Wage Adjustments under Extreme Downward Nominal Wage Rigidity

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Abstract

Using a rich and highly accurate dataset for Portugal spanning from 1986 to 2013, this paper analyzes the determinants of downward nominal wage rigidity, mainly focusing on macroeconomic factors. The data supports the hypothesis that recessionary periods alongside with low inflation contribute to a higher degree of wage rigidity, as measured by the incidence of nominal wage freezes. It is further highlighted how this lack of wage adjustments contributed to an increase in labor costs which culminated in a wage markup of 6-7%. This paper, thus seems to corroborate the argument that low inflation did exacerbated the downward inflexibility of (real) wages after the Great Recession.

1 Introduction

The extent and consequences of Downward Nominal Wage Rigidity (henceforth, DNWR) has been the subject of intense research for its implications on wage adjustments and monetary policy. Going back at least to Tobin (1972), inflation is a potential driver to mitigate the extent of nominal rigidity in so far as it allows real wages to adjust to negative shocks when these are downward nominally rigid. In this paper, it is highlighted that Portugal is a case of extreme nominal rigidity, a feature consistent with the Portuguese institutional framework, and this constraint became strongly binding in the aftermath of the global financial crisis when the fraction of wage freezes amounted to about 80%. The low inflation rate linked with this crisis resurfaced the question of whether higher inflation could have provided a smoother adjustment to the last financial crisis, according to Tobin's hypothesis. The motivation for assessing this issue emerged when contrasting the nominal wage change distribution in 1984 with that in 2013, depicted in figure 1. Both years face a recession, but the prior was accompanied by high inflation and a much lower fraction of wage freezes which allowed real wage cuts to take place.

Figure 1(a): Nominal Wage Change Distribution 1985

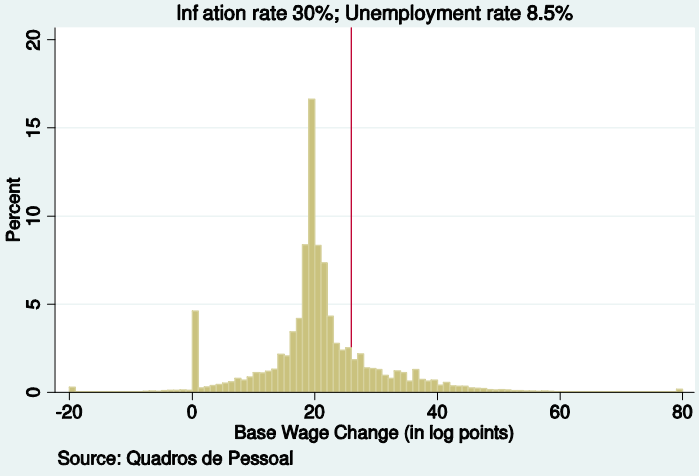
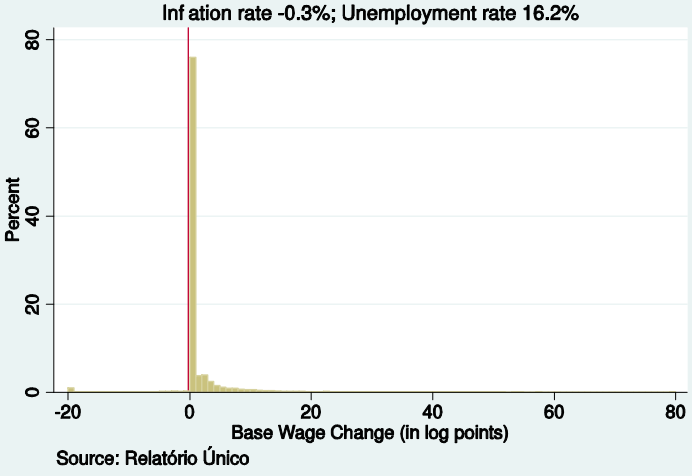


Figure 1(b): Nominal Wage Change Distribution 2013



The contribution of this paper to the existing literature is three-fold. Firstly, all the estimates are retrieved from a representative dataset, *Quadros de Pessoal (QP)*, where measurement errors are unlikely to occur in a significantly scale. The main arguments is that, by law, the information on earnings is reported by the employer rather than by the employee. Adding this to the fact that the information contained in the *QP* survey needs to be available in a public space at the establishment and is monitored by the Ministry of Employment to check if firms comply with the labor law (e.g. minimum wages and wage floors determined by collective wage agreements) further reinforces the argument that the data is very accurate. Previous studies dealt with this problem by assuming a distribution for measurement errors (Altonji and Devereux, 2000; Fehr and Goette, 2005) but this inevitably always cast doubts on the reliability of their results. Secondly, another advantage in using this dataset is the time span it covers, including periods of high and low inflation, and even deflation. This makes it possible to study wage rigidity in those settings, instead of extrapolating implications from high inflation years. This is important because the economic significance of wage rigidity tends to be higher in low inflation regimes. Thirdly, this paper highlights the micro and macroeconomic conditions that contribute for the degree of nominal wage rigidity, by introducing an extension of a parametric model applied previously by Fehr and Goette (2005). This model captures downward nominal rigidity dynamics to such extent that one is able to compute the fraction of workers affected by DNWR, the implied increased labor costs, among other indicators. The model allow me to simulate an economy with different inflation rates (say, 4%), when faced with a downturn similar to the last financial crisis, to show the potential implications of increased inflation.

