Does wage rigidity really exist?

New evidence from US panel data

CAWM-Discussion Paper No 13
February 2009

by

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Abstract Downward nominal wage rigidity (DNWR) could prevent real wage adjustments in times of low inflation rates. Nominal wage rigidity based on annual wages can at least be reduced, if the number of working hours is considered. This leads to a lower degree of DNWR in hourly wage changes. In this paper, we use a histogram-location approach to investigate to what extent annual as well as hourly wages are subject to downward nominal wage rigidity. Using data from the Panel Study of Income Dynamics (PSID) we find that annual wage changes exhibit a substantially higher level of wage rigidity than hourly wage changes which also holds for males compared to females.

Keywords Wage Rigidity, Histogram-Location Approach

JEL Classification E24, J30, J31.

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1. Introduction

Downward nominal wage rigidity (DNWR) and low inflation rates can prevent real wage adjustments which are essential for the efficient functioning of labour markets. Since being established primarily by Tobin (1972), this notion was supported by a study of Akerlof et al. (1996), who showed a substantial impact of downward nominal wage rigidity on the long-run unemployment rate under close-to-zero rates of inflation.

Sticky wages in the US were subject to several studies with different methods based on the Panel Study of Income Dynamics (PSID). First evidence in analyzing wage rigidity with US micro data was presented by McLaughlin (1994) who used a skewness-location approach (SLA), followed by Card and Hyslop (1997) using a symmetry approach (SA) and Kahn (1997) using a histogram-location approach (HLA). These studies provide evidence that downward nominal wage rigidity exists in annual wage changes.

However, downward nominal wage rigidity could be an artifact. Annual wage changes may be sticky in terms of nominal wages, but if firms could alter the working hours of their employees, hourly wages could be kept flexible. In this context, we assume that firms adjust wages by varying (annual) working hours, for example, in order to compass collective agreements. We show that there are fundamental differences in micro data regarding annual and hourly wage rigidity. For this purpose, we use a formal HLA developed by Kahn (1997) and enhanced by Knoppik and Beissinger (2005). Unlike other models, e.g. the SA of Card and Hyslop (1997), the normality approach of Borghijs (2001), the SLA of McLaughlin (1994) or the earnings-function approach of Altonji and Devereux (1999), the HLA is particularly useful to quantify the extent of downward nominal wage rigidity and, therefore, allows a comparison of the level of stickiness in terms of both annual and hourly wages. We especially use data from the PSID to ensure comparability of our results to that of previous studies.

Moreover, DNWR should also be detected in a gender specific context. Because females are supposed to work in different occupations and industries compared to males and, also, have a higher degree in wage elasticities (Hall, 1980), wage cuts are assumed to be observed more frequently for males than for females. Therefore, we will also check if DNWR is higher for males than for females.

This paper is organized as follows. In Section 2, the foundations of the histogram location approach are described. In Section 3, the data sources and preparation of the data are explained. Section 4 presents the empirical results and Section 5 discusses the results.

2 The Model

We follow the new histogram location approach of Knoppik and Beissinger (2001, 2005). The econometric specification of our model is based on the distribution of wage changes taking median centred histograms into account. As this approach is well established in economic literature, it is also an appropriate instrument for estimating the actual magnitude of downward wage rigidity. Therefore, the relative frequencies of wage changes, namely the bins *r*, are used in period *t* to specify the distribution of wage changes (*DWC*)

$$DWC_{r,t} = \hat{\alpha}_r\left(1 - \hat{\rho} DN_{r,t}\right) + (\hat{\gamma} + \hat{\rho} \textstyle\sum_{j=r_{min}}^{r_{max}} \hat{\alpha}_j DN_{j,t}) DZ_{j,t} + \hat{\mu}_{r,t} \qquad (1)$$

