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Nominal wage rigidity in the EU countries before and after the Great Recession: evidence from the WDN surveys

Eva Branten, Ana Lamo and Tairi Rõõm*

Abstract

This paper studies the recent trends in nominal wage rigidity in a large group of EU countries, using survey data. We analyse two forms of nominal wage rigidity: downward nominal wage rigidity (DNWR) and the lagged response of wages to shocks. The frequency of wage changes, which is an indicator of lagged wage setting, slowed down in the aftermath of the Great Recession. We assess the possible reasons for this, and show that it was at least partially caused by a combination of a decline in average wage growth and persistent DNWR. In countries where wage growth slowed down more after the Great Recession, the frequency of wage changes declined more steeply as well. Our data allows evaluating the prevalence of DNWR in diverse economic circumstances. Like earlier research on this topic, we find that DNWR tends to be strongly prevalent, even in periods of slow economic growth and low wage inflation. DNWR declines during severe recessions but even then wage setting does not become completely flexible as the proportion of observed wage cuts is still below the level that would correspond to a flexible regime.

JEL Codes: B41, D22

Keywords: downward nominal wage rigidity, wage change frequency, survey

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Non-technical summary

This paper documents recent trends in nominal wage rigidity in a large group of EU countries. We focus on two forms of nominal wage rigidity: downward nominal wage rigidity (DNWR) and the lagged response of wages to shocks.

The analysis in this paper is based on data from the Wage Dynamics Network (WDN) surveys. The WDN is a research network consisting of researchers from the European Central Bank and the national central banks of the EU member states. It was formed for the purpose of analysing the wage dynamics and wage setting practices in Europe. The WDN conducted three surveys of the wage setting behaviour of firms in 2007, 2009 and 2014. The country coverage of the WDN surveys is extensive, the first wave covering 19 EU member states, the second wave 11 and the third 25. The first WDN survey (WDN1) covers the years of the economic boom before the start of the global financial crisis in 2007, the second survey (WDN2) covers the Great Recession period of 2008–2009, and the third survey (WDN3) focuses on the years 2010–2013. In this paper we mainly use the data from WDN1 and WDN3 so we can evaluate different forms of wage rigidity before and after the Great Recession.

The lagged response of wages is proxied by the frequency of wage changes. The frequency of wage changes slowed down in the aftermath of the Great Recession. We assess the possible reasons for this and show that it was at least partially caused by a combination of a decline in average wage growth and persistent DNWR. In countries where wage growth slowed down more after the Great Recession, the frequency of wage changes declined more steeply as well. The frequency of wage growth is affected not only by the level of nominal wage growth but also by the uncertainty of that growth. We find that wages were changed more often in firms where managers perceived that the uncertainty of demand was higher. In addition, wages were changed more often in larger firms, manufacturing enterprises, subsidiaries and companies with foreign owners.

To assess the prevalence of DNWR before, during and after the Great Recession, we use the range of DNWR measures adjusted for potential biases. Since our study covers many countries and three distinct time periods, we are able to evaluate the prevalence of downward nominal wage rigidity in very diverse economic circumstances. Like earlier studies on this topic, we find that DNWR tends to be strongly prevalent even in periods of slow growth and low wage inflation. We show that it declines during severe recessions but even then wage setting is not completely flexible, as even then the proportion of observed wage cuts stays well below the level that would correspond to a flexible regime.

Contents

1. Introduction

This paper studies recent trends in wage rigidity in a large group of EU countries, focusing on the rigidity in nominal base wages. It is well established that wages tend to be sticky. The two main forms of nominal wage rigidity are distinguished in the economic literature as downward nominal wage rigidity (DNWR) and the lagged response of wages to shocks. We assess the prevalence of both of these forms of wage rigidity and analyse possible interrelations between them.

The causes of DNWR have been extensively studied in the existing literature. Firms abstain from reducing nominal wages because this has a negative effect on workers' productivity (e.g. Bewley (2004), Blinder and Choi (1990), Campbell and Kamlani (1997)).[1] Nominal wage cuts are often also prevented by labour market regulations or collective bargaining agreements (Du Caju et al. (2015)). There has been much less discussion of the possible reasons for the lagged reaction of wages to economic shocks and the reasons why the duration of wage spells can vary across different types of firms or over economic cycles. The second aim of our paper is to contribute towards filling this knowledge gap.

Wage stickiness is an important factor influencing the dynamics of unemployment during economic cycles. The existence of nominal rigidities in prices and wages is the cornerstone of (New) Keynesian models and the question of whether nominal rigidities have real consequences has been one of the central themes in economic disputes.

The rigidity of nominal wages is also of central importance for the conduct of monetary policy, since changes in the money supply impact real variables only until prices and wages adjust to them. In addition, downward nominal wage rigidity is relevant for determining the optimal level of inflation. The presence of DNWR can generate a long-term trade-off between inflation and unemployment at near-zero levels of inflation (e.g. Tobin (1972), Benigno and Ricci (2011)). Therefore monetary authorities should not target complete price stability in the presence of DNWR (Akerlof, Dickens and Perry (1996)). More generally, moderate levels of inflation are desirable to "grease the wheels" of the economy (Tobin (1972)).[2]

Wage rigidity in the form of the slow reaction of wages to economic shocks is relevant for macroeconomic modelling. The delayed response of wages to shocks leads to staggered wage setting if it occurs in a non-synchronised manner. This is a source of considerable wage inertia. Ever since the seminal work by Taylor (1979), staggered adjustment of wages (and prices) has been one of the key ingredients in New Keynesian macroeconomic models.

The current study employs data from the Wage Dynamics Network (WDN) surveys to explore the prevalence of both forms of nominal wage rigidity. The WDN was formed by re-

[1] Several possible reasons have been proposed in the theoretical literature for this slowdown in productivity. Managerial surveys have shown that the two most relevant reasons are: a) wage cuts affect the morale of employees negatively (Bewley (2004), Du Caju et al. (2015)) and b) the best employees are the most likely to quit when wages are lowered (Campbell and Kamlani (1997), Du Caju et al. (2015)).

[2] The positive "greasing" effects are found when inflation rates are moderately above zero and inflation is stable and predictable. As soon as the increase in prices becomes too rapid and changes in inflation cannot be predicted by companies, "sand" or gritting effects dominate and employment adjustments by firms are not optimal (Groshen and Schweitzer (1997)). The "greasing" effects are more relevant in countries with strongly regulated labour markets (Loboguerrero and Panizza (2006)).

searchers from the national central banks of the EU countries and the ECB and it conducted three surveys of the wage setting behaviour of firms in 2007, 2009 and 2014. The country coverage of the WDN surveys is extensive, the first wave covering 19 EU member states, the second wave 11 and the third 25. The first WDN survey covers the years of the economic boom before the start of the global financial crisis in 2007, the second survey covers the Great Recession period of 2008–2009, and the third survey focuses on the years 2010–2013. Given that the WDN surveys cover many countries and three distinct time periods, we were able to evaluate the prevalence of different forms of wage rigidity in a wide range of economic circumstances.

The avoidance of cuts in nominal wages becomes an obstacle for real wage adjustments during periods of low inflation. It was argued in some earlier discussions of this topic that economic agents will react to this by relaxing the nominal constraint (e.g. Gordon (1996), Mankiw (1996)). This argument was based on the well-known Lucas critique, which stipulates that when macroeconomic conditions change then microeconomic behaviour is adjusted accordingly. As Gordon (1996) wrote, nominal wage adjustments would no longer be considered unusual if the aggregate wage level was not rising. Workers would not think of them as unfair and firms would be more willing to impose them. If wage setting behaviour is indeed responsive to inflation, then there would be little reason to be concerned about nominal wage rigidity because it is likely to have only a modest impact on employment in a high inflation environment, while nominal rigidity will be absent in a low inflation environment (Fehr and Goette (2005)).

A strand of empirical literature has addressed the question of whether DNWR is still prevalent in periods of low inflation or low economic growth. The existing empirical evidence suggests that it is. It has been shown that nominal wage cuts remain rare during periods when near-zero growth is coupled with low inflation (e.g. Fehr and Goette (2005), Agell and Lundborg (1995)).[3] We contribute to this topic by looking at the incidence of DNWR in more diverse economic environments. Specifically, we study whether the constraint on cutting nominal wages is relaxed in response to the large declines in output that have occurred in some of the countries that the WDN surveys cover. Our evidence supports earlier findings by showing that DNWR was strongly prevalent (i.e. nominal wage cuts were mostly avoided) both in the Great Recession period and in 2010–2013, when the nominal wage growth was low. The extent of DNWR declined in some of the countries that experienced the most severe recessions but even in these cases this constraint on wage setting was relaxed gradually and not completely.

As well as assessing the prevalence of DNWR, we also study the delay in wage setting, using the frequency of wage changes as an indicator of the lagged response of wages to shocks. We show that the frequency of wage changes slowed down after the Great Recession, relative to the boom years preceding 2007. Wages were changed more often before the global financial crisis than during the years 2010–2013 in every one of the 16 countries for which we have comparative evidence. This slowdown occurred simultaneously with the decline in the aggregate wage growth in the countries surveyed. We also find that in countries where wage growth slowed down more after the Great Recession, the frequency of wage changes declined more strongly as well. This suggests that the level of nominal wage growth and the frequency

[3] Real wages are more responsive to cyclical downturns, as shown for example in a recent study by Verdugo (2016).

of wage changes are positively related. There are at least two reasons why this may be the case.

First, changing wages is costly, and so it would be optimal for profit-maximising firms to change wages more frequently during times of high aggregate wage inflation and vice versa. The existence of the positive relationship between the level of inflation and the frequency of changes in nominal prices was modelled in the study by Ball, Mankiw and Romer (1988). They proved the existence of this relationship for price changes, and by the same mechanism it also applies to wage changes.

Second, in the presence of DNWR, firms are more constrained in their wage setting decisions in times of low wage inflation. When wages are downwardly rigid, firms abstain from wage cuts and freeze wages instead. At times when wage growth is lower, larger fractions of possible cuts are prevented and converted into freezes. The average frequency of wage changes declines as a result.[4]

This reasoning supports the more general result that the frequency of wage changes is procyclical as long as the periods of economic downturn are accompanied by declines in nominal wage growth. It should be noted that although slowdowns of economic growth typically lead to decreases in the growth rates of nominal variables, including wages, this is not a universal rule. The cyclical downfalls that are caused by supply-side shocks (e.g. stagflationary periods in the 1970s and 1980s) have high inflation and may also lead to faster growth rates for nominal variables, even though real GDP growth slows down.

A further factor that can induce movements in the frequency of wage changes is economic uncertainty. Gray (1978) develops a neoclassical model, which among other things enables her to study the relationship between contract length and uncertainty in the wage setting decisions of firms. In her theoretical framework, uncertainty is modelled as stochastic disturbances in the money supply and production functions that generate monetary and real shocks to the system. On the one hand, renewing wage contracts is costly for firms and this induces them to lengthen the duration of wage spells. On the other hand, the longer the wage contracts last for, the larger the losses due to deviations of output and employment from their expected levels are, and this induces firms to change wages as often as possible. Consequently, firms face a trade-off in their wage setting decisions and the optimal contract length increases with transaction costs and decreases with the level of economic uncertainty.[5]

We employ multivariate analysis to study the relationship between idiosyncratic uncertainty and the frequency of wage changes. Since the WDN surveys do not form a panel, this analysis is cross-sectional. Our findings indicate that the higher the perceived increase in idiosyncratic uncertainty in the survey period is, the more often a given firm will change wages, controlling for other firm-specific and institutional characteristics. This finding is in accordance with the theoretical predictions of Gray (1978). We also show that the variation in

[4] If the growth in wages declines then the distribution of wage changes shifts to the left. This has two effects. First, the probability mass at zero (i.e. the fraction of wage freezes) increases. This would happen even in the absence of DNWR. Second, if nominal wages are downwardly rigid and firms avoid cutting wages, the leftward shift of the wage change distribution increases the fraction of cuts that are turned into freezes. Consequently, such a leftward shift leads to more wage freezes, and this is exacerbated by DNWR.

[5] The proof that a similar positive relationship between the frequency of adjustment and variance of firm-specific and aggregate shocks exists for prices is derived in the model by Ball, Mankiw and Romer (1988).

the frequency of wage changes across firm characteristics such as size, sector of operation and ownership structure is explainable by differences in the perceived uncertainty of demand across the same characteristics.

The paper is structured as follows. The second section describes the data that are used for the analysis. The third section gives an overview of the frequency of wage changes before and after the Great Recession and explores how it varies across firms with different characteristics, in response to idiosyncratic shocks, etc. The fourth section assesses the prevalence of downward nominal wage rigidity and the interlinkages between the two forms of wage rigidity. The last section concludes.

2. Data description

The analysis in this paper is based on data from the Wage Dynamics Network surveys. The Wage Dynamics Network (WDN) is a research network consisting of the European Central Bank and the national central banks of the EU member states. It was formed for the purpose of analysing the wage dynamics and wage setting practices of European companies. The national central banks participating in this network conducted three waves of surveys by questioning firm managers. The first survey (WDN1) was mostly run in 2007, although the survey years varied across countries, spanning 2006–2009. It involved 19 countries (Austria, Belgium, the Czech Republic, Cyprus, Estonia, France, Greece, Germany, Hungary, Italy, Ireland, Lithuania, the Netherlands, Luxembourg, Poland, Portugal, Slovakia, Slovenia and Spain). The first WDN survey focused on the wage and price setting practices of companies. It also collected information about firm characteristics, the economic environment and the institutional features of countries where the firms operate.

The second wave of the WDN survey (WDN2) ran in 2009 and aimed to gather data on how firms coped with the negative shocks caused by the Great Recession. WDN2 covered 11 countries (Austria, Belgium, the Czech Republic, Cyprus, Estonia, France, Italy, Luxembourg, the Netherlands, Poland, and Spain). It was run as a panel, covering the subset of firms from the WDN1 survey that had survived the first phase of the crisis and agreed to participate in the second wave.

