DISCUSSION PAPER SERIES

IZA

IZA DP No. 959

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December 2003

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zur Zukunft der Arbeit
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IZA Discussion Paper No. 959
December 2003

ABSTRACT

Real and Nominal Wage Rigidities and the Rate of Inflation: Evidence from West German Micro Data *

The paper examines real and nominal wage rigidities. We estimate a switching regime model, in which the observed distribution of individual wage changes, computed from West German register data for 1976-1997, is generated by simultaneous processes of real, nominal or no wage rigidity, and measurement error. The fraction of workers facing wage increases that are due to nominal, but mostly real wage rigidity is substantial. The extent of real rigidity rises with inflation, whereas the opposite holds for nominal rigidity. Overall, the incidence of wage rigidity, which accelerates unemployment growth, is most likely minimized in an environment with moderate inflation.

JEL Classification: J31, J51, E52

Keywords: downward wage rigidity, real effects of inflation, collective bargaining, switching regime model, West Germany

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* We wish to thank Olivier Blanchard, Erica Groshen, Mark Schweitzer and participants of the AEA Annual meeting 2003 in Washington D.C., the 17th ESPE conference in New York and the CAED 2003 meeting in London for helpful comments. William Dickens and Lorenz Götte provided invaluable support to the development and implementation of the model. The research presented in this paper is part of an ongoing international research project on downward wage rigidity, which receives financial support from the European Central Bank, the Brookings Institution and the Volkswagen Foundation. Any opinions expressed in this paper are those of the authors and should not be attributed to any of these institutions.

1 Introduction

The correct answer to the question whether there exists an optimal positive level of inflation has bothered generations of economists. In a world with downward rigid nominal wages, firms find it less difficult to cut wages in real terms when inflation is high. Hence, inflation facilitates downward adjustment of wages in the face of productivity shocks, leading to the famous claim of Tobin (1972) that inflation *greases the wheels of the labor market.* On the other hand, as argued by Friedman (1977), high inflation, usually associated with higher volatility of price changes, can lead to distortionary price and wage fluctuations by making it more difficult for agents to form precise expectations. With money illusion being less likely, and real instead of nominal wages being downward rigid, inflation only serves to *throw sand into the wheels of labor markets.* This paper contributes to the discussion by providing an empirical framework based on wage change data for individual workers. It thereby complements the attempt of Groshen and Schweitzer (1999) to decompose grease and sand effects of inflation based on wage records of firms.

A growing literature, starting with McLaughlin (1994), employs micro data to test the validity of the claim that nominal wages are downward rigid.[1] Evidence for the relevance of nominal wage rigidity is mixed. Even though there is no clear consensus in the literature yet, the findings seem to point at the existence of some nominal rigidity, however of a limited extent. A potential explanation for this is that the notion of nominally sticky wages does not coincide with the actual constraints on wage setting. While there are several theoretical arguments to support the claim that wages are not fully flexible, for example due to the possibility of efficient wage contracts, loss aversion or fairness standards,[2] it is not obvious why wage rigidity would occur at exactly zero wage growth.

In the presence of wage rigidity, firms cannot implement the wage change they would like to for certain workers. If this is the case, it seems plausible to assume that the wage is changed at the feasible rate closest to the one intended in the absence of rigidities,

[1] A non-exhaustive list of recent studies includes Card and Hyslop (1997), Kahn (1997), McLaughlin (1999), and Altonji and Devereux (2000) for the US, Christophides and Leung (2001) and Christophides and Stengos (2001) for Canada, Smith (2000) and Nickell and Quintini (2003) for the UK, Fehr and Götte (2003) for Switzerland, and Beissinger and Knoppik (2001) for Germany.

[2] Such explanations can be derived from bargaining theory, see MacLeod and Malcomson (1993) and Holden (1994). There is some evidence from surveys, see Campbell and Kamlani (1997), and behavioral experiments, see Fehr and Falk (1999), that these phenomena can indeed prevent firms from cutting wages. Bewley (1999) reviews the relevant literature.

which may be termed the rigidity bound. In the case of nominal downward wage rigidity, this bound is zero. But in principle rigidities might occur at any rate of wage growth. In particular, it is possible that agents can avert real wage cuts so that a rigidity bound occurs in the positive domain of the wage change distribution. Real wage rigidity could be particularly relevant in periods of high inflation when money illusion disappears and real instead of nominal loss aversion is likely to arise. Likewise, on labor markets with centralized wage setting through collective agreements reached by unions, real wages are presumably downward rigid. In Germany, for example, the legal setting is such that the collective wage agreement often constitutes a minimum condition for the individual firm. If trade unions strive for real wage security, the conventional emphasis on nominal wage rigidity may be of little empirical relevance.

Conventionally, real wage rigidity and its relation to employment and unemployment is analyzed on the basis of macro data within a labor demand framework, as surveyed by Nickell and Layard (1999). This framework, however, does not permit to determine what fraction of the population is indeed affected by wage rigidity, since it is not guaranteed that a labor demand curve exists if wages grow by less than the rigidity bound. In contrast to the substantial body of literature using micro data to analyze nominal wage rigidity, little work has been done to analyze the extent, the determinants, and effects of real downward wage rigidity on the individual level. McLaughlin (1994) and Card and Hyslop (1997) investigate to what extent nominal rigidities prevent real wage cuts, using the rate of price inflation as a point of reference. While McLaughlin finds little evidence for real wage rigidity in individual data from the U.S. pooled over the period 1976-1986, Card and Hyslop criticize the pooling of micro data across time as source of potential biases, and propose another methodology with extensive treatment of potential measurement error. Using U.S. data covering the period 1976-1993, they find considerable real wage rigidity as a direct consequence of nominal wage rigidity, in particular in years of low inflation.

However, the view that real rigidities are solely caused by nominal rigidities is very restrictive. Firstly, the mechanisms or constraints preventing nominal wage cuts might not be the same as those preventing real wage cuts. Secondly, price inflation might not provide the right benchmark for real wage rigidity. Rather, (expected) productivity growth or collective agreements might provide the level of wage growth that firms cannot undercut, which might vary across individuals or firms.

Based on data of individual wage changes, this paper makes an attempt to measure the frequency and the strength of co-existing nominal and real downward wage rigidity regimes when the location of the real rigidity bound is can vary across agents. It applies an empirical strategy which is based on the notion that the observed distribution of individual wage changes is generated by simultaneous processes of real, nominal or no wage rigidity, and possibly measurement error. The probabilities that an individual is in one of the different regimes are estimated by maximum likelihood.

The starting point for the econometric model is the work by Altonji and Devereux (2000) who measure the incidence of nominal wage rigidity in micro data by referring to a counterfactual wage change distribution– the wage changes firms would choose in the absence of rigidity constraints. Identification is based the following consideration: If wages are rigid, probability mass accumulates at the rigidity bound such that the observed distribution of wage changes is more skewed than the counterfactual wage change distribution. Unbiased parameters of the latter can be estimated within the empirical model using the observations of those individuals whose wages are flexible.

As shown by Dickens and Götte (2002), it is possible to extend this approach to simultaneously analyze nominal and real wage rigidity. The conceptual difficulty in the presence of real downward wage rigidity is that the location of the rigidity bound is an unknown variable. The only previous empirical study that jointly evaluates the incidence of nominal and real wage rigidity is that by Fehr, Götte, and Pfeiffer (2002). Using German micro data, they interpret real wage rigidity as contractual rigidity and impose the condition that the real rigidity bound equals the collective wage agreement applicable to the agent. The present paper, in contrast, designs the location of the individual real rigidity bound as a realization from a distribution whose parameters are estimated together with the other parameters of the model. This approach permits an investigation of the potential determinants of real wage rigidity. Technically, the model of individual heterogeneity in real rigidity bounds resembles that developed by Fehr and Götte (2003) for estimating individual specific threshold values for nominal wage cuts. For the estimation of the model, we derive individual year-to-year wage changes of prime age West German job stayers using the Regional File of the IAB Employment Subsample.

Our central finding is that, while wage rigidities are in general substantial, real downward wage rigidity seems much more pervasive than nominal wage rigidity. This holds both in terms of the extent of the rigidity measured by the fraction of workers affected, as well as in terms of the average sweep-up in wages caused by the rigidity. Moreover, both higher unemployment as well as lower inflation seem to decrease the extent of real wage rigidity, while the opposite holds for nominal rigidity.

The remainder of the paper proceeds as follows. The next section presents the econometric model and lays out the estimation strategy. Section 3 describes the data used for the empirical analysis and the extracted sample. Section 4 discusses the incidence of downward wage rigidity on the basis of the obtained parameter estimates. Section 5 searches for possible causes for, as well as consequences of the measured wage rigidity on the macro level. Section 6 provides some concluding remarks.

2 Econometric model

This section generalizes the empirical model of nominal wage rigidity developed by Altonji and Devereux (2000), in order to jointly estimate the extent of nominal and real downward rigidity of individual wages in the presence of measurement error. The basic idea underlying the approach is the notion of an optimal wage change that firms would like to implement. The distribution of these *notional* wage changes, however, is not observable in the data for two reasons: firstly, the presence of wage rigidities causes the distribution of *actual* wage changes to differ from the distribution of notional wage changes. Secondly, measurement error, which may affect workers with and without rigidity, renders the distributions of actual and *observed* wage changes different. The empirical task is to estimate the notional wage change distribution on the basis of the observed wage change distribution, and, using this counterfactual, to identify the extent of wage rigidity and measurement error in the data.

2.1 Notional, Actual and Observed Wage Changes

The notional (or counterfactual) wage change is the wage change that an employer would implement in the absence of wage rigidity and that would be observed in the data in the absence of measurement error. It reflects, for example, a change in the efficiency wage that maximizes expected profits of the firm, or, alternatively, a change in the reservation wage of the worker when the reservation wage is known by the firm and offered to the worker. We assume that the notional wage change for individual i from a given period to the next, Δw_i^n, can be written as a function of a vector of explanatory variables X_i, a vector of conforming parameters α, and a normally distributed error term ε_i with mean zero and variance σ_w^2:

$$\Delta w_i^n = X_i \alpha + \varepsilon_i \ . \tag{1}$$

The vector of controls may include personal characteristics, such as age and education, as well as firm characteristics, such as industry and firm size. We will check the robustness of our rigidity estimates using different specifications of the notional wage change equation.

The presence of rigidities truncates or censors the distribution of notional wage changes. We assume that the actual wage change distribution is the outcome of three distinct regimes: the *nominal rigidity regime* which does not permit absolute wage cuts, the *real rigidity regime* which does not permit wage growth of less than some rigidity bound different from zero, and the *fully flexible regime* which permits any wage change. The parameters α in the notional wage change equation (1) will be systematically different depending on whether the individual belongs to the group of workers under the nominal rigidity, real rigidity or fully flexible regime. The structure of our econometric model is such that actual wage growth is invariably identical to notional wage growth, if the individual is affected by the fully flexible regime. Unbiased parameters for equation (1) can only be estimated on the basis of this particular group of workers.

The groups of workers affected by wage rigidity have to be identified within the model. The propensity that an individual is under a specific regime is a latent variable. We observe, however, that the distribution of wage changes is deformed relative to the notional wage change distribution if there is wage rigidity. The mass point of the wage change distribution at the respective rigidity bound can be exploited to disentangle the mixture of regimes generating the actual distribution of wage changes.

Define P_i^n as the propensity that wages of individual i are set under the nominal regime. Likewise, define P_i^r and P_i^f as the propensities that individual i is under the real regime and under the fully flexible regime, respectively. We assume that these propensities are given by

$$P_i^j = Y_i \beta^j + \eta_i^j \ , \tag{2}$$

where Y_i is a vector of observables, β^j are vectors of parameters, and η_i^j are normally distributed error terms with mean zero, for $j = n, r, f$.