where $\hat{\alpha}_r$ is the original and time-constant bin size, given flexible wages, $\hat{\rho}$ is the coefficient of rigidity, which is assumed to represent the nominal wage rigidity, that is, a wage change of zero instead of an otherwise observed negative wage change; $\hat{\gamma}$ determines the size of the zero bin, which exists even without wage rigidity. The exogenous variables $DN_{r,t}$ and $DZ_{r,t}$ are binary, indicating if a bin is below zero ($DN_{r,t}$ takes the value one) or a zero wage change ($DZ_{r,t}$ takes the value one). Consequently, if both binary variables are zero, wage changes are positive. The error term is denoted by $\hat{\mu}_{r,t}$ which is assumed to be i.i.d. with $N(0, \sigma)$. However, in the following analysis, we focus on the bins which change their size over time. These bins are assumed to exist only in the range $[r_{min}, r_{max}]$.

Assumptions

For the following analysis, we have to make assumptions about a (virtual) distribution of wage changes without rigidity (*DWC**) which is essential for estimating the level of wage rigidity. Because this distribution displays wage changes without any distortions, it covers a greater probability mass below zero. In fact, *DWC** is unknown, but a comparison of *DWC** and *DWC* enables us to estimate the degree of wage rigidity, namely the coefficient $\hat{\rho}$, under the following assumptions.

A. Direct relations in nominal wage rigidity: The probability mass of negative wage changes in DWC are assumed to be incurred in the zero bin in the original DWC.*

B. Sufficiently large median, e.g. the highest value affected by wage rigidity is smaller than the median.

C. DWC is time-independent, that is, time variation leads only to positional changes in DWC*, but the shape of the distribution remains unchanged.*

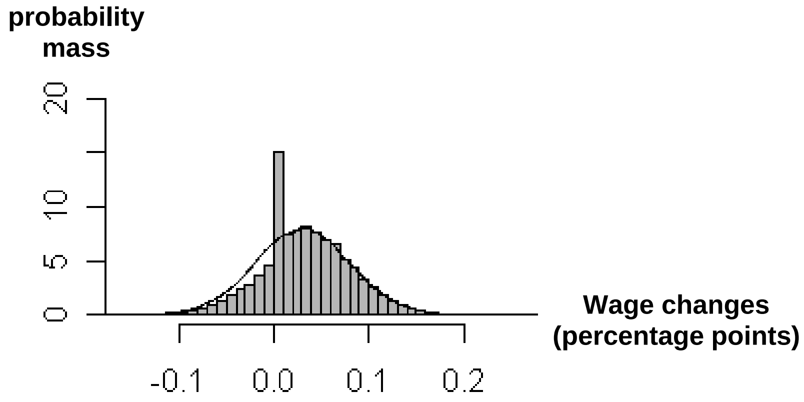
D. Constant coefficient of wage rigidity: The type and structure of wage rigidity is equal for all periods $t = 1,\ldots, n$.

E. The wage rigidity parameter $\hat{\rho}$ is modelled by a time-invariant parameter.

Assumptions A and B ensure a close connection of the *DWC*s. Firstly, this means that wage rigidity in the *DWC* can be immediately traced back to small or negative wage changes in the *DWC**. Second, the median *m* is supposed to be sufficiently large and, hence, both distributions *DWC* and *DWC** have identical medians. They only differ in the size of the zero bins while the number of bins below the zero bin remains constant.

These properties allow a comparative analysis of the *DWC*s. We focus on the zero bins because they are used as the key objects for estimating the level of wage rigidity. Therefore, the deviation of the zero bin in the *DWC* with respect to the zero bin in the *DWC** is taken as a quantitative measure for the probability mass that usually indicates negative wage changes. It shows the frequency of wage changes that are zero instead of being below zero. Thus, it reflects the level of wage rigidity. Bins above the zero bin are identical in both distributions and, hence, do not affect nominal wage rigidity (see Fig. 1).