The third round of the WDN survey (WDN3) was conducted in 2014 as a follow-up to the two previous waves. Most of the questions referred to the time period 2010–2013. This round of the survey covered the largest group of countries, 25 in total (Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, France, Greece, Germany, Hungary, Italy, Ireland, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and the United Kingdom). Unlike the second wave, it was not conducted as a panel, and it targeted a new random sample of companies. Like the first survey, it focused on wage setting practices at the firm level and gathered data on firm and institutional characteristics. In addition, it collected information on employment adjustments, the incidence of various shocks (positive or negative) that firms experienced during the reference period and the opinions of firm managers about the relevance of recent labour market reforms.

In this paper we mainly use the data from WDN1 and WDN3 so we can evaluate different forms of wage rigidity before and after the Great Recession. The WDN2 survey is only used

in part of the analysis, since it does not contain the questions on wage change frequency that are needed for the delay in wage setting to be assessed. The sample used in the analysis covers firms with more than five workers in the following sectors: manufacturing, energy, construction, trade and transportation, market services and financial intermediation.[6] The composition of the samples of WDN1, WDN2 and WDN3 surveys by country, sector and firm size is given in Tables A1.1, A1.2 and A1.3 (please see the Appendix). In the review of the wage rigidity indicators we use employment weights where applicable to make the samples representative of the population of employees in each sector and country.[7]

3. The frequency of wage changes

3.1 Descriptive evidence on the frequency of wage changes

In this section we present descriptive evidence on how often the wages of employees were typically changed in the countries covered by the WDN surveys.[8] The sample of WDN1 that we use for the analysis of wage change frequency takes in 16 of the 19 countries that conducted the survey as we do not include Germany, Cyprus, and Greece. The German data from the first WDN survey are not available for reasons of confidentiality. We also do not report the frequency of wage changes from WDN1 for Cyprus and Greece because the question was formulated differently in the questionnaires in those countries and the answers could not be harmonised.

The WDN surveys asked firms how often they change wages for their main occupational group. The question was worded as follows: "How frequently is the base wage of an employee belonging to the main occupational group in your firm typically changed?". Wage changes could be either wage rises or cuts. Respondents could choose from the following options: more than once a year; once a year; between once a year and once every two years; once every two years; less often than once every two years; and never / not applicable. The WDN1 survey did not specify the exact reference period for this question and it targeted an unspecified number of years preceding the time of the survey fieldwork in 2007. In the WDN3 survey, the question was asked in the past tense and specifically referred to the years 2010–2013.

Table A2 summarises the incidence of replies for each option, grouping the answers into (1) more often than once a year, (2) once a year, (3) less often than once a year, and (4) never/ not applicable. Earlier studies have found that firms most commonly change wages with yearly frequency.[9] This regularity is strongly confirmed by the WDN1 data but is less prevalent in the WDN3 data. The mode frequency for almost all the countries that conducted the WDN1 survey was once a year (see Table A2). The only exception to this was Italy, where

[6] The WDN surveys also cover non-market services or firms with fewer than five workers in some countries. A full description of the coverage in participating countries is given in Durant et al. (2009) for WDN1 and Izquierdo et al. (2017) for WDN3.

[7] The weights are defined as the sum of the population of employees in each sampling stratum (defined by country, sector, and firm size category), divided by the number of observations (firms) in that stratum.

[8] An overview of the wage change frequency for the period before the Great Recession on the basis of the WDN1 survey is also given in Druant et al. (2009).

[9] A comprehensive up-do-date review of the existing studies measuring wage change frequency is provided by Taylor (2016), see also Druant et al. (2009).

the majority of firms changed wages once every two years (Druant et al. (2009)). The yearly frequency for wage changes was not as prevalent in 2010–2013 as it was in the earlier years. The mode frequency was "less often than once a year" in about half of the countries participating in the WDN3 survey, while in the remaining half the mode was yearly frequency.

Across the firms in all countries covered by the survey, the mode frequency was still once a year in WDN3 survey, but this holds for a smaller share of firms (48% in WDN3 relative to 60% in WDN1). The yearly frequency is most dominant in countries where it is common to index wage changes to inflation. This applies to Luxembourg and Spain in the earlier period covered by WDN1, and to Malta in the later period.

The data presented in Table A2 show that the frequency of wage changes declined after the Great Recession. To show this change in the dynamics of wage setting more clearly we present in Figure 1 the share of firms that changed wages with at least yearly frequency in the pre-crisis period (WDN1) and in 2010–2013 (WDN3). This share declined in every country for which comparative data exist. The extent of the decline varied strongly across countries, ranging from 78% in Ireland to 6% in Austria. On average, the employment-weighted share of firms changing wages with yearly frequency or more often dropped by 28% across the countries participating in both surveys.

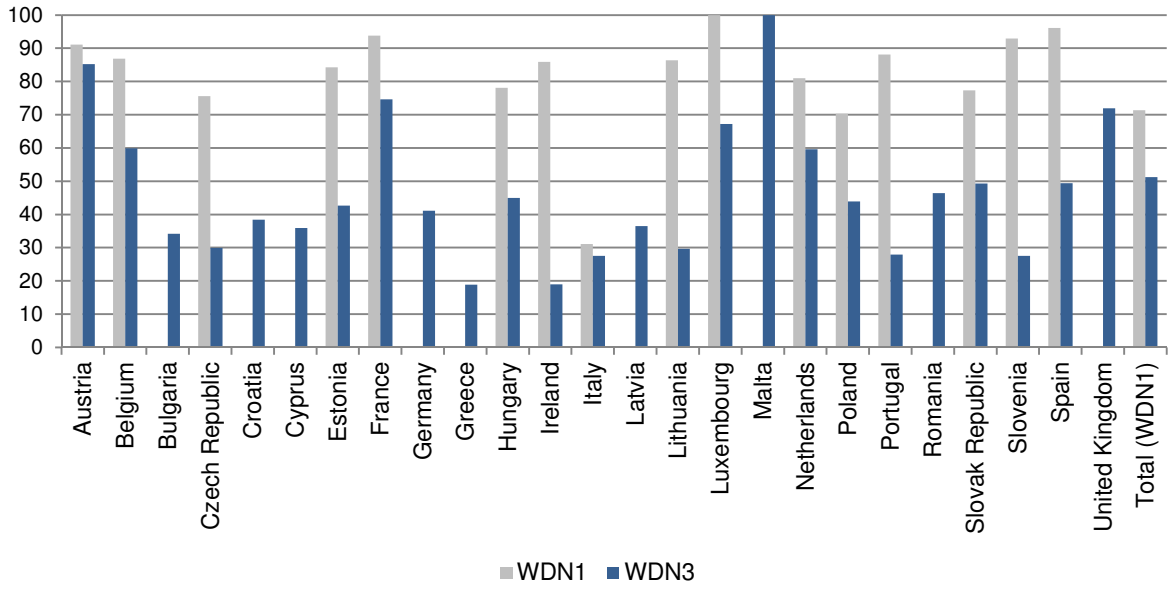

Figure 1: The percentage of firms changing wages with yearly or higher frequency

Note: For comparative purposes, we calculate the totals across the same group of countries for the two surveys, i.e. the group of countries that participated in the WDN1 survey.

Three causes can be identified for this decrease in the frequency of wage changes after the Great Recession, and they are described below. All of them are related to the slower wage growth in 2010–2013 in the countries surveyed than during the economic boom that preceded the Great Recession.

The first cause is that since changing wages is costly, it is optimal for profit-maximising firms to change wages more frequently during times of high aggregate wage inflation and less often when wage inflation is lower. The existence of a positive relationship between inflation and the frequency of changes in nominal variables was first modelled in the study by Ball, Mankiw and Romer (1988). They proved that this relationship exists for price changes, but by the same argument it also applies for wage changes.

Second, the general slowdown in the growth of wages meant the wage change distributions have shifted to the left in the countries that our study covers. As the mode of distribution has come closer to zero, the fraction of wage changes at zero has increased. Consequently, it is optimal for a larger fraction of firms to keep wages unchanged, which reduces the frequency of wage changes. (This argument holds even under the assumption that wages are not downwardly rigid.)

Third, the constraint imposed by downward nominal wage rigidity of avoiding wage cuts becomes more binding at times of low wage inflation. When wages are downwardly rigid then firms avoid wage cuts and replace them with wage freezes. If wage growth decreases, then the mode of the wage change distribution comes closer to zero, so the probability mass of avoided wage cuts increases. Consequently, the fraction of firms freezing wages (instead of cutting them) increases and the average frequency of wage changes declines as a result. If downward nominal wage rigidity is highly prevalent (i.e. the vast majority of wage cuts are avoided) then this effect can have quite a strong impact on the frequency.

As all these are related to a slowdown in wage growth, it may be expected that the decrease in the frequency of wage changes should have been stronger in countries where the decline in wage growth was steeper. Figure 2 illustrates that this is indeed the case. It depicts the correlation between (1) the percentage change between WDN1 and WDN3 in the fraction of firms changing wages with yearly frequency or more often[10]; and (2) the percentage change in average wage growth between the two time periods 2002–2006 and 2010–2013.[11]

The fitted linear regression line plotted in Figure 2 has a positive slope and the slope coefficient is statistically significant. The Pearson correlation coefficient between these two variables is also significantly positive and equals 0.49. When Poland, which is an outlier, is left out, then the correlation coefficient increases to 0.78.[12] These estimations imply that for the fifteen countries for which we can carry out this comparison, there is strong evidence that a steeper decline in wage growth was associated with a more substantial slowdown in the frequency of wage changes.

[10] The fractions of firms adjusting wages with at least yearly frequency in WDN1 and WDN3 surveys are presented in Figure 1.

[11] The data on annual wage changes for countries surveyed are presented in Table A3 in the Appendix.

[12] The slope coefficient for the fitted line in Figure 2 is 0.21. When Poland, that is an outlier, is left out then the fitted line becomes steeper and the slope coefficient equals 0.58.

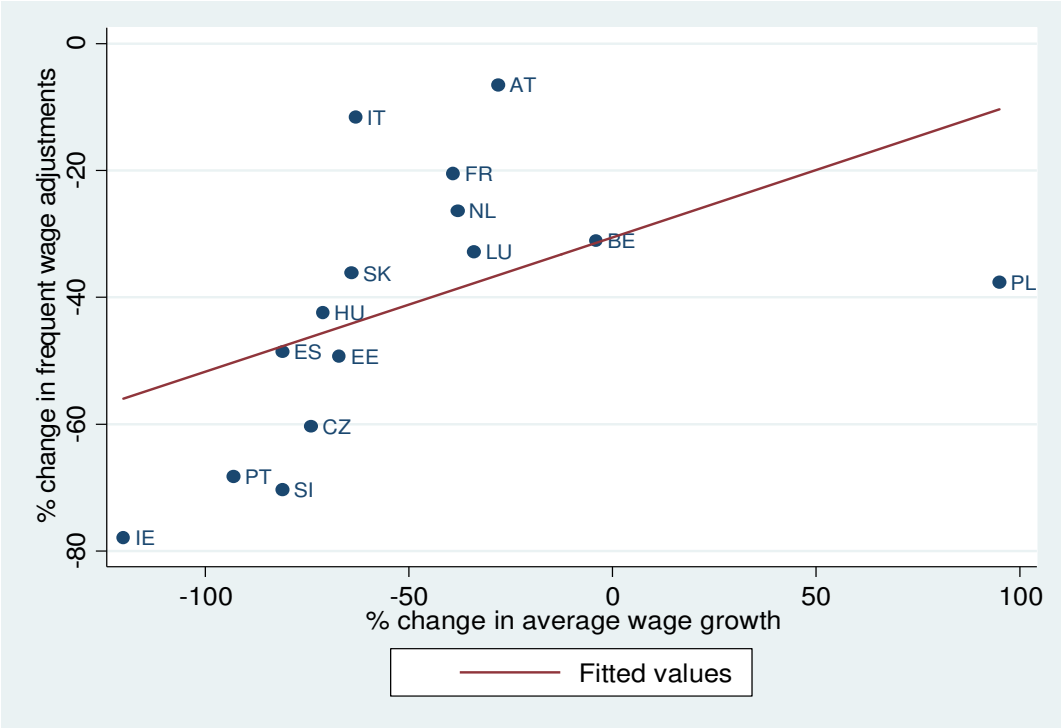

Figure 2: Slowdown in the wage change frequency and change in wage growth

Notes: The variable depicted in the vertical axis measures the percentage change between WDN1 and WDN3 in the fraction of firms changing wages with at least yearly frequency. The variable depicted on the horizontal axis measures the percentage change in the average wage growth between the two time periods 2002–2006 and 2010–2013.

3.2 Wage change frequency: multivariate analysis

We employ two sets of regressions to assess the relationships between wage change frequency and various variables characterizing firms and the institutional environment. First, we run a set of probit models where the dependent variable is a dummy variable that equals one if wages are changed with at least yearly frequency and zero otherwise. In the second set the dependent variable is a categorical variable depicting different frequencies of wage changes. It is ordered from the lowest frequency (wages were never changed in the reference period) to the highest frequency (wages were changed more frequently than once a year). We use the second set of regressions mainly as a robustness check to see whether alternative estimations provide similar results.

All the regressions have a similar structure, differing only in whether measures of collective bargaining are included. We incorporate collective bargaining coverage in one variant of the regressions and two dummy indicators for firm-level and higher-level bargaining agreements in the second variant. These variables are not included together as are strongly correlated.