Agents can only be in one regime at a time. Therefore the number of parameters to be estimated can be reduced by defining *relative* propensities to fall under a specific regime, e.g. as follows

$$P_i^{rn} \quad = \quad P_i^r - P_i^n = Y_i\beta^{rn} + \eta_i^{rn} \text{ , and} \tag{3}$$

$$P_i^{rf} \quad = \quad P_i^r - P_i^f = Y_i\beta^{rf} + \eta_i^{rf} \text{ ,} \tag{4}$$

where $\beta^{rj} = \beta^r - \beta^j$ and $\eta^{rj} = \eta^r - \eta^j$, for $j = n, f$. We assume further that η^{rn} and η^{rf} are standard normal variables uncorrelated with the other random variables of the model.[3]

Under the assumption that actual wages are set under the regime with the highest propensity, we can use expressions (3) and (4) to construct the actual wage change for individual i, Δw_i, as

$$\Delta w_i = \begin{cases} r_i & if\ P_i^{rn} > 0 \ \wedge \ P_i^{rf} > 0 \ \wedge \ \Delta w_i^n \leq r_i \\ 0 & if\ P_i^{rn} < 0 \ \wedge \ P_i^{rn} - P_i^{rf} < 0 \ \wedge \ \Delta w_i^n \leq 0 \\ \Delta w_i^n & otherwise \end{cases} , \tag{5}$$

where r_i is the location of the real wage rigidity bound for individual i. Wage rigidity only constrains the wage setting for those individuals whose notional wage change is below the real rigidity bound at r_{it}, or below the nominal rigidity bound at zero. Equation (5) assumes that rigidity sweeps wage changes up to the relevant rigidity bound for workers with constrained wage setting. This concept is slightly different from the approach of Altonji and Devereux (2000), who assume that individuals in the nominal rigidity regime cannot take *small* wage cuts while wage cuts larger than a threshold value are feasible. Our model puts agents who take large wage cuts into the fully flexible regime. We will call the wage setting for individuals falling under the nominal or real rigidity regime and whose notional wage changes exceed the respective threshold level *unconstrained.* Wage setting for those individuals whose notional wage changes fall short of the respective threshold is called *constrained.*

The real rigidity bound might reflect, for example, collectively bargained wage agreements for a sector or occupation, or the inflation rate expected by firms or workers. It

[3] This assumption is common practice in switching regression models. Without standardization, the regime propensities and the variances for the error terms would only be identified up to a constant of proportionality.

is likely to vary across individuals. We introduce the possibility of heterogenous rigidity bounds by assuming that the location r_i for individual i is given by

$$r_i = \begin{cases} Z_i\gamma + \nu_i & if\ P_i^{rn} > 0 \quad \wedge \quad P_i^{rf} > 0 \\ \cdot & otherwise \end{cases} , \tag{6}$$

where Z_i is a vector of controls, γ a vector of conforming parameters and ν_i is a normally distributed error term uncorrelated with the other error terms of the model, with mean zero and variance σ_r^2. As a real rigidity bound only exists for individuals falling under the real rigidity regime, the parameters γ are identified using the observations for this particular group of workers.

If there is recording or reporting error in wage levels, observed wage changes differ from actual wage changes. To incorporate the possibility that a fraction of wage changes is not correctly observed, we follow the mixed model of measurement error in wage levels proposed by Altonji and Devereux (2000). Measurement error can affect the observed wage change by altering the observed wage at the beginning of the measurement period, or by altering the observed wage at the end of the period, or both. We assume that the probability of mis-measurement, P^m, is the same in each case. Furthermore, we assume that the error in wage levels is i.i.d. across time and individuals and normal with mean zero and variance σ_m^2. We can therefore construct a composite error term for individual wage changes, $\tilde{u}_i$,

$$\tilde{u}_i = \begin{cases} u_i^0 \sim N(0, \sigma_m^2) & & P^m(1 - P^m) \\ u_i^1 \sim N(0, \sigma_m^2) & \text{with probability} & (1 - P^m)P^m \\ u_i^0 + u_i^1 \sim N(0, 2\sigma_m^2) & & (P^m)^2 \\ 0 & & (1 - P^m)^2 \end{cases} , \tag{7}$$

where u_i^0 is the error in the level of the starting wage and u_i^1 is the error in the level of the final wage, for individual i. Using the composite error term, which we assume to be uncorrelated with the other error terms of the model, we can write the observed wage change for individual i, Δw_i^o, as

$$\Delta w_i^o = \Delta w_i + \tilde{u}_i \ . \tag{8}$$

The composite specification of the error structure only identifies three regimes: a *no error regime* where the actual wage change is observed, a *one error regime* with measurement error in either the starting or in the final wage, and a *two error regime* with measurement error both in the starting wage and in the final wage. This simplification of the error structure is convenient since the only parameters to be estimated are the share of incorrect observations in the data and the variance of measurement error in wage levels in of the two observations used to compute a wage change.[4]

2.2 Estimation

The econometric model assumes that the observed distribution of individual wage changes is the outcome of a mixture of various wage setting regimes, which are summarized in Table 1. For each individual, wages are set under one of three possible regimes: the real rigidity, the nominal rigidity or the fully flexible regime. Wage growth under the fully flexible regime is never constrained by definition. This means that the actual wage change of an individual in this regime equals the notional wage change. Wage setting under the nominal or real rigidity regimes, however, can be either constrained or unconstrained. The respective rigidity bounds only bind in cases where the notional wage change is smaller than the relevant threshold. Finally, irrespective of the specific wage setting regime at work, wage changes might be measured without error, with one error or with two errors in the two wage levels required to compute an individual wage change observation.

According to the model, the probability that the wage change observation for an individual is generated by one of the 15 possible regimes is a function of a set of observed characteristics of the individual $C_i = (X_i, Y_i, Z_i)$ and the vector of model parameters $\Omega = (\alpha, \beta, \gamma, \sigma_w^2, \sigma_r^2, \sigma_m^2, P^m)$. Given a set of individual wage changes Δw_i^o and data on individual characteristics C_i, the parameters of the model can be estimated by maximum likelihood. The likelihood function is obtained by combining the probabilities that an observation is generated under a specific regime. The function to be maximized with respect to Ω can be written as

$$\begin{aligned} L(\Delta w_i^o|\Omega, C_i) = \prod_{i=1}^N \Big[\quad & I_{(\Delta w_i^o=0)} P(\Delta w_i^o \in NC0) + \\ & I_{(\Delta w_i^o>0)} P(\Delta w_i^o \in NU0) L(\Delta w_i^o) + \\ & \sum_{j \in R, j \neq NC0 j \neq NU0} I_{(\Delta w_i^o \neq 0)} P(\Delta w_i^o \in R) L(\Delta w_i^o) \Big] , \end{aligned} \quad (9)$$

where R refers to the set of possible regimes as categorized in Table 1, N is the number of

[4] We refrain from assuming a more general error distribution, since measurement error does not appear to be a serious issue in our empirical application, which is based on high-quality register data.

observations, $I_{(\cdot)}$ are indicator functions taking a value of unity if the condition in parentheses is satisfied and zero otherwise, $P(\Delta w_i^o \in R)$ is the probability that an individual is in a certain regime conditional on the observed wage change, and $L(\Delta w_i^o)$ is the likelihood of an observed wage change Δw_i^o.

Equation (9) describes the basic structure of the likelihood function. The details of the likelihood are discussed in the appendix. In general, the contribution of each wage change observation to the likelihood is the product of three probabilities: the probability that the wage of an individual is set under a given rigidity regime, the probability that a wage change observation is affected by a certain measurement error regime, and the probability that wage growth is constrained (or unconstrained) conditional on the regime. These probabilities can be expressed as constraints on the error in the notional wage change equation (1), the errors in the regime switching equations (3) and (4), and the composite error in the observed wage change equation (8).

In principle, any observed wage change can be generated by any regime with the exception of the constrained and unconstrained nominal rigidity regimes with no measurement error. The regime NC0 is unique in that the probability of observing non-zero wage changes is zero. Thus the probability of the regime conditional on the observed wage change collapses to an unconditional probability.[5] The regime NU0 is also special, since it cannot generate wage cuts. Therefore, only positive wage growth observations are considered evaluating the contribution of this regime to the likelihood.

Intuitively, differences between notional and actual wage changes, and thus the incidence and extent of nominal and real rigidity, are identified by observing differences in the structures of the observed and notional distributions of wage changes. Spikes at wage changes of zero and of the real rigidity bound occur in the presence of rigidities. In the case of downward rigidity, the observed density in the left neighborhood of the spike is smaller than that in the right neighborhood. The larger this difference in densities, the larger the fraction of observations affected by rigidity.

Incidence and variance of measurement error, and thus the difference between observed and actual wage changes, is identified by considering observations just around the spikes. Few observations in the very close left and right neighborhood of spikes indicate

[5] While zero wage changes can occur in any regime apart from NU0, the conditional probability of exactly zero wage growth is zero for these regimes.

infrequent measurement error. The parameters governing the distribution of notional wage changes, which provides the counterfactual distribution for the identification of spikes in the actual wage change distribution, are derived from a censored regression model. Unbiased parameter estimates are obtained by correcting for the fact that wage changes smaller than the nominal and real rigidity bounds are not observed for certain fractions of the population.

Our empirical model is likely to tax the identifying information in the data. Since very few individual characteristics are observable, we reduce the number of parameters to be estimated by assuming that Y_i and Z_i in equations (3), (4) and (6) are equal only up to a constant. Put differently, we assume that the probability that the wage faced by an individual falls under a given rigidity regime does not depend on the individual's observed characteristics. Likewise, we do not allow that the location of the real rigidity bound depends on observable differences between individuals. Therefore, we can only recover the incidence of the wage rigidity and the size of the corresponding wage sweep-up on the macro level. Observable individual heterogeneity still enters the analysis through the process generating the notional wage change distribution.

3 Data and Sample

For the empirical analysis we take data from the Regional File of the IAB Employment Subsample (IABS-R). The structure of the IABS-R is very similar to the more widely used standard IAB Employment Subsample, but covers a longer time span ranging from 1975 to 1997.[6] The IABS-R is based on a one percent random sample drawn from German Social Security records, to which all employers are obliged to report at least once a year. The wage information available for employed individuals therefore covers all earnings subject to statutory Social Security contributions. The data is in the form of an event history, which allows to recover the duration of workers' employment and unemployment spells. Wages are reported as gross earnings per day of an employment spell, rounded to the lower integer.

The IABS-R has some limitations. By construction, it misses groups not covered by the mandatory social security system, namely the self-employed, civil servants and workers

[6] For an introductory description of the IABS, which for the most part also applies to the IABS-R, see Bender, Haas, and Klose (2000).

engaged in minor employment contracts. If agents react to wage rigidities by moving in or out of these types of employment, our measurement of the incidence of wage rigidities may be biased. Exclusion of minor employment furthermore truncates the earnings distribution covered by the data at the bottom. Besides, reported earnings are censored at the top. A peculiarity of the German Social Security scheme is that earnings are subject to contributions only up to a unitary threshold. For earnings exceeding the threshold, the IABS-R only reports the threshold value so that actual earnings are unknown. Since we cannot compute wage changes for censored earnings, we eliminate individuals with earnings observations at, or closely below, the threshold. While this approach is common practice, it is important to note that it changes the skill composition of the sample. High-skilled workers are removed more than proportionally. This might cause another selection bias in our rigidity measures, if wage rigidity is correlated with the skill (or wage) level.

