The University of Nottingham

research paper series

Globalisation and Labour Markets

Research Paper 2015/09

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by

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Acknowledgements
The opinions expressed in this paper are those of the authors, and do not necessarily reflect the views of the ECB, the Deutsche Bundesbank or the Eurosystem. All errors are our responsibility. We thank Máté Tóth, Simon Savsek, Arno Hantzsche, as well as fellow authors of ECB Occasional Papers numbers 138 and 159, for very helpful comments and discussions.

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Abstract

This paper estimates wage equations to test for changes in the responsiveness of wages to unemployment using panel estimates which pool the data across the euro area countries. More specifically, we investigate whether the sensitivity of euro area wages to movements in unemployment is different during downturns (i.e., downward wage rigidity), whether it has changed during the crisis and which institutional features might be driving the results. We find evidence of a lower responsiveness of wages to unemployment during downturns, consistent with the stylised facts that euro area wages are rigid downwards. We also find that the degree of downward wage rigidity has declined as the crisis became more prolonged. Overall, it seems that much of the downward wage rigidity reflects institutional factors, such as a high degree of union coverage and employment protection. Additionally, a rising share of the long-term unemployed lowers the responsiveness of wages to unemployment while a rising share of temporary labour seems to dampen wage growth.

JEL classification: E24, E3, J3, J51

Keywords: Downward wage rigidity, (long-term) unemployment, unions, employment protection, temporary labour

Outline

1. *Introduction*
2. *The model*
3. *Econometric results*
4. *Institutional features*
5. *Conclusion*

1 Introduction

In this paper we estimate wage equations to test for changes in the responsiveness of wages to unemployment using panel estimates which pool the data across the euro area countries. The objective of this paper is to improve our understanding of the effect of rising unemployment on the evolution of wages during the recent crisis period and the possible causes behind changes in responsiveness. We estimate equations where wages are explained by inflation, productivity and unemployment and test various hypotheses by extending this basic specification. For example, short and long-term unemployment may have different impact on wage adjustment, and this might also be important during the crisis, since the proportion of those defined as long-term unemployed has increased markedly. A rise in structural unemployment, perhaps due to various factors such as an increase in labour market mismatch, may also reduce the impact on wages of a given change in unemployment. Additionally, employment protection and unionisation might improve the bargaining position of existing workers, thereby enabling them to resist (or reduce) downward pressure on wages. Accordingly, this paper investigates whether the sensitivity of wages to movements in unemployment is different during downturns (i.e., downward wage rigidity), whether it has changed during the crisis and which institutional features might be driving these results.

The main hypothesis tested in this paper is whether wages are less responsive to rising unemployment during downturns. During the crisis, such downward wage rigidity could either be weakened due to increased wage moderation or worsened due to rising long-term unemployment (as the longer-term unemployed tend to put less downward pressure on wages compared to the short-term unemployed). Finally, we expect rigid labour markets with strong insider-outsider features (i.e. high employment protection for permanent workers and strong unions) to be more susceptible to downward wage rigidity.

Our empirical results suggest evidence of downward wage rigidities in the euro area. This result applies to all downturns, even though wage rigidity seems to have decreased as the crisis became more protracted. Additionally, we find that differences between insiders and outsiders — in particularly differences between unionised vs. non-unionised labour — explain a large part of the downward wage rigidity. Such institutions can be analysed within a 'right-to-manage' model of wage setting, in which unions can influence wages to a large extent but firms ultimately choose the level of employment (Leontief (1946), Nickell (1982)). Additionally, stricter employment protection and a larger share of long term unemployment tend to increase the degree of downward wage rigidity. Other

findings show that a higher share of temporary workers lowers overall wage growth but this effect is partially reversed during downturns when the share of temporary workers tends to decline. Including the share of temporary workers also partly addresses the question as to whether skill composition effects in employment disguise the degree of downward wage flexibility.

Our paper builds on an extensive existing literature on the relationship between wages and unemployment. Katz and Blanchard (1999) note that empirics usually show a negative relation between the *change* in wages and unemployment, while theory suggests a negative relation between the *level* of wages and unemployment.[1] However, the empirically observed characteristics are in line with the New Keynesian Wage Phillips Curve (NKWPC) (Galí (2011)). For our baseline wage equation we therefore follow to a large extent the reduced form equation described by Galí (2011) with wage growth as dependent variable and unemployment as the main independent variable. Inflation is included as independent variable if nominal wage growth is used as the dependent variable. In contrast to the NKWPC, we model the dynamics as well as productivity explicitly introducing lagged wage growth and productivity growth as separate variables. Furthermore, we add an asymmetry on the effect of unemployment in normal times and recessions, this way we test for a difference in the wage-unemployment relation in normal times and downturns.[2]

As Holden and Wulfsberg (2009) and Babecký et al. (2010) argue, theories that are commonly used to explain wages above labour market clearing levels can also be applied to wage rigidity.[3] In a standard wage bargaining framework workers and firms bargain over the division of the available economic rent. The division depends on the relative strength of the bargaining positions of the parties involved. There is strong evidence that the bargaining position is not equally strong across groups of potential workers. The insider-outsider theory outlined by Lindbeck and Snower (1988) states that insiders have a more privileged position compared to outsiders.[4] This privileged position includes (but is not limited to) higher wages.