The remainder of this paper is organized as follows. In section II, the existing literature on downward nominal wage rigidity is presented as well as the literature on the role of inflation under this framework. Section III describes the process of wage formation in the Portuguese labor market. Section IV describes the dataset. Section V and VI present the empirical model and its results, respectively. The conclusions are in Section VII.

2 Literature Review

By definition, Downward Nominal Wage Rigidity is the partial or full inability of nominal wages to adjust downwards. Under low inflation, this implies that real wages adjust sluggishly to adverse shocks, which may trigger unemployment (Tobin, 1972). The theoretical foundations for nominal rigidities are, essentially, based on efficient contract theories (MacLeod and Malcomson, 1993; Holden, 2014) and nominal fairness considerations (Bewley, 1999; Elsby, 2009). On one hand, the prior considers that wage rigidity arises as a protection on job-specific investments. This type of behaviour render investments efficient by avoiding hold-up problems (MacLeod and Malcomson, 1993). In the light of this theory, wages are only renegotiated when one party has better outside options. On the other hand, the latter theory holds that a wage cut is seen as unfair, which is likely to lower worker's morale, and hence productivity. Therefore, firms will optimally freeze a fraction of wages scheduled for a cut.

In spite of their differences, it should be kept in mind that both explanations may coexist (Holden, 2014). Nevertheless, both theories predict a large fraction of wage freezes at the expense of infrequent nominal wage cuts, which engender an asymmetry in the nominal wage change distribution. This prediction has been vastly supported in empirical work - Card and Hyslop (1996), McLaughlin (1994) and Kahn (1995) for the US; Devicienti et al. (2007) for Italy; Knoppik and Beissinger (2003) for Germany; Fehr and Goette (2005) for Switzerland.

Even though there is solid evidence that nominal rigidities exist, the importance of this issue has been subject to controversy. For instance, using the same dataset, Altonji and Devereux (2000) report a high degree of DNWR for the U.S, characterized by few wage cuts and a large fraction of freezes, while others (McLaughlin, 1994; Lebow et al., 1995; Card and Hyslop, 1996; Smith, 2000) suggest that this asymmetry is somewhat modest, thus raising doubts about the importance of DNWR. Akerlof et al. (1996) significantly contributed to this discussion, arguing that most wage cuts are spurious and arise as a result of measurement errors. Undeniably, improperly controlling

for measurement errors will most likely downward bias the degree of DNWR and lead to incorrect inference. As discussed afterwards, the need to control for measurement errors is mitigated in this study due to the high quality in the wage data employed.

The role of inflation in easing labor market adjustments arises as a consequence of DNWR. In his influential paper, Tobin (1972) stated that higher inflation can "grease the wheels of the labor market" by allowing real wages to adjust faster when these are nominally rigid. A similar argument is made by Blanchard (2006) who argues that "the slower the adjustment [to prices], the more the monetary authorities could use inflation to reduce real wages and therefore limit the increase in actual unemployment in response to an adverse supply shock". A strand of empirical work sought to determine whether the degree of wage rigidity is related to inflation rate and the finding that DNWR is lightened when inflation is higher seems robust to different specifications [see Kramarz (2001) for an empirical review]. For instance, Card and Hyslop (1997) use a non-parametric approach to point out that a 1 percentage point increase in the inflation rate would decrease the fraction of workers affected by DNWR by 0.5 percentage points, in the U.S; For U.K, Nickell and Quintini (2003) suggest that an increase in inflation from 2.5% to 5.5% would be associated with an increase of 1.7 percentage points of the fraction of male job stayers; For Germany, Bauer et al. (2003) also uncover a negative relation between the extent of nominal wage rigidity and inflation.

Additionally, another strand of literature argue that inflation may also hinder efficient resource allocation by distorting relative prices - "sand effects". Higher inflation is associated with more frequent wage and price changes (i.e. menu costs), higher search costs and greater uncertainty about the future prices which lowers investment (Friedman, 1977). In particular, Groshen and Schweitzer (2000) provide an empirical strategy to disantangle "grease" from "sand" effects. They conclude that a positive net benefit is attained for an inflation lower than 4%, and the maximum is achieved around the 2% level.