A major advantage of the IABS-R earnings data is their official status. There are legal sanctions for misreporting earnings and plausibility checks are performed by the Social Security authorities. Therefore the data are likely to be less affected by reporting or recording error than the survey data frequently used by empirical studies on nominal wage rigidity. Nevertheless problems of unobserved variability in wages arise which are not accounted for by our econometric model of measurement error. One problem is that only categorized information on working hours (full-time, part-time, less than part-time) is available. If hours worked by an individual change within a given category, the corresponding earnings change is not the same as the *wage* change conceptualized by our model. Since fluctuations in working hours tend to be more frequent among employees working less than full-time, we limit the sample to full-timers. This approach does not resolve, however, issues related to overtime.[7] Fringe benefits are another source of potential measurement error. One-time payments were not subject to Social Security contributions and therefore not systematically reported by employers prior to 1984. This causes a structural break in the wage change data at this date. More importantly, if one-time payments are more volatile than regular pay, it is possible that we overestimate wage rigidity at the beginning of the observation period.

[7] Overtime hours might be compensated with higher earnings or spare time. Accurate evaluation of wage changes not only requires information on overtime hours worked, but also on the relevant compensation scheme. Neither is available in our data. Moreover, related work for Germany indicates that the incidence of overtime work seems to be fairly stable, see Bauer and Zimmermann (1999).

The central data requirement for the empirical analysis is the distribution of individual wage changes over a given period. We concentrate on year-to-year wage growth, which we define as the difference in log wages as reported in the IABS-R, over a time interval lasting from September 1^{st} to September 1^{st} of two consecutive years. Given that our time frame mostly covers the second year, we will use the later period to label our annual observations.

We limit the sample to full-time prime age (25-55) workers not in apprenticeship training. Furthermore we concentrate in our analysis on individuals employed in West Germany, since wage developments in East Germany are mostly driven by the transition crisis after German unification, see Hunt (2001). Finally, the analysis is limited to job *stayers*. We define job stayers as workers who are continuously employed with the same employer and in the same occupation at the 3-digit level, during the full length of a given year. Integration of job movers would require introducing individual heterogeneity in regime propensities conditional on the reason of the job move. On the one hand, movers who voluntarily quit are more likely to be under the flexible regime. On the other hand, if adjustment of employment is a correcting mechanism for wage rigidity, involuntary movers due to dismissals are less likely to be under the fully flexible regime. We refrain from analyzing job movers, since the reason for a job change, quit or dismissal, cannot be retrieved from our data.

The data restrictions leave 22 years of observations containing between 63,984 and 86,437 individual wage changes in the private sector for the period 1976-1997. Figure 1 plots the mean of the wage change distribution for each year of the observation period. The ups and downs of mean wage growth closely follow the business cycles of the West German economy. In the second half of the 70s, Germany recovered from the oil crisis recession, and experienced relatively high GDP growth rates (4-6%), not depicted in the figure. This period of high growth was succeeded by a severe recession (real GDP contracted in 1982), followed by a moderate economic upswing during the mid-1980s. The mean of individual wage changes clearly followed the growth pattern also when the moderate economic downswing of the later 80s was overturned by the re-unification boom, which led growth and wage rates to rise to similarly high figures as at the beginning of the sample period. After the re-unification boom, both economic and mean wage growth steadily declined.

Figure 1 also draws time series of variables that are likely to have an impact on nominal wage growth. Mean wage growth seems to be always larger than price inflation as measured by the GDP deflator, unless the economy is close to recession, as it was, for example in the early 1980's.[8] It seems that a wide majority of job stayers benefits from real wage growth over time. Mean wage growth in our sample is highly correlated ($\rho = 0.84$) with average growth of hourly wages in the total labor force, as agreed on by trade unions. In most years, union wage growth exceeds price inflation, which illustrates that unions appropriate some of the gains from real productivity growth, but is smaller than mean wage growth. This suggests that wage drift is a relevant phenomenon. Many workers receive higher wage increases than are designated by collective agreements. With wage drift, actual wages are not necessarily downward rigid even if unions set an effective floor for wage growth. In other words, one cannot *a priori* conclude from aggregate data that collective bargaining outcomes limit wage flexibility.

Figure 2 displays the full distribution of individual wage changes for all years contained in our sample. The central bin of each histogram measures the frequency of wage changes of exactly zero, whereas the adjacent bins cover small wage cuts (increases) of less than (more than) 0.01 log points. Of course, the specific wage change distribution for a given year is dominated by historical circumstances. Nevertheless the sequence of histograms exhibits some striking regularities. Firstly, in almost every year there is a prominent spike at exactly zero. In addition there is an asymmetry around the spike: negative wage changes close to zero are less frequent than positive wage changes close to zero, leading to the impression of skewness to the right. Skewness also seems to be prominent around the mode of the distribution, illustrated by fewer observations of positive wage changes below the mode than above. In accordance with the rigidity concept built into our empirical model, these observations might indicate the presence of nominal *and* real downward wage rigidity in the data. Secondly, compared with the number of observations at exactly zero, the number of observations in the neighboring bins in general is small. This suggests that the data measures individual wage changes fairly accurately. Measurement error would inflate the frequency of very small wage changes at the expense of exactly zero wage changes.

[8] The same is true considering consumer price inflation (CPI). We focus on the GDP deflator as a measure for price inflation, as it covers a wider basket of commodities. We use CPI, however, for sensitivity checks of our empirical results on the macro level where appropriate.

Taken together, the descriptive evidence suggests that both nominal and real rigidity shape the observed wage distribution which is not too different from the actual wage change distribution as measurement error is rare. We now turn to the estimation of our empirical model in order to substantiate these claims.

4 The Extent of Real and Nominal Wage Rigidities

For each cross-section of individual wage changes, we obtain a set of parameter estimates determining the population share of the various wage setting regimes. This section discusses the variation in the incidence of nominal and real wage rigidity over time. The benchmark for judging the wage effects of downward wage rigidity is the notional wage changes estimated for those individuals who are in the fully flexible regime. We first present results obtained from a parsimonious specification of notional wage changes that only accounts for officially recorded worker characteristics. To be specific, our baseline specification includes age, age squared, gender and occupational status (blue vs. white collar), as well as a constant, as explanatory variables in equation (1). For a robustness check, we will then turn to several richer specifications including occupational and self-reported individual characteristics.

Table 2 compares key moments of the wage change distribution as simulated on the basis of the maximum likelihood parameter estimates for the baseline model I to the moments of the wage change distribution of our sample of workers employed in the private sector. Despite the sparse parametrization of notional wage changes, it seems that the empirical model satisfactorily replicates the data. In particular, while the simulated means of the wage change distribution are consistently slightly smaller than the sample means, the two medians are very close. This implies that the simulated wage change distribution is somewhat less skewed to the right than the sample distribution. Since downward wage rigidity leads to higher skewness, the model, if anything, seems to slightly underestimate the extent of wage rigidity.

In Table 3 we summarize the estimates for the notional wage change, real rigidity bound and measurement error parameters of the model. The estimated fraction of mismeasured wages P^m is less than five percent for all years. This confirms that reporting error is not a serious issue, as one would expect of wage data from social security registers.

Measurement error, if it occurs, is rather large, as is indicated by the estimated values for the standard deviation σ_m. This parameter, however, should be interpreted with caution, since it most likely reflects outliers in the tail of the observed wage change distribution, which are difficult to explain by the notional wage change distribution. The estimated size of the standard deviation of the unobserved heterogeneity component impacting notional wage changes, σ_w, appears more reasonable. A range of 0.054 to 0.087 log points is in line with the variation of individual wage changes in the data. The mean of the estimated notional wage change distribution is considerably smaller than that of the observed wage change distribution (compare also Figure 1). This indicates that wage sweep-ups to the nominal or real rigidity bound due to constrained wage setting are likely to be substantial.

Variation in the individual location of the real rigidity bound is relatively small. The estimated standard deviation around the mean γ, σ_r, is generally less than 0.02 log points. One possible explanation for this finding is that some collective behavioral pattern compresses the distribution of the lower bound for wage growth under the real rigidity regime. The fact that the movement of the estimated mean of the real rigidity bound is highly correlated with union wage growth ($\rho = 0.91$) seems to be consistent with this hypothesis. Nevertheless the interpretation that collective wage agreements in a year set the floor for firms adjusting wages is too simple. As shown in Figure 3, which draws a confidence band of plus/minus one standard deviation around the real rigidity bound, the average collective outcome is clearly above the mean of the rigidity bound in numerous years, especially in the second half of the observation period. Judged by the correlation of the GDP deflator and γ ($\rho = 0.86$), inflation might as well be the yardstick for minimum wage growth. From the figure it also emerges, however, that aversion against real wage cuts does not fully explain the real rigidity bound. A substantial fraction of workers under the real rigidity regime, if constrained, experiences an increase in the purchasing power of their wages.

How relevant is this case? Table 4 presents the incidence of the fully flexible as well as the real and nominal wage rigidity regimes in the private sector as estimated by our model. Note that the incidences of the three regimes add up to 100%, since each represents an exclusive state. The real rigidity regime clearly dominates the nominal rigidity regime. The population share of the nominal rigidity regime, without any strong trend, fluctuates between 13 and 20 percent throughout the observation period. In contrast, 30 to 70 percent of wages are set under the real rigidity regime, where the fraction was between 60 and 70 percent during the late 1970s, around 50 percent during the 1980s, and around 30 to 40 percent during the early 1990s. The decline of the real rigidity regime takes place during a period of declining GDP growth, inflation, and union power. According to Schnabel and Wagner (2003), union density fell from roughly one third to roughly one quarter during the observation period. Therefore, if centralized wage bargaining was the dominant source of downward real wage rigidity, collective wage agreements would have to cover a substantial amount of non-union workers. Indeed, union coverage in Germany is more widespread than union membership as indicated by recent evidence from survey data gathered by Franz and Pfeiffer (2002).

Time series variation in the share of workers under fully flexible wage setting mirrors the development of the other two regimes. The incidence of the flexible wage setting regime increases from around 20 percent in the late 1970s to between 30 and 40 percent during the 1980s, and to between 40 and 50 percent in the early 1990s. These estimates, however, represent the lower bound for the population share of workers with flexible wages: wage setting of individuals in one of the rigidity regimes is only constrained for those individuals whose notional wage growth is smaller than the lower bound for wage growth under the respective rigidity regime.

Since the real rigidity bound is positive, it truncates a larger part of the notional wage change distribution than the nominal rigidity bound at zero. Therefore constrained wage setting is necessarily more frequent under the real rigidity than under the nominal rigidity regime. The estimated model parameters indicate that 50 to 60 percent of workers under the real rigidity regime receive a larger wage increase than they would do in a flexible environment, whereas this happens to only 30 to 40 percent of workers under the nominal rigidity regime. This means that, taken together, between 60 percent of workers at the beginning of the observation period in the 1970s, and 75 percent of workers at the end of the observation period during the 1990s, indeed received their notional wage change, that is, were not constrained by any rigidities in their wage setting.

Stable probabilities for constrained wage setting imply that the pattern of the shares of workers who are constrained in the real and nominal rigidity regimes, shown in columns 5-6 of Table 4, basically follows the pattern revealed by the overall shares of the real and nominal rigidity regimes. The estimated proportion of wage changes generated by the constrained real rigidity regime declines, from 37 percent in 1976 to 16 percent in 1997. At the same time, the share of workers protected against nominal wage cuts ranges from 4 to 8 percent, without a clear time trend. Hence downward wage rigidity seems to be less widespread than indicated by previous studies, which exclusively analyze nominal wage rigidity, such as that by Beissinger and Knoppik (2001) using similar German data. The discrepancy reveals why inclusion of the real rigidity regime is important for describing the observed distribution of wage changes. Without the possibility of real wage rigidity, workers whose wages actually cannot fall because of real rigidity constraints are likely to be assigned to the nominal rigidity regime. Thereby the incidence of downward nominal wage rigidity is overestimated.