Fig. 1 *DWC* and the estimated kernel density function of *DWC**, simulated data



The histogram in Fig. 1 describes *DWC* using simulated data. The solid line shows the kernel density function of the *DWC**. As defined in Equation 1, the coefficient $\hat{\rho}$ will only capture the effect that is due to the surplus mass in the zero bin in the *DWC*. In order to estimate $\hat{\rho}$ through Equation 1, a numerical optimization procedure is applied which is useful for solving non-linear functions:

$$H(\hat{\alpha}_r, \hat{\gamma}, \hat{\rho}) = DWC_{r,t} - \hat{\alpha}_r\left(1 - \hat{\rho} DN_{r,t}\right) + (\hat{\gamma} + \hat{\rho} \textstyle\sum_{j=r_{min}}^{r_{max}} \hat{\alpha}_j DN_{j,t}) DZ_{j,t} + \hat{\mu}_{r,t})]^2 \quad (2)$$

with $r = r_{min}, \ldots, r_{max}$ and $t = t_0, \ldots, t_n$.

The estimation procedure aims at a minimization of $H(\hat{\alpha}_r, \hat{\gamma}, \hat{\rho})$ while H is the target function. Such an optimization problem can be solved by standard statistical software using an iterative method. That is, the closer the parameter estimates reflect the original *DWC,* the smaller is the value of *H*. The optimal solution then yields the parameter estimates for the calculated minimum of *H*.

The estimated coefficients can be interpreted as follows. The magnitude of wage rigidity is, in this context, a relative number. It shows the estimated level of wage rigidity in terms of an additional probability mass that is captured in the zero bin, compared to the normal size of the zero bin without wage rigidity. Therefore, if the coefficient of $\hat{\rho}$ is estimated to be zero, the level of wage rigidity is assumed to be zero because the frequency of a “zero wage change” in the original data is equal to a “zero wage change” in the *DWC**. The values of $\hat{\alpha}_r$ reveal the estimation results for the bin sizes (below zero) that could be observed in a system of flexible wage changes. Concerning negative wage changes, it seems that the more the bins differ from the zero bin, the smaller they become. This means that the contribution of each bin to the level of wage rigidity also becomes continuously smaller.

3 Data

Our empirical analysis is based on data of the Panel Study of Income Dynamics (PSID). The PSID exists since 1968 and contains annual data of nearly 8.000 U.S. families. For our estimation we use income data from the years 1980 to 1997, 1999 and 2001. The years 1998 and 2000 are not included because in 1997 the timing of interviews was changed from a one-year to a two-year survey. In the considered period the sample contains 28.133 individuals. We focus on full-time-employees (FTE) with an employment term of at least one year. Employees of all industrial sectors are included. In particular, our analysis concentrates on two core variables: Individual labour earnings which report annual earnings and annual working hours. The latter variable contains data for the main job as well as for extra jobs and includes annual working hours of paid and unpaid overtime. This is important because we suppose that firms are able to alter hourly wages by varying the number of working hours. Hourly wages are estimated by dividing annual wages by annual working hours. The number of observations in the (pooled) sample is 114.437 while missing values are removed from the data set. Table 1 shows some descriptive statistics for age, annual and hourly wages and working hours.

