation. For instance, those who receive nominal wage cuts are on average older, with more labor market experience, and with longer employment tenure. For each of these three variables, the difference between those with and those without nominal wage cuts is only 1 year. Thus many of those who receive wage cuts are young and inexperienced. A stronger feature is that those who receive nominal wage cuts are most often in the managerial and professional occupations and in retail and wholesale trades. In particular, there are disproportionately few nominal wage cuts among craftsmen and operatives, as well as union workers in general.

regression are the estimates of $\Delta\epsilon_{ijt}$ in equation (6). The growth statistics for the residuals are reported in line 12 of Table 2. The results indicate that nearly all of the variation in wage growth is due to random productivity shocks or measurement error.

CEO Comparison

In their study of executive compensation, Jensen and Murphy (1990, 251) conclude that there are "too few major year-to-year percentage changes in CEO compensation to provide the incentives that are likely to make a substantial difference in executive behavior." Their conclusion is based on a comparison of the wage growth distribution they compute for CEOs—using Forbes executive compensation data—with my preliminary analysis of the wage growth distribution of workers in the PSID. In this section, I provide a more detailed comparison of the two groups' wage growth distributions.

Jensen and Murphy's executive compensation data spans the years 1974 to 1986. For comparability with the PSID sample, I exclude the first two years. My CEO sample contains 6,647 observations on the wage growth of male CEOs who do not change firms. For the CEOs, annual wage growth is computed as the log difference of "Salary plus Bonus".

Comparison of the wage growth statistics for CEOs and stayers in the PSID reveals remarkable differences. Consider the statistics reported in panel C of Table 2. CEOs exhibit substantially higher mean wage growth, which results in fewer wage cuts. Nevertheless, nearly 30 percent of CEOs take cuts in real salary-plus-bonus, and the cuts average 12 percent. Counter to the results reported in Jensen and Murphy's paper, the wage growth distribution is also substantially more disperse for the CEOs. (This difference is only partially accountable to the inclusion of movers in the PSID sample analyzed by Jensen and Murphy.) Perhaps the strongest wage growth difference between the CEOs and the PSID workers is in skewness. Unlike the stayers in the PSID, the CEOs exhibit substantial skewness away from wage cuts. The CEOs'

distribution also exhibits fatter tails.

Measurement Error

If the wage data were free of measurement error, or if the measurement error were limited to permanent and smoothing components, then the empirical distributions of wage growth would reveal remarkable variability. But how much error is present in the PSID's wage growth data?

As I indicated in Section III, the wage data are relatively clean. Hourly workers report their straight-time hourly wages; salaried workers report their salaries.¹⁴ Wages are not generated by dividing annual earnings by annual hours. A comparison of the distributions of wage growth, annual earnings growth, hourly earnings growth attests to the quality of the wage data. The distribution of real annual-earnings growth (line 19 of Table 2) is much more disperse than the distribution of real wage growth. Similarly, the standard deviation of real hourly-earnings growth (line 20 of Table 2) is 22.09, which is 56 percent larger than the standard deviation of real wage growth.¹⁵

Although results of validation studies do not directly indicate the quality of the wage variable used here, evidence on earnings and hourly earnings measurement error can be exploited to investigate the quality of the wage growth data. The results, which are summarized and applied in the appendix, contain three important lessons for

¹⁴One source of error in my wage growth variable might be induced by changes in mode of pay between surveys. Lines 17 and 18 of Table 3 report real wage-growth statistics for stayers who are paid an hourly wage in period $t-1$ *and* t , and for stayers who are paid salary in period $t-1$ *and* t . Stayers whose mode of pay changes between surveys (8 percent of the sample) are excluded. The results indicate that changes in mode of pay are not an important source of reported wage variability. The frequency of real wage cuts exceeds 42 percent for both hourly and salaried workers. The process generating wages of salaried workers appears to differ from the hourly workers' process as the salaried workers exhibit substantially more variability of wages.