In addition, there are some differences in the choice of control variables between the models based on the WDN1 survey and those based on the WDN3 survey, as the survey questionnaires were not identical and some variables appear in only one of the two surveys. Specifically, detailed questions about firm-specific shocks to demand and access to credit

were only asked in the WDN3 survey, while the questions about the nature of wage setting (time-dependent vs state-dependent) and the possible interdependence between wage setting and price setting only appear in the WDN1 survey. The complete results of both probit and ordered probit models are shown in Table A4.1 for the WDN3 survey and in Table A4.2 using the WDN1 survey. A selected set of predicted probabilities comparing pre- and post-crisis values (i.e. WDN1 and WDN3 results) from those estimations are in shown in Table 1.

Table 1: **W**age change frequency 2010–2013 vs 2002–2007. Selected results
Predicted probabilities

Dependent variable: frequency of base wage changes is at least once a year	**Predicted probability Probit**	
	WDN3 (2010–2013)	WDN1 (2002–2007)
Sector		
Manufacturing	0.468 [R]	0.881 [R]
Electricity, gas & water	0.519	0.925
Construction	0.431**	0.888
Trade	0.423**	0.866**
Business services	0.391**	0.861**
Financial intermediation	0.425	0.863
Size		
5–19 employees	0.406 [R]	0.839 [R]
20–49 employees	0.419	0.870**
50–199 employees	0.437**	0.879**
more than 200 employees	0.469**	0.904**
Ownership status		
Mainly foreign	0.517**	
Mainly domestic	0.409 [R]	
Autonomy of the company		
Company is a subsidiary/affiliate	0.482**	
Parent company	0.419 [R]	
Demand shock		
Strong decline in demand	0.382	
Moderate decline in demand	0.413	
No change	0.408 [R]	
Moderate increase in demand	0.483**	
Strong increase in demand	0.498**	
Credit availability shock		
Strong decline in access to credit	0.389**	
Moderate decline in access to credit	0.412**	
No change	0.439 [R]	
Moderate increase in access to credit	0.446	
Strong increase in access to credit	0.451	
Time-dependent wage setting		
Base wage changes are concentrated in a particular month/months		0.925**
Obs.	14990	13460

Notes: Detailed results in Table A4.1 (column 3) and A4.2 (column 4). Superscript R stands for reference category. ** means that the predicted probability is significantly different at the 5% level from that of the reference category.

3.2.1 Wage change frequency vs firm characteristics

In this section we give an overview of the selected results from the regressions described above. The first two findings discussed below are supported by the regressions that use data from both surveys, implying that they do not depend on cyclical effects. The third one could only be assessed from the WDN3 survey as the related questions were not asked in WDN1.

First, firms operating in different sectors do not change wages with the same frequency. Wages are changed less often in trade and business services than they are in manufacturing. In terms of predicted probabilities (see Table 1), the probability of wages being changed with yearly or higher frequency before the crisis was approximately 86% in trade and in business services, and in 2010–2013 it was about 42% in trade and 39% in business services. The predicted probability of wages being changed with yearly or higher frequency in manufacturing was 88% before 2007 and 47% in 2010–2013, which implies that the sectoral differences were relatively modest in the earlier period but larger the later period.

The second finding that emerges from the regressions based on both surveys is that the frequency of wage changes is positively related with firm size. The estimated effects increase monotonically across firm size groups. The predicted probabilities for wages being changed with yearly or higher frequency found from the WDN3 survey range from 40% for the reference group of the smallest firms with 5–19 employees to about 47% for firms with more than 200 employees (84% and 90% accordingly on the basis of the WDN1 survey).

This positive relationship between firm size and wage change frequency can partly be explained by differences in the wage setting practices of small and large firms. Large firms are more likely to have formal procedures for regular wage reviews and wage adjustments, and these are typically extended to all employees. The existence of formal and extendable wage setting procedures should make wage changes more frequent on average across all employees. A variable that at least partly controls for these differences is the indicator of time-dependent wage setting, which is covered by the WDN1 survey. Larger firms are more likely to apply time-dependent wage setting, conditional on other firm and institutional characteristics (see Table A4.2). Firms that use time-dependent wage setting practices change wages more often (see Table A4.2). Together these two results indicate that there are indeed differences in the wage-setting practices of large and small firms, which can lead to divergent wage change frequencies.

However, the estimated effects for the firm size groups in regressions on wage change frequency remain positive and statistically significant even when the dummy for time-dependent wage setting is included as a control variable (see Table A4.2). This shows that there are additional reasons for wage changes to have a higher frequency in larger firms. It is possible that the indicator for time-dependent wage setting does not capture the differences in the wage setting procedures between large and small firms to the full extent, but the divergences in frequency may also be driven by additional factors. The impact of economic uncertainty, which may be one additional factor, is discussed below.

The third finding is that business entities operating as subsidiaries and companies with foreign owners change wages more frequently than other companies do. The predicted probability of wages being changed with at least yearly frequency is 51% for companies with mainly foreign owners, while it is 41% for other firms. If a company is a subsidiary, then the

predicted probability of wages being changed with at least yearly frequency is about 48%, while it is 42% for parent companies or for firms without subsidiaries.

This third finding can be partly explained by the regularity that these companies tend to be larger firms, but the estimated effects remain significant even after firm size is controlled for in the regressions. Additional possible explanations for this relationship overlap with those used to explain the higher frequency of wage changes in large firms. Like companies with more employees, subsidiaries of multinational enterprises and companies with foreign owners may have more regulated wage setting procedures than domestic companies do, making wage changes more frequent. We are not able to test this hypothesis using the WDN data since the indicators of ownership status and establishment structure are only available in the WDN3 survey, whereas the measure of time-dependent wage setting is covered only by the WDN1 survey.

As hinted above, a common factor that can be underlying all these three relationships is economic uncertainty. As the theoretical model by Gray (1978) showed, more volatile demand conditions induce firms to change wages more often. The WDN3 survey contains a variable that can be used as a proxy of demand volatility.[13] We run an ordered probit regression with this measure as a dependent variable to see whether it is different across firm size, sector of operation, ownership status, etc. The results of this regression, presented in Table A6, indicate that demand was more volatile in subsidiaries and firms with foreign owners and volatility was positively related with firm size when sector and country effects were controlled for. A potential explanation for the higher wage change frequency may thus be that the economic environment is more unpredictable for these firms. The finding that firms with foreign owners are exposed to more volatile demand conditions is also supported by some earlier studies on this topic (e.g. Meriküll and Rõõm (2014)). There is also empirical evidence showing that large firms are affected by economic recessions more negatively, as they have higher cyclical fluctuations in sales turnover (Kudlyak and Sanchez (2016)). As will be shown in the following section, higher perceived volatility of demand is associated with a higher frequency of wage changes.

The results in Table A6 also imply that demand was more uncertain in manufacturing companies than in all the other sectors covered by the WDN survey except electricity, gas and water supply. This difference in demand volatility may also partially explain why the frequency of wage changes was lower in trade and business services than in manufacturing.[14]

3.2.2 Wage change frequency vs idiosyncratic shocks

The WDN3 survey includes variables that measure firm-level shocks. Firms were asked whether they experienced changes in demand or access to credit in 2010–2013. The answer options for these questions were the following: (1) a strong decrease; (2) a moderate decrease; (3) no change; (4) a moderate increase; and (5) a strong increase. Although these measures do

[13] A description of the related survey question is given in section 3.2.3

[14] As an additional robustness check, we estimated the regressions presented in Table A4.1 for the subset of countries that participated in the WDN1 survey. The regression results were similar to the findings described in this section and all implications that could be drawn from the regressions presented in Table A4.1 remained valid.

not provide an exact quantification of the magnitude of these changes, they give qualitative information about how firms perceive the nature and the strength of each shock. We include them in the regressions on wage change frequency described in the previous section to assess whether wage setting is influenced by changes in demand or access to credit. Since the regressions also include country and sector dummies, which control for common changes in the economic environment, the regression estimates for the variables measuring firm-level changes show how idiosyncratic shocks are related to wage change frequency.[15]

The estimated regression effects indicate that wage change frequency is positively related to both types of shock (see Table A4.1). However, these relationships are not symmetric, as the frequency of wage changes is more responsive to positive changes in demand than to negative ones. Shocks to credit constraints exhibit the opposite pattern, as the frequency declines if access to credit becomes more restrictive but it is not responsive to a relaxation of credit constraints.

In terms of predicted probability (Table 1), the probability that a firm will change wages with at least yearly frequency is 42% with a moderate increase in demand and 50% when there is a strong increase. A moderate decline in demand had no significant impact on the probability of changing wages frequently while the predicted probability is 38% when there is a strong fall in demand. The magnitude of the estimated effects in response to credit shocks is similar. The predicted probability that a firm will change wages with at least yearly frequency was 44% if access to credit did not change, while it was 41% among firms experiencing a moderate decline in access to credit and 39% for firms experiencing a strong decline.

There could be two possible reasons why idiosyncratic shocks would impact the frequency of wage changes. First, the average wage growth at the firm level is positively related with the nature of these shocks and, as the theoretical model by Ball, Mankiw and Romer (1988) implies, higher wage inflation leads to more frequent wage changes.[16] Second, the positive relationship between idiosyncratic shocks and the frequency of wage changes is the result of downward nominal wage rigidity.

This poses the question why DNWR would create a positive association between idiosyncratic shocks and wage change frequency. In the absence of nominal rigidities, firms experiencing negative shocks would be more likely to reduce wages than (otherwise similar) firms experiencing positive shocks would. In the presence of DNWR firms avoid wage cuts and instead opt for wage freezes. The fraction of potential cuts replaced by freezes is larger for firms exposed to negative shocks, which automatically means that the frequency of wage changes is lower for such firms as well. It is relevant in this context that changes in the frequency are evaluated in response to idiosyncratic shocks, i.e. firms are facing the same common shocks at sector and country level, implying that their wage growth distributions would otherwise be similar.

[15] We ran additional regressions which included the interactions of country and sector dummies alongside the levels of these variables to capture the full extent of the impact of common shocks. Including interaction terms had a negligible impact on the estimated effects for idiosyncratic shocks and so these results are not reported.

[16] The model by Ball, Mankiw and Romer (1988) implied the existence of such a relationship for prices, but it is also applicable to wages.

3.2.3 Wage change frequency vs the perceived volatility of demand

As was shown in Gray (1978), more volatile demand conditions induce firms to change wages more often. This result stems from the assumption that reviewing and renegotiating wage agreements entails "menu costs". As it is costly to renew wage contracts, firms minimise these costs by lengthening the duration of wage spells. However, the lengthier the contracts, the larger the losses due to deviations of output and employment from their expected levels are, and this creates an incentive to opt for shorter wage spells. Consequently, firms face a trade-off in their wage setting decisions and the optimal contract length increases with transaction costs and decreases with the level of economic uncertainty.

We test the prediction by Gray (1978) at the firm level using the data from the WDN3 survey. As well as collecting information about firm-specific changes in demand, the WDN3 survey also contains a variable that measures demand volatility. Firm managers were asked to assess the change in the volatility/uncertainty of demand in 2010–2013 with the following answer options: (1) a strong decrease; (2) a moderate decrease; (3) unchanged; (4) a moderate increase; or (5) a strong increase.

We use the similar regression setup as before, running ordered probit regressions on a categorical variable of wage change frequency and probit regressions on a binary dependent variable indicating that wages are changed with at least yearly frequency. The regressions include the measure of demand uncertainty as an additional control variable. The estimated results point to an asymmetric relationship, as a decrease in demand volatility leads to lower wage change frequency while an increase in volatility has no significant effect (see Table A7). Given that the regressions include country and sector effects, these estimations depict the relationship between idiosyncratic changes in volatility and wage change frequency. Although the underlying variable measures the change in volatility during the reference period, it can also serve as a proxy for the level, assuming that the firm-specific change and the firm-specific level of volatility are sufficiently correlated. Thus, with some generalisation, the regression results imply that lower demand uncertainty leads to lower wage change frequency. The causal interpretation of the regression results is warranted in this case as it is highly unlikely that there is a feedback from firm-specific wage change frequency to idiosyncratic demand volatility.

The regressions presented in Table A7 include two types of firm-specific shocks: credit availability shocks and demand uncertainty shocks. If an additional variable depicting changes in demand is added to the regressions then the estimated results for demand uncertainty are rendered insignificant. Changes in demand seem to play the dominant role in the wage setting decisions of firms, as changes in the volatility of demand do not have additional explanatory power when demand shocks are accounted for.[17]

[17] The results of the regressions including simultaneous controls for demand shocks and for demand uncertainty shocks are not included in the paper, but available upon reuqest.

3.2.4 Wage change frequency vs labour market institutions

The role played by labour market institutions for DNWR has been studied extensively. The evidence from most of the studies that focus on this issue is that more regulated labour markets are associated with stronger DNWR. Labour market regulations are typically measured by two main institutional characteristics in these studies: strictness of employment protection legislation (EPL) and collective bargaining coverage (e.g. Dickens et al. (2007), Holden and Wulfsberg (2008), Babetsky et al. (2010), Holden (2002)).

In contrast, evidence on the relationship between the institutional environment and wage change frequency is much scarcer. To the best of our knowledge, there is only one previous study, by Druant et al. (2009), that uses the data from the WDN1 survey to assess the impact of institutions. They find that the frequency of wage changes is lower in countries with stricter EPL. In addition, their study indicates that the level of collective bargaining is relevant, as the existence of firm-level agreements is associated with higher wage change frequency; while higher-level bargaining contracts have no significant relationship with how often wages are changed. Collective bargaining coverage is negatively related with wage change frequency.

In this study we replicate the results of Druant et al. (2009) when using the WDN1 data (the regression estimates are presented in Table A4.2), but get divergent results on the basis of the WDN3 survey (see Table A4.1). The estimated effects for 2010–2013 imply positive relationships between wage change frequency and all three measures of unionisation: collective bargaining coverage, an indicator for the existence of a firm-level collective wage agreement, and an indicator for a higher-level agreement.

