How Costly is Downward Nominal Rigidity in the United Kingdom?

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7 August 2006

Executive Summary

Data from the British Household Panel Study, representative of the population of England, Wales and southern Scotland since the early 1990s, are used to examine inflexibility in nominal pay. Tests are conducted to investigate how costly this inflexibility is.

A significant fraction of employees who remain in the same job report no change in their nominal pay from one year to the next. On average over the period 1992-2002, just over 8% of job stayers exhibited such nominal rigidity in their weekly pay. Among hourly-paid workers, rigidity in the basic hourly wage rate is typically higher, applying to around 15% of non-job-changers on average over the period 2000-2002. These figures are similar to those found in some other countries, including the United States, and are similar to statistics derivable from other United Kingdom data sources.

Lower inflation could have a detrimental impact in the face of such nominal rigidity. As inflation falls, it will typically be the case that an increasing fraction of workers should accept nominal pay cuts. If firms do not feel they can cut pay, pay freezes are likely. The analysis here supports this: a one percentage point fall in average (median) nominal pay growth, reflecting lower inflation, results in an extra 0.5 percentage point of workers experiencing nominal pay freezes.

The cost of low inflation, which arises because it increases nominal rigidity, can be thought of in two ways. First, nominal pay inflexibility makes it more difficult to reduce nominal wages, so that consequently real wages and unemployment are higher than they would be if nominal pay were flexible. Second, nominal pay inflexibility means that unemployment needs to rise by more to successfully exert downward pressure on pay.

The estimation of the real wage–unemployment relationship indicates that downward nominal rigidity does not have a significant detrimental impact. Overall, if the unemployment rate doubled, real pay growth would fall by around 1 percentage point. There is little evidence that real wage growth would decline by less at lower rates of inflation, so the unemployment cost of lower inflation appears negligible.

Introduction

This paper investigates the unemployment cost of one type of wage inflexibility in the United Kingdom. The wage inflexibility studied here is known as downward nominal wage rigidity (DNWR), which captures the idea that nominal wages can fail to decline 'as they should' in response to adverse shocks. Instead of the warranted nominal cuts, the pay of workers affected by DNWR will be maintained constant in nominal terms, so their nominal wage growth will be zero.

The relationship between real wages, unemployment, inflation and DNWR

A failure of nominal wages to fall in response to negative shocks will result in real wages that are in excess of the market clearing wage. Unemployment is likely to result from this wage inflexibility. The Appendix contains a theoretical model demonstrating the link between DNWR, real wage growth and unemployment. The linkage can be best understood in stages.

First it is shown that DNWR is likely to be more severe when inflation is low (or when average pay growth is low). Under these circumstances, more workers 'should' have nominal pay cuts. If these are prevented by DNWR, there will be many workers with real wages that are 'too high'. This is investigated empirically in Section B.

Then it is shown that this extra wage stickiness occurring at low inflation could adversely affect the wage–unemployment trade-off. Under DNWR, the lower is inflation, the bigger the rise in unemployment that would be needed to generate the real wage fall that is required to restore labour market equilibrium after a negative shock. In other words, the Phillips curve relationship between wage growth and unemployment could be flatter at lower rates of inflation.[1] This is investigated empirically in Section C.

The rationale for DNWR

Several theories have been put forward to try to explain why nominal wages might not fall. One reason relates to 'money illusion'. Workers might be under the illusion that what matters are money values: in that case, rather than focusing on their real wage, they might mistakenly try to prevent declines in their nominal wage. Economists are typically unwilling to rely on this type of 'irrationality' to explain DNWR. A second explanation is institutional: there are often legal impediments preventing unilateral

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[1] It would in principle be possible to 'invert' this Phillips-type relation, estimating unemployment equations instead of wage growth equations. Theoretically, if DNWR exists, the coefficient on wage growth in unemployment equations should vary in a similar way to that in which the unemployment coefficient varies in the wage growth equations estimated here. A finding of significant change in the wage growth–unemployment relationship as inflation changes should carry over to the inverted equation. Complications arise, however: this paper is careful to adjust for all other factors affecting wage growth; a similar adjustment would need to be made to unemployment if inverted Phillips curves were estimated. That is beyond the scope of this paper. In addition, it should be noted that simply putting a measure of rigidity on the right-hand side of either wage growth or unemployment equations is likely to lead to an error-ridden measure of its impact, as it is endogenous (inherently involving wage growth). This paper evades endogeneity problems by focusing on the inflation rate as a measure of the extent of rigidity.

wage cuts by employers.[2] There is limited hard evidence on the extent to which such contractual features prevent wage cuts in the United Kingdom. A third type of explanation proposes that firms are reluctant to cut workers' nominal pay because doing so would reduce morale, causing productivity to fall to such an extent as to outweigh the cost reduction from the pay cut.[3] This type of theory falls within the class of efficiency wage models, which all postulate a positive wage-effort relationship that induces firms to pay a wage which is both above the market clearing level and that does not vary with macroeconomic shocks.

The explanations for DNWR all relate to a particular employment relationship: it is workers remaining with a given employer, and indeed who continue to perform the same job for that employer, whose wages might fail to fall. Because of this, empirical studies of DNWR tend to focus on these 'stayers'. In contrast, no theories hypothesise that wages of workers who change job – 'movers' – will fail to fall. The focus here is therefore on stayers. But because the picture of the extent of wage flexibility in the United Kingdom labour market would be otherwise incomplete, the basic facts about nominal pay rigidity are also presented for movers.

Data

The primary source of the data used is the British Household Panel Survey (BHPS). Around 10,000 individuals were surveyed in 1991, and these people have been interviewed (whenever possible) on an annual basis since then. This study uses only data relating to that original sample, as it was designed to be representative of the British population south of the Caledonian Canal.[4] The first twelve waves of data are used here, up to 2002. The sample is restricted to working age (16-65) employees.