Table 1 Descriptive statistics of the key variables

YEAR	AGE		ANNUAL WAGES (US-$)		WORKING HOURS		HOURLY WAGES (US-$)	
	Males	Females	Males	Females	Males	Females	Males	Females
1980	36.01	34.43	18429	10308	2345	2098	7.86	4.91
1981	35.89	34.5	20206 (+9.64%)	11210 (+8.75%)	2337 (-0.34%)	2091 (-0.33%)	8.65 (+10.05%)	5.36 (+9.16%)
1982	36.15	34.93	22095 (+9.35%)	12468 (+11.22%)	2325 (-0.51%)	2089 (-0.10%)	9.50 (+9.83%)	5.97 (+11.38%)
1983	36.22	34.99	23356 (+5.71%)	13407 (+7.53%)	2335 (+0.43%)	2109 (+0.96%)	10.00 (+5.26%)	6.36 (+6.53%)
1984	36.36	35.69	24725 (+5.86%)	14493 (+8.10%)	2326 (-0.39%)	2113 (+0.19%)	10.63 (+6.30%)	6.86 (+7.86%)
1985	36.43	35.32	26425 (+6.88%)	14954 (+3.18%)	2361 (+1.50%)	2152 (+1.85%)	11.19 (+5.27%)	6.95 (+1.31%)
1986	36.32	35.57	27126 (+2.65%)	16158 (+8.05%)	2350 (-0.47%)	2154 (+0.09%)	11.54 (+3.13%)	7.50 (+7.91%)
1987	36.52	35.69	27964 (+3.09%)	16934 (+4.80%)	2365 (+0.64%)	2137 (-0.79%)	11.82 (+2.43%)	7.92 (+5.60%)
1988	36.92	35.96	29784 (+6.51%)	17795 (+5.08%)	2367 (+0.08%)	2143 (+0.28%)	12.58 (+6.43%)	8.30 (+4.80%)
1989	37.07	36.15	31004 (+4.10%)	19185 (+7.81%)	2376 (+0.38%)	2160 (+0.79%)	13.05 (+3.74%)	8.88 (+6.99%)
1990	37.34	36.38	32241 (+3.99%)	20379 (+6.22%)	2381 (+0.21%)	2155 (-0.23%)	13.54 (+3.75%)	9.46 (+6.53%)
1991	37.99	36.89	33834 (+4.94%)	21100 (+3.54%)	2374 (-0.29%)	2164 (+0.42%)	14.25 (+5.24%)	9.75 (+3.07%)
1992	38.32	37.56	34943 (+3.28%)	22024 (+4.38%)	2380 (+0.25%)	2177 (+0.60%)	14.68 (+3.02%)	10.12 (+3.79%)
1993	39.19	37.54	37749 (+8.03%)	23689 (+7.56%)	2367 (-0.55%)	2159 (-0.83%)	15.95 (+8.65%)	10.97 (+8.40%)
1994	39.26	38.44	40142 (+6.34%)	25233 (+6.52%)	2379 (+0.51%)	2172 (+0.60%)	16.87 (+5.77%)	11.62 (+5.93%)
1995	39.29	38.53	40394 (+0.63%)	25617 (+1.52%)	2385 (+0.25%)	2164 (-0.37%)	16.94 (+0.41%)	11.84 (+1.89%)
1996	38.91	38.67	42258 (+4.61%)	26564 (+3.70%)	2400 (+0.63%)	2174 (+0.46%)	17.61 (+3.96%)	12.22 (+3.21%)
1997	39.69	37.41	42744 (+1.15%)	27773 (+4.55%)	2392 (-0.33%)	2193 (+0.87%)	17.87 (+1.48%)	12.66 (+3.60%)
1999	39.72	38.99	46087 (+7.82%)	29369 (+5.75%)	2420 (+1.17%)	2209 (+0.73%)	19.04 (+6.55%)	13.30 (+5.06%)
2001	40.13	39.16	51675 (+12.12%)	32781 (+11.62%)	2399 (-0.87%)	2190 (-0.86%)	21.54 (+13.13%)	14.97 (+12.56%)
Mean	37.69	36.64	32659 (+5.62%)	20072 (+6.31%)	2368 (+0.12%)	2150 (+0.23%)	13.76 (+5.49%)	9.30 (+6.08%)
Standard Deviation	1.48	1.55	9192 (+2.96%)	6446 (+2.67%)	26 (+0.62%)	34 (+0.70%)	3.74 (+3.18%)	2.86 (+3.02%)