The question then arises of why collective bargaining coverage was associated with lower frequency of wage changes in the years before 2007, while the opposite holds for 2010–2013. Collective wage agreements tend to be re-negotiated at regular intervals, and so it may be that during the upward phase of the economic cycle prior to 2007, when the yearly average wage growth was high, the desired wage change frequency for firms was above the frequency imposed by collective bargaining contracts, while in the period 2010–2013, when the wage growth slowed down substantially, the desired frequency was below that imposed by collective bargaining. Firms that were not covered by collective bargaining could change wages at a frequency that was responsive to the economic cycle, while covered firms had to change wages at the regular frequency imposed by collective bargaining. Although this is a probable explanation for the finding, it is not possible to test it using the data from the WDN surveys. The assessment from the WDN1 survey data implies that collective bargaining is associated with a higher incidence of time-dependent wage setting (see Table A5), but whether it leads to smoothing of the frequency of wage changes over the economic cycles still needs to be proven.

Although collective bargaining agreements are typically re-negotiated at regular intervals, these intervals may be dependent on economic cycles, since recessions may lead to delays in the renewal of collective agreements. In this case there would be wage freezes in the periods between the expiration of the collective agreements and their renewals. This would make wage changes less frequent during downturns not only for individual wage contracts but also for collectively bargained wages. We use a variable measuring the relevance of firing costs in the employment decisions of firms to assess the impact of EPL on the wage change frequen-

cy.[18] This firm-level measure is only available in the WDN3 survey. The study by Druant et al. (2009) used the aggregate EPL index published by the OECD in their multivariate assessments. Despite not having the firm level measure and relying instead on the country-level variable for EPL, they obtained results that are similar to those of the current study, namely, that stricter EPL is associated with less frequent wage changes. It is notable that this characteristic of the institutional environment has a similar impact on both forms of wage rigidity, as stricter EPL is associated with stronger DNWR (Holden (2002), Holden and Wulfsberg (2008)) as well as with longer wage spells, as shown in the current paper.

4. Downward nominal wage rigidity

Downward nominal wage rigidity refers to the reluctance of firms to cut nominal wages. It has been argued in the literature that firms avoid reducing the nominal wages of their employees because wage reductions have a negative effect on the productivity of workers (e.g. Bewley (2004), Blider and Choi (1990), Campbell and Kamlani (1997)). Nominal wage reductions are often also prevented by labour market regulations or collective bargaining agreements (Du Caju et al. (2015)). We use survey information on wage cuts and freezes to evaluate the prevalence of DNWR in EU countries.

The three waves of the WDN survey collected information on whether firms cut or froze the base wages of some of their employees and on the proportion of workers affected. The incidence of wage cuts and freezes found from the WDN surveys is discussed in Izquierdo et al. (2017).

Although all three waves of the WDN survey collected information on wage cuts and freezes from similar and comparable questions, the length of the reference period for this set of questions differed across the waves. WDN1 asked whether wages were cut or frozen during the five-year period 2002 to 2006 prior to the survey. WDN2 covered the incidence of wage cuts and freezes during the early phase of the Great Recession, from the third quarter of 2008 until the summer of 2009. Finally, WDN3 collected information on wage cuts and freezes for each year separately, covering the four years from 2010 to 2013. Since the reference periods differ in length, the incidence of wage cuts and freezes cannot be directly compared across the surveys.

Cuts in nominal base wages were rare over the three waves of the WDN survey, which is indicative of the presence of DNWR throughout the entire time period covered by the surveys (Izquierdo et al. (2017)). Only 2.3% of firms in the countries sampled in 2007 reported that they had cut wages in the previous five years. In 2008–2009 only 3.1% of the firms surveyed reported wage cuts, and only 4.5% of the firms reduced wages at least once over the four-year period of 2010–2013.

Since wage cuts were typically not extended to all employees, the incidence of wage cuts was even lower in terms of workers affected. In the pre-crisis period in 2002–2006, only about 0.8% of workers were affected by wage cuts. During the intense crisis period of 2008–2009 the share of wage cuts increased only moderately to 1.7% of workers. During the period

[18] The measure of firms' firing costs is a categorical variable with four answer options: 1) not relevant; 2) of little relevance; 3) relevant; and 4) very relevant.

of low wage growth in 2010–2013 the incidence of wage cuts ranged from 1.3% to 2.0% of workers per year.

4.1 The measurement of DNWR

The extent of DNWR cannot be quantified solely by accounting for the incidence of wage cuts. Even in the absence of downward rigidity, the proportion of wage cuts in the whole distribution of wage changes depends on the mode and the variance of the distribution. If nominal wages grow fast (i.e. the mode is far from zero) and the variance is sufficiently low, then the wage change distribution can only include a negligible fraction of wage decreases even if wages are not downwardly rigid. Therefore it is relevant to quantify the extent of wage cuts relative to the location of the whole distribution of wage changes. As the information about wage changes is not available in the WDN surveys, it is not possible to determine the shape of the whole distribution, but we can use partial information about the proportions of wage cuts and freezes.

In the presence of DNWR firms avoid cutting nominal wages and instead leave wages unchanged, i.e. freeze them. Therefore a small amount of wage cuts relative to freezes is indicative of DNWR. A measure that lets us quantify DNWR from the relative shares of cuts and freezes was proposed by Dickens et al. (2007). We employ it in the current study as a proxy for DNWR.

The study by Dickens et al. (2007) used the following measure of DNWR:

$$\mathrm{DNWR} = \frac{f}{f+c} \tag{1}$$

where f represents the fraction of workers whose wages were frozen and c represents the fraction of workers whose wages were cut. This measure can be interpreted as the share of wage cuts that did not occur because of DNWR. This interpretation is based on the assumption that every employee whose nominal wage was frozen would have had a nominal wage cut in the absence of DNWR. Given that assumption, the formula shows the share of workers who received a wage freeze although it would have been optimal for their firm to cut their wages, i.e. the fraction of workers subject to DNWR. In the absence of DNWR there would be no wage freezes and DNWR = 0, whereas when there were no wage cuts then DNWR = 1.

The measure given by equation (1) overestimates the actual level of DNWR, measured as the share of wage cuts prevented, since it is based on an assumption that every wage freeze represents a prevented cut. However, it would be optimal to freeze the wages of a certain share of workers even in the absence of DNWR. At moderate levels of nominal wage inflation wage change distributions contain some positive mass of observations at zero even under the assumption of complete wage flexibility. Since the measure given by equation (1) does not take into account that a subset of observed wage freezes does not represent avoided cuts, it is upward biased.

We conducted simulations to evaluate the extent of the upward bias in the measure of DNWR given by equation (1). The simulations were based on the assumption that wage changes are normally distributed in the absence of DNWR. The simulations indicate that the bias for the share of wage cuts prevented remains in the range of 3–25%. This is the share of

the probability mass at zero under the counterfactual distribution relative to the probability mass at zero when all wage cuts are prevented.

The extent of the bias depends on (1) the standard deviation of the wage change distribution; (2) the mean of the wage change distribution (more exactly, the bias depends on the location of the zero bar relative to the mean); and (3) the extent of DNWR (i.e. the share of wage cuts that are prevented due to wage rigidity).[19] The graphs depicting the estimated range of the bias under different assumptions about the extent of the wage cuts prevented, and the mean and standard deviation of the wage change distribution are presented in Figures A1–A3 (in the Appendix). In general, the closer the estimated measure of DNWR given by formula (1) is to one, the smaller is the bias caused by the assumption that *all* freezes represent prevented cuts.

Following the results of the simulations we estimate a range of adjusted measures of DNWR using the formula given above, but letting the amount of cuts converted to freezes vary from 80% to 50% of the share of freezes observed. It should be noted that this range is wider than the estimated maximum extent of bias resulting from simulations. The assessments of DNWR from the initial measure and from the two adjusted measures are presented in the following section.

4.2 DNWR: Descriptive statistics

Tables A8.1–A8.3 present the estimates of DNWR based on the measure given by equation (1) and on the two adjusted measures described in the previous section. The information given in Tables A8.1–A8.3 is also shown in Figure 3 for the period 2010–2013. The bars in this figure present the estimated level of DNWR using the adjusted measure that is based on the assumption that 80% of the observed freezes represent prevented cuts in wages. The interval around the central value has the estimate of the DNWR given in equation (1) as the upper point and the estimate based on the assumption that 50% of observed freezes represent prevented wage cuts as the lower point. This interval gives an approximate range for the possible values for the share of wage cuts that were prevented because of DNWR, based on the assumptions described above.

Since the questions on wage cuts and wage freezes refer to time periods of different lengths across the WDN surveys, comparing downward wage rigidity before and after the Great Recession is not feasible using these data. DNWR is measured as a proportion of wage freezes relative to cuts and freezes and assessment of it should therefore mostly be independent of the length of the period during which the incidence of cuts and freezes is observed. Even so, during the longer period (i.e. the five-year period of the WDN1 survey) certain employees may have experienced multiple cuts or freezes, which means the DNWR measures estimated for this period are not directly comparable with those computed for the yearly periods.

[19] Leaving everything else unchanged, the following applies: 1) Larger variance means less bias; 2) The closer the zero bar is to the mean/mode of the distribution, the lower the bias is; 3) The larger the share of prevented wage cuts is (or the higher the actual level of DNWR is), the smaller the bias is.

The estimates shown in Tables A8.1–A8.3 imply that DNWR is strongly prevalent in all the periods covered by the three WDN surveys. The estimated share of wage cuts prevented by DNWR is consistently high, at above 0.8 for the vast majority of observations and approaching one (meaning that no wage cuts are observed) for some countries (e.g. the Netherlands, France, and Belgium).

As the WDN2 survey covered a smaller set of 10 countries, we have only limited evidence for DNWR during the acute phase of the Great Recession in Q3/2008–Q2/2009. Most of the firms surveyed reacted to strong negative demand shocks in this period by freezing wages (Fabiani et al. 2015), but wage cuts were only moderately more frequent than in the boom period and in most countries DNWR was still prevalent. It was only significantly below its level in the boom in Estonia, a country that experienced a double-digit GDP decline in 2008–2009.

Since labour markets react with lags to GDP changes, the impact of the Great Recession was still reflected by increasing unemployment rates in 2010 in many countries. It appears that DNWR also reacted with a lag to the decline in economic activity, as the level of DNWR was lower in 2010 than in subsequent years in several countries that were affected most by the Great Recession (e.g. Ireland, Estonia, Latvia, and Lithuania).

While DNWR increased from 2010 to 2013 in Ireland and the Baltic States, a strong trend in the opposite direction was present in some other countries such as Croatia, Greece and Cyprus. The fall in the prevalence of DNWR coincided with very substantial declines in GDP in these countries, especially in Greece and Cyprus, which were the most affected by the sovereign debt crisis in 2010–2013. DNWR was also declining in some additional countries where the crisis continued in 2010–2013, such as Italy and Spain.

The evidence from the WDN surveys shows that DNWR is persistent, as it is not responsive to slower wage growth and does not decline in response to adverse economic shocks, unless these shocks are very strong or long-lasting. The relaxation of nominal rigidity only occurs in periods of severe economic decline and even then wage setting is not completely flexible. The lowest levels of the DNWR measure depicted in Figure 3 were in the range of 0.4–0.5, implying that 40–50% of potential wage cuts were still prevented by DNWR even during the periods of most adverse aggregate shocks.

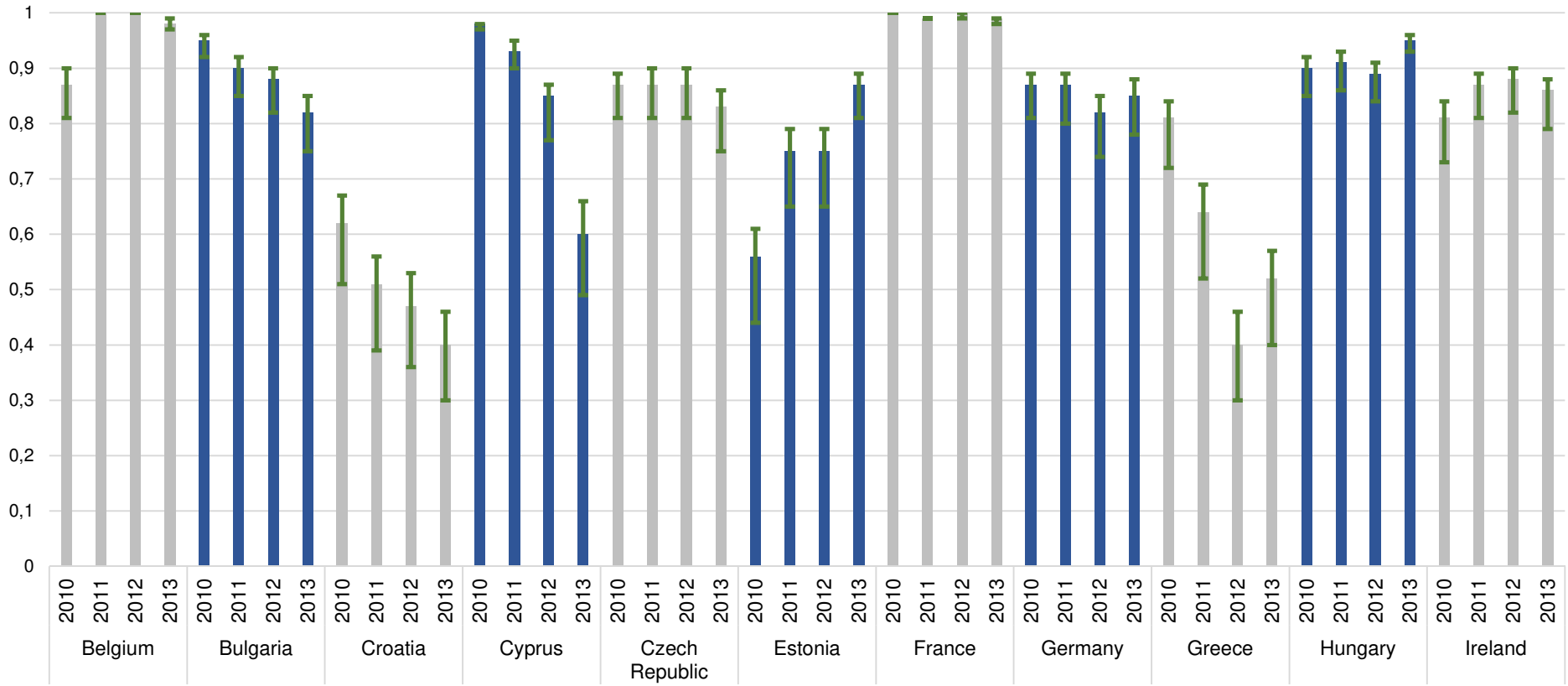

Figure 3: Downward nominal wage rigidity

Notes: The figure presents the estimated values of DNWR using the measure proposed by Dickens et al. (2007). The bars show the estimates of DNWR taking the assumption that 80% of observed wage freezes represent prevented wage cuts. The upper (lower) values of the interval around the central measure are estimated assuming that 100% (50%) of observed wage freezes account for prevented wage cuts.