One example of insiders versus outsiders is unionised versus non-unionised workers. Some of the most commonly mentioned models are the monopoly union model (Dunlop

[1] See Blanchard and Diamond (1994) for another discussion on the Phillips curve (Phillips (1958)) vs. wage curve (Blanchflower and Oswald (1990))

[2] Galí (2011) observes that the wage equation in its most basic form does not fit the data well if the crisis is included, the main cause mentioned is downward wage rigidity, excluding the crisis improves the fit and raises the negative effect of unemployment on wages.

[3] Some of these theories can only be tested on a firm or industry level. In this analysis we are evidently limited to institutional features for which data are available on the aggregate level.

[4] It should however be noted that the effect of outsiders on bargaining can extend beyond the influence through an outside option (see Anderton and Barrell (1995))

(1950)), the right to manage model (Leontief (1946), Nickell (1982)) and the efficient bargaining model (McDonald and Solow (1981)). Even though the models differ in many respects, one commonality is that wages are typically higher and employment lower than under the competitive solution. In this framework, wages also decline less in the case of a negative shock to the economy with employment taking part of the hit. Both the unions' bargaining power and the fact that unions typically represent only part of the labour force are important drivers behind these results.

Even though the exact modeling of these theories cannot be directly adopted to test for wage rigidity on an aggregate level, some can be assessed through the use of proxies. Union data can be used to test for the effects described in the above-mentioned union theory. Other sources of insider-outsider differences can be proxied by long-term unemployment, employment protection legislation and the share of temporary workers.[5]

Our empirical results relate to a number of studies. The European Commission (2011) estimates an error correction model in which long run wages depend negatively on unemployment and positively on productivity and prices. In another closely related paper (Nunziata (2005)) wages are determined by prices (expected and actual), unemployment (both level and change), productivity, macroeconomic shocks and institutional features.

Several papers in the literature confirm the existence of downward wage rigidity. Arpaia and Pichelmann (2007) find significant nominal wage rigidity for 12 euro area countries between 1970-2005. However, they also find a large degree of heterogeneity between countries. Du Caju et al. (2007) find strong real wage rigidity for Belgium on a firm level. However, the degree of wage rigidity declines during downturns. Heinz and Rusinova (2011) find wages to be less responsive to unemployment during times with a positive unemployment gap. Daly et al. (2013) find substantial wage rigidity during recessions in the US. They find that at high unemployment levels the Phillips curve bends (ie, becomes flatter) indicating that during recessions adjustment occurs through rising unemployment rather than falling wages.

In terms of the effects of institutions on wage setting the literature generally reports union density (or coverage), employment protection, wage bargaining coordination and centralization, active labour market policies and the tax wedge to have a significant impact on wage flexibility (Clar et al. (2007)). Babecký et al. (2010), for instance find both real and nominal wage rigidity, which is positively related to collective bargaining coverage, employment protection (also in combination with the use of permanent contracts),

[5]Other variables that have been tested but were not found to be significant are: union density, the share of young workers, the share of low skilled workers and the share of high skilled workers.

share of high skilled workers, employee tenure and firm size.

The remainder of this paper is structured as follows. In section 2 we describe our model, in section 3 we present the results for our baseline model, in section 4 we test for the effects of institutional features and in section 5 we conclude.

2 The model

In this paper we use quarterly data for 14 euro area countries between 1995 and 2014.[6] Our baseline model is a relatively straightforward dynamic fixed effects panel model.[7] All variables are stationary as we use log differenced variables (except for unemployment).[8] We define the following wage specification based on quarterly data:

$$\Delta W_{i,t} = \alpha_i + \sum_{j=1}^{4} \gamma_j \Delta W_{i,t-j} + \sum_{k=0}^{4} \beta_{1,k} U_{i,t-k} + \sum_{k=0}^{4} \beta_{2,k} \Delta Prod_{i,t-k} + \left(\sum_{k=0}^{4} \beta_{3,k} \Delta CPI_{i,t-k} \right) + \beta_4 D_{i,t} \cdot U_{i,t} + e_{i,t} \quad (1)$$

In which $\Delta W_{i,t}$ is the change in real (nominal) compensation per person-hour at time t in country i, $U_{i,t}$ is the unemployment rate, $\Delta Prod_{i,t}$ is change in real output per person-hour, $\Delta CPI_{i,t}$ is annual inflation, α_i are fixed effects and $e_{i,t}$ is an error term. We experiment with two main variants of the above equation (ie, nominal wages and real wages as the dependant variable). If we use nominal compensation as the dependent variable then inflation is included as an explanatory variable. When real compensation is the dependent variable, then inflation is not included in the regression and we effectively restrict $\beta_{3,0}$ to unity and $\beta_{3,i\neq 0}$ to zero. The nominal compensation specification, on the other hand, allows $\beta_{3,i} \forall i$ to be freely estimated.[9] Our differenced variables are year-on-

[6] We include Austria, Cyprus, Germany, Estonia, Spain, Finland, France, Ireland, Italy, Malta, the Netherlands, Portugal, Slovenia and Slovakia. No data available for Belgium, Greece and Luxembourg. Latvia joined after the start of this paper. For an overview of data sources see Appendix A.1

[7] We use a panel fixed effect estimator instead of one of the instrumental variable approaches. The reason for this is that our lag structure is quite rich which would lead to a large number of instruments, which would take a toll on the efficiency of the estimation. Moreover, we have a relatively small N (14) and large T (60 on average) which reduces the usual bias experienced in dynamic panel models (see Anderson and Hsiao (1981)). However, as a robustness check we estimate our model using the Arellano-Bover/Blundell-Bond linear dynamic panel estimator and the Mean Group estimator (results are reported in the appendix).