The focus of this paper is on job stayers, as it is the pay of these workers that theory suggests might be rigid. Job stayers are defined as those whose job started more than a year before the relevant survey. The specific question asked by the BHPS ensures that job stayers were not promoted, did not change grades, and did not change employer.[5] This definition is strict relative to most countries' surveys, and should help ensure that the sample of stayers really has no change in job that would necessitate a pay change. 67% of employees are stayers, on average over 1991-2002.[6]

The main pay variable used is usual gross weekly pay. From 1999, the BHPS asked hourly-paid workers to state their basic hourly wage rate. 41% of employees report

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[2] Holden (2004)

[3] Bewley (1999)

[4] The sample used includes Original Sample Members, their descendants, and any other adults who become members of OSM households. Various sub-samples have been added to the BHPS over the years, including special samples from Scotland, Wales and Northern Ireland, and a sample taken over from the European Community Household Panel. These sub-samples are omitted from this study because their composition is not representative.

[5] The BHPS asks: "What was the date you started working in your present position? If you have been promoted or changed grades, please give me the date of that change. Otherwise please give me the date when you started doing the job you are doing now for your present employer."

[6] Restricting the sample to only those that remain in the same job means that some movements in and out of the sample may be non-random. That does not matter in the context of measuring the extent of rigidity, in that it is precisely rigidity among stayers that is of interest. It would mean, though, that $E(\Delta w_{rt}) \neq E(w_{rt}) - E(w_{rt-1})$ (as noted for example by Solon, Barsky and Parker (1994)), which is relevant in the context of the model underlying the calculation of the cost of DNWR (see Appendix).

themselves to be hourly-paid. Some have argued that the basic hourly wage rate is the variable that should be studied when investigating rigidity. It is certainly true that the basic rate is less likely to change than total pay, as total pay includes overtime, bonuses, performance-related pay, and shift payments. On theoretical grounds, it is possible to make arguments for studying either pay measure. Legal considerations can explain rigidity in the basic wage rate, but clearly do not apply to overtime or bonus payments for example, thus suggesting that it is the basic rate that will reflect the extent of rigidity. But from the point of view of theories that justify pay rigidity on 'fairness' grounds, it would seem reasonable to study total pay, as this determines workers' utility. In principle, total pay per hour worked would also be relevant in this case. Hourly total pay measures can be calculated by dividing usual gross weekly pay by number of hours worked per week. Unfortunately, hours are reported with even more error than pay, so hourly pay is more error-ridden and probably less reliable.[7] To get as comprehensive picture of pay rigidity in the United Kingdom as possible, all pay measures are initially investigated.

The BHPS is a survey, and as such is prone to measurement error. This contrasts with some 'administrative' data sets – such as the New Earnings Survey in the United Kingdom – which are essentially error-free, being based on tax or social security data. Counterbalancing arguments in favour of survey data such as BHPS include the much broader set of variables available. The BHPS provides data on individual characteristics (age, gender, education, marital status, job tenure, employment experience, and so on).[8] These variables are essential in constructing a valid empirical model of the notional wage, for example (see below). Information about the region in which the individual lives is used to match BHPS data to regional unemployment data from ONS, and to regional price data from the Reward Group. Aggregate price and unemployment data are also taken from ONS.[9]

Results

A. The extent of nominal pay rigidity in the United Kingdom

Statistics are presented first for job stayers, including measures of the proportion of workers who have no change in their pay from one year to the next. The degree of asymmetry in the distribution is also calculated, as this could capture the extent to which workers' pay is 'held up' by DNWR. Statistics are then shown for job movers.

The extent of nominal pay rigidity

On average over 1991-2002, 8.3% of employees aged 16-65 who remained in the same job from one year to the next (stayers) report no change in their pay from one year to the next (see Table 1). The proportion of stayers reporting the same pay level as they did the previous year varies somewhat from year to year. The maximum is 9.7% in 1994, and the minimum is 6.1% in 1999.

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[7] Bound, Brown, and Mathiowetz (2001)

[8] Data on tenure and experience are derived from an updated version of the BHPS-based data set described in Paull (2003).

[9] The annual round of interviews for the BHPS begins in September. Most are completed by the end of the year, but some occur in the first few months of the following year. Annual variables are calculated as the average of monthly data over September to August, to correspond with BHPS interview dates.

It is far more common for hourly-paid workers to report no variation in their hourly basic wage rate from one year to the next than for salaried workers to report unchanged pay. On average, for the four years for which there are basic rate data, 15.3% of hourly-paid stayers' wage rates were rigid.

The proportion of stayers reporting no change in their hourly pay is lower, mainly due to measurement error in hours lowering the likelihood that the same values are calculated in consecutive years. 3.9% of stayers have hourly pay that does not change from year to year. There is again some variation over time in the extent of hourly 'pay freezes'. As with weekly pay, fewer freezes appear to have occurred in 1999 (2.6%) than in any other year, and more occurred during 1994 than at any other time. Overall, there is a 91% correlation between the proportions of stayers reporting freezes in weekly and hourly pay. Because the measure of hourly pay appears to be badly distorted by measurement error in hours, subsequent analysis focuses on weekly pay and the hourly basic rate.

Table 1: Proportion of stayers reporting no change in pay compared to previous year

	Weekly pay	Basic hourly wage rate	Hourly pay
Full sample	8.3%	15.3%	3.9%
1992	7.8%		3.6%
1993	9.6%		4.7%
1994	9.7%		4.8%
1995	9.1%		4.6%
1996	7.5%		3.1%
1997	8.1%		3.7%
1998	8.6%		4.1%
1999	6.1%		2.6%
2000	8.9%	15.0%	3.5%
2001	7.9%	14.0%	3.6%
2002	8.6%	16.0%	4.5%

Source: Author's calculations, based on BHPS data.
Note: Stayers are employees who do not change job between year *t-1* and year *t*. Full sample is 1992-2002 for weekly and hourly pay, and 2000-2002 for basic hourly wage rate. Data for '1992' refer to rigidity between 1991 and 1992. Weekly pay is total pay per week. Basic hourly wage rate applies to hourly-paid workers only. Hourly pay is total weekly pay divided by total hours worked per week. Sample includes employees aged 16-65 and excludes unrepresentative later BHPS sub-samples.