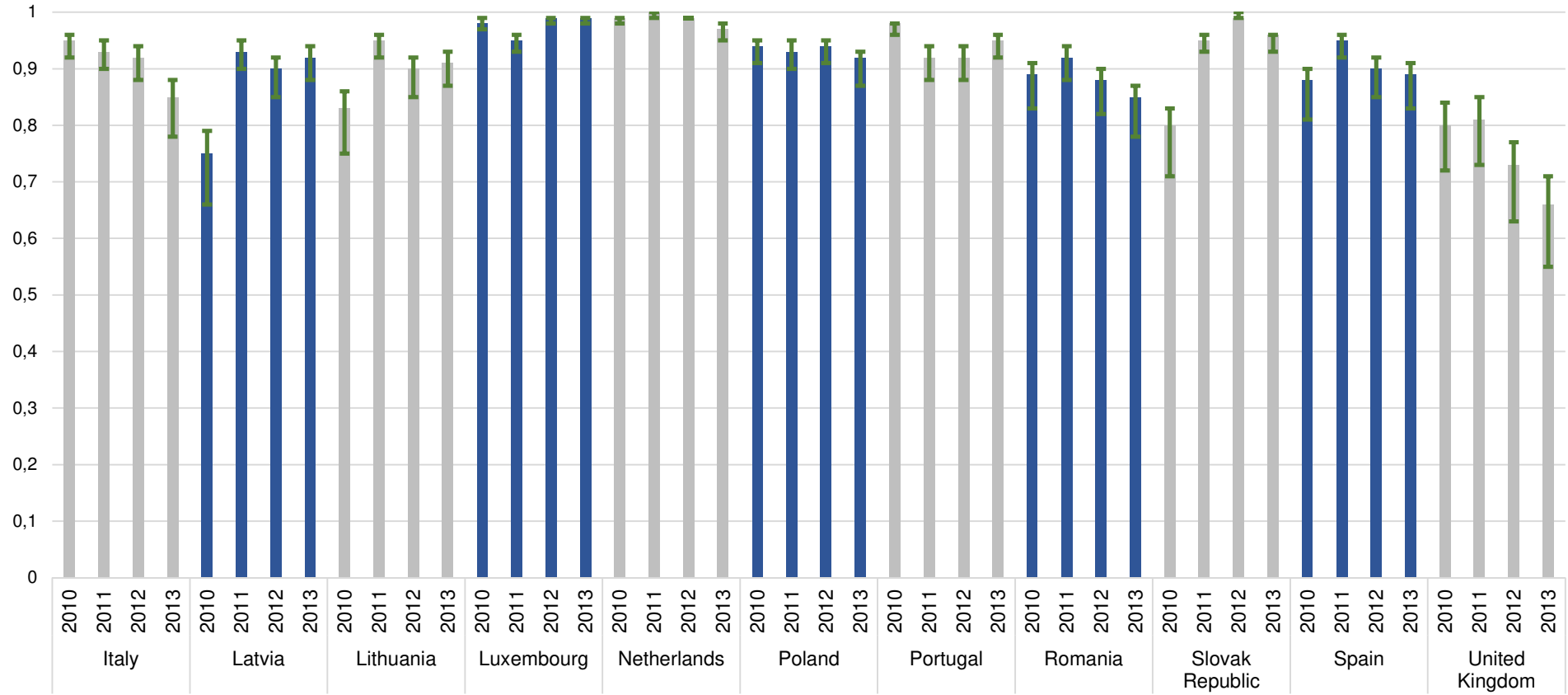

Figure 3: Downward nominal wage rigidity (continued)

Notes: See previous page.

4.3 Change in the rigidity of wage setting in 2010–2013 in the perception of firms

The WDN3 survey collected information from firms on whether it was easier or more difficult to adjust labour costs through various margins in 2013 than in 2010. One of the margins the survey asked firms to evaluate was the adjustment of wages. The answers to this question can be used to assess how firm managers perceive wage rigidity. We use this information mainly as a robustness check for the estimated trends in DNWR that were assessed on the basis of the incidence of wage cuts and freezes (equation (1)).

Figure 4 gives an overview of the perceived change in the ease of adjusting wages across the countries sampled. This figure displays the difference in percentage points between the shares of firm managers who believed that it became easier to adjust wages in 2013 than in 2010 and those who believed it became more difficult. The estimates presented in Figure 4 are mainly negative, implying that the share of firms finding it more difficult to adjust wages at the end of the reference period for the WDN3 survey was larger than the share of firms finding it easier. They are positive for only three countries, Spain, Cyprus and Greece.

For comparison, we display in Figure 4 the percentage changes from 2010 to 2013 in the estimated DNWR measures using equation (1). The Pearson correlation coefficient between the change in this measure of DNWR and the perceived change in wage rigidity in the opinion of managers across countries equals 0.71. Although firm managers on average tend to have more negative views on the ease of wage adjustment than is implied by the estimated DNWR measures, the two alternative evaluations of trends in wage rigidity are highly correlated across countries. This supports the validity of our estimates of DNWR using the measure proposed by Dickens et al. (2007).

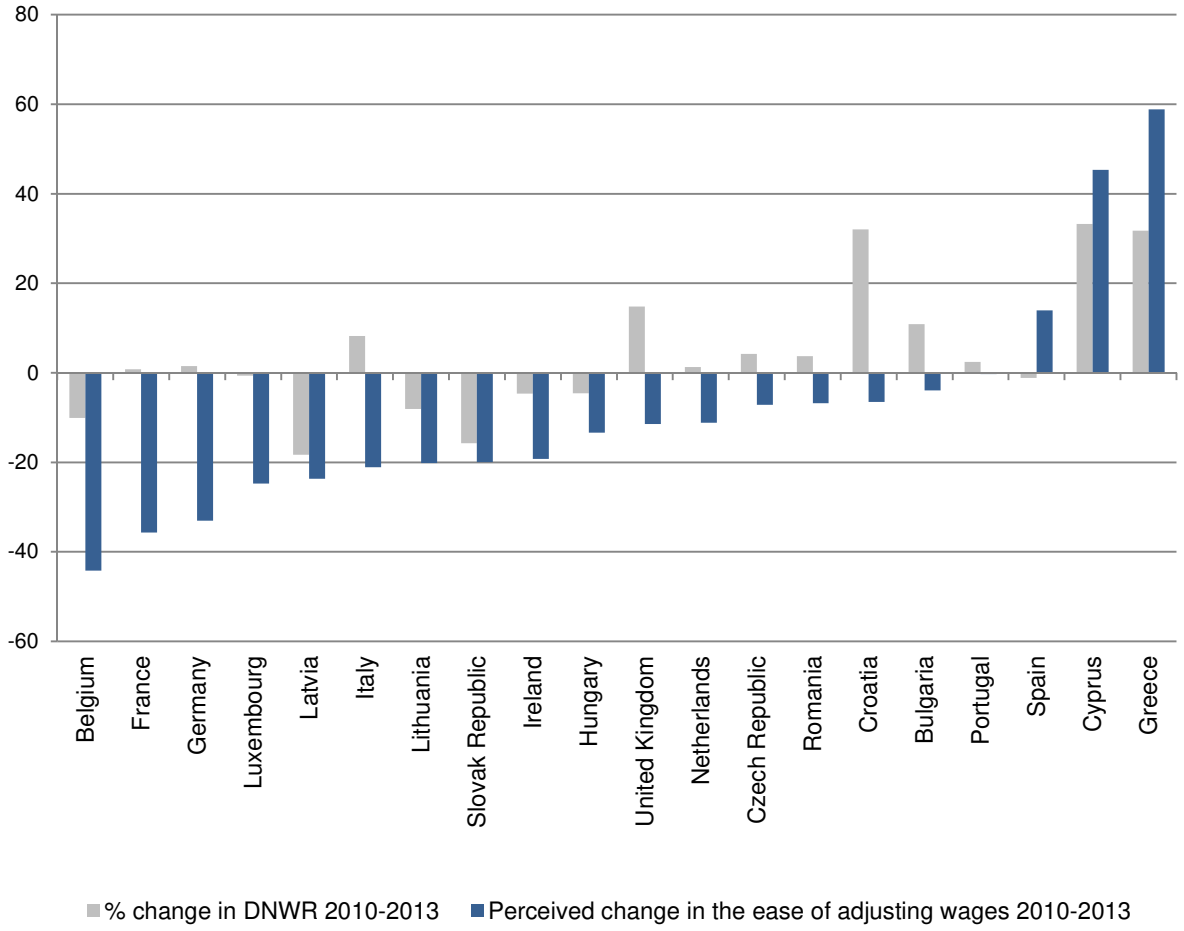

Figure 4: Perceived change in wage rigidity vs change in DNWR measured on the basis of wage cuts and freezes in 2010–2013

Notes: Perceived change in the ease of adjusting wages is measured as the percentage point difference between the shares of firm managers in whose opinion adjustment become easier and those who had the opposite opinion. The percentage change in DNWR is assessed using the measure based on equation (1).

5. Conclusion

This paper documents recent trends in nominal wage rigidity in a large group of EU countries, using survey data, the Wage Dynamics Network (WDN) surveys. We analyse two forms of nominal wage rigidity: downward nominal wage rigidity (DNWR) and the lagged response of wages to shocks. The lagged response is proxied by the frequency of wage changes.

The frequency of wage changes slowed down in the aftermath of the Great Recession. The prevalence of persisting DNWR together with the decline in average wage growth are among the possible reasons for this. Indeed, in countries where wage growth slowed down by more after the Great Recession, the frequency of wage changes declined more strongly. However, not only the level, but also the uncertainty, of nominal wage growth is positively related to wage change frequency. By using multivariate analysis we find that wages were changed more often in firms where managers perceived that the uncertainty of demand was higher. In

addition, wages were changed more often in larger firms, manufacturing enterprises, subsidiaries and companies with foreign owners.

Studies based on administrative data evaluate DNWR on the basis of asymmetries in the observed distributions of wage changes relative to the counterfactual distributions that would exist if wages were flexible. As our surveys do not contain information about wage changes, we could not assess the shape of the whole wage change distribution. The WDN data show that wage cuts are usually infrequent, which signals that DNWR is prevalent. However, the prevalence of DNWR cannot be assessed from wage cuts alone, as even in the absence of DNWR the share of cuts may be small, depending on the mean and variance of the distribution of wage changes. If the mean is sufficiently high and variance is low, the share of wage cuts may be negligible even with highly flexible wages.

Since the shape of the whole distribution of wage changes was not observable, we could only use information about nominal wage cuts and freezes. Therefore we applied a proxy measure of DNWR that is proposed by Dickens et al. (2007) and measures the share of wage freezes as a proportion of cuts plus freezes. We explain in the paper that this measure is likely to be upward biased relative to the actual share of wage cuts prevented by DNWR. We conduct simulations assuming that the counterfactual distribution of wage changes is a normal distribution, and estimate a range of adjusted DNWR values that correct for the bias. Our simulations indicate that the measure of DNWR proposed by Dickens et al. (2007) is a good approximation of the actual share of wage cuts prevented, since the upward biases tend to be small, especially at high levels of DNWR.

We use the range of DNWR measures that have been adjusted for the upward bias to assess the prevalence of DNWR before, during and after the Great Recession, i.e. during the reference periods of the WDN surveys. Since our study covers many countries and three distinct time periods, we are able to evaluate the prevalence of downward nominal wage rigidity in very diverse economic circumstances. Like earlier studies on this topic, we find that DNWR tends to be strongly prevalent even in periods of slow growth and low wage inflation. We show that it declines during severe recessions but even then wage setting is not completely flexible, as even then the proportion of observed wage cuts stays well below the level that would correspond to a flexible regime.