To summarize, it seems that in Germany wage rigidity, though clearly in decline, has remained important. Even at the end of our observation period, close to one quarter of individual wage adjustments were larger than intended – two-thirds of them as a consequence downward real wage rigidity. The plain number of workers affected by downward wage rigidity, however, might not be informative with regard to its economic consequences. We therefore express the extent of wage rigidity in terms of the corresponding unintended pay rise. This requires comparing the actual wage growth of a constrained individual, i.e. the rigidity bound, to the counterfactual wage change in a flexible wage setting environment i.e. the notional wage change.

Columns 7-8 of Table 4 present the average wage growth that is a direct consequence of downward rigid wages computed with regard to the entire sample. The rightward shift of the mean of the observed wage change distribution due to the fact that a certain fraction of wage changes cannot be smaller than a threshold value reveals that in the absence of downward real wage rigidity, wages would have grown by about 3 percent less per year on average during the 1970s. Wage sweep-ups decreased to between 1 and 2 percent during the 1980s, and to less than 1 percent during the 1990s. In comparison, the aggregate sweep-up caused by nominal rigidity, ranging between 0.20 and 0.34 log points, is persistently much smaller.

These numbers might seem moderate, but one has to keep in mind that they represent sample averages. In other words, they are the product of the sample share of the constrained rigidity regimes, discussed above, and the average wage sweep-up conditional on being constrained under a regime. The magnitude of the latter suggests that wage rigidities may indeed have substantial consequences for affected firms and workers. For constrained individuals under the nominal rigidity regime, the conditional wage sweep-up is around 6 percent at the beginning of the observation period, and decreases to around 4 percent at the end. For constrained workers under the real rigidity regime, the wage sweep-up is naturally larger. The conditional wage sweep-up due to downward real wage rigidity amounts to around 8 percent during the 1970s, 6 percent during the 1980s, and 5 percent during the 1990s. The decline of the conditional wage sweep-up is somewhat steeper than that of the sweep-up due to rigid nominal wages, because of the downward shift of the real rigidity bound. Still, the downward movement of the average wage sweep-up is dominated by the declining sample share of constrained individuals.

For a robustness check of the previous results, we estimate the model for different specifications of notional wage changes. A first alternative specification, denoted model II, includes dummies for 116 occupations in addition to the variables of the baseline specification, denoted model I. Model III is the same as model II, but also includes 12 dummies for industry. Model IV extends model II by including dummies for the decile of the starting wage distribution occupied by a worker. Model V, in addition, includes industry dummies. Model VI is identical to model II, but incorporates worker characteristics known to be affected by measurement or reporting problems, namely education and citizenship. Finally, model VII integrates all variables contained in any of the previous specifications.

Table 5 shows that the model estimates for downward wage rigidity are satisfactorily robust with respect to different specifications of notional wage changes. In particular the estimated incidence of the real and nominal rigidity regimes, or, equivalently, the incidence of the fully flexible regime, is almost constant. This indicates that no mixture of the explanatory variables in the notional wage growth relationship is able to create the multi-modalities and asymmetries in the observed wage change distribution, which the empirical model exploits to identify downward wage rigidity. The fact that the estimated location of the real rigidity bound varies very little across the models supports this interpretation.

The chosen specification of the notional wage growth relationship is likely to impact stronger on the estimated aggregate wage sweep-up due to downward rigid nominal and real wages, as it shifts the counterfactual distribution used for the benchmark. The average distance between notional wage changes and fixed rigidity bounds then shifts accordingly. The effect on the estimated aggregate wage sweep-up, however, does not turn out to be very systematic. If anything, adding occupation dummies (models II, III, VI) seems to reduce the predicted adverse wage effects. The impact of including workers' position in the wage distribution (models IV, V, VII) is less clear. In any case, variation in the estimated wage sweep-ups across models is not substantial.

In the light of these observations and given that it is equally impossible to single out a most preferred specification in terms of goodness of fit or likelihood scores, we decide to continue to work with the most parsimonious specification of the notional wage growth relationship in the following.

5 Sources and Consequences of Wage Rigidity

This section makes an attempt to explore the potential sources and consequences of wage rigidity using variation in the estimated model parameters over time and across industrial sectors. Differences in the extent of nominal and real wage rigidity across industrial sectors are informative from several perspectives. First, in Germany unions typically bargain on the industry level rather than on the occupational level. Different rigidity outcomes in different industries therefore might be a sign of differences in union power or union strategy. Moreover, comparing the extent of wage rigidity across sectors might offer information as to whether workers trade-off higher wage security against higher job security.

The relevance of sector effects is evident when we estimate the model for workers employed in the public sector, and compare the obtained outcomes to the previous results for all workers employed in the private sector. To facilitate comparison, Table 6 presents the estimated rigidity indicators in terms of the mean taken over certain periods.[9] The locations of the real rigidity bound are practically identical for both sectors. Differences are less than one percent and not systematic. Nevertheless wage setting is drastically less flexible in the public sector. Initially 90 percent of public sector workers are either under the real or under the nominal wage rigidity regime, compared to 80 percent of private sector workers. Moreover, while wage setting in the public sector seems to become more flexible over time, the trend is less pronounced than in the private sector so that the gap in overall rigidity rates reaches 25 percentage points in the mid-1990s.

[9] The periods reflect different stages: the high inflation period of the 1970s, the comparatively calm economic environment of the 1980s, the unification boom of the early 1990s, and the subsequent recession.

There also seem to be systematic differences between the two sectors concerning the nature of wage rigidity. In comparison, the real rigidity regime is even more dominant in the public sector, whereas the sample share of the nominal rigidity regime is as much as 7 percentage points smaller. Nominal wage rigidity appears even less important considering constrained wage setting. As the notional wage change distribution estimated for the public sector has little mass in the negative domain, wage setting under the nominal rigidity regime is actually constrained for very few workers. As a result the aggregate wage sweep-up due to downward rigid nominal wages is negligible. The different shape of the notional wage change distributions also explains why the average wage sweep-ups due to real wage rigidity are smaller in the public sector than in the private sector, despite the relatively larger number of constrained cases.

Workers employed in the public sector do not seem to trade-off the higher job security it offers in exchange for more flexible wages. On the other hand, the higher degree of wage rigidity might be less of a risk for job security, due to generally large notional wage growth. To take a deeper look at the relationship of wage rigidities and employment, we estimate the empirical model separately for twelve private sector industries identified in the data set. These industries are agriculture (including energy and mining), production of basic goods, production of investment goods, production of consumption goods, production of food, construction, construction finishing trade, retail, traffic and telecommunications, industrial services, household related services, and societal services. The results are summarized in Table 7, which shows that there is indeed substantial variation across sectors, both in terms of the incidence of the rigidity regimes and the corresponding wage sweep-up. Two sectors stand out. Wages are the least flexible in societal services where the incidence of the real and nominal rigidity regimes is similarly high as in the public sector. This is plausible because the two sectors are close to each other and workers potentially covered by one union. If wage sweep-ups in societal services are nevertheless considerably larger, this is a result of systematically less favorable notional wage growth. At the other end, the most flexible wage changes, equally leading to the smallest wage sweep-up, take place in construction. Again, this seems to be a plausible outcome considering that this sector is characterized by particularly frequent and large demand shocks.

In search of the potential sources of wage rigidities on the macro level, we more systematically exploit the fact that there is variation in wage rigidity and unemployment across sectors by running within-group estimations on the panel of rigidity measures estimated for 22 years of observations and 12 industries in the private sector. Unemployment rates by sector can be recovered from the IABS-R.[10] Additional explanatory variables, however, are only available on the national level due to the special sector classification of the IABS-R data. The obtained estimates therefore primarily make use of variation over time. We determine significance levels for the within-group estimates on the basis of efficient standard errors which account for the fact that many of the regressors do not vary across sectors.

Table 8 presents a representative selection of results for the relationship between the extent of nominal and real downward wage rigidity and indicators for (expected) inflation, the economic environment and wage pressure through union bargaining. The regressions furthermore allow for an independent time trend and account for the structural break in the definition of reported wages in year 1984, discussed in section 3. The linear time trend is always negative and significant not only for the real rigidity regime, but also for the nominal rigidity regime, which would not be immediately evident from the raw figures (see Table 4). This outcome indicates that wage setting in Germany has indeed gradually become more flexible over the observation period.

The following broad picture emerges: Inflation, regardless whether measured by the GDP deflator or CPI, has a significant negative effect on the fraction of workers who are constrained under the nominal rigidity regime, as the population share of the nominal rigidity regime decreases. This result holds even when including union wage growth, which is obviously highly correlated with inflation. We find precisely the opposite, a significant positive inflation effect, when considering the share of constrained workers under the real regime. Moreover, we observe that while the sign of the inflation effects does not change when we use contemporaneous rather than lagged measures, the estimated parameters get considerably smaller. This finding supports the hypothesis that (static) inflation expectations are relevant for the formation of downward wage rigidity. Hence we conclude that real wage rigidity becomes more relevant when expected inflation is high, while the opposite holds for nominal wage rigidity.

Somewhat surprisingly, GDP growth does not have a significant effect on the incidence of downward wage rigidity. The reason seems to be that there are two effects

[10] The data set also includes unemployed workers who are assigned to sectors according to prior employment. The yearly unemployment rate is computed as the mean of the unemployment rates determined at the beginning of each quarter.

working in opposite directions. Unreported regressions indicate that, on the one hand, the fraction of workers under the nominal and real rigidity regime is significantly and positively correlated with the GDP growth rate. On the other hand, higher GDP growth shifts the notional wage growth distribution upward such that a smaller fraction of workers has wage freezes. For workers under the real regime the latter effect is strengthened by a significant upward shift of the rigidity bound. Considering labor productivity growth, we find a significant negative effect on constrained wage setting under the real regime, while the effect of labor productivity on the share of workers constrained under the nominal regime is positive and significant. This at first sight contradictory result can be explained by technology adoption, re-organization, and the dismissal of the marginally least productive workers during economic downturns, leading to increases in labor productivity (see Caballero and Hammour, 1994). Productivity growth due to such 'cleansing' effects of recessions, which is associated with a downward shift of the wage distribution of the remaining workforce as well as with lower inflation rates, then leads to more nominal, and less real wage rigidity.

Finally, and along the same lines, the effect of the unemployment level on the incidence of constrained wage setting is negative for the real rigidity regime, whereas it is positive for the nominal rigidity regime. One interpretation of this finding would be that workers who are under the real rigidity regime in good times move into the nominal rigidity regime in bad times. Another reason for the positive outcome is that conditional on being under the nominal wage setting regime the probability of being constrained increases when unemployment goes up, since the notional wage change distribution shifts downward when the economic environment is unfavorable. This effect is present also under the real rigidity regime but additional regressions indicate that it is counterbalanced by a significant downward shift in the location of the real rigidity bound when unemployment increases. Accordingly the probability that notional wage growth is less than the value of the real rigidity threshold declines. It appears that if union wage growth is included as an explanatory variable, it takes away the unemployment effect on downward real wage rigidity. In fact, previous empirical results confirm that in Germany collective agreements are moderated when unemployment pressure is high.[11]

[11] See Fitzenberger and Franz (1999) for a description of the wage setting process in Germany. Evidence for the determinants of collective bargaining outcomes suggests that German unions are prepared to moderate wage claims in periods of weak economic growth (or high unemployment), but not to accept

Regressions using the wage sweep-ups caused by downward nominal and real rigidity as the dependent variable reveal basically the same picture. However, the productivity effects become insignificant. Moreover, controlling for union wage changes removes significance not only of the growth and unemployment effects, but also of the inflation effects under the real rigidity regime. This outcome is consistent with the hypothesis that collective bargaining is the dominant source of downward real wage rigidity.