The extent of nominal rigidity found here for weekly pay is similar to that found previously for the United Kingdom.[10] This is the first time data on basic hourly wage rate have been presented for the United Kingdom. The difference between rigidity in weekly pay and among hourly paid workers is strikingly similar to estimates from the United States.[11]

As a caveat, it should be noted that previous work has suggested that there might be reasons other than DNWR for the apparently significant proportion of pay freezes. The primary alternative explanations involve various forms of measurement error.[12]

[10] Smith (2000) and Nickell and Quintini (2003) (the latter using measurement-error-free administrative New Earnings Survey panel data).
[11] For example, Card and Hyslop (1997) and Altonji and Devereux (2000).
[12] Smith (2000)

For example, consider rounding error. The statistics in Table 1 are based on reported pay, and if these reports involve rounded numbers, the reported rounded figures might not change from year to year even though true pay had changed. If measurement error rather than DNWR is responsible for apparent rigidity, the investigations in subsequent sections into the impact of low inflation on rigidity and the real wage–unemployment trade-off should find no impact.

The extent of asymmetry

Consider the distribution of pay growth that would arise in the absence of DNWR. Under the assumption that this 'counterfactual' distribution is symmetric, it is possible to calculate what proportion of workers are 'missing' from the lower tail, below nominal zero. These are the workers who 'should' have had their nominal pay cut, but instead have had their pay frozen (and thus appear in the zero 'spike' analysed in the previous section).

Asymmetry below zero is of a similar order of magnitude to the proportion rigid. On average over 1992-2002, 9.5% of stayers are 'missing below zero' – the fact that they have not experienced wage cuts tallying with the possibility that they have experienced nominal rigidity through pay freezes. As with rigidity, the minimum asymmetry is found in 1999 and the maximum in 1994. There is a 55% correlation in the degree of asymmetry found and the proportion rigid each year.

Table 2: Proportion of the distribution 'missing' below zero, calculated for stayers and weekly pay

	Stayers
Full sample	9.5%
1992	7.9%
1993	8.6%
1994	12.3%
1995	10.7%
1996	11.2%
1997	10.5%
1998	11.4%
1999	6.2%
2000	10.6%
2001	9.3%
2002	7.4%

Source: Author's calculations, based on BHPS data.
Note: Stayers are employees who do not change job between year *t-1* and year *t*. Full sample is 1992-2002 for weekly and hourly pay, and 2000-2002 for basic hourly wage rate. Data for '1992' refer to rigidity between 1991 and 1992. Weekly pay is total pay per week.

It should be noted that the method of calculation of the statistics in Table 2 relies on the notional pay growth distribution – the distribution that would arise in the absence of DNWR – being symmetric about the median. Although this is likely to be not too far from the truth, it would be unwise to place great confidence in the assumption, and so the asymmetry estimates should be treated with a degree of caution. For that reason, subsequent analysis will use the proportion rigid rather than the asymmetry statistics.

Movers

As explained above, there is no reason to believe that job movers' pay will exhibit nominal rigidity. Some workers that change job will enjoy pay rises, because of promotion or moving to another company. Other, perhaps involuntary, movers will take pay cuts.

Movers are less likely to report that their pay has not changed (see Table 3). 3.4% do so. This might seem a relatively high proportion, as there seems no rationale for pay constancy over a job change. Factors that might account for this include measurement error such as rounding error or incorrect classification as mover, or a change of grade within an employer which does not entail a pay change. A substantial fraction (6.0% over 2000-2002) of hourly-paid workers who changed job report no change in their hourly basic wage rate.

Table 3: Proportion of movers reporting no change in pay compared to previous year

	Weekly pay	Basic hourly wage rate
Full sample	3.4%	6.0%
1992	3.9%	
1993	4.1%	
1994	3.0%	
1995	4.5%	
1996	2.5%	
1997	4.0%	
1998	3.8%	
1999	3.4%	
2000	3.2%	8.3%
2001	2.8%	5.0%
2002	2.9%	4.5%

Source: Author's calculations, based on BHPS data.
Note: Movers are employees who change job between year *t-1* and year *t*. Full sample is 1992-2002 for weekly and hourly pay, and 2000-2002 for basic hourly wage rate. Data for '1992' refer to rigidity between 1991 and 1992. Weekly pay is total pay per week. Basic hourly wage rate applies to hourly-paid workers only. Sample includes employees aged 16-65 and excludes unrepresentative later BHPS sub-samples.

B. The relationship between rigidity and inflation

It is necessary now to check that the observed nominal pay rigidity actually reflects DNWR – that is, nominal pay being held up so that pay does not change even though a pay cut was warranted. If observed rigidity reflects DNWR, it should rise as the wage growth distribution shifts to the left, reflecting lower average pay growth and a lower rate of inflation. (The Appendix discusses this in further detail.)

The proportion of workers whose pay does not change between *t-1* and *t* is calculated for each region *r* and each year *t*, $P(rigid_{rt})$. This is regressed on median nominal pay growth between *t-1* and *t* for region *r*, $\overline{\Delta W_{rt}}$. A set of region dummies $region_r$ and a set of year dummies $year_t$ are also included as controls.[13]

$$P(rigid_{rt}) = \alpha + \beta(\overline{\Delta W_{rt}}) + \sum_{r=2}^{11} \gamma_r region_r + \sum_{t=1992}^{2001} \delta_t year_t + \varepsilon_{rt} \qquad (1)$$

[13] London is the omitted region and 2002 the omitted year.

The equation is estimated over 1992-2002 for the 11 standard regions of the United Kingdom.

If rigidity varies inversely with the location of the pay growth distribution, β will be negative: the lower is median pay growth, the greater the number of workers who 'should' have had pay cuts but whose pay will be held rigid by DNWR.