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Appendix 1: Tables

Table A1.1: Sample composition across the countries surveyed

	WDN1		WDN2		WDN3	
Country	Number of firms	Percentage	Number of firms	Percentage	Number of firms	Percentage
Austria	555	3.4%	339	5.9%	780	3.4%
Belgium	1431	8.7%	997	17.4%	989	4.3%
Bulgaria	-	-	-	-	420	1.8%
Cyprus	208	1.3%	208	3.6%	133	0.6%
Czech Republic	399	2.4%	241	4.2%	1011	4.4%
Germany	-	-	-	-	2193	9.4%
Estonia	366	2.2%	163	2.9%	489	2.1%
Spain	1834	11.1%	995	17.4%	1975	8.5%
France	2011	12.2%	818	14.3%	1156	5.0%
Greece	401	2.4%	-	-	402	1.7%
Croatia	-	-	-	-	301	1.3%
Hungary	2006	12.1%	-	-	2032	8.7%
Ireland	854	5.2%	-	-	886	3.8%
Italy	952	5.8%	676	11.8%	1098	4.7%
Lithuania	337	2.0%	-	-	515	2.2%
Luxembourg	456	2.8%	299	5.2%	530	2.3%
Latvia	-	-	-	-	557	2.4%
Malta	-	-	-	-	164	0.7%
Netherlands	1068	6.5%	670	11.7%	727	3.1%
Poland	908	5.5%	311	5.4%	1178	5.1%
Portugal	1331	8.1%	-	-	1167	5.0%
Romania	-	-	-	-	2043	8.8%
Slovenia	666	4.0%	-	-	1268	5.5%
Slovakia	745	4.5%	-	-	621	2.7%
United Kingdom	-	-	-	-	591	2.5%
Total	**16528**	**100.0%**	**5717**	**100.0%**	**23226**	**100.0%**

Table A1.2: Sample composition by sector

Sector	WDN1		WDN2		WDN3	
	Number of firms	Percentage	Number of firms	Percentage	Number of firms	Percentage
Manufacturing	6575	40%	2401	42.0%	7884	34%
Energy	219	1%	45	0.8%	239	1%
Construction	1337	8%	453	7.9%	2306	10%
Trade and transportation	3351	20%	1102	19.3%	5162	22%
Services	4614	28%	1548	27.1%	6947	30%
Financial intermediation	432	3%	168	2.9%	688	3%
Total	**16528**	**100%**	**5717**	**100%**	**23226**	**100%**

Table A1.3. Sample composition by size group

Size group	WDN1		WDN2		WDN3	
(Number of employees)	Number of firms	Percentage	Number of firms	Percentage	Number of firms	Percentage
5–19	4365	26%	1565	27.4%	6844	29%
20–49	3847	23%	1310	22.9%	5705	25%
50–199	4964	30%	1647	28.8%	5904	25%
More than 200	3352	20%	1195	20.9%	4773	21%
Total	**16528**	**100%**	**5717**	**100%**	**23226**	**100%**

Table A2: The frequency of wage changes by country

	WDN1				WDN3			
Country	More frequently than once a year (%)	Once a year (%)	Less frequently than once a year (%)	Never/not applicable (%)	More frequently than once a year (%)	Once a year (%)	Less frequently than once a year (%)	Never/not applicable (%)
Austria	6.9	84.2	5.8	3.0	2.6	82.6	12.2	2.6
Belgium	22.2	64.7	9.7	3.4	19.8	40.1	31.4	8.8
Bulgaria	-	-	-	-	1.1	33.1	51.5	14.3
Czech Republic	11.5	64.1	23	1.4	1.3	28.6	53.9	16.2
Croatia	-	-	-	-	3	35.4	42.1	19.5
Cyprus	-	-	-	-	0.7	35.2	38.5	25.6
Estonia	19.9	64.4	10.5	5.2	3	39.7	50.4	6.9
France	19.7	74.1	5.2	1.1	9.2	65.4	22.8	2.5
Germany	-	-	-	-	2.6	38.5	54.8	4
Greece	-	-	-	-	2.1	16.8	46.7	34.5
Hungary	2.7	75.4	11.9	10.0	1.4	43.6	47.2	7.8
Ireland	14.5	71.4	9.8	4.3	0.9	18.1	38.3	42.7
Italy	4.2	26.9	64.6	4.3	2.9	24.6	59.8	12.7
Latvia	-	-	-	-	5.3	31.2	53.3	10.2
Lithuania	42.6	43.8	7.4	6.3	9.8	19.9	46.6	23.6
Luxembourg	7	93	-	-	21	46.2	24.3	8.4
Malta	-	-	-	-	7.3	92.7	0	0
Netherlands	11.1	69.9	16.9	2.1	8.2	51.4	30.4	10
Poland	13.5	56.8	27.9	1.8	1.5	42.4	46.9	9.1
Portugal	5.8	82.3	8.4	3.5	0.7	27.2	38	34.1
Romania	-	-	-	-	12.9	33.5	40.3	13.3
Slovak Republic	7.5	69.8	20.5	2.2	3	46.3	39.5	11.2
Slovenia	27.4	65.5	5.8	1.3	3.7	23.8	48.7	23.8
Spain	12.1	84.0	2.5	1.4	2.7	46.7	24.9	25.7
United Kingdom	-	-	-	-	0.8	71.1	25.4	2.7
Total (WDN3)	-	-	-	-	4	48	39.4	8.6
Total (WDN1)	11.6	59.8	25.7	2.9	5.3	45.9	37.1	11.6

Notes: The table presents the employment-weighted percentages of firms changing wages at different frequencies. Total (WDN1) refers to the averages across countries that participated in the WDN1 survey. Results for Luxembourg are not included in the WDN1 aggregate.

Table A3: Year-on-year changes (%) in average annual wages, current prices in national currency units

	2002	2003	2004	2005	2006	**Average, over 2002–2006**	2007	2008	2009	**Average, over 2007–2009**	2010	2011	2012	2013	**Average, over 2010–2013**
Austria	2.6	1.8	3.7	3.0	3.5	**2.9**	3.0	3.9	2.1	**3.0**	1.3	2.0	3.0	2.2	**2.1**
Belgium	3.1	2.0	1.9	2.1	3.5	**2.5**	2.4	3.5	0.4	**2.1**	1.1	3.9	2.8	1.8	**2.4**
Bulgaria															
Croatia															
Cyprus															
Czech Republic	9.1	7.7	8.2	4.1	5.8	**7.0**	6.0	4.8	0.6	**3.8**	2.8	2.6	2.1	–0.3	**1.8**
Estonia	8.7	12.0	11.4	11.2	13.8	**11.4**	24.5	9.2	–3.9	**9.9**	3.0	0.8	6.4	5.0	**3.8**
France	3.6	2.6	3.8	3.0	3.3	**3.3**	2.5	2.5	1.6	**2.2**	3.1	1.6	2.1	1.3	**2.0**
Germany	1.8	1.7	1.0	1.4	1.1	**1.4**	1.5	2.3	0.0	**1.3**	2.4	3.8	2.7	2.3	**2.8**
Greece	11.5	7.0	5.2	2.6	4.5	**6.2**	3.7	2.7	5.7	**4.0**	–3.3	–4.4	–4.1	–7.7	**–4.9**
Hungary	11.5	13.8	10.4	7.3	5.3	**9.7**	5.3	6.9	0.4	**4.2**	3.0	3.4	2.9	2.0	**2.8**
Ireland	5.4	7.0	5.1	5.6	3.9	**5.4**	5.8	4.5	0.7	**3.7**	–3.9	1.1	0.0	–1.6	**–1.1**
Italy	2.2	2.8	4.5	3.3	3.3	**3.2**	2.2	3.2	0.1	**1.8**	2.4	1.3	–0.4	1.4	**1.2**
Latvia	2.1	12.9	16.0	27.5	21.4	**16.0**	37.7	17.1	–13.0	**13.9**	–6.3	2.3	7.5	5.1	**2.2**
Lithuania															
Luxembourg	3.5	1.6	3.5	3.6	4.0	**3.2**	4.9	2.6	2.2	**3.2**	2.2	1.5	1.1	3.4	**2.1**
Malta															
Netherlands	3.8	3.0	3.1	1.8	2.6	**2.9**	3.5	2.8	2.8	**3.0**	1.6	1.5	1.7	2.4	**1.8**
Poland	2.9	1.8	1.5	1.8	2.3	**2.0**	4.8	10.1	2.5	**5.8**	6.7	4.9	2.4	1.5	**3.9**
Portugal	3.4	3.3	2.5	3.2	1.3	**2.8**	4.1	2.5	2.6	**3.1**	1.4	–0.8	–2.6	2.9	**0.2**
Romania															
Slovak Republic	8.3	8.9	9.0	9.4	8.3	**8.8**	8.9	5.5	3.4	**6.0**	5.4	2.9	2.3	2.1	**3.2**
Slovenia	7.5	7.4	7.9	6.2	5.7	**6.9**	6.4	7.2	1.8	**5.1**	4.5	1.5	–1.5	0.6	**1.3**
Spain	3.5	2.9	2.6	4.0	3.2	**3.2**	4.7	7.7	5.8	**6.1**	0.2	1.0	–0.8	1.9	**0.6**
United Kingdom	2.3	3.8	4.0	1.9	5.2	**3.4**	4.9	1.2	2.6	**2.9**	1.9	1.1	1.4	0.9	**1.3**
Average	**5.1**	**5.5**	**5.5**	**5.4**	**5.4**	**5.4**	**7.2**	**5.3**	**1.0**	**4.5**	**1.6**	**1.7**	**1.5**	**1.4**	**1.6**

Source: OECD (data extracted on 30th March 2017), authors' calculations.

Table A4.1: Wage change frequency vs firm characteristics, idiosyncratic shocks and institutional environment, results based on the WDN3 survey (reference period 2010–2013)

	Ordered probit estimates Dependent variable: frequency of base wage changes		Probit average marginal effects Dependent variable: frequency of base wage changes is at least once a year	
	(1)	(2)	(3)	(4)
Sector (reference group: manufacturing)				
Electricity, gas, water	0.0406	0.0445	0.0454	0.0437
	(0.112)	(0.102)	(0.0393)	(0.0367)
Construction	–0.0420	–0.0153	–0.0322**	–0.0253*
	(0.0353)	(0.0336)	(0.0143)	(0.0133)
Trade	–0.127***	–0.108***	–0.0402***	–0.0374***
	(0.0266)	(0.0255)	(0.0112)	(0.0107)
Business services	–0.189***	–0.172***	–0.0685***	–0.0668***
	(0.0254)	(0.0242)	(0.0105)	(0.00998)
Financial intermediation	–0.0935	–0.0587	–0.0374	–0.0282
	(0.0596)	(0.0576)	(0.0256)	(0.0244)
Size (reference group: number of employees 5–19)				
Number of employees 20–49	0.0549**	0.0664**	0.0118	0.0149
	(0.0272)	(0.0266)	(0.0114)	(0.0110)
Number of employees 50–199	0.0953***	0.112***	0.0286**	0.0317***
	(0.0281)	(0.0273)	(0.0121)	(0.0115)
Number of employees more than 200	0.152***	0.184***	0.0576***	0.0713***
	(0.0335)	(0.0318)	(0.0145)	(0.0137)
Ownership status and autonomy of the company				
Ownership status is mainly foreign	0.194***	0.199***	0.0982***	0.102***
	(0.0268)	(0.0250)	(0.0119)	(0.0111)
Company is a subsidiary/affiliate	0.0751***	0.0653***	0.0569***	0.0515***
	(0.0268)	(0.0248)	(0.0120)	(0.0111)
Occupational group (reference group: low skilled manual employees)				
Share of high skilled non-manual employees	–0.0137	–0.00931	–0.000391	–0.00407
	(0.0428)	(0.0418)	(0.0181)	(0.0174)
Share of low skilled non-manual employees	–0.113**	–0.124***	–0.0356*	–0.0453**
	(0.0481)	(0.0463)	(0.0200)	(0.0191)
Share of high skilled manual employees	0.0146	0.0262	–0.00197	0.00248
	(0.0385)	(0.0373)	(0.0159)	(0.0152)
Demand shock (reference: no change in demand)				
Strong decline in demand	–0.128***	–0.140***	–0.0239*	–0.0290**
	(0.0340)	(0.0325)	(0.0139)	(0.0131)
Moderate decline in demand	–0.00308	–0.0217	0.00495	–0.00288
	(0.0258)	(0.0248)	(0.0110)	(0.0104)
Moderate increase in demand	0.183***	0.161***	0.0681***	0.0598***
	(0.0262)	(0.0249)	(0.0114)	(0.0108)
Strong increase in demand	0.203***	0.186***	0.0810***	0.0820***
	(0.0435)	(0.0414)	(0.0204)	(0.0192)
Credit availability shock (reference: no change in access to credit)				
Strong decline in access to credit	–0.130***	–0.157***	–0.0453***	–0.0504***
	(0.0364)	(0.0348)	(0.0141)	(0.0134)
Moderate decline in access to credit	–0.0486*	–0.0559**	–0.0241**	–0.0272***
	(0.0265)	(0.0253)	(0.0111)	(0.0105)
Moderate increase in access to credit	0.0349	0.0420	0.00611	0.00839
	(0.0303)	(0.0289)	(0.0133)	(0.0126)
Strong increase in access to credit	0.0690	0.0878	0.0104	0.0110
	(0.0764)	(0.0667)	(0.0330)	(0.0301)

Variables describing labour market institutions				
Company's share of employees covered by collective agreement		0.121***		0.0409***
		(0.0251)		(0.0106)
Collective agreement signed at the firm level	0.0728***		0.0264***	
	(0.0235)		(0.00995)	
Collective agreement signed outside the firm	0.0784***		0.0339***	
	(0.0270)		(0.0110)	
Relevance of firing costs	–0.00870	–0.00398	–0.00835**	–0.00650*
	(0.00977)	(0.00924)	(0.00406)	(0.00382)
Other characteristics of the company				
Company's share of employees with tenure of more than 5 years	–0.127***	–0.137***	–0.0534***	–0.0525***
	(0.0336)	(0.0328)	(0.0137)	(0.0133)
Share of labour costs in firm's total costs	0.168***	0.156***	0.0777***	0.0661***
	(0.0470)	(0.0449)	(0.0190)	(0.0180)
Share of performance related bonuses in company's total wage bill	0.0453	0.0991	0.0229	0.0412
	(0.0871)	(0.0854)	(0.0348)	(0.0336)
Observations	15,141	16,635	14,990	16,484

Notes: Robust standard errors in parentheses, significance levels *** p<0.01, ** p<0.05, * p<0.1. Regressions include country dummies. The probit regressions do not include observations for Malta since due to wage indexation no firms changed wages with less than yearly frequency in this country.

