COORDINATION VERSUS FLEXIBILITY IN WAGE FORMATION

A focus on the nominal wage impact of productivity in Germany, Greece, Ireland, Portugal, Spain and the United States[1]

Marga Peeters[2] and Ard den Reijer[3]

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ABSTRACT

Wage coordination between countries of the European Monetary Union (EMU) aims at aligning nominal wage growth with labour productivity growth at the national level. We analyse the developments in Germany, the EMU's periphery countries Greece, Ireland, Portugal, and Spain along with the US over the period 1980-2010. Apart from the contribution of productivity to nominal wages, we take into account the contributions of prices, unemployment, replacement rates and taxes by means of an econometrically estimated non-linear equation resulting from a wage bargaining model. We further study the downward rigidities of nominal wages. The findings show that in past times of low productivity, price inflation and reductions in unemployment still put significant upward pressure on nominal wage growth. The periphery countries are far from aligning nominal wage growth with productivity growth. German productivity is a major wage determinant, but surely not the only one. Within the context of a free bargaining process between employers and labour unions, policy makers can effectively use the replacement rate to steer the nominal wages outcome.

Key words: compensation per employee, unit labour costs, productivity, labour market, unemployment, prices, replacement rate, monetary union.

JEL codes: C22, E5, E6, E24, J30.

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All remaining errors are ours.

[2] Corresponding author: Marga Peeters, European Commission – DG ECFIN BU-24, B-1049 Brussels, tel: +32 2 296 1689, email marga.peeters@ec.europa.eu. Marga was affiliated with the Netherlands Institute for Advanced Study of the Royal Netherlands Academy of Arts and Science when writing this manuscript.

[3] Ard den Reijer, Sveriges Riksbank, SE – 10337 Stockholm, tel: +46 8 787 0149, email, Ard.den.Reijer@Riksbank.se

1. INTRODUCTION

Private sector wages and to a lesser extent government sector wages are in a free market economy the outcome of a bargaining process between employers and employees. In the literature and in policy debates, the focus often lies on the direct impact of labour productivity on nominal wages. The main aim of this study, however, is to analyse to what extent other factors than productivity growth determined nominal wage growth in the recent past. We study the determinants of nominal wage developments at the national level for some European countries and the United States over the last three decades. The different economies potentially exhibit different unemployment rates, labour productivity growth rates, differences in social security systems and tax rates. These macroeconomic factors, the stance of the business cycle and the negotiation power of the employees in relation to employers all play a role in the wage formation process. We aim to estimate causal relationships from productivity, price levels and the other factors to nominal wage growth[4] based on a wage bargaining model. For this purpose, we employ a model that possesses a rather unique feature in that the nominal wage elasticities with respect to the different determinants are allowed to vary over time. This type of model contrasts with the commonly assumed constant elasticities (see for instance Layard *et al*., 1991). We estimate the long run responses of the *level* of nominal wages to, amongst others, the *levels* of productivity and prices (see Phillips, 1958). Relative price levels are a key determinant of competitiveness for member economies in a monetary union, who can no longer adjust their nominal exchange rate. The only mechanism to adjust the real exchange rate is then through the relative price level, the so-called 'internal devaluation'. As nominal wages and prices are closely interlinked, nominal wage coordination is therefore a potential policy instrument within a monetary union. Within the context of a free bargaining process between employers and labour unions, we will quantify the extent to which national authorities can steer wage developments by policy measures related to tax rates and social contributions

[4] Another interesting avenue is the causal relationship from productivity to wages. Several theories argue that higher wages push up labour productivity, while others argue that high wage depress labour productivity (see Caballero and Hammour (1996), Fase and Tieman (2001) and Kleinknecht (2003)). It is however beyond the scope of this paper to investigate this further, as our main aim is to investigate the policy suggestions laid down in the introduction and understand the wage growth.

The paper is organised as follows. Section 2 highlights stylised facts about the development of real and nominal unit labour costs within the context of a monetary union. Section 3 presents the theoretical model and the non-linear wage equation. Section 4 reports the econometric estimates of the nominal wage equation for each of the countries. Based on these results, Section 5 quantifies the contributions of the different determinants to the nominal wage formation, while considering downward wage rigidity. Finally, Section 6 concludes. The appendices provide analytical derivations of the wage bargaining model, including the elasticities and nominal wage contributions, and describe the time series used in this paper.