¹⁵The dispersion of wage growth is not attributable to changes in hours worked. In line 13 of Table 3, I report real wage growth statistics for the sample of workers with fairly stable reports of annual hours worked. A worker is sorted into the "stable hours" sample if annual hours at t and $t-1$ differ by less than 50 hours, which is about 2 percent of the mean of annual hours. Compared to the full sample in line 3, the "stable hours" sample exhibits only slightly less dispersion of real wage growth.

the current analysis.

First, earnings and earnings growth data are surprisingly reliable. Bound and Krueger (1991) use matched data from the Current Population Survey and social security earnings records in finding that 83 (93) percent of the variance in men's (women's) reported annual log-earnings is true variation rather than noise. (Bound, Brown, Duncan, and Rodgers (1989) report similar estimates.) The reliability of the data survives first differencing. The ratios of signal variance to total variance for earnings growth of men and women are 0.78 and 0.85, respectively. Perhaps the "salary on the main job" data in the PSID are even more reliable.

Second, the reliability of the earnings data is underestimated because the covariance between the signal and noise is negative. That is, smoothing errors compress the distribution. For earnings growth in particular, the covariance is large and the signal-to-total-variance ratio *exceeds* one. (See the appendix.)

Third, average hourly earnings data are replete with error. Bound, Brown, Duncan, and Rodgers (1989) use the two waves of data from the PSID Validation Study of one large unionized manufacturing firm to estimate the degree of measurement error in hourly earnings data. They find that the ratio of signal to signal-plus-noise for hourly earnings *growth* of hourly workers is 0.13. Even with the large standard deviation of hourly earnings growth in the PSID, concern over the lack of reliability of the hourly workers' wage growth is probably warranted.

In the appendix, I apply the estimated reliabilities of earnings and hourly earnings to the sample of stayers in the PSID. The standard deviation of real wage growth falls from 14.18 to 12.95. (That the standard deviation falls so little is a result of the estimated high quality of the salaried workers' data.) Although there is some error in the wage growth data, a corrected standard deviation of real wage growth of nearly 13 reflects substantial flexibility.

Another approach is to identify the error components from time series properties of

wages. Although one can decompose residual wage growth $\Delta\epsilon_{ijt}$ into random walk and transitory components, the measurement error component cannot be disentangled from a transitory component of productivity (Result 5, above). Nevertheless, the time series decomposition is useful in bounding the effect of measurement error. If the variance of the transitory component is small relative to the variance of residual wage growth, the variance of measurement error must be small. From equation (7), the variance of real wage growth is the sum of the variances of observables, $\sigma_{\Delta\delta}^2 + \beta^2 \cdot \sigma_{\Delta x}^2$, the variance of the permanent shocks to productivity σ_p^2 , and twice the variance of transitory shocks, $2 \cdot [(1-\eta)^2 \cdot \sigma_T^2 + \sigma_C^2]$. Analysis of the autocovariance structure of real wage growth residuals (not reported) reveals the random walk process of real wages in panel data. The correlation of real wage growth with its first lag is -0.31 , and higher order lags are indistinguishable from zero. (See Topel (1990) for more on the time series properties of wage variables in the PSID.) Minus the covariance of the real wage growth residual with its first lag, which is the variance of the transitory component under the random walk assumption, is 7.44^2 . Subtracting twice this from the variance of the residuals yields the variance of the random walk component: $14.08^2 - (2 \times 7.44^2) = 9.36^2$. And given that the variances of real wage growth and real wage growth residuals are 14.18^2 and 14.08^2 , the variance attributed to observables is the difference 1.69^2 . Pulling these results together, I estimate that the standard deviation of real wage growth attributable to observable and random walk components is 9.51 (i.e., the square root of $14.18^2 - (2 \times 7.44^2)$), which is a lower bound for the standard deviation of the true component of real wage growth.