The DNWR literature has also attracted attention to macroeconomists for its potential implications on aggregate wages and unemployment dynam-

ics (i.e. Phillips Curve), and also for its importance to monetary policy as inflation targets should depend on the degree of wage rigidity (Akerlof et al., 1996). Surprisingly, it is frequently concluded that wage rigidities have a trivial impact at the macro scale, even though their prevalence are well documented at the micro level (Card and Hyslop, 1997; Nickell and Quintini, 2003). This is often called the "micro-macro puzzle" (Lebow et al., 1999). An exception is Akerlof et al. (1996) who claims that DNWR leads to employment reductions, through the use of a stochastic simulation of a calibrated general equilibrium model. Several explanations have been proposed in order to reconcile this apparent contradiction. Elsby (2009) asserts that previous literature did not consider the inter-temporal optimization of the firm. The author shows that the risk of future DNWR will lead forward-looking firms to not only avoid nominal wage cuts, but also compress wage increases. Another explanation is that a significant part of real wage adjustments is experienced by new hires, for whom DNWR is less binding but are usually not considered in empirical work (Farès and Lemieux, 2000). Indeed, there is evidence that real wages for new hires are more procyclical than for job stayers (Carneiro et al., 2010).

More recently, the debate on wage rigidity and inflation has gained renewed proeminence. The financial crisis of 2008 was followed by a period of low inflation and productivity growth, which has given rise to wage freezes and an upward trend in unemployment. Blanchard et al. (2010) and Krugman (2014) question the adequacy of 2% inflation target in the last crisis and argue in favour of a higher target (typically suggested to be around 4%) as the actual one most likely did not provide sufficient cushion to circumvent nominal rigidities. Undoubtedly, this resurfaced the question of whether higher inflation could ease labor market adjustments.

3 Wage formation in Portugal

The Portuguese labor market is often regarded as an extreme case of downward nominal wage rigidity (Dickens et al., 2006). Indeed the Portuguese labor law legally prohibit nominal wage cuts for job stayers, since the 1950s. The article n^o 129 sets that "The employer is prohibited to decrease employee's compensation, except for particular cases provided in this code or in regulation of collective bargaining instruments".[1] Ultimately, this means that a nominal wage decrease is hardly imposed, as non-compliance with the law results in heavy sanctions to the firm.

Adding to the feature of wage formation described above, the Portuguese labor market is strongly driven by collective bargaining outcomes which are mostly determined by industry-wide agreements. These negotiations, even though affecting a whole sector, are only taken by union members and employer's associations which have a low national representation. Indeed, the most relevant mechanism shaping the process of wage formation in Portugal is the extension of collective agreements by the Ministry of Employment which reaches 90 percent of the Portuguese private sector, most times setting the same conditions for companies with very different sizes and economic environments. For this reason, the contents of these agreements tend to be general, setting minimum working conditions in particular the base monthly wage for each job title, overtime pay and the normal duration of work. Moreover, only a narrow set of topics is updated annually, and therefore the content of collective agreements is often pointed out as being too immobile and containing little innovation (Addison, Portugal and Vilares, 2015). Nevertheless, Cardoso and Portugal (2005) show that firms often deviate from the wage floors agreed upon for each category of workers, paying higher wages to adjust for firm-specific conditions.

In this context it is more likely that firms benefit from inflation, by allowing firms to comply both with mandatory wage floors and the prohibition

[1] In Portuguese, the labor code says: "É proibido ao empregador diminuir a retribuição, salvo nos casos previstos neste Código ou em instrumento de regulamentação coletiva de trabalho".

to cut wages while simultaneously decreasing real wages which provides a leeway for adjustment, if it is needed. Conversely, in a low inflation environment, nominal rigidities may impede companies to adjust to product demand shocks through wage accommodations. The last crisis, when both productivity growth and inflation were very low, gives some insights on how firms adjusted in such setting. As depicted in figure 1, during the great recession, the response of employers was, to a large extent, to freeze wages so as to reduce real wages as much as possible. In such an extreme case the pace of real adjustment is essentially set out by the inflation rate.

4 Dataset

The dataset used for this study is *Quadros de Pessoal* (*QP*) which is an annual administrative matched employer-employee dataset. Each year, every establishment in Portugal with at least one employee is legally obliged to fill in a standardized requirement with detailed information on worker's characteristics, firm's characteristics and the establishment itself (See Cardoso et al. 2012 for detailed information).[2]

One important advantage of using *QP* is its highly accurate wage data. These data are collected through employer-reported wage information rather than worker-reported information which tends to be more imprecise. Moreover, the fact that the information contained in the *QP* survey needs, by law, to be available in a public space at the establishment and submitted through regular quality checks by the Ministry of Employment (the entity responsible for the dataset) further ensures a high degree of accuracy. Therefore, in contrast with a large portion of previous literature, the empirical strategy used in this study does not account for measurement errors as they are likely to be mitigated in the dataset employed. A "clean" dataset is particularly important here, as reporting errors could severely bias the estimates on the degree of DNWR. Nevertheless, one important limitation of this dataset is the short time period covered (1986-2013). There are few observations regarding the inflation rate and unemployment rate, even though these variables varied widely over the period analyzed which makes the identification of the corresponding parameters less problematic.