[8] We do not difference the unemployment rate as it is frequently found to be stationary in levels. However, we also experimented with a specification with the unemployment rate in differences and obtained largely similar parameter estimates and results. All other differenced variables are tested for stationarity and found — as expected — to be stationary.

[9] Hence the CPI term in Equation 1 is put in parentheses.

year log differences using quarterly data.[10] To test for possible differences in the effect of unemployment on wages in normal times and recessions, we include a dummy for GDP downturns and interact this with unemployment. The interaction term $(D_{i,t} \cdot U_{i,t})$ is designed to test for the possible different impact of economic downturns on wage determination, focusing on the possible change in the wage elasticity with respect to the unemployment rate, thereby capturing any downward wage rigidities.[11] A country-specific dummy $(D_{i,t})$ takes the value of 1 if yearly GDP growth is negative: this dummy captures downturns but typically lags common recession indicators because *annual* GDP growth turns negative somewhat later than the start of a recession and persists somewhat longer after the end of a recession.[12] However, this lagged indicator of recessions also more accurately captures the lagged impact of GDP downturns on unemployment.[13] In our sample the longest period of economic downturn is the recent crisis. In the section on institutions we include a matrix of institutional variables $(Z_{i,t})$:

$$\Delta W_{i,t} = \alpha_i + \sum_{j=1}^{4} \gamma_j \Delta W_{i,t-j} + \sum_{k=0}^{4} \beta_{1,k} U_{i,t-k} + \sum_{k=0}^{4} \beta_{2,k} \Delta Prod_{i,t-k} + \left(\sum_{k=0}^{4} \beta_{3,k} \Delta CPI_{i,t-k} \right) + \beta_4 D_{i,t} \cdot U_{i,t} + Z_{i,t}\zeta + e_{i,t} \quad (2)$$

In which $Z_{i,t}$ contains institutional variables and institutional variables interacted with the downturn dummy.

We expect the sign on the unemployment rate to be negative as a rise in the unemployment rate should put downward pressure on wages. The sign on productivity should be positive, on the assumption that employees' wages incorporate some rises in productivity. The sign on inflation should also be positive as nominal compensation should rise in accordance with prices as wage setters will attempt to (at least partially) preserve wages in real terms. A coefficient of (close to) unity for inflation may reflect

[10] For wages this means $\Delta W_{i,t} = \ln(W_{i,t}) - \ln(W_{i,t-4})$.

[11] While our baseline model is largely consistent with the reduced form NKWPC framework as described by Galí (2011), the asymmetry on the effect of unemployment and the explicit modelling of the wage inertia are clear deviations. Allowing for an unemployment asymmetry makes wage changes state dependent and modelling the wage dynamics explicitly makes wage changes time dependent. Both are fully consistent with reality but not included in the NKWPC. See Daly et al. (2013) for asymmetric Calvo pricing in a Phillips curve setting. Other examples of state and time dependent pricing include Burstein (2006), McAdam and Willman (2007), Klenow and Kryvtsov (2008) and Woodford (2008).

[12] One commonly used rule of thumb to indicate recessions is two consecutive quarters of q-on-q GDP decline.

[13] We also experimented with various lag structures of the downturn dummy which confirmed the reported results for our standard dummy variable.

strong employee bargaining power or a high degree of wage indexation.[14] The sign for the interaction term $(D_{i,t} \cdot U_{i,t})$ will be positive if wages are less responsive to increases in unemployment during downturns.

One reason for the latter phenomenon could be that during downturns a rising share of long-term unemployment puts less downward pressure on wages, because of the relatively lower probability of re-employment of the long-term unemployed, as they become less able to effectively compete for jobs (due to a loss of human capital). Therefore, we also experiment with a measure of long term unemployment in our specification and explicitly estimate its impact. A positive sign for $(D_{i,t} \cdot U_{i,t})$ could also be due to the generally observed downward wage rigidity for many euro area countries due to labour market institutions. Another reason could be a rising mismatch between vacancies and the unemployed: if a large proportion of the unemployed is not suitable for existing vacancies, less downward pressure is applied to wages for those positions.[15] Or it could be because the public employment services of countries with rapidly rising unemployment are overloaded with job seekers, decreasing their ability to effectively place people into work. By contrast, non-significant parameters for the interaction term, in combination with significant and correctly signed other coefficients, implies that the effect of unemployment on wages is the same for upturns and downturns.

3 Econometric results

All results in the main text are reported as long-run parameters which are calculated as follows:[16]

$$\bar{\beta}_x = \frac{\sum_{k=0}^{4} \beta_{x,k}}{1 - \sum_{j=1}^{4} \gamma_j} \tag{3}$$

Starting with our basic equation (Equation 1) we see a clear negative and statistically significant relation between wage growth and unemployment in Table 1 (columns 1 and 2 for the real and nominal wage equations respectively). The unemployment rate is found to have the expected negative sign and is statistically significant, suggesting downward pressure from the unemployed on wages. The downturn-unemployment interaction term $(D \cdot U)$ is positive and significant, indicating a lower downward responsiveness of wages to higher unemployment during downturns. The interaction term reduces the downward

[14] In some countries wage indexation is automatic or widespread (i.e. BE, CY, ES, MT and SI).