Because the variables included are calculated at region-year level, the sample size used varies by region and over time. Some regions are populous, but others less so. To check for bias caused by overly small cell size, weighted or robust regression was used, but in no case was the result substantially affected.[14]

The results strongly suggest that rigidity rises as median pay growth falls. A 1 percentage point fall in median pay growth leads to a 0.5 percentage point rise in the proportion of weekly pay that is held rigid. The measured relationship is stronger for basic hourly wage rate: a 1 percentage point fall in median pay growth leads to an increase in the proportion of rigidity in basic rate by around 2 percentage points. Recall that on average, rigidity in weekly pay during 1992-2002 was 8.3%, whereas during 2000-2002 rigidity was 15.3% for basic rate. Thus even in relative terms, the relationship seems stronger for the basic hourly wage rate. This is consistent with the notion that the basic wage is more likely to exhibit downward rigidity than non-basic-wage components such as overtime and bonuses. It may also reflect differences in individual and institutional characteristics between hourly paid and salaried workers that may be correlated with the likelihood of rigidity. For example, compared to salaried workers, hourly paid workers are less likely to work in the public sector and are less likely to be trade union members or to be covered by a union. (Note that the weekly pay measure covers both salaried and hourly-paid workers.)

Table 4: Relationship between nominal rigidity and location of nominal pay growth distribution, for stayers

Dependent variable: % rigid	Weekly pay				Basic hourly wage rate			
Median	-0.514 (-2.90)	-0.607 (-3.60)	-0.522 (-2.98)		-2.416 (-2.69)	-1.522 (-3.46)	-2.276 (-2.84)	
Median*D_3				-1.86 (-2.02)				-4.03 (-1.33)
Median*D_4				-1.26 (-1.95)				-4.00 (-1.70)
Median*D_5				-1.13 (-2.16)				-3.16 (-1.67)
Median*D_6				-0.97 (-2.23)				-3.16 (-2.08)
Median*D_7				-0.94 (-2.49)				-3.09 (-2.25)
Median*D_8				-0.91 (-2.64)				
$\overline{R}^2$	0.33		0.36	0.32	0.31		0.28	0.24
Estimator	OLS	Robust	Weighted	OLS	OLS	Robust	Weighted	OLS

Source: Author's calculations, based on BHPS data.

[14] Because there are only 11 time-series observations per region, it is not feasible to use SURE to allow for cross-region correlation of errors.

Note: All regressions are run on data aggregated at region-year level. Number of regions *R*=11. For weekly pay, number of time periods *T*=11; observations used *RT*=121. For basic hourly wage rate, number of time periods *T*=3; observations used *RT*=33. *t* statistics given in parentheses. Region and time effects included in all regressions except final column, where they were omitted due to lack of degrees of freedom. Stayers are employees who do not change job between year t-1 and year t. Sample is 1992-2002 for weekly pay, and 2000-2002 for basic hourly wage rate. Weekly pay is total pay per week. Basic hourly wage rate applies to hourly-paid workers only. Sample includes employees aged 16-65 and excludes unrepresentative later BHPS sub-samples.

In fact, the relationship between the location of the nominal pay growth distribution and the proportion rigid should be non-linear. The nearer is the 'hump' of the distribution to 0%, the greater are the number of workers on the borderline of potential rigidity. A one percentage point reduction in average pay growth (and inflation) would raise rigidity by more, the closer is the median to 0% (see the Appendix for further details). To capture the consequent nonlinearity in the effect of median pay growth on rigidity, the median is interacted with dummy variables D_k capturing the distance of the median above 0% (see Table 4). For example, D_5 takes value 1 when median pay growth is at least 4 percentage points, but less than 5 percentage points, above 0%. The proportion rigid should also depend on the dispersion of the pay growth distribution: if the distribution becomes more dispersed, potential and thus actual rigidity should increase (see the Appendix for further details). However, no impact whatsoever of a measure of dispersion based on the distance between the median and the upper quartile was found, and so this is omitted from Table 4.

As hypothesised, a one percentage point shift towards 0% in the position of the pay growth distribution will have a larger impact on rigidity the lower is the distribution to start with. At the lowest observed pay growths in the sample – between 2 and 3% – a one percentage point decline in median pay growth would lead to an increase of close to 2% in rigidity in weekly pay, and 4% in rigidity in basic rate. In contrast, rigidity would in increase by less – 1% and 3% respectively – following a one percentage point decline in median pay growth from the highest levels in the sample.

To summarise this section, the evidence appears consistent with DNWR affecting pay in the United Kingdom. The following section investigates how costly this DNWR may be.

C. The cost of rigidity

The cost of rigidity can be expressed as the additional unemployment that is the result of the higher wage growth due to DNWR. This cost can be calculated from the relationship between the real wage and unemployment. DNWR implies that this relationship will be non-linear. The 'wedge' that DNWR drives between notional and actual nominal wages also, obviously, applies to real wages. Under DNWR, on average the real wage will be (permanently) too high, and this will lead to (permanently) higher unemployment.

The real wage–unemployment relationship could either be in the form of a Phillips curve, relating wage growth to unemployment, or a 'wage curve', relating the level of real wages to unemployment (or equivalently, real wage growth to growth in unemployment). Empirical tests to distinguish these alternatives involve testing whether the coefficients on current and lagged (log) unemployment in a real wage growth regression are equal and opposite (which would indicate a wage curve relationship). Past evidence has been mixed; most previous work prefers Phillips curves, while others cite evidence in favour of wage curves.[15] The evidence here is similarly mixed. ILO regional unemployment rejects equality of coefficients on current and lagged values, but for claimant count regional unemployment equality can only be rejected at the 10% level.[16] Because measurement reasons favour ILO unemployment, and because on balance the evidence points that way, the Phillips curve specification will be used here.

The non-linearity in the Phillips curve caused by DNWR takes the form of a variable (rather than constant) negative trade-off between real wage growth and unemployment. This trade-off will be lowest in absolute terms when inflation is high. As inflation falls, the wedge between actual and notional wage growth rises. This worsens the trade-off, in that unemployment needs to rise by more to generate the same reduction in (actual) real wage growth.

To model the non-linearity, the relationship between real pay growth and unemployment can be allowed to depend on the rate of inflation Δp_t (or in general, anything that increases the proportion of workers potentially affected by DNWR). Because real wages depend on factors other than unemployment, it is wise to control for these factors when assessing the real wage–unemployment relationship, otherwise their omission could potentially bias the results. A preliminary regression is used to calculate the adjusted wage dependent variable $\Delta \tilde{w}_{rt}$, regional pay growth calculated using pay adjusted for human capital and other individual characteristics (see the Appendix for details).