The final sample spans from 1986 to 2013 and comprises only job stayers (workers staying in the same firm in two consecutive years), aging from 18 to 64 years old, and full-time workers. The source for the unemployment and price series is INE (*Instituto Nacional de Estatística*). The inflation rate is measured by the log difference of Consumer Price Index.

Finally, in this study, the base wage is used instead of total compensation. There are two main reasons for taking this decision. Firstly, the base wage is

[2]The dataset does not include the years 1990 and 2001. Additionally, public administration and non-market services are excluded.

the portion of earnings that is more likely to be subject to downward nominal wage rigidity since it is the main target of negotiation between firms and trade unions. Secondly, considering extra compensations may bias the degree of nominal rigidity as these are more volatile and prone to measurement errors. In this sense, base wages allow to obtain a "cleaner" picture of wage formation than total compensation. Nevertheless, it is acknowledged that other regular compensations may help firms to adjust to negative shocks since these are less prone to nominal rigidities. Still, base wages account for roughly 80% of total compensation.

5 Empirical Model

The estimation procedure used in this study tests the impact of inflation on firms' wage policy, based on the work of Altonji and Devereux (2000) and Fehr and Goette (2005). The underlying idea is that firms find it costly to cut nominal wages, either due to the resistance of workers to this policy, or firms' reluctance in doing so because it reduces workers' morale (hence, productivity), or both. One way to model this feature is to assume that worker's nominal wage *change*, in the absence of DNWR, is defined by the following equation (denoted by "notional" wage *change*):[3]

$$\Delta \ln(W_{it}^*) = \mathbf{X}_{it}\beta + \theta\pi_t + \phi\Delta u_t + \varepsilon_{it}$$

However, when downward nominal wage rigidities are taken into account, a fraction of workers scheduled for a wage cut will instead have a wage freeze. A nominal freeze occurs when the "notional" wage *change* is between a specific threshold (c_{it}) and zero:

$$\Delta \ln(W_{it}) = \left\{ \begin{array}{c} \Delta \ln(W_{it}^*), \text{ if } \Delta \ln(W_{it}^*) > 0 \\ 0, \text{ if } -c_{it} < \Delta \ln(W_{it}^*) < 0 \\ \Delta \ln(W_{it}^*), \text{ if } \Delta \ln(W_{it}^*) < -c_{it} \ , \ \Delta \ln(W_{it}^*) < 0 \end{array} \right\}$$

where $\Delta \ln(W_{it}^*)$ is the "notional" wage *change* and $\Delta \ln(W_{it})$ stands for the first difference of the natural logarithm of **observed** monthly nominal wage of individual i at time t; $\mathbf{X}_{it}$ is a vector of firm and individual observable characteristics (age,tenure, education, gender and firm size); π_t is the inflation rate and Δu_t is the first difference of unemployment rate, a business cycle indicator; ε_{it} stands for the usual error term. In addition, it is assumed that the threshold follows a normal distribution and is uncorrelated with ε_{it}.

$$c_{it} \sim N(\mu_{ic}, \sigma_c)$$

[3]This can be interpreted as the efficient wage that maximizes firm's expected profit when wages are flexible (Altonji and Devereux, 2000)

This model is appropriate to study wage rigidity as it explicitly describes the restriction imposed to firms arising from DNWR and, at the same time, is flexible enough to allow for a nominal wage cut if the "notional" wage change is sufficiently negative (i.e. below $-c_{it}$). Modelling wage rigidity in this way has several advantages. Firstly, it provides a natural way to measure the degree of downward nominal wage rigidity, where a perfectly flexible labor market exists if $c_{it} = 0$, and a rigid one if $c_{it} \to +\infty$ (i.e. no wage cuts).[4] Secondly, specifying an individual threshold as in Fehr and Goette (2005) instead of a constant threshold (Altonji and Devereux, 2000) imposes less counterfactual implications.[5] Thirdly, and one of the main contributions of this paper, it is possible to specify a functional form for the mean threshold (μ_{it}) as a function of observable micro and macroeconomic factors.

$$\mu_{it} = \mathbf{X}_{it}\lambda + \gamma_1 \pi_t + \gamma_2 \Delta u_t$$

where the variables above have the same meaning as before.