What is the effect of the measurement-error corrections on the frequencies of real and nominal wage cuts and on the average sizes of the wage cuts? The following exercise demonstrates that substantial flexibility survives even a sizable degree of measurement error. Assume that the standard deviation of real wage growth falls from 14.18 to 9.5 —the estimated lower bound for true wage growth—as a result of

correcting for measurement error. The wage growth observations are transformed as a *mean preserving compression* to generate a real wage growth distribution with mean 1.90 and standard deviation 9.5, and a nominal wage growth distribution with mean 7.72 and standard deviation 9.5. The frequency of real wage cuts falls from 43 percent to 39 percent, and the frequency of nominal wage cuts falls from 17 percent to 12 percent. Consequently, the estimated upper bound on the variance of measurement error renders neither real nor nominal wage cuts infrequent. However, the average sizes of the wage cuts fall more substantially. Correcting for measurement error reduces (a) the average real wage cut from 9 percent to 6 percent, and (b) the average nominal wage cut from 12 percent to 8 percent. Of course, this correction understates the amount of wage variability if, as is likely, productivity includes a transitory component.

Menu Costs

The spike at zero nominal wage growth and kurtosis suggest menu costs to changing wages nominally. In addition to the 17 percent of the stayers exhibiting negative nominal wage growth, 7 percent report *exactly* zero nominal wage growth. (Zero percent of the stayers report *exactly* zero real wage growth.) The large kurtosis coefficients reported in Table 2 are also consistent with menu costs because small wage changes would be censored. I take this as some preliminary evidence of nominal wage rigidity resulting from menu costs.

In addition, small nominal wage increases to stayers are less frequent than slightly larger increases: the frequency of 0–1 percent wage raises for stayers is 1.6 percent, of 1–2 percent raises is 2.2 percent, of 2–3 percent raises is 2.8 percent, of 3–4 percent raises is 3.5 percent, of 4–5 percent raises is 4.6 percent, of 5–6 percent raises is 4.4 percent, and of 6–7 percent raises is 5.2 percent. However, analysis of wage cuts reveals the opposite pattern. Very small wage cuts are more frequent than slightly larger wage cuts.

Consider an alternative interpretation. For most workers, real wages are flexible

even for small changes.¹⁶ Indeed, small real wage increases (0–2 percent) comprise the mode of the real wage growth distribution. But for some workers, nominal wages are rigid. Mixing of the two distributions generates (a) the spike at zero in the nominal wage growth distribution, and (b) frequencies of nominal wage changes increasing in the size of the change up to about 7 percent (slightly more than the average inflation rate in the sample).

Although the evidence is inconsistent with the simple model of a large, common menu cost that censors small wage changes, the data do not reject other specifications of menu costs. In particular, if the cost of changing a worker's wage is in evaluating his performance, the optimal contract would most likely contain infrequent evaluations and real wage changes. However, when the worker is evaluated, even the smallest change in productivity would translate into a wage change. Small wage changes would not be censored.

Wage-Cut Equations

As discussed in Section II, estimates of the effects on anticipated and unanticipated inflation on the frequency of wage cuts can be instrumental in detecting nominal wage rigidity. To estimate the probability of taking a wage cut, I extend the sample back to 1970 and aggregate 24,879 observations on the wage growth of stayers to 16 time-series observations on the following variables: average nominal wage growth, average real wage growth, and the proportions of nominal and real wage cuts.¹⁷ These four variables are supplemented with the growth rate of real output per man-hour and

¹⁶In his study of industrial price variability among individual buyer-seller pairs, Carlton (1986) finds that a substantial fraction of price changes are quite small, less than 1 percent in absolute value. He concludes: "... theories that postulate rigid prices solely because of a common high fixed cost of changing price to each buyer are not supported by the evidence" (p. 648).

¹⁷I have also estimated the wage-cut and wage-growth equations on the disaggregated data. None of the results presented in the text depends on the level of aggregation. I prefer aggregating the data because this highlights that the regressors of interest, the rates of inflation and productivity growth, do not vary across individuals at a point in time.

the inflation rate. Over the post-war period, I estimate a third-order autoregressive model of inflation to decompose the inflation rate into anticipated and unanticipated components.