The non-linear real wage–unemployment relationship can then be estimated using data for 11 standard regions of the United Kingdom over 1992-2002:

$$\Delta \tilde{w}_{rt} = \alpha + \beta U_{rt} + \gamma \Delta p_t . U_{rt} + \varepsilon_{rt} \qquad (2)$$

where U_{rt} is the natural log of the unemployment rate and other variables are as previously defined. The non-linear term should have a negative coefficient, indicating that as inflation rises, the Phillips curve becomes more steeply negatively sloped. Year and region dummies can be added to the regression; year dummies allow for annual differences in wage growth, whereas region dummies perhaps more controversially allow for (permanent) regional differences in wage growth. Region dummies were not found to have explanatory power (see Table 5(a), column 7) and were consequently omitted from the main analysis.

The results in columns 1 and 2 of Tables 5(a) and 5(b) indicate that, on average, for the linear model, a doubling of the unemployment rate will reduce growth in real weekly pay by just over 1 percentage point, and growth in the real hourly basic rate by just under 1 percentage point.

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[15] Examples of Phillips curve-type estimates include Card and Hyslop (1997) and Fares and Lemieux (2000). Yates (1998) surveys previous non-linear Phillips curve estimates. Brown *et al* (2004) find evidence for wage curves.

[16] The *p*-values for these tests were 0.02 and 0.09 respectively. The tests were based on regressions using stayers' real weekly pay, where log unemployment and its first lag were the only regressors.

The results of non-linear models are in general not supportive of any detrimental effect of DNWR on the real wage–unemployment trade-off. For real weekly pay, the coefficients on aggregate price inflation interactions are positive in all cases but one. The coefficients are insignificantly different from zero, although their positive sign would indicate that if anything the Phillips curve becomes flatter at higher inflation rates. For the real basic hourly wage rate, however, three of the four interaction terms are negative, which would be consistent with DNWR preventing warranted nominal cuts in the wage rate as inflation falls. The effect is not large. Consider for example the estimates in column (6) of Table 5(c). When regional inflation is zero (which corresponds to the lowest values in the sample), a doubling of the unemployment rate will reduce real basic wage rate growth by 0.7 percentage points. If regional inflation rose to 4% (which is above the sample maximum), downward wage pressure from a doubling of unemployment would rise: such an increase would lower real basic wage rate growth by 1 percentage point.

Table 5: Phillips curve estimates, for stayers
(a) Relationship between real weekly pay growth and unemployment

	Dependent variable: Unadjusted real weekly pay growth						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\ln(U_{rt})$	-0.0139 (-2.13)	-0.0108 (-1.07)	-0.0141 (-2.12)	-0.0784 (-2.15)	-0.0138 (-2.09)	-0.0128 (-1.25)	-0.0183 (-0.57)
$\Delta p_t \times \ln(U_{rt})$			0.0176 (0.15)	2.762 (1.92)			
$\Delta p_{rt} \times \ln(U_{rt})$					0.0074 (0.15)	0.0690 (1.06)	
Year dummies	No	Yes	No	Yes	No	Yes	Yes
Region dummies							Yes
$\bar{R}^2$	0.028	0.071	0.021	0.093	0.021	0.072	0.016
Observations (*RT*)	121	121	121	121	121	121	121

(b) Relationship between adjusted real weekly pay growth and unemployment

	Dependent variable: Adjusted real weekly pay growth					
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(U_{rt})$	-0.0168 (-1.80)	-0.0127 (-0.93)	-0.0199 (-2.06)	-0.0694 (-1.30)	-0.0173 (-1.84)	-0.0137 (0.98)
$\Delta p_t \times \ln(U_{rt})$			0.2019 (1.15)	2.3874 (1.09)		
$\Delta p_{rt} \times \ln(U_{rt})$					-0.0301 (-0.44)	0.0347 (0.39)
Year dummies	No	Yes	No	Yes	No	Yes
$\bar{R}^2$	0.203	0.089	0.023	0.091	0.012	0.081
Observations (*RT*)	110	110	110	110	110	110

(c) Relationship between real hourly basic wage rate growth and unemployment

	Dependent variable: Unadjusted real hourly basic wage rate growth					
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(U_{rt})$	-0.0096 (-1.17)	-0.0082 (-0.98)	-0.0123 (-1.48)	0.0275 (0.81)	-0.0088 (-1.05)	-0.0071 (-0.85)
$\Delta p_t \times \ln(U_{rt})$			0.1836 (1.43)	-1.713 (-1.08)		
$\Delta p_{rt} \times \ln(U_{rt})$					-0.0535 (-0.77)	-0.0746 (-1.05)
Year dummies	No	Yes	No	Yes	No	Yes
$\overline{R}^2$	0.012	0.020	0.043	0.256	0.001	0.024
Observations (*RT*)	33	33	33	33	33	33

Note: *t* ratios in parentheses. U_{rt} is regional ILO unemployment rate (the regional claimant count rate gave very similar results) (source: ONS). Δp_t is aggregate price inflation (source: ONS). Δp_{rt} is regional price inflation (source: Reward Group). Real weekly pay growth is adjusted for the effects of human capital and other individual characteristics. The OLS estimator is used.

Conclusion

A minority of employees in the United Kingdom have pay that remains at a given nominal level for a substantial duration – at least a year. Nominal inflexibility in the United Kingdom labour market thus appears substantial.

Evidence was presented consistent with the notion that low inflation tends to increase the likelihood of nominal inflexibility. This suggests that such inflexibility stems from reluctance among employers to cut nominal pay, or reluctance among employees to accept nominal pay cuts. It also implies that lower inflation will drive an increasing wedge between the wage that workers 'should' receive and the wage they actually receive, on average. Although this implies that real wages will be 'too high' and that this will increasingly be the case as inflation falls, no evidence was found of any cost to the United Kingdom economy in terms of unemployment.