[15] See for instance Hobijn and Şahin (2013) and Bonthuis et al. (2015) for the possible existence of mismatch in the euro area.

[16] The significance of the long-run parameter is tested with a non-linear joined F-test. In Appendix A.2 Tables 5 and 6, the full dynamic results are shown, including the sum of the coefficients of the lagged dependent variable which gives an insight into the wage transition speed.

Table 1: Results baseline

	(1) Real	(2) Nominal	(3) Real	(4) Nominal
U	-0.440***	-0.477***	-0.378***	-0.424***
	(0)	(0)	(0)	(0)
Prod	0.607***	0.788***	0.597***	0.776***
	(0)	(0)	(0)	(0)
CPI		0.827***		0.840***
		(0)		(0)
U·D	0.146***	0.136***	0.285***	0.257***
	(0)	(0)	(0)	(0)
U·D·Trend			-0.010***	-0.010***
			(0.002)	(0.009)
Constant	3.632***	4.027***	3.097***	3.538***
	(0)	(0)	(0)	(0)
Observations	860	860	860	860
Number of countries	14	14	14	14
SER	1.548	1.400	1.539	1.395
Adj-R-sq	0.682	0.764	0.685	0.766

Notes: *** 1%; ** 5%; * 10% significance. P-values in brackets. Maximum data range: 1995 Q1-2014 Q1. Unbalanced panel.

pressure of unemployment on wages by roughly 1/3 to 1/4 during downturns. This could be capturing the impacts of higher long-term and/or structural unemployment on wage pressures, or it could indicate general downward wage rigidity, possibly due to difficulties in negotiating wage growth downwards.

In columns 1 and 2 of Table 1, the long-run parameter on productivity ranges from 0.61 to 0.79, indicating that only part of productivity gains are incorporated into wages. This seems to be consistent with the well-documented decline in the labour share in the euro area over past decades.[17] The sign of the parameter on CPI is positive as expected, but again not all of the change in prices is transmitted to wages (only around 83% of the change in the CPI is passed through to wages in the long run). Our results are robust to changes in the estimation technique, in Table 5 in the appendix we estimate an instrumental variable estimator (Arellano-Bover linear dynamic panel estimator) and the Mean Group estimator, both return results similar to Table 1 .

Our next step is to test whether the degree of downward wage rigidity changes over

[17]See, for example, Anderton and Hiebert (2010).

the duration of the crisis. Various arguments suggest that the results could go either way regarding the latter. On the one hand, stylised facts suggest that wage moderation increased during the crisis, possibly related to labour market reforms implemented during the crisis, which may help to increase the impact of unemployment on wages. By contrast, the rapid rise in long-term unemployment as the crisis continued may lead to less downward pressure on wages from unemployment.

To see if downward wage rigidity changes during the course of the crisis, we add an additional term which simply multiplies the unemployment interaction term ($D \cdot U$) by a simple time trend starting in 2008 ($D \cdot U \cdot Trend$). The sign and significance of $D{\cdot}U{\cdot}Trend$ will indicate whether the degree of downward wage rigidity rises or decreases as the duration of the crisis becomes more prolonged.

The results indicate that the degree of downward wage rigidity has declined as the crisis became more prolonged. Columns 3 and 4 of Table 1 show that the term $D{\cdot}U{\cdot}Trend$ is negatively signed and statistically significant. This indication of a decline in wage rigidity as the crisis became more prolonged could be explained by several factors: (a) the magnitude of the rise in unemployment, also over an extended period during the crisis, may lead to threshold effects which deliver stronger downward pressure on wages relative to previous downturns; (b) The wave of labour market reforms since the onset of the crisis, particularly those aimed at reforming wage setting, may already have a significant downward impact on wages (eg, Spain); (c) the continuation of fiscal consolidation and persistent downward pressure on public sector wages which may also entail spill over effects to private sector wages; (d) it may also be the case that downward rigidities tend to mostly slow down the responsiveness of wages to unemployment, implying that rigidities become weaker as downturns become more prolonged and extended.

This result is corroborated using a rolling regression of the interaction term ($D \cdot U$) in the original specification. Figure 1 in the appendix shows that the rolling regressions of the long-run parameter of ($D \cdot U$) tends to decline as the length of the crisis increased. However, the charts show that long after the start of the crisis downward wage rigidity is still present (ie, the $D \cdot U$ parameter is still positive and statistically significant at the end of the sample period in 2014Q1).

4 Institutional features

Wage rigidity might depend on the relative strengths of bargaining positions of different groups. Those that are covered by unions or enjoy stricter employment protection tend to have a stronger bargaining position. On the other hand, temporary workers can function

as a limit to insider employee power but can also become outsiders once the economy is in decline. Similarly, the long-term unemployed are likely to put less downward pressure on wages, because of their relatively lower probability of re-employment. In this section we therefore test for the effects of union coverage, employment protection, temporary work and long term unemployment on wage setting.[18] In Appendix B we show a simple theoretical model to investigate the effects of bargaining power on wages.