Table A4.2: Wage change frequency vs firm characteristics and institutional environment, results based on the WDN1 survey (reference period: before 2007)

	Ordered probit estimates Dependent variable: frequency of changes of base wage		Probit average marginal effects Dependent variable: frequency of changes of base wage is at least once a year	
	(1)	(2)	(3)	(4)
Sector (reference group: manufacturing)				
Sector=Electricity, gas, water	0.141	0.130	0.0473	0.0478
	(0.0902)	(0.0852)	(0.0319)	(0.0317)
Sector=Construction	0.235***	0.237***	0.00936	0.00970
	(0.0523)	(0.0483)	(0.0124)	(0.0114)
Sector=Trade	–0.0626*	–0.0710**	–0.0171*	–0.0149*
	(0.0319)	(0.0296)	(0.00925)	(0.00864)
Sector=Business services	–0.101***	–0.0978***	–0.0195**	–0.0182**
	(0.0272)	(0.0257)	(0.00815)	(0.00784)
Sector=Financial intermediation	–0.0473	–0.0790	–0.0122	–0.0182
	(0.0630)	(0.0588)	(0.0220)	(0.0214)
Size (reference group: number of employees 5–19)				
Number of employees 20–49	0.0371	0.0563*	0.0196**	0.0254***
	(0.0340)	(0.0312)	(0.00865)	(0.00786)
Number of employees 50–199	0.118***	0.107***	0.0334***	0.0331***
	(0.0332)	(0.0306)	(0.00855)	(0.00800)
Number of employees more than 200	0.263***	0.212***	0.0665***	0.0591***
	(0.0355)	(0.0337)	(0.00904)	(0.00894)
Occupational group (reference group: low skilled blue collar employees)				
Share of high skilled blue collar employees	0.0220	0.0259	0.00684	0.00721
	(0.0445)	(0.0421)	(0.0128)	(0.0122)
Share of low skilled white collar employees	–0.0622	–0.109**	0.0322*	0.0208
	(0.0586)	(0.0550)	(0.0171)	(0.0157)
Share of high skilled white collar employees	–0.107**	–0.0965**	–0.0162	–0.00895
	(0.0534)	(0.0488)	(0.0146)	(0.0137)
Variables describing labour market institutions				
Firm's share of employees covered by collective agreement	–0.0704**		–0.0163*	
	(0.0319)		(0.00895)	
Collective agreement signed at the firm level		0.0927***		0.0280***
		(0.0278)		(0.00768)
Collective agreement signed outside the firm		–0.0459		–0.0164
		(0.0330)		(0.0110)
Change in revenue				
Company's revenue in the reference period, compared to the previous year	0.0498***	0.0519***	0.0154***	0.0154***
	(0.0114)	(0.0106)	(0.00312)	(0.00296)
Time-dependent wage setting				
Base wage changes are concentrated in a particular month/months	0.421***	0.421***	0.179***	0.177***
	(0.0265)	(0.0241)	(0.00791)	(0.00729)
Observations	12,312	13,878	11,904	13,460

Notes: Robust standard errors in parentheses, significance levels *** p<0.01, ** p<0.05, * p<0.1. Regressions include country dummies. Regressions do not include observations for Slovakia since occupational groups were missing in the Slovakian national survey. Probit regressions do not include observations for Luxembourg since due to wage indexation no firms changed wages with less than yearly frequency in this country. Regressions including collective bargaining coverage at the firm level as a control variable do not cover Slovenia since this variable was missing in the Slovenian national survey.

Table A5: Probit regressions, average marginal effects with robust standard errors, WDN1 survey. Dependent variable: dummy for time-dependent wage setting (i.e. base wage changes are concentrated in a particular month/months)

	(1)	(2)	(3)	(4)
Sector (reference group: manufacturing)				
Sector=Electricity, gas, water	0.0842**	0.0717**	0.112***	0.116***
	(0.0375)	(0.0357)	(0.0394)	(0.0368)
Sector=Construction	0.0102	0.0132	0.0224	0.0105
	(0.0179)	(0.0169)	(0.0187)	(0.0182)
Sector=Trade	–0.00602	0.00202	–0.0199	–0.0134
	(0.0122)	(0.0117)	(0.0130)	(0.0127)
Sector=Business services	–0.0116	–0.00994	0.0242**	0.0249**
	(0.0105)	(0.0102)	(0.0113)	(0.0110)
Sector=Financial intermediation	0.102***	0.0884***	0.122***	0.109***
	(0.0277)	(0.0267)	(0.0284)	(0.0285)
Size (reference group: number of employees 5–19)				
Number of employees 20–49	0.0593***	0.0630***	0.0586***	0.0803***
	(0.0113)	(0.0107)	(0.0121)	(0.0113)
Number of employees 50–199	0.112***	0.116***	0.137***	0.172***
	(0.0109)	(0.0105)	(0.0113)	(0.0105)
Number of employees more than 200	0.147***	0.154***	0.178***	0.224***
	(0.0119)	(0.0118)	(0.0120)	(0.0112)
Occupational group (reference group: low skilled blue collar employees)				
Share of high skilled blue collar employees	0.0414**	0.0455***	0.0283*	0.0664***
	(0.0163)	(0.0159)	(0.0166)	(0.0162)
Share of low skilled white collar employees	0.0961***	0.0895***	0.0205	0.0333
	(0.0232)	(0.0223)	(0.0254)	(0.0246)
Share of high skilled white collar employees	0.135***	0.129***	0.0311	0.0488**
	(0.0207)	(0.0197)	(0.0206)	(0.0200)
Variables describing labour market institutions				
Company's share of employees covered by collective agreement	–2.51e–05		0.0718***	
	(0.0116)		(0.00905)	
Collective agreement signed at the firm level		–0.00577		–0.0411***
		(0.0103)		(0.0106)
Collective agreement signed outside the firm		–0.0517***		0.0533***
		(0.0136)		(0.00877)
Other characteristics of the company				
Sales revenue from foreign markets	0.0474***	0.0495***	0.0113	–0.00228
	(0.0146)	(0.0139)	(0.0157)	(0.0151)
Timing of wage changes is related to the timing of price changes	0.0260***	0.0292***	–0.0255***	–0.0108
	(0.00839)	(0.00813)	(0.00917)	(0.00889)
The company has a policy that adapts changes in base wages to inflation	0.146***	0.143***	0.159***	0.142***
	(0.00895)	(0.00859)	(0.00888)	(0.00858)
Country dummies	Yes	Yes	No	No
Observations	11,326	12,441	11,326	12,441

Notes: Robust standard errors in parentheses, significance levels *** p<0.01, ** p<0.05, * p<0.1.

Table A6: Ordered probit estimates, WDN3 survey. Dependent variable: perceived changes in volatility/uncertainty of demand during 2010–2013

Explanatory variable	Coefficient
Sector (reference group: manufacturing)	
Sector=Electricity, gas, water	–0.0306
	(0.0552)
Sector=Construction	–0.266***
	(0.0300)
Sector=Trade	–0.0910***
	(0.0212)
Sector=Business services	–0.0373**
	(0.0189)
Sector=Financial intermediation	–0.120***
	(0.0451)
Size (reference group: number of employees 5–19)	
Number of employees 20–49	0.0839***
	(0.0228)
Number of employees 50–199	0.164***
	(0.0232)
Number of employees more than 200	0.206***
	(0.0262)
Ownership status and autonomy of the company	
Ownership status is mainly foreign	0.0719***
	(0.0206)
Company is a subsidiary/affiliate	0.0634***
	(0.0208)
Observations	20,266

Notes: Robust standard errors in parentheses, significance levels *** p<0.01, ** p<0.05, * p<0.1. Regressions include country dummies. The dependent variable has the following values: (1) strong decrease; (2) moderate decrease; (3) unchanged; (4) moderate increase; (5) strong increase.

Table A7: Wage change frequency vs perceived volatility/uncertainty of demand, WDN3 survey

	Ordered probit estimates Dependent variable: frequency of changes of base wage		Probit average marginal effects Dependent variable: frequency of changes of base wage is at least once a year	
	(1)	(2)	(1)	(2)
Sector (reference group: manufacturing)				
Sector=Electricity, gas, water	–0.00410	–0.00278	0.0304	0.0290
	(0.111)	(0.102)	(0.0389)	(0.0365)
Sector=Construction	–0.0653*	–0.0382	–0.0402***	–0.0334**
	(0.0352)	(0.0334)	(0.0143)	(0.0132)
Sector=Trade	–0.143***	–0.125***	–0.0451***	–0.0429***
	(0.0266)	(0.0255)	(0.0112)	(0.0107)
Sector=Business services	–0.201***	–0.183***	–0.0733***	–0.0710***
	(0.0253)	(0.0241)	(0.0105)	(0.00996)
Sector=Financial intermediation	–0.105*	–0.0732	–0.0411	–0.0330
	(0.0594)	(0.0574)	(0.0255)	(0.0244)
Size (reference group: number of employees 5–19)				
Number of employees 20–49	0.0675**	0.0785***	0.0160	0.0190*
	(0.0272)	(0.0265)	(0.0115)	(0.0110)
Number of employees 50–199	0.104***	0.121***	0.0323***	0.0355***
	(0.0280)	(0.0273)	(0.0121)	(0.0115)
Number of employees more than 200	0.161***	0.196***	0.0603***	0.0751***
	(0.0335)	(0.0318)	(0.0145)	(0.0137)
Ownership status and autonomy of the company				
Ownership status is mainly foreign	0.201***	0.205***	0.101***	0.104***
	(0.0268)	(0.0250)	(0.0119)	(0.0112)
Company is a subsidiary/affiliate	0.0750***	0.0661***	0.0574***	0.0523***
	(0.0267)	(0.0247)	(0.0120)	(0.0111)
Occupational groups (reference group: low skilled manual employees)				
Share of high skilled non-manual employees	–0.00901	–0.00137	0.00309	–5.57e–06
	(0.0428)	(0.0418)	(0.0181)	(0.0174)
Share of low skilled non-manual employees	–0.118**	–0.127***	–0.0370*	–0.0454**
	(0.0481)	(0.0463)	(0.0201)	(0.0192)
Share of high skilled manual employees	0.00941	0.0235	–0.00270	0.00239
	(0.0386)	(0.0374)	(0.0160)	(0.0152)
Credit availability shock (reference group: no change)				
Strong decline in access to credit	–0.155***	–0.180***	–0.0548***	–0.0589***
	(0.0365)	(0.0349)	(0.0142)	(0.0135)
Moderate decline in access to credit	–0.0575**	–0.0669***	–0.0269**	–0.0310***
	(0.0266)	(0.0254)	(0.0111)	(0.0106)
Moderate increase in access to credit	0.0861***	0.0941***	0.0246*	0.0276**
	(0.0300)	(0.0286)	(0.0133)	(0.0126)
Strong increase in access to credit	0.153**	0.171***	0.0393	0.0436
	(0.0740)	(0.0646)	(0.0328)	(0.0299)
Demand volatility shock (reference: no change)				
Strong decrease in the volatility/uncertainty of demand	–0.140***	–0.145***	–0.0259*	–0.0296**
	(0.0382)	(0.0356)	(0.0151)	(0.0142)
Moderate decrease in the volatility/uncertainty of demand	–0.0727***	–0.0742***	–0.0227**	–0.0246***
	(0.0232)	(0.0221)	(0.00985)	(0.00932)
Moderate increase in the volatility/uncertainty of demand	0.0300	0.00649	0.0113	0.00215
	(0.0248)	(0.0238)	(0.0109)	(0.0104)
Strong increase in the volatility/uncertainty of demand	–0.0468	–0.0752*	–0.00571	–0.0138
	(0.0473)	(0.0457)	(0.0201)	(0.0188)

Variables describing labour market institutions				
Company's share of employees covered by collective agreement		0.120***		0.0415***
		(0.0252)		(0.0106)
Collective agreement signed at the firm level	0.0732***		0.0273***	
	(0.0235)		(0.00997)	
Collective agreement signed outside the firm	0.0742***		0.0326***	
	(0.0269)		(0.0110)	
Relevance of firing costs for hiring	–0.00892	–0.00485	–0.00845**	–0.00687*
	(0.00977)	(0.00926)	(0.00407)	(0.00384)
Other characteristics of the company				
Company's share of employees with tenure of more than 5 years	–0.163***	–0.175***	–0.0656***	–0.0660***
	(0.0333)	(0.0325)	(0.0136)	(0.0132)
Share of labour costs in firm's total costs	0.156***	0.141***	0.0733***	0.0610***
	(0.0470)	(0.0449)	(0.0190)	(0.0180)
Share of performance related bonuses and benefits in company's total wage bill	0.0766	0.134	0.0331	0.0523
	(0.0868)	(0.0852)	(0.0347)	(0.0335)
Observations	15,110	16,598	14,959	16,447

Notes: Robust standard errors in parentheses, significance levels *** p<0.01, ** p<0.05, * p<0.1. Regressions include country dummies.