The latter equation provides a measure for the degree of DNWR in Portugal, as a higher average threshold implies more nominal rigidity. Furthermore, to the best of my knowledge, this is the first study explicitly modelling the rigidity parameter as a function of observable characteristics, most notably macroeconomic variables (inflation and unemployment), which is crucial to understand what drives downward nominal wage rigidity. Following the line of reasoning of Devicienti (2002), one possible reason for the lack of this parameterization in previous literature might be that this makes the model harder to estimate due to lack of a rich dataset.

[4] Altonji and Devereux (2000) suggested that the U.S labor market is closer to a perfectly rigid labor market than a flexible one, by using a similar model.

[5] In contrast to the model presented in this study, the approach followed by Altonji and Devereux (2000) imposes that no wage cuts exist in the interval $[-c, 0]$.

6 Empirical Results

6.1 Wage rigidity across workers and firms

Table 1: Estimation of the empirical model

Variables	**Wage Equation**	**Threshold Equation**
Log age	-0.036***	0.060***
	(0.003)	(0.014)
Log tenure	-0.003***	0.000
	(0.000)	(0.001)
Education	0.000	-0.004**
	(0.000)	(0.002)
Female	0.001	-0.018***
	(0.001)	(0.006)
Log size	0.003***	-0.013***
	(0.000)	(0.004)
Inflation	0.973***	-1.093***
	(0.140)	(0.308)
Change in unemployment	-0.022***	0.028***
	(0.004)	(0.006)
Constant	0.135***	0.009
	(0.013)	(0.028)
Number of observations	24,195,747	
Log likelihood	12,583,324	

Note: Cluster-robust standard errors in parentheses;
*** significant at 1%, ** significant at 5%, * significant at 10%.

Table 1 presents the results from the empirical model proposed in the previous section. The wage setting equation shows the determinants for wage growth. It is found that older workers and those more attached to the firm face lower wage growth rates. Furthermore, education does not have a statistically significant impact on nominal wage growth. The same holds for gender. It is also found that workers in larger firms have a higher wage growth, which may reflect that larger firms have better opportunities

to make their workers more productive. Finally, the semi-elasticity of wages with respect to aggregate unemployment for stayers (ϕ) is negative, showing that (real) wages are procyclical (Carneiro et al. 2012). Regarding the effect of inflation (θ), one cannot reject the null hypothesis that there is a one-for-one relation between nominal (base) wages and consumer prices, thus showing that wages are likely to be fully indexed to inflation.

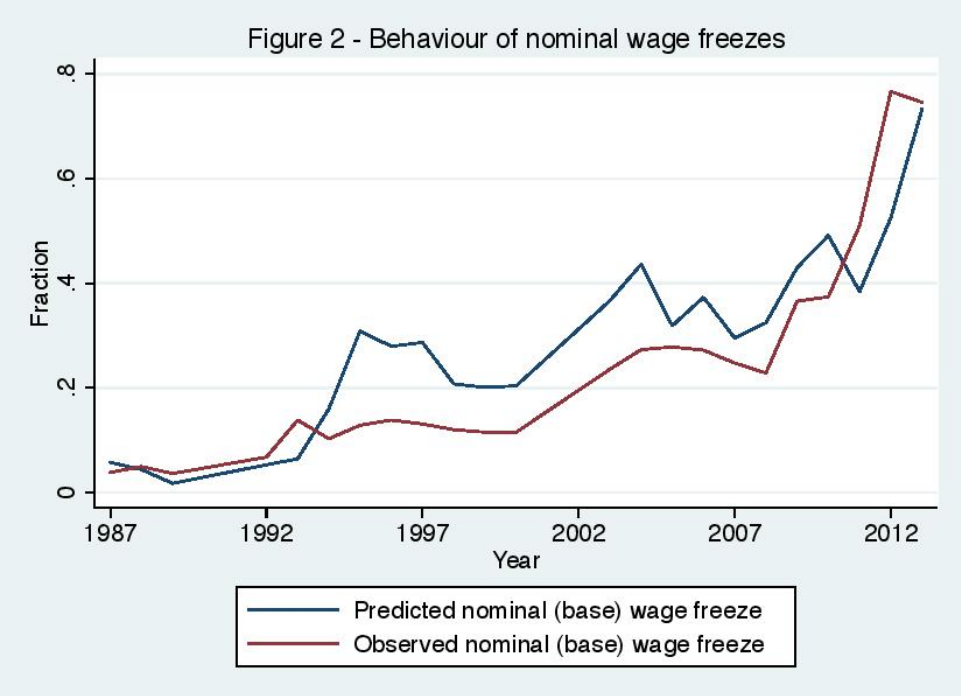
The threshold equation shows the determinants for a higher degree of nominal rigidity. Under the Portuguese legal framework of forbidden wage cuts, one should expect that $c_{it} \longrightarrow +\infty$, as any counterfactual wage cut should be converted into a freeze. However, a (small) fraction of workers were confronted with a wage cut due to the fact that labor law provides some exceptional cases.[6] Nevertheless, the threshold is expected to be large. The estimates reveal that older workers offer a higher resistance against wage cuts. This may reflect the higher propensity for workers to become unionized when they are older (Vilares, 2013) or the higher risk-aversion associated with age which makes the worker willing to negociate a constant wage against the risk of adverse events. Another possible explanation is that older workers have higher standards of fairness than younger ones. Furthermore, male workers have a higher degree of rigidity than females, on average. This may be the case because female workers have less bargaining power over wages (MacLeod and Malcomson, 1993) or lower fairness standards than males (Akerlof and Yellen, 1990). Also, education does increase the degree of nominal rigidity as firms might be more reluctant to cut wages for high skilled workers because their replacement is more costly to the firm (e.g. training costs) and their effort is less easily monitored (Caju et al., 2012). By contrast, tenure does not have a significant impact on the degree of wage rigidity. Regarding firm's size, it is found that smaller firms face a higher degree of nominal rigidity possibly because, under the Macleod and Malcomson model, it is easier for workers to coordinate in a smaller environment to inflict a cost on the firm (e.g. strikes).