To proxy for the effects of union power we experiment with union coverage ($Union$) in our wage equation (see Table 2 columns 1 and 2, Table 6 in the Appendix shows all dynamic results presented in this section). Union coverage reflects the share of wage earners covered by unions during wage negotiations, these workers are therefore considered insiders.[19] The results show that a higher union coverage raises wage growth in general (the $Union$ variable is positively signed and statistically significant), confirming the notion that unionised labour has wage bargaining strength which can put upward pressure on wages. Additionally, we find that wages indeed decline less during downturns if union coverage is high (the $D \cdot Union$ variable is also positively signed and statistically significant). Both effects are in accordance with the union theory described in the introduction. It is interesting to see that the general interaction term for downturns ($D \cdot U$) becomes statistically insignificant, indicating that wage rigidity during downturns can be explained away by union coverage. Furthermore, the wave of labour market reforms during the crisis may have reduced the bargaining power of unions by, for example, removing some employment protection or increasing the role of firm-level bargaining. Hence, these changes in bargaining power could explain the reduction in downward wage rigidity during the crisis evident in Table 1. We explore this further below by assessing changes in hiring and firing costs and empirically testing their impacts on wage setting.

Sources of differences in bargaining power between insiders and outsiders may occur through the existence of hiring and firing costs (Emerson (1988) and Stiglitz (1974)). Because of hiring and firing costs companies either have to pay higher wages because of an improved bargaining position of workers (Emerson (1988)) or firms want to pay higher wages to avoid recurring search, recruitment and training cost (labour turnover

[18] Since union coverage data (from the ICTWSS database) and employment protection data (from the OECD) are only available on a yearly basis we interpolate them using a cubic spline.

[19] We use union coverage instead of union density because union density measures only the share of the wage earners with a union membership while union coverage reflects the share of wage earners covered by unions during wage negotiations. Since we are interested in the effect on wage setting for all workers, union coverage better suits our needs. Many European countries tend to have union coverage of 80% or higher with the notable exceptions of Cyprus, Estonia, Ireland, Malta and Slovakia. In Germany the union coverage significantly decreased over time from 85% in 1990 to 60% in 2010.

Table 2: Results institutional variables

	(1) Real	(2) Nominal	(3) Real	(4) Nominal
U	-0.292***	-0.342***	-0.390***	-0.416***
	(0)	(0)	(0)	(0)
Prod	0.590***	0.662***	0.549***	0.777***
	(0)	(0)	(0)	(0)
CPI		0.680***		0.771***
		(0)		(0)
U·D	-0.013	-0.015	0.059	0.032
	(0.852)	(0.846)	(0.276)	(0.578)
Union	0.108**	0.139***		
	(0.015)	(0.005)		
Union·D	0.031***	0.030***		
	(0)	(0)		
EPL			1.174	1.380*
			(0.112)	(0.070)
EPL·D			0.357*	0.410*
			(0.085)	(0.053)
Constant	-5.434*	-6.706*	-0.039	-0.212
	(0.096)	(0.065)	(0.984)	(0.921)
Observations	636	636	658	658
Number of countries	14	14	12	12
SER	1.466	1.366	1.418	1.260
Adj-R-sq	0.617	0.697	0.635	0.741

Notes: *** 1%; ** 5%; * 10% significance. P-values in brackets. Maximum data range: 1995 Q1-2014 Q1. Unbalanced panel. Union coverage ($Union$) and employment protection legislation (EPL) not available for full sample.

model, Stiglitz (1974)).

To assess the firing cost component we use the OECD's employment protection legislation index (EPL), where countries with stricter rules on individual and collective dismissals have a higher EPL index (the EPL index ranges from 0-6). We use the indicator on regular contracts since we will cover temporary contract separately later on and since rules concerning regular contracts are more binding for firms.[20] Higher employment protection raises firing costs which potentially can lead to higher wages.

Countries with stricter employment protection legislation seem to experience higher wage growth during downturns (Table 2 columns 3-4, parameters of EPL and $D \cdot EPL$ are jointly significant with p-values of $p = 0.046$ and $p = 0.024$ respectively).[21] One possible explanation could again be improved bargaining strength when firing costs are high: lower wage growth can be resisted if layoffs are less likely due to more employment protection. Employment protection legislation seems to have a smaller impact on wage setting in normal times. Intuitively this makes sense since the restrictions on dismissals are less binding in normal times. Including the EPL terms again leads to the general interaction term ($D{\cdot}U$) becoming statistically insignificant, implying that a higher degree of employment protection is associated with downward wage rigidity. Furthermore, the reforms in a number of euro area countries during the crisis resulted in reductions in employment protection and a decline in the EPL index. Hence, these changes in EPL could also explain the reduction in wage rigidity during the crisis evident in Table 1.