Table A8.1: Estimated level of downward nominal wage rigidity, based on the assumption that 100% of observed wage freezes represent prevented cuts (the formula of Dickens et al. (2007))

	Downward nominal wage rigidity					
	WDN1 (2002–2006)	WDN2 (2008–2009)	WDN3			
			2010	2011	2012	2013
Belgium	0.90	0.98	0.90	1.00	1.00	0.99
Bulgaria	-	-	0.96	0.92	0.90	0.85
Croatia	-	-	0.67	0.56	0.53	0.46
Cyprus	-	-	0.98	0.95	0.87	0.66
Czech Republic	0.89	0.93	0.89	0.90	0.90	0.86
Estonia	0.97	0.65	0.61	0.79	0.79	0.89
France	0.82	0.98	1.00	0.99	1.00	0.99
Germany	-	-	0.89	0.89	0.85	0.88
Greece	-	-	0.84	0.69	0.46	0.57
Hungary	0.92	-	0.92	0.93	0.91	0.96
Ireland	0.94	-	0.84	0.89	0.90	0.88
Italy	0.88	0.96	0.96	0.95	0.94	0.88
Latvia	-	-	0.79	0.95	0.92	0.94
Lithuania	0.81	-	0.86	0.96	0.92	0.93
Luxembourg	0.87	1.00	0.99	0.96	0.99	0.99
Netherlands	0.99	0.91	0.99	1.00	0.99	0.98
Poland	0.74	0.87	0.95	0.95	0.95	0.93
Portugal	0.98	-	0.98	0.94	0.94	0.96
Romania	-	-	0.91	0.94	0.90	0.87
Slovak Republic	-	-	0.83	0.96	1.00	0.96
Spain	0.99	0.94	0.90	0.96	0.92	0.91
United Kingdom	-	-	0.84	0.85	0.77	0.71
Total, all countries	0.86	0.95	0.88	0.89	0.87	0.86
Total (WDN1)	-	-	0.94	0.96	0.95	0.94

Notes: The estimated values show the share of wage cuts prevented by DNWR. Figures are employment-weighted. Three countries participating in the WDN3 survey – Malta, Slovenia and Austria – are not covered because the data on the share of employees affected by wage cuts and freezes were missing (Slovenia, Malta) or because there were not enough observations for assessing the share of cuts and freezes (Austria).

Table A8.2: Estimated level of DNWR, based on the assumption that 80% of observed wage freezes represent prevented cuts

	WDN1 (2002–2006)	WDN2 (2008–2009)	WDN3			
			2010	2011	2012	2013
Belgium	0.87	0.98	0.87	1.00	1.00	0.98
Bulgaria	-	-	0.95	0.90	0.88	0.82
Croatia	-	-	0.62	0.51	0.47	0.40
Cyprus	-	-	0.98	0.93	0.85	0.60
Czech Republic	0.87	0.92	0.87	0.87	0.87	0.83
Estonia	0.97	0.60	0.56	0.75	0.75	0.87
France	0.78	0.98	1.00	0.99	1.00	0.99
Germany	-	-	0.87	0.87	0.82	0.85
Greece	-	-	0.81	0.64	0.40	0.52
Hungary	0.90	-	0.90	0.91	0.89	0.95
Ireland	0.93	-	0.81	0.87	0.88	0.86
Italy	0.86	0.95	0.95	0.93	0.92	0.85
Latvia	-	-	0.75	0.93	0.90	0.92
Lithuania	0.77	-	0.83	0.95	0.90	0.91
Luxembourg	0.85	1.00	0.98	0.95	0.99	0.99
Netherlands	0.98	0.89	0.99	1.00	0.99	0.97
Poland	0.70	0.85	0.94	0.93	0.94	0.92
Portugal	0.97	-	0.98	0.92	0.92	0.95
Romania	-	-	0.89	0.92	0.88	0.85
Slovak Republic	-	-	0.80	0.95	0.99	0.96
Spain	0.99	0.92	0.88	0.95	0.90	0.89
United Kingdom	-	-	0.80	0.81	0.73	0.66
Total, all countries	0.83	0.94	0.85	0.87	0.84	0.83
Total (WDN1)	-	-	0.92	0.95	0.94	0.93

Notes: See notes for Table A8.1.

Table A8.3: Estimated level of DNWR, based on the assumption that 50% of observed wage freezes represent prevented cuts

	WDN1	WDN2	WDN3			
	(2002–2006)	(2008–2009)	2010	2011	2012	2013
Belgium	0.81	0.96	0.81	1.00	1.00	0.97
Bulgaria	-	-	0.92	0.85	0.82	0.75
Croatia	-	-	0.51	0.39	0.36	0.30
Cyprus	-	-	0.97	0.90	0.77	0.49
Czech Republic	0.81	0.88	0.81	0.81	0.81	0.75
Estonia	0.95	0.48	0.44	0.65	0.65	0.81
France	0.69	0.97	1.00	0.99	0.99	0.98
Germany	-	-	0.81	0.80	0.74	0.78
Greece	-	-	0.72	0.52	0.30	0.40
Hungary	0.85	-	0.85	0.86	0.84	0.93
Ireland	0.89	-	0.73	0.81	0.82	0.79
Italy	0.79	0.93	0.92	0.90	0.88	0.78
Latvia	-	-	0.66	0.90	0.85	0.88
Lithuania	0.68	-	0.75	0.92	0.85	0.87
Luxembourg	0.77	1.00	0.97	0.93	0.98	0.98
Netherlands	0.97	0.83	0.98	0.99	0.99	0.95
Poland	0.59	0.78	0.91	0.90	0.91	0.87
Portugal	0.96	-	0.96	0.88	0.88	0.92
Romania	-	-	0.83	0.88	0.82	0.78
Slovak Republic	-	-	0.71	0.93	0.99	0.93
Spain	0.98	0.88	0.81	0.92	0.85	0.83
United Kingdom	-	-	0.72	0.73	0.63	0.55
Total, all countries	0.75	0.90	0.78	0.81	0.77	0.76
Total (WDN1)	-	-	0.88	0.92	0.90	0.89

Notes: See notes for Table A8.1.

Appendix 2: Figures

The extent of the bias in the share of prevented wage cuts when DNWR is estimated using equation (1)

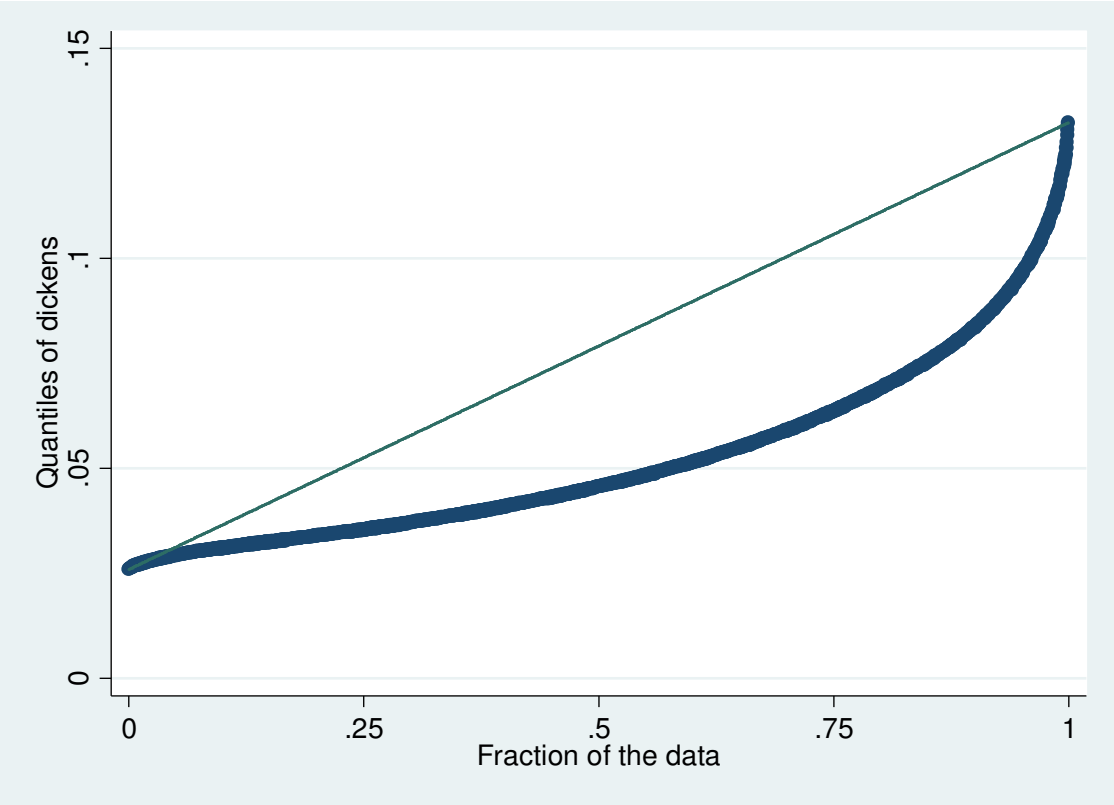

Figure A1: The range of the bias under the following assumptions: 100% of wage cuts are prevented, mean of the % wage change distribution $\mu \in (0, 10\%)$ and standard deviation $\sigma \in (10\%, 30\%)$.

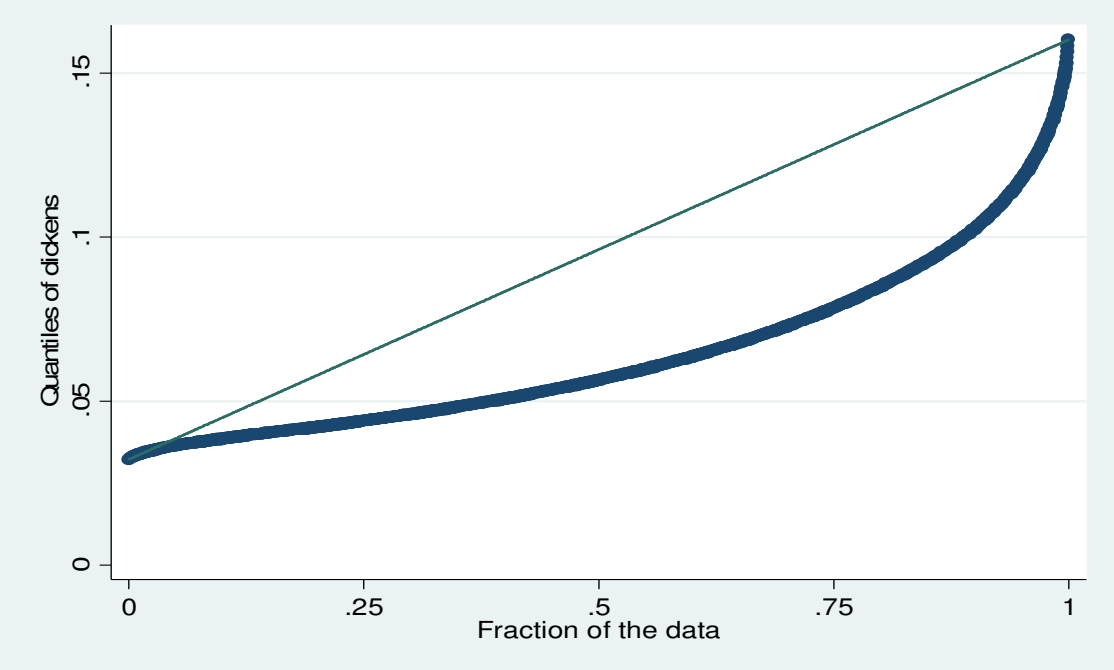

Figure A2: The range of the bias under the following assumptions: 80% of wage cuts are prevented, mean of the % wage change distribution μ∈(0, 5%) and standard deviation σ∈(10%, 30%)

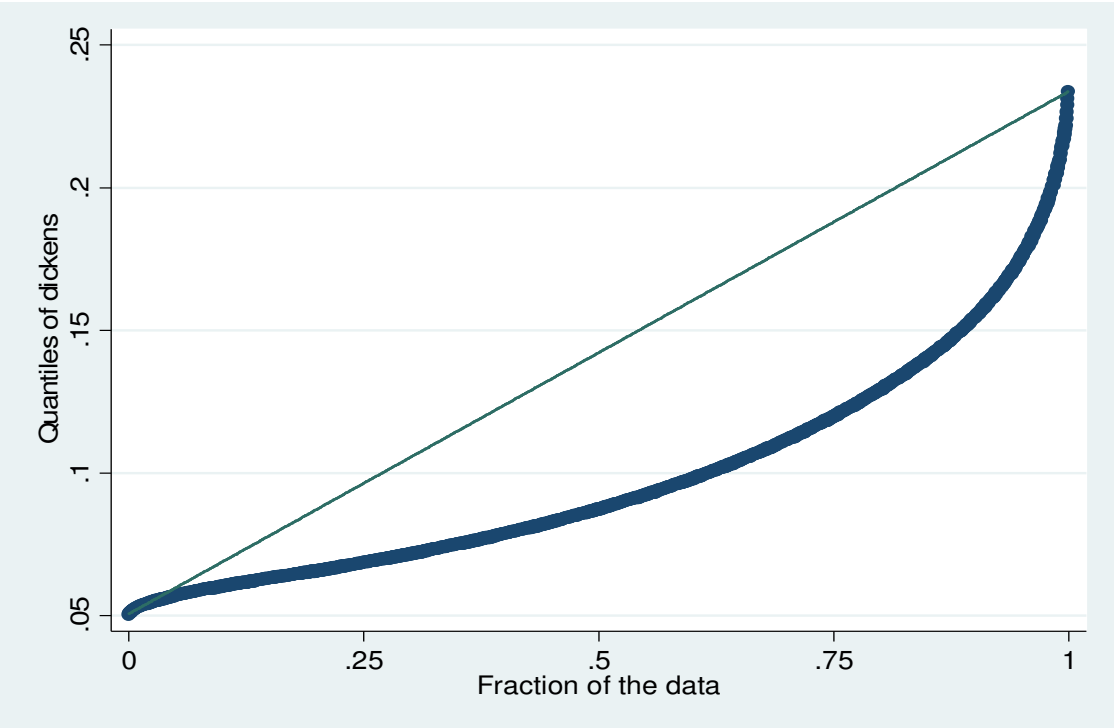

Figure A3: The range of the bias under the following assumptions: 50% of wage cuts are prevented, mean of the % wage change distribution μ∈(0, 5%) and standard deviation σ∈(10%, 30%)

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No 1
Sang-Wook (Stanley), Cho Julián P. Daz. Skill premium divergence: the roles of trade, capital and demographics

No 2
Wenjuan Chen, Aleksei Netšunajev. Structural vector autoregression with time varying transition probabilities: identifying uncertainty shocks via changes in volatility