If firms cannot implement notional wages for some workers, the involuntary wage sweep-up might lead firms to adjust at the external margin and reduce employment. Since the empirical model does not allow for individual-specific propensities of constrained wage setting under a rigidity regime, the obtained estimation results are only useful to analyze potential employment consequences on the macro level.[12] To this end, we regress changes in the unemployment rate on variables covering the contemporary economic environment and lagged values of the estimated wage sweep-up due to downward wage rigidity. Table 9 contains the core results.

Specifications including the lagged change in unemployment rates as a regressor indicate that the estimates are consistent with unemployment hysteresis. After a one time-shock changing the unemployment rate, the system converges to a new long-term level of unemployment. In other words, the difference in the yearly levels of unemployment is stationary i.e. the estimated parameter for the lagged change is significantly smaller than one. As expected, instantaneous GDP growth (or labor productivity) growth always has a strongly significant negative impact on the unemployment outcome. Inflation, as measured by the GDP deflator, on the other hand, does not have a significant effect on unemployment changes.

Concerning the impact of the total wage sweep-up, the estimates indicate that downward wage rigidity does not have an immediate impact on the unemployment rate. The estimated coefficients are insignificant when looking at a one-period lag. However, it seems that downward wage rigidity affects unemployment over the longer term. With a lag of two periods, higher total wage sweep-ups lead to significantly faster unemployment growth. Decomposing the wage sweep-up into the sweep-ups caused by the nominal and real rigid-

wage agreements that do not cover expected inflation.

[12] See Fehr, Götte, and Pfeiffer (2002) for a study of the relationship between wage rigidity and employment probabilities on the individual level.

ity regimes, respectively, indicates that it is primarily the latter that is responsible for this effect. While the estimated coefficient for real wage sweep-up is significant, the coefficient for nominal wage sweep-up is insignificant. However, these regressions on the macro level should be interpreted cautiously. On the one hand it is highly unlikely that the constraints and wage sweep-ups caused by nominal rigidity have no adverse effects whatsoever. On the other hand, it is not clear that the macro approach to the consequences of rigidity is fully appropriate: an examination of the consequences of being affected by real or nominal rigidity on the individual level might lead to much stronger results e.g. in terms of job instability.

6 Conclusion

This paper makes an attempt to measure nominal and real downward wage rigidity in the West German labor market since the mid-1970s. The results of our empirical analysis based on individual wage change data indicate that wage rigidity is a robust phenomenon. Although the incidence of wage rigidity has significantly decreased over time, at the end of the observation window still one third of workers who do not change their job do not receive the notional wage change. However, there is substantial variation across sectors. Bad outside options for workers, as measured by higher unemployment, tend to decrease real, but increase nominal rigidities.

In general, most of the wage rigidity can be attributed to real wage rigidity, which seems to increase with inflation and centralized wage bargaining outcomes, while the opposite holds for nominal wage rigidity. By definition, both types of rigidities lead to faster wage growth than under fully flexible wage setting. Our estimation results imply that average wage growth would have been between two and six percent lower if wages had been fully flexible. After an adjustment period, these wage sweeps-ups seem to lead to higher unemployment. This is an indication that firms respond to constrained wage setting by adjusting on the external margin.

Consequently, it seems that prudent monetary policy might help reducing the adverse labor market effects of downward wage rigidity. Although we find evidence that the incidence of nominal wage rigidity increases with lower inflation, we also observe that the incidence and the intensity of real rigidity decreases the lower the rate of inflation.

Together with the result that wage sweep-ups caused by wage rigidities have real effects in terms of higher unemployment, this suggests that an environment of moderate inflation and moderate bargaining outcomes might be most favorable in order to minimize the adverse labor market effects of downward rigid wages.

Appendix

The appendix describes the likelihood contributions of the 15 wage setting regimes, which constitute the likelihood function. In general, the contribution of a particular wage change observation to the likelihood has three components: (1) the likelihood that the observation falls under a certain combination of the three rigidity and the three measurement error regimes, (2) the likelihood that a wage change observation is constrained or not conditional on it being in a certain regime, and (3) the likelihood of a wage change observation conditional on the respective regime.

Given the assumptions made concerning the error structure of the empirical model, the probabilities of the rigidity regimes and the probabilities of the measurement error regimes are independent of each other. Therefore we can treat them separately. The probability of a specific measurement error regime follows directly from equation (7). Observations with no measurement error occur with probability $P(M0) = (1 - P^m)^2$, observations with one error with probability $P(M1) = 2P^m(1 - P^m)$, and observations with two errors with probability $P(M2) = (P^m)^2$.

The likelihood of a specific rigidity regime can be expressed in terms of conditions on on the error terms in the regime propensity equations (3) and (4). The real rigidity regime requires that $P^{rn} > 0$ and $P^{rf} > 0$. Given the standard normality assumptions made on the distribution of the error terms η, the probability of an observation falling in the real regime, denoted $P(R)$, is given by

$$P(R) = P(P^{rn} > 0)P(P^{rf} > 0) = P(\eta^{rn} < \beta^{rn})P(\eta^{rf} < \beta^{rf}) = \Phi(\beta^{rn})\Phi(\beta^{rf}) \ , \quad (10)$$

where $\Phi(\cdot)$ refers to the cumulative density function of a standard normal variable. Similarly, an observation is in the nominal regime if $P^{rn} < 0$ and $P^{rn} - P^{rf} < 0$. The likelihood that an observation falls under the nominal regime, $P(N)$, therefore can be stated as

$$P(N) = P(\eta_i^{rn} > \beta^{rn})P(\eta_i^{rn} - \eta_i^{rf} < \beta^{rf} - \beta^{rn}) = \Phi(-\beta^{rn})\Phi\left(\frac{\beta^{rf} - \beta^{rn}}{\sqrt{2}}\right) \ . \quad (11)$$

As the probabilities of the possible regimes add up to unity, the likelihood that an observed wage change comes from the flexible regime, $P(F)$, can be calculated as a residual:

$$P(F) = 1 - \Phi(-\beta^{rn})\Phi\left(\frac{\beta^{rf} - \beta^{rn}}{\sqrt{2}}\right) - \Phi(\beta^{rn})\Phi(\beta^{rf}) \ . \tag{12}$$

Since the regime probabilities are independent of the measurement error probabilities, the likelihood that an observation falls under a particular combination of the rigidity and measurement regimes is the product of the individual regime probabilities. For example, the probability that an observation is in the nominal regime without measurement error, $P(N0)$, is equal to $P(N) \times (1 - P^m)^2$.

Next, the probability of observations conditional on being in a certain regime is derived. We begin with the nominal rigidity regime. Within the regime, there are six possibilities. Observations can be either affected by one measurement error, two measurement errors, or no error, and wage setting can be either constrained or unconstrained. First consider the conditional likelihood contribution of the constrained nominal rigidity regime without measurement error. If an observation is in the constrained nominal regime, $X_i\alpha + \varepsilon_i < 0$, whereas the actual wage change is zero. Without measurement error, the actual wage change is observed, so that $\Delta w_i^o = 0$. Wage changes observed in the regime hence do not have a density, but only a mass point at zero. Conditional on being in the nominal regime without measurement error, the likelihood of a constrained observation is therefore determined by

$$P(\Delta w_i^o \in C | i \in N0) = P(\varepsilon_i < -X_i\alpha | i \in N0) = \Phi\left(\frac{-X_i\alpha}{\sigma_w}\right) \tag{13}$$

evaluated if $\Delta w_i^o = 0$. If wage setting is unconstrained in the regime without measurement error, $\Delta w_i^o = X_i\alpha + \varepsilon_i$. The likelihood contribution of an unconstrained observation in the regime therefore can be written as

$$P(\Delta w_i^o \in U | i \in N0) = P(\varepsilon_i = \Delta w_i^o - X_i\alpha | i \in N0) = \frac{1}{\sigma_w} \cdot \phi\left(\frac{\Delta w_i^o - X_i\alpha}{\sigma_w}\right) \ , \tag{14}$$

where $\phi(\cdot)$ refers to the density of a standard normal variable. Wage changes observed in the regime do have a density. Since the regime is only consistent with positive wage growth, it is truncated at zero, which means that (14) only takes non-zero values if $\Delta w_i^o > 0$.

Regimes with measurement error are consistent with any observed wage change, although the conditional probability of observing exactly zero wage growth is zero. When there is measurement error, the observed wage change differs from the actual wage change by $\tilde{u}_i$. If an observation comes from the constrained regime, it must satisfy the condition $\Delta w_i^o - \tilde{u}_i = 0$. The likelihood contribution of a constrained observation conditional on it being affected by measurement error therefore follows from the assumed distribution of the composite error term. In the case of one measurement error, it is given by

$$P(\Delta w_i^o \in C | i \in N1) = P(\tilde{u}_i = \Delta w_i^o | i \in N1) = \frac{1}{\sigma_m} \cdot \phi\left(\frac{\Delta w_i^o}{\sigma_m}\right) \tag{15}$$

Likewise, the likelihood contribution of a constrained observation affected by two errors, can be written as

$$P(\Delta w_i^o \in C | i \in N2) = P(\tilde{u}_i = \Delta w_i^o | i \in N2) = \frac{1}{\sqrt{2}\sigma_m} \cdot \phi\left(\frac{\Delta w_i^o}{\sqrt{2}\sigma_m}\right) . \tag{16}$$

The unconstrained regimes with measurement error require that $\Delta w_i^o = X_i\alpha + \varepsilon_i + \tilde{u}_i$ conditional on $X_i\alpha + \varepsilon_i > 0$. Since the two conditions are interdependent via ε_i the likelihood contributions of the regimes are more difficult to derive. The calculation starts from the joint density of ε_i and $\tilde{u}_i$, which is

$$f(\varepsilon_i, \tilde{u}_i) = \frac{1}{2\pi\sigma_w\sigma_m} \exp\left(-\frac{1}{2}\left[\left(\frac{\varepsilon_i}{\sigma_w}\right)^2 + \left(\frac{\tilde{u}_i}{\sigma_m}\right)^2\right]\right) , \tag{17}$$

in the case of one measurement error, given the independency assumption of made on the two variables. The likelihood of an unconstrained observation conditional on being in the nominal regime with one error, follows from

$$\begin{aligned} P(\Delta w_i^o \in U | i \in N1) &= P(\tilde{u}_i = \Delta w_i^o - X_i\alpha - \varepsilon_i | \varepsilon_i > -X_i\alpha, i \in N1) \\ &= \int_{-X_i\alpha}^{\infty} f(\varepsilon_i, \Delta w_i^o - X_i\alpha - \varepsilon_i) d\varepsilon_i , \end{aligned} \tag{18}$$

which can be solved to yield

$$P(\Delta w_i^o \in U | i \in N1) = \frac{\phi\left(\frac{\Delta w_i^o - X_i\alpha}{\sqrt{\sigma_w^2 + \sigma_m^2}}\right)}{\sqrt{\sigma_w^2 + \sigma_m^2}} \left[1 - \Phi\left(\frac{-X_i\alpha - \frac{\sigma_w^2}{\sigma_w^2 + \sigma_m^2}(\Delta w_i^o - X_i\alpha)}{\sqrt{\frac{\sigma_w^2\sigma_m^2}{\sigma_w^2 + \sigma_m^2}}}\right)\right] . \tag{19}$$

To get the likelihood contribution of unconstrained observations in the nominal rigidity regime for the two error case, $P(\Delta w_i^o \in U | i \in N2)$, replace σ_m with the appropriate standard deviation of the distribution of the measurement error term, i.e. $\sqrt{2}\sigma_m$.