[6] Two other explanations are possible: Firms do not comply with the labor law, or wage cuts are due to measurement error. However, both are very unlikely. The latter due to the quality of the dataset used, as already mentioned. The prior because not complying with the law results in heavy sanctions to the firm.

Finally, the threshold equation suggest that inflation does ease labor market adjustments, through a positive effect on the mean threshold, while unemployment has a statistically significant negative impact. During recessions and/or low inflation, firms are more likely to accommodate wage cuts, thus facing higher average labor costs. This finding supports the fact that inflation allows real (base) wages to adjust downwards when these are nominally rigid. To further reinforce this point, the following sections are devoted to clarify how inflation facilitates wage adjustments.

6.2 Implications from the empirical model

To provide robustness to the empirical model proposed in the previous section, figure 2 shows the predicted fraction of wage freezes against their observed values.



Notably, the probability of a wage freeze exhibit an upward trend during the period covered, most notably in the last years when the economy faced a severe economic downturn along with low inflation, which the model predicts with a high degree of precision. This behaviour sharply contrast with the probability of a worker having a wage cut, which is low and quite stable over time (2 - 4%), a result consistent with the Portuguese institutional framework of wage formation that sets legal boundaries to nominal wage decreases. As a complement to this analysis, the marginal effects of inflation and (variation in) unemployment on these probabilities were retrieved from the empirical model proposed in the previous section (Table 2). As expected, a higher inflation rate and decreases in unemployment contribute to a lower probability of a nominal wage freeze. Conversely, these macroeconomic vari-

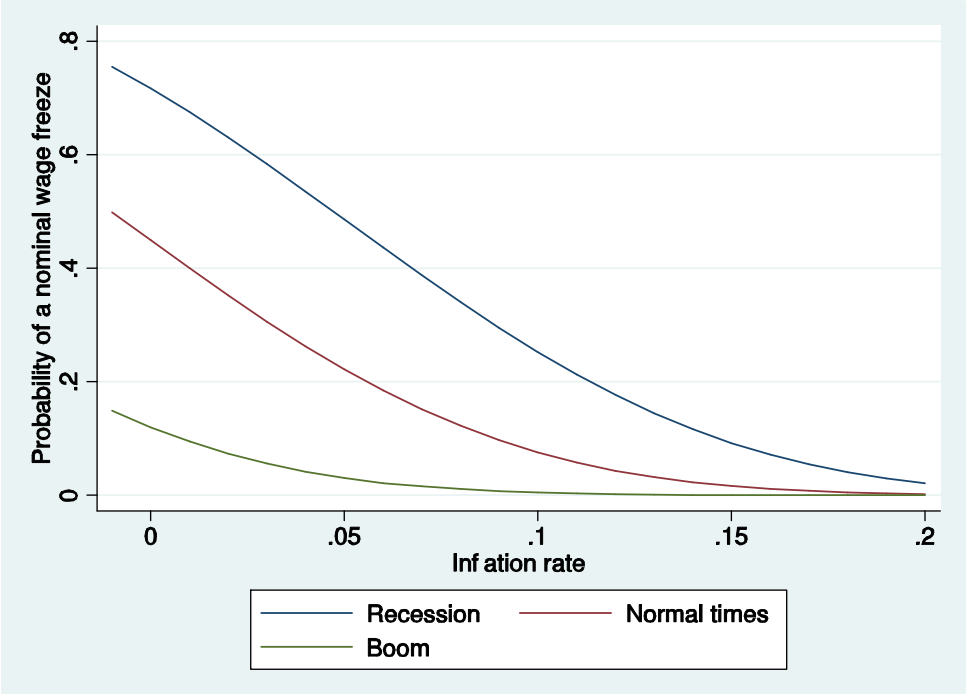
ables do not seem to have a large impact on the probability of a nominal wage cut, even though statistically significant.