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Appendix

The impact of downward nominal wage rigidity

The best way to consider the impact of DNWR is to first consider wage determination in its absence. Without DNWR, the (log) nominal wage level for individual *i* at time *t*, W^*_{it}, is determined by a set of variables X_{it}:

$$W^*_{it} = bX_{it} + e_{it} \qquad (1)$$

This wage, which would prevail in the absence of DNWR, is known as the 'notional' wage. DNWR may affect a worker at time *t* only if the notional wage at *t* is lower than his actual wage in *t-1*, i.e. if $W^*_{it} < W_{it-1}$, so the worker 'should' face a nominal pay cut. If $W^*_{it} < W_{it-1}$ and DNWR prevails, then clearly the worker's wage will not change.

'Perfect' DNWR can be defined as a situation in which no-one actually has a nominal pay cut: everyone whose pay should have fallen, whose notional pay is lower than their pay last period, will have instead a 'pay freeze'. Everyone else will receive their notional pay.

Assuming perfect DNWR:

$$\begin{aligned} W_{it} &= W^*_{it} && \text{if } W^*_{it} \geq W_{it-1} \\ W_{it} &= W_{it-1} && \text{if } W^*_{it} < W_{it-1} \qquad (2) \end{aligned}$$

This can be rewritten in terms of wage growth $\Delta W_{it} = W_{it} - W_{it-1}$ (recall *W* denotes the log of the nominal wage; Δ denotes a first difference over time). Also substituting for W^*_{it} using equation (1) gives:

$$\begin{aligned} \Delta W_{it} &= bX_{it} + e_{it} - W_{it-1} && \text{if } bX_{it} + e_{it} - W_{it-1} \geq 0 \\ \Delta W_{it} &= 0 && \text{if } bX_{it} + e_{it} - W_{it-1} < 0 \qquad (3) \end{aligned}$$

More complex models have been proposed in the literature, allowing for example for measurement error, non-unit probability of a pay freeze if notional wage cuts are warranted, and the implementation of large but not small cuts. However, these modifications do not change the basic notion investigated here that DNWR leads to non-linearity in the real wage–unemployment relationship.[17]

As has been previously noted, the situation is complicated by the fact that the previous wage W_{it-1} may have been affected by DNWR.[18] A full model would incorporate this dynamic behaviour, but here it is ignored to keep the model simple. The phrase "notional wage growth" can therefore be used to refer to the difference between this period's notional wage and last period's actual wage, on the grounds that we are assuming no difference between last period's actual and notional wages.

Rigidity and the location of the pay growth distribution

The unconditional probability of worker *i*'s pay being rigid at time *t* will depend on both the conditional probability of rigidity given that a pay cut is warranted, and the probability of a pay cut being warranted:

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[17] See Altonji and Devereux (2000), Fehr and Goette (2003), Barwell and Schweitzer (2004) and Beissinger and Knoppik (2003) for details of modified models.
[18] Altonji and Devereux (2000)

$$P(rigid_{it}) = P(rigid_{it} \mid W^{*}_{it} < W_{it-1}) \times P(W^{*}_{it} < W_{it-1}) \tag{4}$$

Factors that increase the probability of the notional wage lying below last period's wage include everything that lowers nominal pay growth. All such factors will shift the pay growth distribution to the left, raising the fraction of workers falling to the left of 'nominal zero' and thus facing notional pay cuts.

The observed (unconditional) proportion rigid will therefore depend on the location of the pay growth distribution. This location can be summarised in various ways. One simple measure of location is the median $\overline{\Delta W_{it}}$. The lower is median nominal pay growth, the greater the fraction of workers potentially affected by DNWR $P(W^{*}_{it} < W_{it-1})$, and the higher will be the proportion rigid $P(rigid_{it})$. Median nominal pay growth will be lower when inflation is lower, so inflation could also be used as an indicator of the location of the pay growth distribution. Note that it is assumed that $\overline{\Delta W_{it}} \equiv \overline{\Delta W^{*}_{it}}$: the effects of nominal rigidity are only felt in parts of the pay growth distribution (some way) below the median.

If the proportion rigid is regressed on median pay growth, the coefficient β should be negative:[19]

$$P(rigid_{rt}) = \alpha + \beta\left(\overline{\Delta W_{rt}}\right) + \varepsilon_{rt} \tag{5}$$

The question arises of the level of aggregation of such a regression. To obtain repeated observations, the proportion rigid and the median both need to be calculated over subsamples of the data set. The BHPS used here only has 12 waves to date, so using annual averages does not give sufficient degrees of freedom. Thus averages for each region *r* and each year *t* are used.[20]

$-\beta$ in (5) gives the *average* percentage point rise in rigidity that results from a one percentage point fall in median pay growth. Note that the density of the pay growth distribution is not uniform; in particular, the density is greatest around the median. Consider the proportion of workers whose notional nominal pay growth is driven below 0% as the pay growth distribution shifts downwards by one percentage point. This proportion is greater, the closer is median pay growth to 0%. In other words, $P(W^{*}_{it} < W_{it-1})$ in (4) is greater, the closer is median pay growth to 0%. Hence, for a given 'rigidity propensity' $P(rigid_{it} \mid W^{*}_{it} < W_{it-1})$, β will vary with the distance $\left(\overline{\Delta W_{rt}} - 0\right)$. In sum, the relationship between $P(W^{*}_{it} < W_{it-1})$ and the median $\overline{\Delta W_{rt}}$ is non-linear. Assuming the density function of pay growth to be linear over the region that contains 0%, it would be possible to explicitly model the nonlinearity by a quadratic function of the median.[21] A less restrictive method would involve interaction terms using dummy variables, for example capturing each percentage

[19] A negative relationship should also be evident between rigidity and inflation, and this was tested. However, no significant negative relationship was found. This is difficult to explain, given the results for median wage growth (see main text), but one reason could be measurement error in the inflation measure used, which was regional inflation calculated by the Reward Group.

[20] Industry-year and occupation-year averages were also tried, but results were not substantively altered. Region-year averages correspond with the level of aggregation that must be used for data availability reasons below, when non-linearity in the real wage–unemployment relationship is studied.

[21] Nickell and Quintini (2003)

point of the (variable) distance $\left(\overline{\Delta W_{rt}} - 0\right)$. This method is incorporated in the regression (5').