For observations falling under the real rigidity regime, there are again six possible regimes. The likelihood contribution of each regime resembles that of the counterpart for the nominal rigidity case. Derivation of the likelihoods is more complicated, however, since the threshold for censored observations, r_i, is not a constant. Therefore one has to account for the variance of the distribution of the unobserved heterogeneity term ν_i. For reasons of space, we only discuss the likelihood contribution of selected regimes.

As a first example, consider the probability of a constrained observation conditional on being in the real regime with no measurement error. The observation must satisfy two conditions: $\varepsilon_i < \Delta w_i^o - X_i\alpha$ and $\nu_i = \Delta w_i^o - \gamma$. Given the normality assumption made on the distribution of ν_i, the conditional likelihood of a constrained observation is equal to

$$P(\Delta w_i^o \in C | i \in R0) = \frac{1}{\sigma_r}\phi\left(\frac{\Delta w_i^o - \gamma}{\sigma_r}\right)\Phi\left(\frac{\Delta w_i^o - X_i\alpha}{\sigma_w}\right) \ . \tag{20}$$

As a second example, consider the likelihood of an unconstrained observation conditional on being in the real rigidity regime with one measurement error. This case requires that $\tilde{u}_i = \Delta w_i^o - X_i\alpha - \varepsilon_i$ conditional on $\varepsilon_i > \gamma - X_i\alpha + \nu_i$. The problem to solve is similar to the unconstrained cases with measurement in the nominal rigidity regime, but in addition ν_i needs to be integrated out. Thus, with ν_i being normally distributed with mean 0 and variance σ_r^2 and denoting the respective p.d.f. by $g(\nu_i)$, we have

$$\begin{aligned} P(\Delta w_i^o \in U | i \in R1) &= P(\tilde{u}_i = \Delta w_i^o - X_i\alpha - \varepsilon_i | \varepsilon_i > \gamma - X_i\alpha + \nu_i, i \in R1) \\ &= \textstyle\int_{-\infty}^{\infty}\int_{\gamma - X_i\alpha + \nu}^{\infty} f(\varepsilon_i, \Delta w_i^o - X_i\alpha - \varepsilon_i)\ g(\nu_i)\ d\varepsilon_i d\nu_i \\ &= \frac{\phi\left(\frac{\Delta w_i^o - X_i\alpha}{\sqrt{\sigma_w^2 + \sigma_m^2}}\right)}{\sqrt{\sigma_w^2+\sigma_m^2}}\left[1 - \Phi\left(\frac{\gamma - X_i\alpha - \frac{\sigma_w^2}{\sigma_w^2+\sigma_m^2}\left(\Delta w_i^o - X_i\alpha\right)}{\sqrt{\sigma_r^2 + \frac{\sigma_w^2\sigma_m^2}{\sigma_w^2+\sigma_m^2}}}\right)\right] . \end{aligned} \tag{21}$$

In the fully flexible regimes, all wages are unconstrained by definition. Then the likelihood contribution of an observation is simply the conditional density of wage changes depending on the type of measurement error. Without measurement error, $\varepsilon_i = \Delta w_i^o - X_i\alpha$. Hence the likelihood of a particular observation is

$$P(\Delta w_i^o | F0) = \frac{1}{\sigma_w}\phi\left(\frac{\Delta w_i^o - X_i\alpha}{\sigma_w}\right) \ . \tag{22}$$

This likelihood appears to be the same as that derived for the case of unconstrained wage setting in the nominal rigidity regime with no error, see equation (14). Note, however, that the expression was only valid conditional on $\Delta w_i^o > 0$ in the previous case. An observation in the flexible regime measured with error has to satisfy the condition $\varepsilon_i + \tilde{u}_i = \Delta w_i^o - X_i\alpha$.

Therefore, the contribution to the likelihood is

$$P(\Delta w_i^o|F1) = \frac{1}{\sqrt{\sigma_w^2 + \sigma_m^2}} \phi \left(\frac{\Delta w_i^o - X_i \alpha}{\sqrt{\sigma_w^2 + \sigma_m^2}} \right) \tag{23}$$

given one measurement error, and

$$P(\Delta w_i^o|F2) = \frac{1}{\sqrt{\sigma_w^2 + 2\sigma_m^2}} \phi \left(\frac{\Delta w_i^o - X_i \alpha}{\sqrt{\sigma_w^2 + 2\sigma_m^2}} \right) \ . \tag{24}$$

given two measurement errors.

We have now all ingredients to build up the likelihood function to be maximized. Using indicator functions $I(\cdot)$ taking the value of unity if the condition in the brackets is satisfied and zero otherwise, we get

$$\begin{aligned} L(\Delta w_i^o|\Omega, X_i) = \quad & P(N)P(M0)P(\Delta w_i^o \in C|i \in N0)I(\Delta w_i^o = 0)+ \\ & P(N)P(M0)P(\Delta w_i^o \in U|i \in N0)I(\Delta w_i^o > 0)+ \\ & [P(N)P(M1)[P(\Delta w_i^o \in C|i \in N1) + P(\Delta w_i^o \in U|i \in N1)]+ \\ & P(R)P(M0)[P(\Delta w_i^o \in C|i \in R0) + P(\Delta w_i^o \in U|i \in R0)]+ \\ & P(R)P(M1)[P(\Delta w_i^o \in C|i \in R1) + P(\Delta w_i^o \in U|i \in R1)]+ \\ & P(R)P(M2)[P(\Delta w_i^o \in C|i \in R2) + P(\Delta w_i^o \in U|i \in R2)]+ \\ & P(F)P(M0)P(\Delta w_i^o|i \in F0)+ \\ & P(F)P(M1)P(\Delta w_i^o|i \in F1)+ \\ & P(F)P(M2)P(\Delta w_i^o|i \in F2)]\, I(\Delta w_i^o \neq 0)\ , \end{aligned} \tag{25}$$

where $\Omega = (\alpha, \beta^{rn}, \beta^{rf}, \gamma, \sigma_m^2, \sigma_w^2, \sigma_r^2, P^m)$ is the vector of parameters to be estimated.

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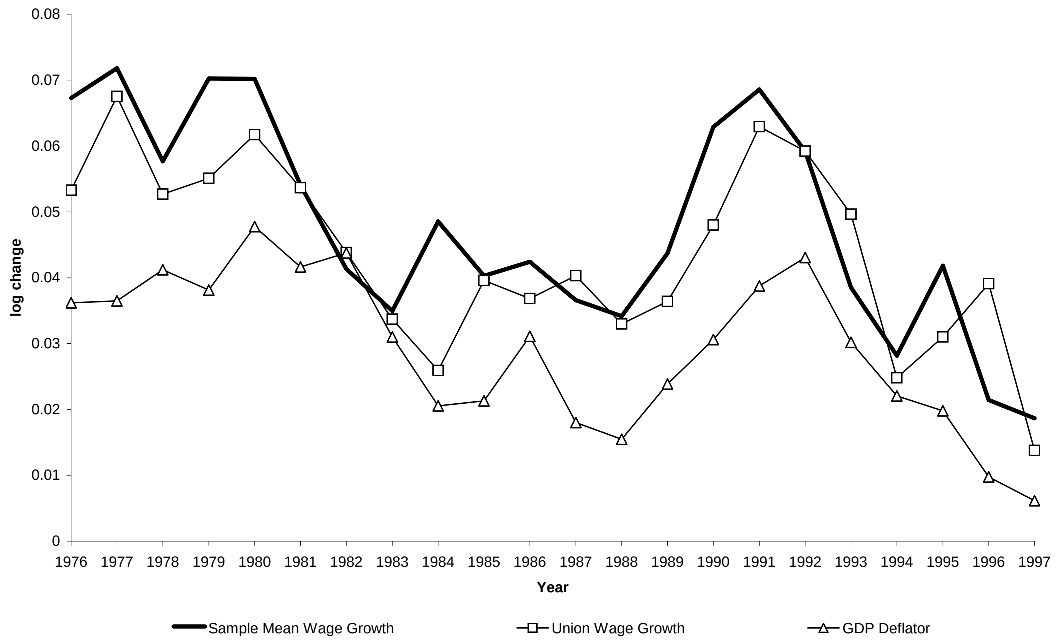
Figure 1: Sample Mean Wage Changes, Standard Wage Growth and Inflation



Notes: Union wage growth variable refers to the mean change of standard wages written into collective bargaining agreements. The union wage growth and inflation time series are taken from SVR (1998).