In addition to the effects described above, the crisis has had a severe impact on other parts of the labour market. Both the share of temporary workers has decreased at the start of the crisis and the share of long-term unemployment has increased. Both effects are likely to have influenced wage growth. Temporary workers typically have low hiring cost (less intense search and less training required) and low firing cost (contracts simply run out, or are not extended), additionally temporary workers are likely to receive lower wages compared to permanent workers. We would therefore expect an increase in the share of temporary workers to generally have a negative effect on wage growth which is indeed what we find when we add such a variable to our wage equation (see negative and statistically significant parameter for $Temp$ — temporary workers as share of total employment — in Table 3 columns 1 and 2).[22] Interestingly, the parameter and significance of the $D \cdot U \cdot Trend$ is largely unchanged when the share of temporary

[20] In the case of a temporary contract, an employer can in the worst case simply wait out the term of the relatively short contract without much cost.

[21] Cyprus and Malta are not included in this analysis because of missing EPL series.

[22] Spain is the absolute front-runner in terms of use of temporary contracts with over 30% pre-crisis. In 2013 most countries typically have around 10% temporary contracts with the upper bound set by Spain, the Netherlands and Portugal at 20% and the lower bound at less than 5% set by Estonia.

Table 3: Results institutional variables

	(1) Real	(2) Nominal	(3) Real	(4) Nominal
U	-0.384***	-0.430***	-1.036***	-1.143***
	(0)	(0)	(0)	(0)
Prod	0.552***	0.725***	0.595***	0.767***
	(0)	(0)	(0)	(0)
CPI		0.792***		0.831***
		(0)		(0)
U·D	0.264***	0.236***	0.307***	0.286***
	(0)	(0)	(0)	(0)
U·D·Trend	-0.008***	-0.007***	-0.010***	-0.009***
	(0.003)	(0.008)	(0)	(0.003
Temp	-0.164***	-0.153**		
	(0.003)	(0.015)		
LTU			0.854***	0.889***
			(0.008)	(0.009)
Constant	5.352***	5.815***	4.124***	4.956***
	(0)	(0)	(0)	(0)
Observations	860	860	848	848
Number of countries	14	14	14	14
SER	1.532	1.391	1.528	1.387
Adj-R-sq	0.688	0.768	0.688	0.768

Notes: *** 1%; ** 5%; * 10% significance. P-values in brackets. Maximum data range: 1995 Q1-2013 Q4. Unbalanced panel. Share of temporary contracts ($Temp$) and share of long-term unemployed (LTU) not available for full sample.

workers is added to the equation (compare Table 3 with Table 1). Given that temporary workers are largely low-skill, low-pay workers this implies that significant downward wage rigidities are evident even when upward wage bias from employment skill composition effects are taken into account.

Finally, to test for the potential effect of long-term unemployment on wage setting we add the share of long-term unemployed, LTU, (ie, those unemployed for more than 6 months as share of the labour force) to the existing wage equation revealing that the long-term unemployed indeed lower the responsiveness of wages to unemployment (see columns 3 and 4, Table 3). A possible explanation behind these results is loss of skills from unemployment which makes it harder for the long-term unemployed to effectively compete with both the short-term unemployed and the employed. Again, the downward

wage rigidity parameters are still correctly signed and statistically significant, indicating that other factors in addition to long-term unemployment are responsible for the more limited response of wages to unemployment during downturns.

5 Conclusion

In summary, panel estimates across the euro area countries suggest a lower responsiveness of wages to rising unemployment during economic downturns. This may indicate that rising long-term unemployment reduces the elasticity of wages with respect to unemployment during downturns, or that the euro area is generally characterised by downward wage rigidities due to institutional features. However, the downward wage rigidities tend to become weaker as the crisis became more protracted.

Overall, we find that insider-outsider differences can explain a large part of the observed downward wage rigidity. Extensive union coverage, high long-term unemployment and high employment protection seem to drive up wages and hamper downward adjustment during downturns. A rising share of temporary labour seems to dampen wage growth but this is likely due to the generally lower wages for temporary contracts, conversely, the large labour shedding of temporary workers, who tend to be low-skilled and low-paid, will put upward pressure on aggregate wages during the crisis. However, downward wage rigidities are still evident after allowing for this latter employment composition effect on wages. Furthermore, the decline in wage rigidity as the crisis became more protracted may have been due to the wave of labour market reforms in a number of euro area countries during the crisis or it may be the case that rigidities slow down the response of wages to unemployment during downturns and become weaker as downturns become more protracted and extended.

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A Appendix

A.1 Data sources

Table 4: Data

Variable	Source	Frequency	Adjustment	Availability
Compensation per hour	Eurostat	Quarterly	SA	1995 Q1-2014 Q1
Unemployment	Eurostat	Quarterly	SA	1995 Q1-2014 Q1
Productivity	Eurostat	Quarterly	SA	1995 Q1-2014 Q1
Consumer price index	Eurostat	Quarterly	SA	1995 Q1-2014 Q1
Union coverage	ICTWSS	Y	INT	1995 - 2011
EPL	OECD	Y	INT	1998 - 2013
Temporary employment	Eurostat	Quarterly	SA, INT	1995 Q1-2014 Q1
Unemployment $>$ 6 months	Eurostat	Quarterly	SA, INT	1995 Q1-2014 Q1

Notes: SA=seasonally adjusted; INT=interpolated, cubic spline. EPL is employment protection for regular contracts. Data on temporary employment and unemployment for more than 6 months are interpolated because of missing values early in the sample.