In turning to estimates of inflation's effect on the frequency of wage cuts, I note one fundamental property of the wage-growth time series that drives the results. A least squares regression on the sample of 16 annual observations—and weighted by the number of underlying individual observations—reveals that nominal wage growth moves one-for-one with anticipated inflation π_t^a .

$$\Delta \log W_t = \begin{matrix} 1.82 \\ (0.80) \end{matrix} + \begin{matrix} 1.02 \\ (0.13) \end{matrix} \pi_t^a + \begin{matrix} 0.42 \\ (0.17) \end{matrix} \pi_t^u, \quad \begin{matrix} R^2 = .84, \\ DW = 1.59, \end{matrix} \quad (7)$$

(GLS standard errors are reported in parentheses.) The estimated effect of unanticipated inflation π_t^u on nominal wage growth is consistent with 42 percent indexation to surprises in the realized price level.¹⁸ These estimates are consistent with Card (1990) who finds evidence that in Canadian union contracts nominal wages are set in advance and are not fully indexed to the price level.

Table 3 displays grouped-data maximum-likelihood probit estimates of nominal and real wage cuts. In addition to imposing normality, this probit estimator weights the observations by the number of underlying observations used to compute each year's proportion, corrects for heteroskedasticity, and produces asymptotically correct standard errors. (OLS estimates are displayed for reference.) The estimates reveal how wage cuts, inflation, and productivity growth vary in the data; no attempt is made to identify structural relationships.

¹⁸The aggregated data also reveal that the standard deviation of real wage growth trends up at a rate of .14 percentage points per year, but the standard deviation is related to neither anticipated nor unanticipated inflation. Skewness, which is not trended, increases with anticipated and unanticipated inflation. This relationship between skewness and inflation is not consistent with inflation relaxing a left censoring of real wage cuts.

TABLE 3

WAGE-CUT EQUATIONS^a

Variable	Nominal Wage Cuts		Real Wage Cuts	
	OLS	Probit	OLS	Probit
Constant	0.28 (0.04)	-0.49 (0.04)	0.38 (0.06)	-0.29 (0.03)
Inflation	-1.92 (0.54)	-8.07 (0.52)	1.02 (0.76)	2.28 (0.43)
Anticipated Inflation	-2.05 (0.64)	-8.85 (0.60)	0.06 (0.67)	-0.25 (0.50)
Unanticipated Inflation	-1.67 (0.81)	-6.56 (0.78)	2.91 (0.85)	6.97 (0.64)
Productivity Growth	-0.64 (0.78)	-1.87 (0.87)	-1.09 (1.08)	-1.68 (0.70)
Durbin-Watson	1.45	1.28	1.97	1.53
R ²	.53	.54	.33	.63
Log-Likelihood		-10,809		-10,806
				-16,969
				-16,920

^aThe sample consists of 16 time-series observations computed from 24,879 individual observations on nominal and real wage cuts. The "Probit" columns list grouped-data maximum likelihood estimates of the probit coefficients and asymptotic standard errors.

The estimated effects are broadly consistent with neoclassical wage determination, but nominal contracting effects are present. First, consider the effects of inflation. The frequency of nominal wage cuts is decreasing in inflation, both anticipated and unanticipated. Anticipated inflation has no effect on the frequency of real wage cuts. Unanticipated inflation, however, increases the frequency of real wage cuts; one percentage point of unanticipated inflation increases the frequency of real wage cuts by nearly 3 percentage points. Second, turn to the effects of productivity growth. That the estimated effects of productivity growth on the frequencies of nominal and real wage cuts are significantly negative is also consistent with flexible wages: productivity growth increases the probability of receiving a raise, both nominal and real.

What bearing does this evidence of nominal wage rigidity have on the overall frequency of real wage cuts? Unanticipated inflation averaged zero from 1976–1986, so nominal wage rigidity should have little effect on the frequencies reported in Table 2. This turns out to be correct. Equation (7) is used to transform the real wage growth variable to reflect full indexation to the price level. This correction affects neither the frequency of real wage cuts (42.9 percent) nor the average real wage cut (8.9 percent).