Changes in the *shape* of the distribution would also cause changes in the proportion of workers whose notional nominal pay growth is below 0%, $P(W^*_{it} < W_{it-1})$, so it is necessary to control for such changes. It is also necessary to chose a measure that itself is unaffected by rigidities. 0% can lie at the 45th percentile for some of the wage measures used here, at region-year level, so a distribution measure referring only to the upper half of the pay growth distribution is used, namely the distance between the 75th percentile and the median (75th-50th).[22] The more dispersed the distribution, the greater should be $P(W^*_{it} < W_{it-1})$, so the effect of (75th-50th) on rigidity should be positive.

The relationship between the proportion rigid and the location of the pay growth distribution can then be written

$$P(rigid_{rt}) = \alpha + \beta_k \sum_k D_{krt}^{\overline{W_{rt}}} \left(\overline{\Delta W_{rt}}\right) + \gamma(75^{th}\text{-}50^{th}) + \varepsilon_{rt} \qquad (5')$$

where k takes integer values spanning each unit of the range of the median $\overline{\Delta W_{rt}}$. For example, $D_{5rt}^{\overline{W_{rt}}}$ takes value 1 if the median $\overline{\Delta W_{rt}}$ lies in the range (4,5] and takes value 0 otherwise.[23] For stayers, the median region-year nominal pay growth never exceeds 10% over the sample.

Nominal rigidity, real wage growth and unemployment

The cost of DNWR can be measured in terms of the extra unemployment that results as real wages are held too high as a result of DNWR. There are two competing real wage–unemployment relationships that could underlie this. The Phillips curve embodies a relationship between real wage *growth* and unemployment, while the 'wage curve'[24] represents a relationship between the real wage *level* and unemployment. It is possible to construct a simple empirical test of which relationship best describes the data.

It was shown above that the impact of DNWR varies inversely with average nominal pay growth. The unemployment cost should vary in exactly the same way. The effect of DNWR (preventing real wages from falling to their warranted levels) will increase as the pay growth distribution shifts leftwards, as inflation falls. The more rigid are wages, the greater the impact of any negative shock on unemployment.

The increased impact on unemployment would be embodied in a flatter Phillips (or wage) curve. Thus the lower is inflation, given DNWR, the flatter will be the Phillips (or wage) curve. A flatter Phillips curve indicates that a greater rise in unemployment would be required to generate a given reduction in real wage growth. A flatter wage curve indicates that a greater rise in unemployment would be required to generate a given reduction in real wages.

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[22] In explaining the proportion of real wage cuts, Nickell and Quintini (2003) use the difference between the 75th and 35th percentiles as a measure of dispersion (of the real wage growth distribution).
[23] In practice, where a unit-range dummy contained only a very small fraction of the sample (<1%), the relevant dummy was combined with the adjacent one. This only applies to some sample end-points.
[24] Blanchflower and Oswald (1994)

To see how this ties in with the previous discussions, first consider the model of DNWR above. The determinants of the notional wage W^*_{it} include the unemployment rate.[25]

For simplicity, consider the model in (2) and (3) above with unemployment separated out from the other determinants Z_{it} of notional wage W^*_{it} (Z_{it} now includes the lagged wage W_{it-1}):

$$\begin{aligned} \Delta W_{it} &= a + bU_{it} + cZ_{it} + e_{it} && \text{if } W^*_{it} \geq W_{it-1} \\ \Delta W_{it} &= 0 && \text{if } W^*_{it} < W_{it-1} \qquad (7) \end{aligned}$$

Unemployment only impacts on nominal wage growth if a pay cut is not warranted. The greater is $P(W^*_{it} < W_{it-1})$, the less impact does unemployment have on average nominal wage growth.

The real wage growth distribution is the same as the nominal one, except that the horizontal axis scale is shifted up by the rate of inflation Δp_t.[26]

$$\Delta w_{it} = \Delta W_{it} - \Delta p_t$$

where w denotes the log real wage and p_t is the log price level. The spike indicating nominal pay rigidity occurs at $-\Delta p_t$ when wage growth is expressed in real terms.

Now consider the basic Phillips or wage curve, describing the relationship between real wage growth and unemployment. This relationship is considered here at regional level:[27]

$$\Delta w_{rt} = \alpha + \beta U_{rt} + \varepsilon_{rt} \qquad (8)$$

The modifications that need to be made to the Phillips or wage curve in the light of DNWR can now be seen. Express the model of DNWR (7) in terms of real wage growth:

$$\begin{aligned} \Delta w_{it} &= a + bU_{rt} + cZ_{it} + e_{it} - \Delta p_t && \text{if } w^*_{it} - w_{it-1} \geq - \Delta p_t \\ \Delta w_{it} &= - \Delta p_t && \text{if } w^*_{it} - w_{it-1} < - \Delta p_t \qquad (9) \end{aligned}$$

Unemployment only impacts on real wage growth if $w^*_{it} - w_{it-1} \geq - \Delta p_t$. The effect of unemployment on real wage growth varies in proportion to the likelihood of nominal raises $P(w^*_{it} - w_{it-1} \geq - \Delta p_t)$. Hence the unemployment coefficient in the Phillips or wage curve should vary with this probability too:

$$\Delta w_{rt} = \alpha + \beta U_{rt} + \gamma P(w^*_{it} - w_{it-1} \geq - \Delta p_t).U_{rt} + \varepsilon_{rt}$$

As discussed above in relation to nominal wage growth, $P(w^*_{it} - w_{it-1} \geq - \Delta p_t)$ depends on the location of the pay growth distribution. The location will depend on the rate of inflation, so the modified Phillips or wage curve can be written:[28]

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[25] If the underlying real wage–unemployment relationship is the Phillips curve, it is the *level* in unemployment that appears in the real wage growth equation. If on the other hand the underlying real wage–unemployment relationship is the wage curve, it is the *growth* of unemployment that appears in the real wage growth equation. In what follows, the unemployment variable is simply represented as U.

[26] Assume for the moment that all workers face the same inflation rate Δp_t.