A.2 alternative estimation techniques and dynamic results

Table 5: Results alternative estimation technique and dynamic results baseline estimates

	(1) Real AB	(2) Nominal AB	(3) Real MG	(4) Nominal MG	(5) Real	(6) Nominal	(7) Real	(8) Nominal
W					0.527***	0.589***	0.516***	0.580***
					(0)	(0)	(0)	(0)
U	-0.415	-0.403	-0.301	-0.658	-0.208***	-0.196***	-0.183***	-0.178***
	(0)	(0)	(0.052)	(0)	(0)	(0)	(0)	(0)
Prod	0.661	0.873	0.695	0.686	0.287***	0.324***	0.289***	0.326***
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
CPI		0.899		0.428		0.340***		0.353***
		(0)		(0.001)		(0)		(0)
U·D	0.163	0.138	0.213	0.179	0.069***	0.056***	0.138***	0.108***
	(0)	(0)	(0.004)	(0.030)	(0)	(0)	(0)	(0)
U·D·Trend							-0.005***	-0.004***
							(0.002)	(0.009)
Constant	3.292	3.082	1.473	1.512	1.718***	1.655***	1.499***	1.486***
	(0)	(0)	(0)	(0.002)	(0)	(0)	(0)	(0)
Obs.	860	860	902	902	860	860	860	860
Nr. coutr.	14	14	14	14	14	14	14	14
SER					1.548	1.4	1.539	1.395
Adj-R-sq					0.682	0.764	0.685	0.766

Notes: Sum of coefficients of current period and lagged terms are reported ($\sum_{k=0}^{4} \beta_{x,k}$), for compensation $\sum_{j=1}^{4} \gamma_j$. P-values in brackets. Maximum data range: 1995 Q1-2014 Q1. Unbalanced panel. AB= Arellano-Bover/Blundell-Bond linear dynamic panel estimator, MG=mean group estimator.

Table 6: Dynamic results institutional variables

	(1) Real	(2) Nominal	(3) Real	(4) Nominal	(5) Real	(6) Nominal	(7) Real	(8) Nominal
W	0.380***	0.462***	0.459***	0.524***	0.500***	0.563***	0.501***	0.567***
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
U	-0.181***	-0.184***	-0.211***	-0.198***	-0.192***	-0.188***	-0.517***	-0.495***
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Prod	0.366***	0.356***	0.297***	0.370***	0.276***	0.317***	0.297***	0.332***
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
CPI		0.366***		0.367***		0.346***		0.360***
		(0)		(0)		(0)		(0)
U·D	-0.008	-0.008	0.032	0.015	0.132***	0.103***	0.153***	0.124***
	(0.852)	(0.846)	(0.276)	(0.577)	(0)	(0)	(0)	(0)
U·D·Trend					-0.004***	-0.003**	-0.005***	-0.004***
					(0.003)	(0.016)	(0)	(0.003)
Union	0.067**	0.075***						
	(0.014)	(0.006)						
Union·D	0.019***	0.016***						
	(0)	(0)						
EPL			0.635	0.657*				
			(0.115)	(0.0736)				
EPL·D			0.193*	0.195*				
			(0.0845)	(0.0524)				
Temp					-0.082***	-0.067***		
					(0.003)	(0.009)		
LTU							0.426***	0.385***
							(0.009)	(0.009)
Constant	-3.369*	-3.608*	-0.021	-0.101	2.676***	2.541***	2.058***	2.146***
	(0.095)	(0.065)	(0.985)	(0.923)	(0)	(0)	(0)	(0)
Obs.	636	636	658	658	860	860	848	848
Nr. coutr.	14	14	12	12	14	14	14	14
SER	1.466	1.366	1.418	1.26	1.532	1.391	1.528	1.387
Adj-R-sq	0.617	0.697	0.635	0.741	0.688	0.768	0.688	0.768

Notes: Sum of coefficients of current period and lagged terms are reported ($\sum_{k=0}^{4} \beta_{x,k}$), for compensation $\sum_{j=1}^{4} \gamma_j$. P-values in brackets. Maximum data range: 1995 Q1-2014 Q1. Unbalanced panel. AB= Arellano-Bover/Blundell-Bond linear dynamic panel estimator, MG=mean group estimator.

A.3 Rolling regression

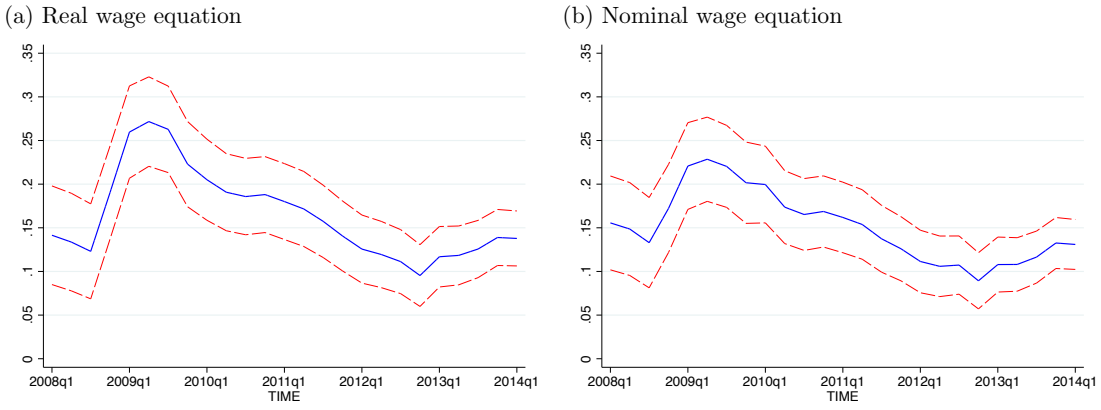

Figure 1: Rolling regression

B Wage bargaining framework

In this section we largely follow Manning (1993).