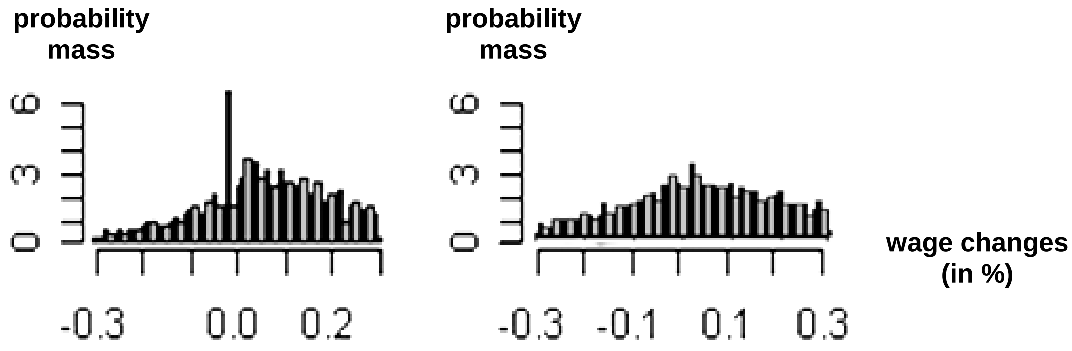
As can be seen from Table 1, full-time employed females receive substantially lower annual wages than full-time employed males. This can partly be explained by a lower number of working hours each year for women and/or by lower mean hourly wages. Males gain annual wages that are roughly 1.5 times higher than those of females. The annual wages of *males* increase at an average rate of 5.62 percent p.a. while hourly wages raise at a rate of 5.49 percent p.a. *Females*, in contrast, realize annual wage changes with a higher average rate of 6.31 percent and, respectively, hourly wage changes increase with a rate of 6.08 percent. In this respect, females' wages seem constantly to catch up with males' wages in the period 1980 to 2001.

4 Results

Figures 2.a and 2.b depict the estimated annual and hourly wage changes in 1999. Fig. 2.a shows large bin sizes for the zero bin of annual wage changes. In addition, the bins are substantially smaller on the left side of the zero bin, as will be expected for a symmetrical *DWC**. This indicates a certain level of wage rigidity in 1999.

In Fig. 2.b, hourly wage changes are displayed graphically. The extent of the zero bin yields a much lower probability mass and the bins of the *DWCs* are much more symmetrical distributed than in the case of annual wage changes. Therefore, we suppose that only low levels of wage rigidity can be detected in hourly wages.

Fig. 2 Annual and hourly wage changes in the US, 1999



a. Annual Wage Changes *b. Hourly Wage Changes*

Wage inflexibilities could be quantitatively detected in the regression results which are given in Table 2 [see also Equation 1]. Therefore, we used a bin width of 0.1 percent. For the sake of simplicity, the coefficients of $\hat{\alpha}_{min}$ (refers to the first bin below zero) and $\hat{\alpha}_{max}$ (refers to the last bin below zero) are presented, rather than displaying any estimated coefficient $\hat{\alpha}_r$. Moreover, we focus on the interpretation of $\hat{\rho}$ because this coefficient indicates if the probability mass in the zero bin is (significantly) different for the *DWC* and the *DWC**. The extent of wage rigidity is 0.141 for annual wage changes and 0.051 for hourly wage changes. As supposed, the level of wage rigidity is significantly different for hourly wage changes compared to annual wage changes. This means that negative nominal wage changes are more likely to occur in hourly wages than in annual wages. This supports the assumption of a flexible use of working hours.

Table 2 Regression results

	$\hat{\rho}$	$\hat{\gamma}$	$\hat{\alpha}_{min}$	…	$\hat{\alpha}_{max}$
Annual wage changes	0.141***	0.348*	0.440*	…	0.336*
	(0.001)	(0.183)	(0.285)		(0.199)
Hourly wage changes	0.051*	0.010	0.501	…	0.383
	(0.034)	(0.186)	(0.466)		(0.564)

PSID, 1980-1997, 1999 and 2001. Standard errors in parentheses. *, **, *** denote statistical significance at 10, 5, 1 % level.