[27] In principle the relationship between real wage growth and unemployment could be estimated using data on individual wage growth. But if individual-level wage growth were regressed on regional unemployment, bias in the variance of the unemployment coefficient would result (Moulton (1990)). Correlation in the disturbances within region would lead to downward bias in OLS standard errors, which could lead to erroneous conclusions of statistical significance.

$$\Delta w_{rt} = \alpha + \beta U_{rt} + \gamma(\Delta p_{rt}).U_{rt} + \varepsilon_{rt} \qquad (10)$$

Region and time dummies can also be included to capture factors that are specific to a particular region or a particular year (hence, comparing (10) with (9), there is no need to include separately the aggregate inflation rate Δp_t).

Comparing (9) and (10), it is clear that it will be necessary to control for other determinants of real wage growth in order to get an unbiased estimate of the unemployment effect. The most straightforward solution is to control in an initial (individual-level) regression for all other determinants of wages, and calculate regional average wage growth using this adjusted wage measure.

The adjusted wage $\tilde{w}_{it}$ is calculated as the difference between the actual wage and the predicted value assuming all individuals *i* live in a particular region (which is the omitted region in the set of region dummies in the 'control' regression (12), region 1: London). The 'control' regression is

$$w_{it} = \phi Z'_{it} + \sum_{r=2}^{11} \lambda_r region_{rit} + e_{it} \qquad (12)$$

where *Z'* includes all *Z* variables except the set of region dummies. The adjusted wage is

$$\tilde{w}_{it} = w_{it} - \hat{\phi} Z'_{it} \qquad (13)$$

where $\hat{\phi}$ are the estimated coefficients from the control regression (12). This method essentially controls for regional variation in (12), then reinstates that variation in the calculation of the adjusted wage by omitting the regional effects from (13). If this unusual manipulation of regional dummies were not used, regional variation in the adjusted wage might be lost, as it might be picked up by other *Z'* variables if they systematically vary across regions. Because the Phillips and wage curves will be estimated at regional level, it is necessary to retain regional variation in the wage.

In principle, Z_{it} should include factors affecting the notional wage, the wage that would prevail without the effect of rigidities. A human capital model seems the most reasonable basis for the notional wage equation. Variables included in Z_{it} are years of education, a quartic in job tenure with the firm, a quartic in employment experience, together with dummies for gender, white, and married, and (for non-hourly wage variables) total hours worked per week.[29] The inclusion of the lagged wage W_{it-1} in Z_{it} presents a potential problem, in that it is endogenous. The simplest solution, which has been previously adopted, is to assume that $W_{it-1} = a + bX_{it-1} + e_{it-1}$.[30] This is consistent with the assumption used above that there is no difference between last period's notional and actual wages. In that case, W_{it-1} can be validly proxied by lagged values of the *Z'* variables in the control regression to obtain adjusted real wage $\Delta\tilde{w}_{rt}$. These lagged values necessitate 'losing' 1992 data for the estimation of the real wage–unemployment relationship.

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[28] Both regional and aggregate price inflation are used. Care must be taken with the interpretation of the results for aggregate inflation, however, since if inflation and unemployment are correlated at regional level, the error term will contain regional differences from aggregate inflation which would be correlated with regional unemployment, causing biases in estimated coefficients.
[29] This method is similar to that used by Card and Hyslop (1997).
[30] Altonji and Devereux (2000)

The cost of DNWR is measured by the degree to which the effect of unemployment varies with the location of the pay growth distribution. If the unemployment effect is non-linear, the coefficient γ on the interaction term should be negative. As inflation rises, so the effects of DNWR will diminish and the Phillips curve will become more steeply negatively sloped, meaning that a smaller increase in unemployment is needed to generate a given fall in real wage growth.

Comparison with previous work

This measure of the cost of DNWR is similar to some derived previously. Akerlof, Dickens and Perry (1996) show theoretically that DNWR leads to an additional term *S* in the Phillips curve. *S* embodies the rise in (expected) labour costs due to DNWR, and captures the difference between average expected real actual and notional wages (deflated by labour productivity). Akerlof *et al* (1986) show theoretically that this implies that the long-run unemployment rate is not constant, and is a (non-linear) function of inflation. Empirically, using US aggregate data, they find that the additional DNWR term significantly improves the fit and forecasting performance of the Phillips curve. Akerlof *et al* (1986) estimate that a 3 percentage point reduction in inflation to 0% would result in a permanent rise of between 1 and 2.6 percentage points in the unemployment rate.

Knoppik and Beissinger (2003) use a similar framework to estimate a non-linear Phillips curve relationship, with the impact of DNWR calculated on the basis of German individual-level administrative social security data. They find that at 0% inflation, DNWR causes about 1 percentage point extra unemployment. This is at the low end of Akerlof *et al*'s (1986) estimates, partly because Knoppik and Beissinger (2003) explicitly allow for the fact that even at 0% inflation, expected notional wage growth is significantly positive (around 2% in their sample), due for example to productivity growth.

Card and Hyslop (1997) also measure the cost of DNWR via a Phillips curve, but estimate a regional Phillips curve for each year, then investigate the correlation between the coefficient on unemployment and the inflation rate. Their estimates are too imprecise to conclude that DNWR has a significant effect, but numerically their estimates suggest that raising the inflation rate by 5 percentage points would widen the gap in wage growth between high- and low-unemployment states (8% and 4% unemployment respectively) by between 0 and 0.8 percentage points. On average, when they pool data over regions, Card and Hyslop (1997) find that a doubling of the unemployment rate would reduce wage growth by 1.7-2.4% per year.

Fares and Lemieux (2000) and Brown, Ingram and Wadsworth (2004) both estimate the real wage–unemployment relationship allowing for inflation interactions with the unemployment term. Fares and Lemieux (2000) estimated found that a 1 percentage point increase in the unemployment rate reduced real wage growth by 0.8%, using Canadian province-level data for 1982-97. For United Kingdom manufacturing (in a wage curve specification), Brown *et al* (2004) found that a 1 percentage point rise in the unemployment rate reduces the level of real wage settlements by 0.7 percentage points.

Using a different method based on their estimates of the effect of inflation on real wage growth using annualised NES data, Nickell and Quintini (2003) calculated that a reduction in inflation of 3 percentage points from 5.5% to 2.5% would raise real wage growth by (only) 0.082 percentage points, which in turn would raise equilibrium unemployment by 0.13 percentage points.