Figure 2: Histograms of Individual Wage Changes 1976-1997

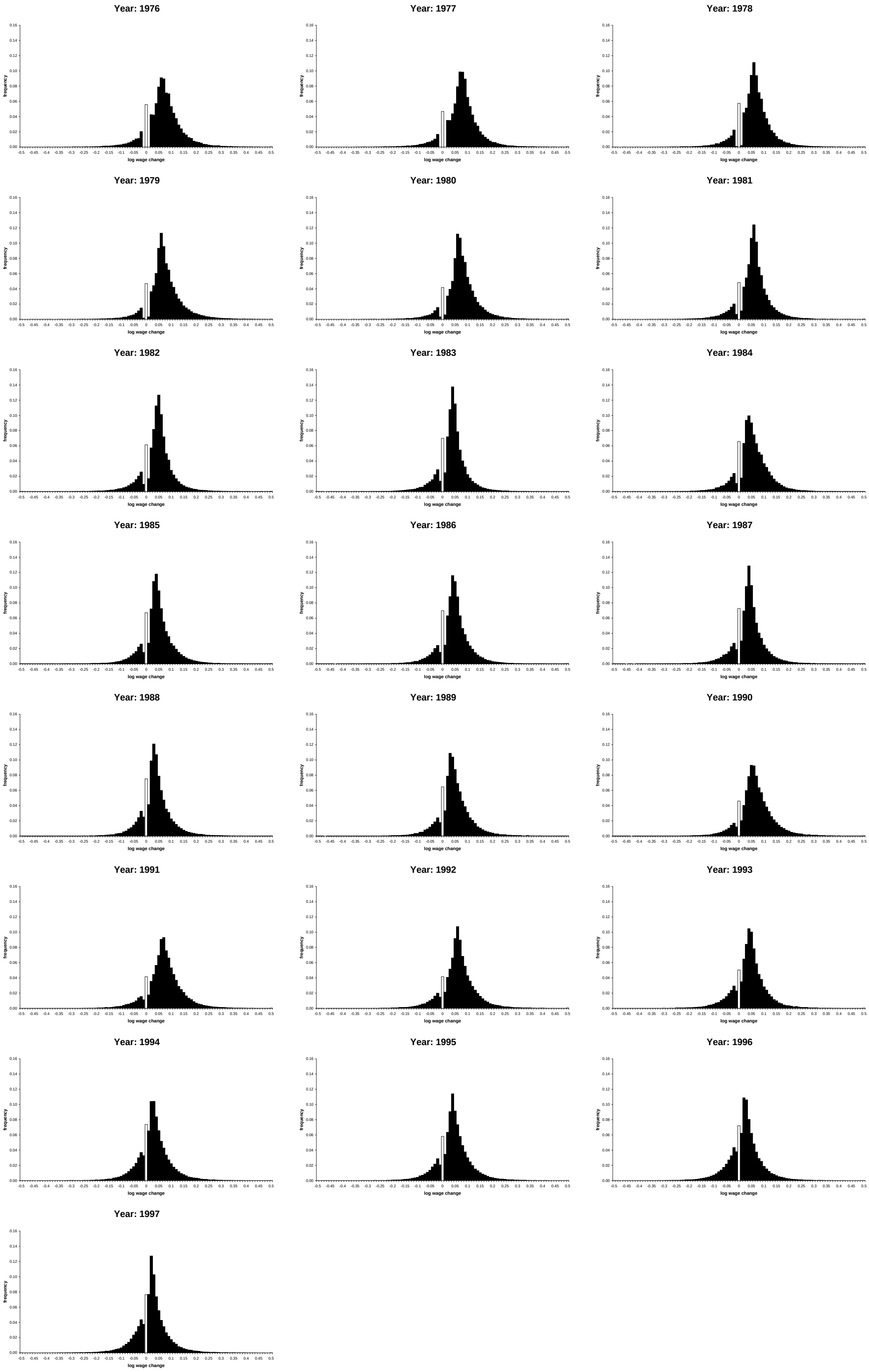
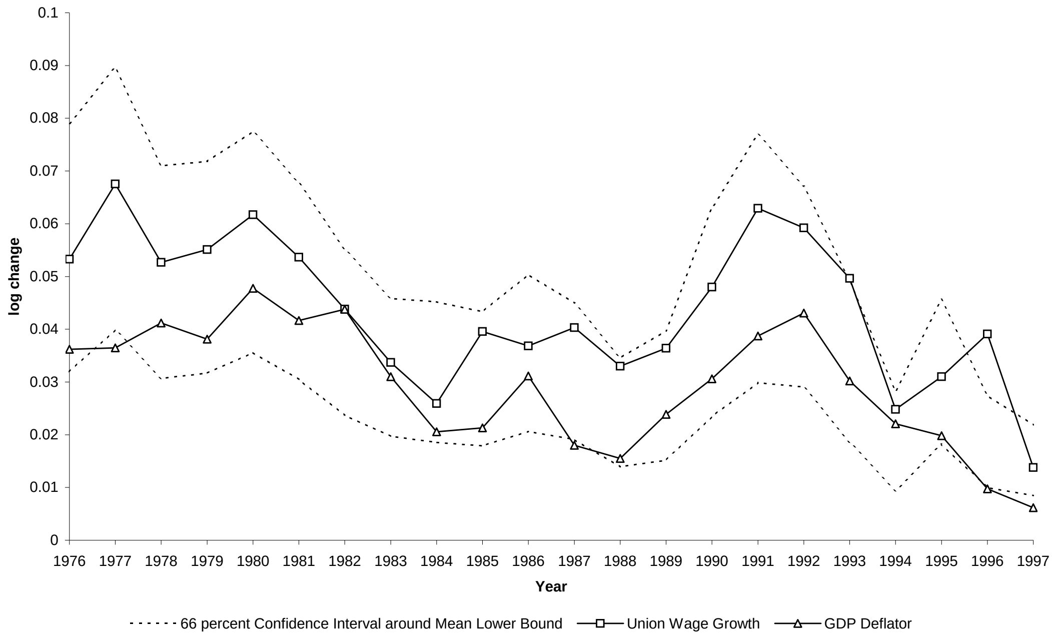


Figure 3: Location of the Lower Bound for Wage Changes in the Real Rigidity Regime



Notes: Width of the confidence interval is plus/minus one standard deviation around the real rigidity bound, based on the estimated value of the model variance σ_r^2. Model specification I. Sample of workers employed in private sector.

Table 1: Possible Regimes Generating Observed Wage Changes

	Wage Setting Regime				
		Real Rigidity		Nominal Rigidity	
	Flexible	Constrained	Unconstrained	Constrained	Unconstrained
No Error	F0	RC0	RU0	NC0	NU0
One Error	F1	RC1	RU1	NC1	NU1
Two Errors	F2	RC2	RU2	NC2	NU2

Table 2: Sample and Simulated Moments of Wage Change Distribution

	Mean		Median		Standard Deviation	
Year	Sample	Simulated	Sample	Simulated	Sample	Simulated
1976	0.067	0.066	0.064	0.064	0.087	0.088
1977	0.072	0.072	0.072	0.072	0.082	0.081
1978	0.058	0.056	0.056	0.056	0.082	0.081
1979	0.070	0.068	0.063	0.063	0.085	0.083
1980	0.070	0.069	0.066	0.066	0.080	0.081
1981	0.054	0.053	0.054	0.054	0.079	0.077
1982	0.041	0.041	0.042	0.042	0.076	0.074
1983	0.035	0.034	0.035	0.035	0.072	0.072
1984	0.049	0.047	0.043	0.042	0.076	0.075
1985	0.040	0.039	0.036	0.036	0.076	0.074
1986	0.042	0.041	0.040	0.040	0.074	0.073
1987	0.037	0.035	0.035	0.035	0.075	0.074
1988	0.034	0.032	0.029	0.029	0.077	0.075
1989	0.044	0.042	0.037	0.037	0.079	0.077
1990	0.063	0.061	0.056	0.056	0.085	0.083
1991	0.069	0.066	0.065	0.065	0.085	0.084
1992	0.059	0.057	0.056	0.056	0.083	0.081
1993	0.039	0.037	0.038	0.038	0.080	0.079
1994	0.028	0.026	0.023	0.023	0.079	0.078
1995	0.042	0.041	0.038	0.038	0.079	0.078
1996	0.021	0.021	0.020	0.020	0.079	0.078
1997	0.019	0.018	0.016	0.016	0.079	0.077

Notes: Simulation based on parameter estimates obtained with model specification I, i.e. only including officially reported individual characteristics as explanatory variables of notional wage changes. Sample of workers employed in private sector

Table 3: Baseline Model Parameter Estimates

Year	$X_i\alpha$	σ_w	γ	σ_r	P^m	σ_m
1976	0.032	0.087	0.055	0.024	0.019	0.300
1977	0.033	0.083	0.065	0.025	0.022	0.270
1978	0.026	0.076	0.051	0.020	0.022	0.274
1979	0.035	0.084	0.052	0.020	0.022	0.280
1980	0.037	0.079	0.057	0.021	0.018	0.285
1981	0.023	0.072	0.049	0.019	0.021	0.273
1982	0.014	0.065	0.039	0.016	0.024	0.248
1983	0.011	0.061	0.033	0.013	0.027	0.226
1984	0.033	0.065	0.032	0.013	0.028	0.223
1985	0.020	0.065	0.031	0.013	0.029	0.225
1986	0.019	0.066	0.036	0.015	0.023	0.240
1987	0.015	0.063	0.032	0.013	0.029	0.225
1988	0.016	0.059	0.024	0.010	0.033	0.224
1989	0.026	0.063	0.027	0.012	0.033	0.224
1990	0.040	0.074	0.043	0.020	0.022	0.280
1991	0.042	0.078	0.053	0.024	0.022	0.276
1992	0.035	0.071	0.048	0.019	0.029	0.245
1993	0.020	0.063	0.034	0.015	0.037	0.210
1994	0.014	0.058	0.019	0.009	0.041	0.204
1995	0.023	0.065	0.032	0.014	0.031	0.225
1996	0.009	0.056	0.019	0.009	0.047	0.193
1997	0.006	0.054	0.015	0.007	0.049	0.193

Notes: $X_i\alpha$ refers to the estimated mean of the notional wage change given by equation (1), while σ_w is the corresponding standard deviation of the unobserved heterogeneity component. γ refers to the estimated mean of the lower bound of wage changes for constrained individuals under the real rigidity regime according to equation (6). σ_r is the estimated standard deviation of the individual variation around this mean. Finally, P_m refers to the estimated probability of measurement error in wages, whereas σ_m is the estimated standard deviation of one-period measurement error in wages given by equation (7). Sample of workers employed in private sector.

Table 4: Estimated Extent of Wage Rigidity in the Private Sector

Year	Incidence (in %) of Regimes (Overall) Fully Flexible	Incidence (in %) of Regimes (Overall) Real Rigidity	Incidence (in %) of Regimes (Overall) Nominal Rigidity	Incidence (in %) of Constrained Real Regime	Incidence (in %) of Constrained Nominal Regime	Wage Sweep-up from (in log points) Real Rigidity	Wage Sweep-up from (in log points) Nominal Rigidity
1976	22.6	62.0	15.4	37.3	5.5	3.05	0.33
1977	19.4	67.0	13.6	42.9	4.7	3.54	0.26
1978	24.3	60.2	15.5	37.3	5.7	2.74	0.30
1979	17.8	68.2	13.9	39.0	4.7	2.97	0.27
1980	19.9	67.2	13.0	39.7	4.2	2.93	0.22
1981	26.1	60.9	13.0	38.6	4.9	2.72	0.24
1982	29.8	55.1	15.1	35.3	6.2	2.25	0.29
1983	31.3	52.0	16.8	32.7	7.1	1.92	0.32
1984	34.7	43.8	21.5	21.6	6.7	1.17	0.29
1985	34.0	47.9	18.0	26.8	6.8	1.53	0.31
1986	31.5	50.2	18.3	29.7	7.0	1.81	0.33
1987	34.0	47.8	18.1	28.8	7.4	1.70	0.34
1988	39.1	41.1	19.7	22.5	7.7	1.16	0.32
1989	34.5	46.0	19.4	23.4	6.7	1.23	0.28
1990	28.6	55.8	15.5	28.8	4.6	1.82	0.22
1991	28.7	57.2	14.2	31.7	4.2	2.24	0.22
1992	33.3	52.9	13.8	29.9	4.3	1.92	0.20
1993	42.9	43.1	14.0	25.1	5.3	1.47	0.24
1994	49.5	31.1	19.4	16.4	7.8	0.81	0.33
1995	40.1	43.3	16.6	23.8	6.0	1.35	0.27
1996	54.1	28.2	17.7	15.9	7.7	0.79	0.33
1997	52.9	28.8	18.2	16.1	8.2	0.77	0.34

Notes: Baseline specification, Model I. The wage sweep-up is derived by aggregating the prevented individual wage cuts for constrained workers within a regime. It is an average value based on the wage change distribution including all sample observations. Sample of workers employed in private sector.