Table 2: Estimation of marginal effects on wage freezes and cuts

Variables	**Marginal effect of π**	**Marginal effect of Δu**
Probability of a nominal wage freeze	-3.920***	0.089***
Probability of a nominal wage cut	-0.150***	0.002***

Note: All marginal effects are analytically derived from the empirical model proposed (See appendix
*** significant at 1%, ** significant at 5%, * significant at 10%.

Nevertheless, the potential implications of inflation are not invariant to the business cycle. Figure 3 simulates the probability of having a freeze for different inflation rates and (variations in) unemployment rate. This highlights that low inflation leads to a disproportionally high levels of nominal freezes, and this effect becomes sharper when the economy faces a downturn. This exercise motivates one of the underlying reasons exacerbating the impact of the last financial crisis. Firms were facing a severe downturn and inflation did proved to be insufficient for firms to adjust real wages to this shock.

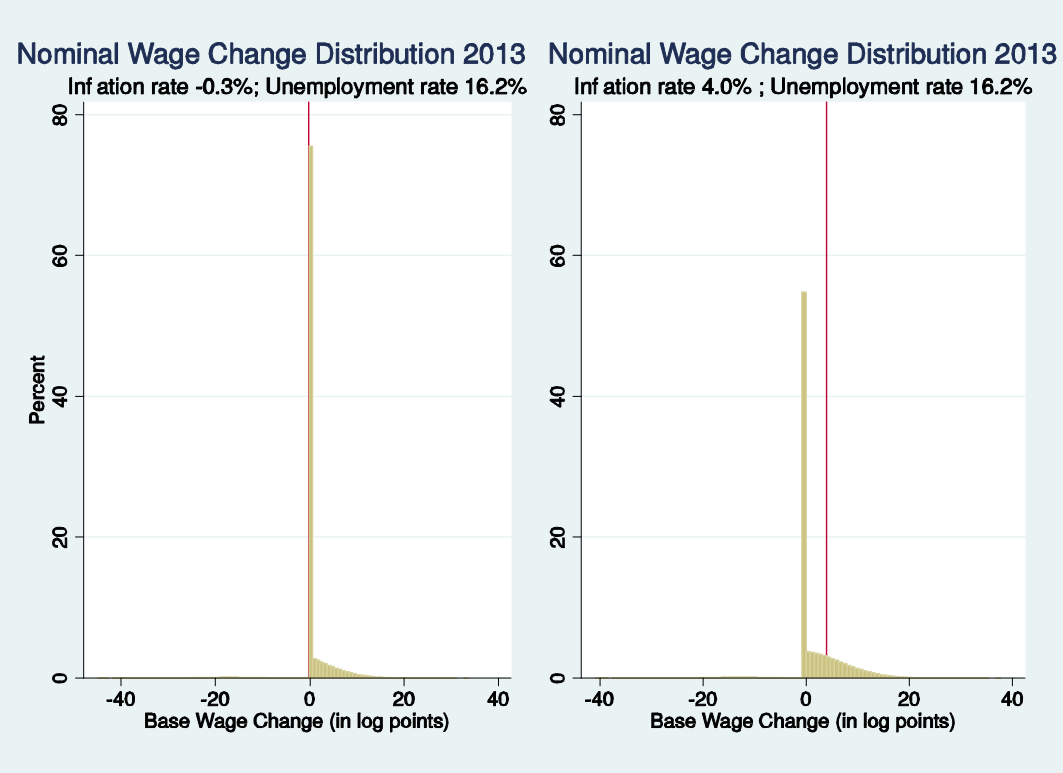


Another interesting aspect to consider is to know how much was the average nominal increase in labor costs due to the inability of (base) wages to adjust downwards. The estimates for this "wage sweep-up" by year is shown in Figure 3.[7] It is revealing to note the upward trend in these costs, specially after the great recession, which peaked to about 6-7%. This lack of wage adjustment may compromise future wage increases by the effect of "pent-up wage deflation" (Janet Yellen, 2014). Furthermore, it should be emphasized that inflation could partially mitigate these costs by allowing real wages to adjust downwards.

[7] The derivation can be found in appendix 8.2.

Finally, the model allows me to simulate what would have been the adjustment of wages if inflation was higher (say, 4%).[8] The figures below present the predicted real wage distribution for 2013 in two different settings: (i) when inflation is -0.3%, the observed value in that year. (ii) When inflation is 4%.