In our model the workers, organised in a union, bargain with the firm over the wage. The firm ultimately determines the level of employment L. Starting with firm i's profit function, it will choose L in order to maximise:

$$\Pi_{it} = \Pi(A_{it}, L_{it}, w_{it}, G_{it}) \tag{4}$$

in which Π is a continuously differentiable function of productivity A, the wage w, labour L and any other input influencing production G_{it}.

Turning to the unions utility function we define:

$$U_{it} = L_{it}[V_{it} - V_t^u] \tag{5}$$

in which V_{it} is the value of being employed at firm i for a wage negotiated between the firm and the union and V_t^a is the value of the alternative. For the moment we will assume that the alternative means being unemployed, later this can also mean alternative

employment. Both value functions are defined as:

$$V_{it} = w_{it} + \rho E_t[q_{t+1}V^u_{t+1} + (1 - q_{t+1})V_{t+1}] \quad (6)$$

$$V^u_t = b + \rho E_t[s_{t+1}V^u_{t+1} + (1 - s_{t+1})V_{t+1}] \quad (7)$$

in which $\rho < 1$ is the discount rate, q_{t+1} is the probability that the worker becomes unemployed next period and s_{t+1} is the probability that an unemployed worker stays unemployed.[23]

The firm and the workers bargain over the wage, they maximise:

$$\max_{w_{it}} \Omega = U^{\beta}_{it}\Pi^{1-\beta}_{it} \quad (8)$$

in which β is the relative bargaining power of the workers. This gives the following first order condition:

$$\frac{1-\beta}{\beta} = -\frac{U_w}{U_{it}}\frac{\Pi_{it}}{\Pi_w} \quad (9)$$

in which:

$$U_w = L_w[V_{it} - V^u_t] + L_{it} \quad (10)$$

in which L_w is the derivative of labour demand with respect to wages. We can rewrite the first order condition as:

$$\frac{1-\beta}{\beta} = \left(\frac{L_w[V_{it} - V^u_t] + L_{it}}{L_{it}[V_{it} - V^u_t]}\right)\left(\frac{\Pi_{it}}{\Pi_w}\right) \quad (11)$$

after rearranging we get:

$$w_{it} = \left(\frac{1-\beta}{\beta}\epsilon_{\Pi t} + \epsilon_{Lt}\right)[V_{it} - V^u_t] \quad (12)$$

in which ϵ_L and ϵ_Π are the absolute values of the elasticity of labour and profits respectively with respect to wages. Using the steady state value for $V_{it} - V^u_t$ (using equations 6 and 7) and imposing symmetry ($w_{it} = w_t = w$) in equation 12:

$$w = \left(\frac{1-\beta}{\beta}\epsilon_\Pi + \epsilon_L\right)\frac{w - b}{1 - \rho[s - q]} \quad (13)$$

[23]For simplicity we assume linear utility.

after rearranging:

$$w = \frac{\left(\frac{1-\beta}{\beta}\epsilon_{\Pi} + \epsilon_L\right)}{\frac{1-\beta}{\beta}\epsilon_{\Pi} + \epsilon_L + \rho[s-q] - 1} b \tag{14}$$

A higher bargaining power of the union leads to higher wages: $\frac{dw}{d\beta} > 0$. The size of β is likely to differ between different groups in the labour market. Those organised in unions and those with employment protection are likely to have higher β's than unorganised workers and temporary labour. It should be noted that the term in round brackets is constant for certain functional forms of production functions (such as a Cobb-Douglas production function) for the moment we will assume it is indeed constant. We can therefore write the wage equation as:

$$w = \frac{\frac{1-\beta}{\beta}\epsilon_{\Pi} + \epsilon_L}{\frac{1-\beta}{\beta}\epsilon_{\Pi} + \epsilon_L + \rho[s-q] - 1} b \tag{15}$$

Next, we want to express the wage equation in terms of unemployment. In the steady state the following must hold:

$$q(1-u) = (1-s)u \tag{16}$$

the flow into unemployment must equal the flow out of unemployment. We ignore for the moment the flows in and out of the labour force, in our model if you are not employed you are unemployed. Therefore:

$$w = \frac{\frac{1-\beta}{\beta}\epsilon_{\Pi} + \epsilon_L}{\frac{1-\beta}{\beta}\epsilon_{\Pi} + \epsilon_L + \rho\frac{u-q}{u} - 1} b \tag{17}$$

which means that:

$$\frac{dw}{du} = -\rho q \frac{\frac{1-\beta}{\beta}\epsilon_{\Pi} + \epsilon_L}{\left[\frac{1-\beta}{\beta}\epsilon_{\Pi} + \epsilon_L u + \rho[u-q] - u\right]^2} b < 0 \tag{18}$$

The assumption is of course made that we keep all else in the wage equation constant.