Furthermore, wage adjustments seem to be different for males and females. Table 3 shows the coefficients of wage rigidity ($\hat{\rho}$) which are obtained from different regression estimates. Firstly, the data reflect the supposed relationship, controlling for gender-specific differences. The level of wage rigidity, however, is greater in annual wage changes than in hourly wage changes. Males experience wage rigidity in annual wage changes to the extent of 0.1966 while females face (annual) wage rigidity only to an extent of 0.1056. Concerning hourly data, the respective coefficients are 0.0167 for males and $7.01 \cdot 10^{-5}$ for females. Therefore, males seem to face higher levels of wage rigidity compared to females.

Table 3 Rigidity coefficients for males and females.

	$\hat{\rho}$
Annual wage changes (females)	0.1056*
	(0.062)
Hourly wage changes (females)	$7.01 \cdot 10^{-5}$ (≈ 0)
	(0.017)
Annual wage changes (males)	0.1966**
	(0.114)
Hourly wage changes (males)	0.0167*
	(0.01)

PSID, 1980-1997, 1999 and 2001. Standard errors in parentheses; *, **, *** denote statistical significance at 10, 5, 1 % level.

5 Discussion

The aim of this analysis was to examine whether downward nominal wage rigidity (DNWR) is an artifact. Using data from the Panel Study of Income Dynamics (PSID) over the period 1980 to 2001 (without the years 1998 and 2000) we conclude that DNWR is lower if hourly wage changes are considered. Rigidity in annual wage changes seems to have a substantial amount while rigidity in hourly wage changes is much lower. This leads to the assumption that working hours are of crucial relevance to avoid nominal wage rigidity. Therefore, if working hours are held flexible the economic implications of DNWR on the labour market could be tempered. The "degree" of reduction in DNWR could, then, be approximately measured by the difference in the coefficients between annual and hourly wage rigidity, which is roughly 9 percentage points. Compared to an absolute level of wage rigidity in hourly wages of 5.1 percent, the effect of working hours is relatively large. In this context, the results indicate that DNWR exists to a (relatively) large extent in annual wages and only to a smaller extent in hourly wages. Hence, DNWR is not an artifact but the degree seems to be different between both wage concepts.

In line with Kahn (1997) and Holden / Wulfsberg (2005), we also present evidence that DNWR exists within hourly wage changes. However, the degree of DNWR differs across these studies and ranges between moderate levels of DNWR and a "substantial stickiness of nominal wages" (Kahn, 1997). Even though DNWR can be attributed to many factors, such as an increasing foreign competition or a declining inflation, it is not clear to what extent the use of working hours can help to prevent DNWR. This was emphasized here.

Furthermore, we reveal gender-specific differences with respect to the level of wage rigidity. To the best of our knowledge, this has not been stressed before. Our empirical results indicate a considerably higher level of wage rigidity for males than for females in annual data. In hourly data, only small degrees of DNWR can be detected. Hence, we conclude that from a gender-specific perspective DNWR is not an artifact considering annual wage changes. In hourly wage changes, no (significant) DNWR can be detected for females but a small degree of DNWR is observed for males. Respectively, the calculated difference in the coefficients between annual and hourly wage rigidity is about 10.5 percentage points for females and about 18.0 percentage points for males. Therefore, the impact of working hours is supposed to reduce DNWR more intensively for males. Concerning the levels of DNWR, it is not unlikely that DNWR in hourly data could be an artifact.

The results presented here are not obvious as one could expect that women's labour supply is more elastic than that of men and, therefore, men should more often accept wage cuts. In particular, this could potentially be explained by gender-specific self-selection in industrial sectors and ocuupations. Since firms in specific industrial sectors have different opportunities to vary working hours and males and females are not equally distributed across industrial sectors, this could lead to different DNWR for males and females.

However, this is only one potential source of "gender-specific DNWR". The reasons for lower rigidity in hourly wage changes for females compared to males are complex and should be object to future research in more detail.

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