The left panel describes the actual situation for Portugal in 2013, characterized by a wage change distribution almost collapsing to zero, with nearly 80% of wage freezes, and an inflation rate that does not provide a leeway for real wage cuts. When contrasting this with the right panel, we observe that a higher inflation rate allows real wages to decrease not only for workers having a nominal wage freeze but also a fraction of those having a nominal wage increase. Also, this larger margin of manoeuvre for real wage adjustments reduces the need of nominal freezes (in this simulation, reduces to slightly above 50%).



[8] 4% inflation is chosen arbitrarily, based on the value proposed by Blanchard (2010).

7 Conclusion

This paper evaluates the extent of downward nominal rigidity in Portugal under different macroeconomic conditions, by using a representative dataset (*Quadros de Pessoal*) which contains rich and very accurate wage data. The results show that Portugal is characterized by extreme downward nominal wage rigidity, which is consistent with the Portuguese labor law and a strongly unionized labor market. In this paper, we further highlight differences in the degree of rigidity across workers and firms, explained by the patterns predicted by several labour market theories.

A focus on the impact of inflation is sustained throughout this study. It is found that inflation render downward nominal wage rigidity less binding, in line with previous literature, and that this effect tends to be stronger when the economy faces a severe downturn. Based on the latter argument, a simulation was executed to show the "benefits" from an increased inflation during the last financial crisis and emphasize the extent to which low inflation contributed for a binding downward nominal wage rigidity.

Finally, the empirical model allowed me to derive to which extent the absence of (downward) wage adjustments may impact on real labor costs. In the aftermath of the great recession, a truly binding DNWR leaded to a wage markup that peaked to about 6-7%.

8 Appendix

8.1 Probability of a Freeze

For simplicity, assume that $\Delta \ln(W_{it}^*) = X_{it}\beta + \varepsilon_{it}$ and $c_{it} = X_{it}\gamma + v_{it}$ where both, ε_{it} and v_{it}, follow a normal distribution and are uncorrelated with each other.

The probability of having a wage freeze can de defined as:

$$\Pr[-c_{it} < \Delta \ln(W_{it}^*) < 0] = F(\ x_1, x_2, \rho)$$

where $F(.)$ stands for the c.d.f of the standard bivariate normal distribution, and $x_1 = \frac{X_{it}(\beta+\gamma)}{\sqrt{\sigma_\varepsilon^2+\sigma_v^2}}, x_2 = -\frac{X_{it}\beta}{\sigma_\varepsilon}$ and $\rho = -\frac{\sigma_\varepsilon}{\sqrt{\sigma_\varepsilon^2+\sigma_v^2}}$.

Differentiating F(.) with respect to X_{it}, yields:

$$\frac{\partial F(x_1,x_2,\rho)}{\partial X_{it}} = \phi(x_1)\Phi(x_2)[\frac{\beta+\gamma}{\sqrt{\sigma_\varepsilon^2+\sigma_v^2}}] + \phi(x_2)\Phi(x_1)[-\frac{\beta}{\sigma_\varepsilon}]$$

where $\phi(.)$ and $\Phi(.)$ stand for the p.d.f and c.d.f of the standard univariate normal distribution, respectively.

8.2 Wage sweep-up

Using the same notation as above, the wage sweep-up can be written as:

$$E[\Delta \ln(W_{it}) - \Delta \ln(W_{it}^*)] = \Pr(wage\ increase) * E[X_{it}\beta + \varepsilon_{it}|$$
$$X_{it}\beta + \varepsilon_{it} > 0] + \Pr(wage\ cut) * E[X_{it}\beta + \varepsilon_{it}|$$
$$X_{it}\beta + \varepsilon_{it} < 0, X_{it}\beta + \varepsilon_{it} < -c_{it}] - X_{it}\beta$$

The latter expression simplifies to:

$$\Pr(wage\ increase) * [X_{it}\beta + \sigma_\varepsilon * \frac{\phi(-\frac{X_{it}\beta}{\sigma_\varepsilon})}{1-\Phi(-\frac{X_{it}\beta}{\sigma_\varepsilon})}] + \Pr(wage$$
$$cut) * [X_{it}\beta - \sigma_\varepsilon * (\phi(h)\Phi(\frac{k+\rho h}{\sqrt{1-\rho^2}}) - \rho\phi(k)\Phi(\frac{h+\rho k}{\sqrt{1-\rho^2}})] - X_{it}\beta$$

where $k = \frac{X_{it}(\beta+\gamma)}{\sqrt{\sigma_\varepsilon^2+\sigma_v^2}}$ and $h = \frac{X_{it}\beta}{\sigma_\varepsilon}$.

9 References

References

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