Table 5: Specification Analysis: Notional Wage Models and Rigidity Indicators

	Incidence of Fully Flexible Regime (%)							Aggregate Wage Sweep-Up (log points)						
	Model							Model						
Year	I	II	III	IV	V	VI	VII	I	II	III	IV	V	VI	VII
1976	22.6	23.6	23.7	22.6	22.8	22.3	21.6	3.38	2.96	2.85	3.40	3.28	3.00	3.34
1977	19.4	19.9	20.1	19.3	19.5	19.3	18.9	3.80	3.51	3.36	3.90	3.77	3.55	3.84
1978	24.3	24.5	24.3	24.0	24.0	24.0	23.5	3.04	2.93	2.95	3.12	3.12	2.88	3.05
1979	17.8	17.6	17.6	17.1	17.1	16.9	16.4	3.24	3.14	3.13	3.52	3.48	3.18	3.53
1980	19.9	19.9	19.9	19.2	19.2	19.5	18.8	3.15	3.01	2.98	3.31	3.28	3.00	3.27
1981	26.1	26.4	26.4	26.1	26.2	25.7	25.5	2.96	2.84	2.83	2.96	2.93	2.86	2.94
1982	29.8	30.1	30.0	30.1	30.0	29.3	29.2	2.55	2.45	2.45	2.52	2.52	2.46	2.54
1983	31.3	31.5	31.5	31.5	31.5	30.9	30.9	2.24	2.14	2.14	2.19	2.18	2.16	2.20
1984	34.7	34.7	34.6	33.3	33.3	34.2	32.8	1.45	1.33	1.32	1.24	1.24	1.31	1.22
1985	34.0	34.2	34.1	34.4	34.4	33.5	33.7	1.85	1.78	1.77	1.79	1.77	1.81	1.80
1986	31.5	32.1	32.3	32.4	32.5	31.5	31.9	2.14	1.97	1.90	1.96	1.91	1.98	1.93
1987	34.0	34.4	34.4	34.6	34.6	34.0	34.3	2.04	1.95	1.93	1.97	1.95	1.97	1.97
1988	39.1	39.0	38.9	39.2	39.1	38.6	38.6	1.48	1.48	1.48	1.50	1.49	1.48	1.50
1989	34.5	34.3	34.1	34.6	34.4	33.9	34.0	1.51	1.50	1.51	1.50	1.51	1.49	1.50
1990	28.6	29.6	29.5	29.7	29.6	29.3	29.4	2.04	1.81	1.80	1.85	1.83	1.81	1.83
1991	28.7	30.0	30.6	30.1	30.4	29.8	29.9	2.46	2.17	2.07	2.22	2.14	2.13	2.16
1992	33.3	34.0	34.2	33.9	34.0	33.5	33.5	2.11	2.00	1.96	2.07	2.02	2.05	2.07
1993	42.9	43.8	43.9	44.0	44.1	43.5	43.8	1.71	1.59	1.57	1.61	1.59	1.60	1.61
1994	49.5	49.5	49.4	49.6	49.5	49.2	49.3	1.14	1.13	1.13	1.14	1.14	1.12	1.13
1995	40.1	40.4	40.6	40.6	40.7	39.7	39.9	1.62	1.53	1.49	1.54	1.52	1.54	1.54
1996	54.1	54.3	54.2	54.5	54.4	53.5	53.7	1.12	1.12	1.10	1.12	1.11	1.12	1.13
1997	52.9	53.0	53.1	53.2	53.3	52.6	52.8	1.11	1.08	1.08	1.09	1.09	1.08	1.08

Notes: Model specifications I-VII for notional wage changes as defined in text. The aggregate wage sweep-up is derived by summing up the prevented individual wage cuts for constrained workers in the nominal and real regimes. It is an average value based on the wage change distribution including all sample observations. Sample of workers employed in private sector.

Table 6: Estimated Wage Rigidity Indicators - Private vs. Public Sector

Period	Real Rigidity Bound	Incidence of Rigidity Regimes (%) Overall Real	Overall Nominal	Constrained Real	Constrained Nominal	Wage Sweep-up (log points) Real	Nominal
Private Sector							
1976/80	0.056	64.9	14.3	39.3	4.9	3.05	0.28
1981/89	0.034	49.4	17.8	28.8	6.7	1.72	0.30
1990/93	0.045	52.3	14.4	28.9	4.6	1.86	0.22
1994/97	0.021	32.8	18.0	18.1	7.4	0.93	0.32
Public Sector							
1976/80	0.051	80.1	8.9	48.7	2.1	2.35	0.07
1981/89	0.032	74.8	10.4	43.2	2.7	1.88	0.08
1990/93	0.047	74.4	8.9	38.8	1.2	1.66	0.03
1994/97	0.014	59.0	16.7	22.7	3.8	0.55	0.06

Notes: Period averages. Baseline specification. The wage sweep-up is derived by aggregating the prevented individual wage cuts for constrained workers within a regime. It is an average value based on the wage change distribution including all sample observations.

Table 7: Estimated Wage Rigidity Indicators by Sector

Sector	Incidence of Fully Flexible Regime (%) Period 1976/80	1981/89	1990/93	1994/97	Aggregate Wage Sweep-up (log points) Period 1976/80	1981/89	1990/93	1994/97
1	18.5	33.6	33.8	45.0	3.90	2.14	2.07	1.41
2	22.8	37.3	40.7	59.7	3.03	1.84	1.83	0.94
3	23.9	39.8	41.6	56.4	3.07	1.64	1.93	1.08
4	22.0	35.7	37.3	56.4	3.20	2.07	1.79	1.08
5	20.0	30.0	32.3	45.0	3.10	2.08	1.77	1.39
6	41.9	49.1	30.9	68.5	2.32	1.69	2.86	0.90
7	24.9	41.3	34.1	55.4	3.46	1.77	2.11	1.15
8	17.0	27.1	29.6	43.1	3.41	2.14	2.01	1.41
9	15.8	27.4	32.9	54.9	3.20	2.26	2.07	1.03
10	13.0	25.7	26.9	44.5	2.43	1.71	2.13	1.09
11	17.6	24.1	26.7	34.9	3.40	2.50	2.15	1.59
12	13.1	17.7	20.4	30.5	3.08	2.23	1.91	1.53

Notes: Period averages. Baseline specification. The aggregate wage sweep-up is derived by summing up the prevented individual wage cuts for constrained workers in the nominal and real regimes. It is an average value based on the wage change distribution including all sample observations. The sector definitions are taken from the codification of the source data. Sector 1: agriculture (including energy and mining); Sector 2: production of basic goods; Sector 3: production of investment goods; Sector 4: production of consumption goods; Sector 5: production of food; Sector 6: Construction; Sector 7: Construction finishing trade; Sector 8: retail; Sector 9: traffic and communication; Sector 10: industrial services; Sector 11: household related services; Sector 12: societal services.

Table 8: Macroeconomic Causes of Wage Rigidities

	Dependent Variable:															
	Percent of Workers Constrained by								Average Wage Sweep-Up due to							
	Nominal Rigidity				Real Rigidity				Nominal Rigidity				Real Rigidity			
Intercept	3.329**	3.233**	2.647**	3.178**	12.082**	12.945**	14.308**	12.541**	.188**	.168**	.155**	.182**	.946**	.914**	1.088**	1.000**
	(7.88)	(7.73)	(6.17)	(8.59)	(6.39)	(6.83)	(7.49)	(7.00)	(8.49)	(7-40)	(6.87)	(8.81)	(5.49)	(5.42)	(6.23)	(6.29)
Linear Trend x 100	-.129**	-.135**	-.121**	-.142**	-.711**	-0.703**	-.735**	-.672**	-.007**	-.007**	-.007**	-.008**	-.054**	-.051**	-.056**	-.050**
	(6.70)	(6.92)	(6.32)	(8.39)	(8.26)	(7.98)	(8.58)	(8.22)	(7.34)	(7.03)	(7.05)	(8.47)	(6.90)	(6.57)	(7.11)	(6.89)
GDP Deflator$_{t-1}$	-.597**		-.348**	-.241**	2.051**		1.251**	.971*	-.029**		-.017**	-.015**	.136**		.085*	.016
	(6.63)		(3.87)	(2.71)	(5.08)		(3.12)	(2.26)	(6.16)		(3.59)	(3.04)	(3.70)		(2.33)	(0.42)
CPI$_{t-1}$		-.418**				1.248**				-.015**				.114**		
		(6.50)				(4.29)				(4.29)				(4.41)		
GDP Growth	-.113*	-.086		-.031	.246	.064		-.001	-.006*	-.003		-.003	.014	.017		-.014
	(2.08)	(1.65)		(0.64)	(1.01)	(0.27)		(0.01)	(2.27)	(0.89)		(1-19)	(0.63)	(0.81)		(0.66)
Productivity Growth			.159*				-.655*				.006				-.044	
			(2.30)				(2.13)				(1.76)				(1.55)	
Unemployment Rate	.453**	.474**	.498**	.243**	-.615**	-.709**	-.746**	.022	.011**	.014**	.014**	.004	-.100**	-.102**	-.108**	-.029
	(10.58)	(11.20)	(12.04)	(5.45)	(3.20)	(3.70)	(4.05)	(0.10)	(5.32)	(5.95)	(6.51)	(1.47)	(5.70)	(5.99)	(6.40)	(1.51)
Union Wage Growth				-.722**				2.186**				-.028**				.243**
				(8.73)				(5.45)				(6.15)				(6.87)
1984-Dummy	-.001	-.002	-.005	-.008*	-.109**	-.106**	-.099**	-.088**	-.0002	-.0003	-.0003	-.0005*	-.008**	-.008**	-.007**	-.006**
	(0.37)	(0.50)	(1.17)	(2.37)	(6.26)	(6.01)	(5.74)	(5.22)	(1.17)	(1.43)	(1.90)	(2.60)	(4.92)	(5.00)	(4.55)	(3.68)
R^2	0.504	0.502	0.506	0.622	0.659	0.649	0.664	0.696	0.274	0.220	0.268	0.370	0.666	0.673	0.669	0.720
Observations	252	252	252	252	252	252	252	252	252	252	252	252	252	252	252	252

Notes: Estimates are Within-Group estimates. Hausman-tests reveal that the null that differences between random and fixed effects coefficients are not systematic cannot be rejected at any level of significance. Absolute $t-$values in parentheses. **, * are used to indicate that a parameter value is significant at the one or five percent level, respectively.

Table 9: Unemployment Consequences of Wage Rigidities

	Dependent Variable:									
	ΔUnemployment Rate$_{t+1}$					ΔUnemployment Rate$_{t+2}$				
Intercept	1.183**	.278	-.789*	.200	.310	-.119	-.207	1.264**	-.241	-.145
	(3.43)	(0.90)	(2.31)	(0.52)	(1.01)	(0.39)	(0.69)	(3.96)	(0.64)	(0.48)
Linear Trend x 100	-.040*	.005	.017**	.007	.002	-.024	.027	.079**	.029	.024
	(2.40)	(0.33)	(3.30)	(0.45)	(0.18)	(1.65)	(1.93)	(4.97)	(1.78)	(1.65)
Total Wage Sweep-Up$_t$	-.062	-.012	.213	-.023		.253*	.226*	.484**	.223*	
	(0.49)	(0.12)	(1.69)	(0.20)		(2.27)	(2.07)	(4.02)	(2.02)	
Nominal Wage Sweep-Up$_t$					-1.148					-.819
					(1.31)					(0.95)
Real Wage Sweep-Up$_t$					-.028					.216*
					(0.25)					(1.98)
GDP Growth$_{t+i}$	-.372**	-.365**		-.362**	-.349**	-.359**	-.342**		-.341**	-.328**
	(10.00)	(11.42)		(11.02)	(10.30)	(11.04)	(10.67)		(10.37)	(9.62)
Productivity Growth$_t$			-.331**					-.322**		
			(5.63)					(5.62)		
GDP Deflator$_{t+i}$				.024					.010	
				(0.34)					(0.15)	
ΔUnemployment Rate$_t$		.172**	.347**	.178**	.184**		.164**	.317**	.167**	.159**
		(3.64)	(6.22)	(3.53)	(3.83)		(3.53)	(5.78)	(3.38)	(3.40)
1984-Dummy	-.005	-.002	.001	-.001	-.002	-.001	-.001	-.000	-.001	-.001
	(1.40)	(0.57)	(0.32)	(0.49)	(0.57)	(0.29)	(0.24)	(0.12)	(0.24)	(0.26)
R^2	0.319	0.439	0.221	0.439	0.443	0.421	0.452	0.274	0.468	0.455
Observations	252	252	252	252	252	240	240	240	240	240

Notes: Estimates are Within-Group estimates. Absolute $t-$values in parentheses. **, * are used to indicate that a parameter value is significant at the one or five percent level, respectively. $i = 1, 2$ for estimations of ΔUnemployment$_{t+1}$ and ΔUnemployment$_{t+1}$, respectively.

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