V. Conclusions

In the twenty years since Arrow told *New York Times* readers of the mystery of wage rigidity, volumes of elegant models of wage rigidity have been published by macroeconomists, labor economists, and game theorists. And Kahneman, Knetsch, and Thaler (1986, 739) voice the conviction of many that "the existence of wage stickiness is not in doubt." But perhaps it should be.

In this paper, I document that wage cuts are frequent. Reported wages in panel data reveals remarkable downward flexibility annually; even nominal wage cuts are not rare. In addition, aggregate wage cuts historically, as well as recently, were common and sometimes deep. Union wage concessions are also observed.

Although there is clear evidence of wage variability annually, the wage data alone cannot determine whether wages are more or less flexible than productivity. Nevertheless, some forms of rigidities can be rejected by these data. The large variance of wage growth does not support contracting models with risk neutral firms and risk averse workers. The symmetry of the wage growth distribution is inconsistent with models of downward rigidities (e.g., Harris and Holmstrom 1982). Both features strain the efficiency wage models' properties of (a) super-competitive wages insulated from market forces and (b) aversion to wage cuts because they reduce effort and morale and induce the best workers to quit. Also, the high frequency of small wage changes is inconsistent with the simple model of menu costs.

The data do provide evidence of some nominal wage rigidity. There is no evidence of money illusion, and observations with no change in the nominal wage are not common; nevertheless, the data reveal that nominal wages are not fully indexed to *unanticipated* inflation. In addition, models with nominal wage rigidity are fully consistent with substantial variation in individual wages.

It is unlikely that either the rigid wage approach or the flexible wage approach alone captures all the rich features of the labor market. However, these results indicate that wage flexibility is an empirically supportable benchmark. Whether neoclassical models of the labor market can capture other salient features remains a challenge. One challenge for the rigid wage approach is in confronting the large degree of wage flexibility. Why would individual wages fluctuate sizably but not respond to market forces?

Appendix

The purpose of this appendix is to use the results from the validation studies of Bound and Krueger (1991) and Bound, Brown, Duncan, and Rodgers (1989) to correct the variance of wage growth in the PSID. With classical measurement error, the exercise would be straightforward; but with mean-reverting errors generating a negative covariance between the signal and noise, the analysis is more complicated. In the more general case the ratio of signal variance to total variance can exceed one. Indeed, this is the case for annual earnings growth in Bound and Krueger's study.

Measures of Reliability

Let wage growth ΔW be the sum of the changes in the signal $\Delta\eta$ and changes in the noise $\Delta\nu$. Most generally, the variance of wage growth is $\sigma_{\Delta W}^2 \equiv \sigma_{\Delta\eta}^2 + \sigma_{\Delta\nu}^2 + 2\sigma_{\Delta\eta, \Delta\nu}$. If the noise is classical measurement error, then the covariance is zero.

The two validation studies report several measures of the reliability of earnings and hourly earnings data. Two measures are important here.

$$(A1) \quad \lambda_1 \equiv \frac{\sigma_{\Delta\eta}^2}{\sigma_{\Delta\eta}^2 + \sigma_{\Delta\nu}^2}$$

$$(A2) \quad \lambda_2 \equiv \frac{\sigma_{\Delta\eta}^2 + \sigma_{\Delta\eta, \Delta\nu}}{\sigma_{\Delta\eta}^2 + \sigma_{\Delta\nu}^2 + 2\sigma_{\Delta\eta, \Delta\nu}} \equiv \frac{\sigma_{\Delta\eta}^2 + \sigma_{\Delta\eta, \Delta\nu}}{\sigma_{\Delta W}^2}$$

The first reliability statistic λ_1 is the signal-to-noise ratio transformed to lie between zero and one. The second reliability statistic λ_2 generalizes λ_1 for the non-zero covariance. Because λ_2 is the ratio of (a) the covariance between wage growth and the signal to (b) the variance of wage growth, it is the slope coefficient of a least squares regression of the signal on wage growth. As such, $1-\lambda_2$ is the attenuation bias resulting from using reported wage growth as a regressor.

A third measure of reliability is appropriate for correcting the variance of observed

wage growth. Let λ^* denote the signal-to-total-variance ratio.

$$(A3) \quad \lambda^* \equiv \frac{\sigma_{\Delta\eta}^2}{\sigma_{\Delta\eta}^2 + \sigma_{\Delta\nu}^2 + 2\sigma_{\Delta\eta,\Delta\nu}} \equiv \frac{\sigma_{\Delta\eta}^2}{\sigma_{\Delta W}^2}$$

If the covariance term is negative and large relative to the variance of the noise, $\lambda^* > 1$. Although the validation studies do not report λ^* , λ^* is easily computed using the reported values of λ_1 and λ_2 .

$$(A4) \quad \lambda^* \equiv \left[\frac{2\lambda_2 - 1}{2\lambda_1 - 1} \right] \cdot \lambda_1$$

Applying the Validation Results

Although the validation studies do not directly indicate the quality of the straight-time wage variable in the PSID, evidence on the reliability of the earnings and hourly earnings data can be exploited to estimate the quality of the wage growth data. The method is to apply the λ^* of earnings growth (λ_E^*) to correct salaried workers' wage growth and the λ^* of hourly earnings growth (λ_H^*) to correct hourly workers' wage growth.

Bound and Krueger (1991, Table 6), using matched data from the Current Population Survey and social security earnings records, report $\lambda_1^E = 0.648$ and λ_2^E of 0.775 for men. The two reliability statistics are 0.814 and 0.848 for women. Equation (A4) implies that λ_E^* is 1.20 for men and 0.90 for women. Although men's reports contain substantially more error than women's, the variance of earnings growth is *understated* for men due to the strong smoothing component of the men's errors. In Bound and Krueger's data and my PSID data, men comprise 80 percent of the sample. Consequently, the weighted average of the two signal-to-total-variance ratios is 1.14. This ratio *inflates* the standard deviation of earnings growth of stayers in the PSID from 20.74 to 22.14. If the signal-to-total-variance ratios are the same for earnings

growth and wage growth of salaried workers, then the standard deviation of salaried workers' wage growth grows from 16.23 to 17.33.

Bound, Brown, Duncan, and Rodgers (1989, Table 2), using the two waves of data from the PSID Validation Study of one large unionized manufacturing firm, report the degree of measurement error in hourly earnings growth data. (Their results are similar to Bound and Krueger's in validating the quality of earnings and earnings growth data.) They find that average hourly earnings data are replete with error. In particular, $\lambda_1^H = 0.179$ and $\lambda_2^H = 0.130$, which implies that the covariance between the signal and noise is positive in hourly earnings growth. Equation (A4) implies that $\lambda_H^* = 0.113$. This factor deflates the standard deviation of hourly earnings growth of stayers in the PSID from 22.81 to 7.67.

Perhaps the best estimate of the standard deviation of true wage growth in the PSID is obtained from the weighted average of the salaried and hourly workers' corrected variances of wage growth. Such a computation yields a corrected standard deviation of wage growth equal to 12.95.

A Second Correction

A second method for estimating the true variance of wage growth is to employ a control group for which the variance of the error is known. If the measurement error process is common across groups, the true variances of wage growth for other groups are identified. A variant of this method can be applied to minimum wage workers. If few minimum wage stayers report nominal wage cuts, the measurement error component is likely to be small. The results in line 10 of Table 2 indicate that workers at or below the minimum wage in period $t-1$ are less than half as likely to take nominal wage cuts as non-minimum-wage workers: only 7.7 percent of the minimum wage workers report nominal wage cuts.

How much measurement error would be required to generate a nominal wage-cut frequency of 7.7 percent if *no* wage cuts occurred? Adopt the counter-factual

assumption that wage growth of minimum wage workers is normally distributed, and let the mean take on its value in the data, 8.39. A standard deviation of the change in classical measurement error of 5.88 produces a 7.7 percent frequency of wage cuts. This implies that the standard deviation of real wage growth falls from 14.18 to 11.49, which is somewhat smaller than the estimate from the validation studies but substantially larger than the lower bound of 9.51 estimated from the autocovariance structure.

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