2. WAGE COORDINATION IN A MONETARY UNION

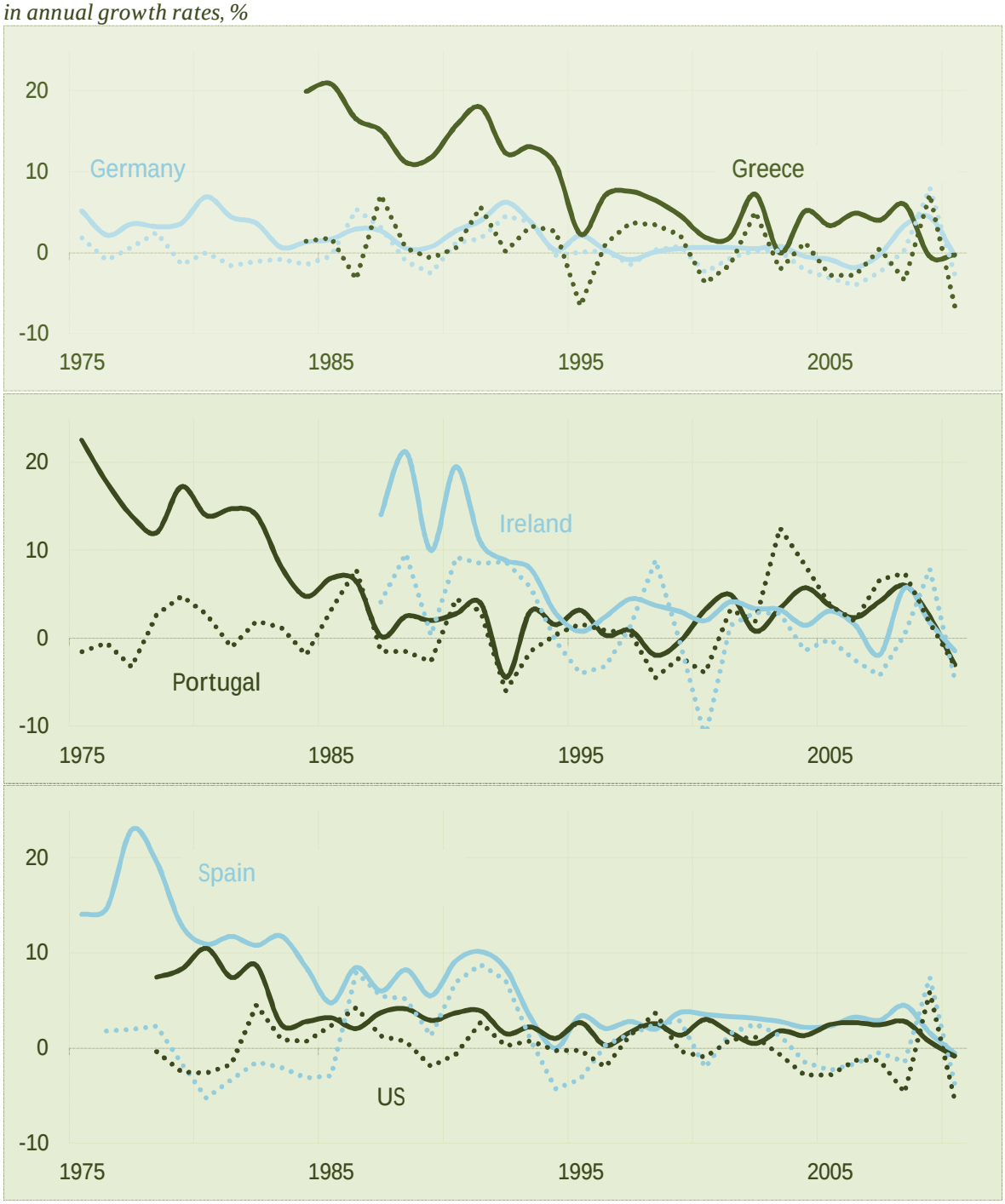
Nominal unit labour cost, which consists of nominal wage divided by productivity, is a better proxy for competitiveness than real unit labour cost, especially for member economies in a monetary union. The real measure captures the extent to which real wages are aligned with productivity, while the nominal measure moreover captures relative price competitiveness at world markets. Nominal wage coordination within a monetary union entails aligning nominal unit labour costs such that above average nominal wage increases occur only insofar sustained by comparably higher productivity growth rates. Nominal wage coordination is especially relevant for the European Monetary Union (EMU), which is characterized by a limited fiscal transfer union, a limited labour mobility due to cultural and language barriers and a high degree of intra-union trade rather than with economies outside the euro area. Recently, the EMU-leaders aimed to formalize nominal wage coordination in the "Euro-Plus Pact"[5] to ensure that nominal wage growth in a monetary union is conducive for price competitiveness. Wage coordination consists of aligning nominal unit labour costs across union member states, thereby anchoring national price levels

Figure 1 shows the growth rates of nominal and real unit labour costs for Germany, Greece, Ireland, Portugal, Spain and the United States over the period 1975-2010. Germany was often mentioned and praised for its relatively moderated nominal wage development (see for instance Boysen-Hogrefe, 2010, or De Grauwe, 2011). German nominal unit labour costs were low in comparison with the periphery countries Greece, Ireland, Portugal and Spain. Especially noteworthy is that in terms of real developments, the difference between, for instance, Greece and Germany vanishes. As the growth in nominal unit labour costs equals, by approximation, the nominal wage growth minus the productivity growth, we disentangle it. Figure 2a shows the results. For illustration purposes, the global recession year 2009 is not included as it was exceptional. Nor is the year 2010 included as this was again a recession year for the periphery countries. The figure corroborates once more that Germany differs from the others. It not only follows that German productivity grew faster than German nominal wages in several years during the period 2000-08, but also that productivity growth and nominal wage

[5] *see Council of the European Union*, *11 and 25 March 2011*

growth were in a much smaller range in comparison with the other countries. Relevant to our analysis is the fact that most data points are far from the 45° line in the graph. In Greece, Ireland and Portugal and to a lesser extent Spain, nominal wage growth in several years remained very high while productivity growth was relatively low. Figure 2b tells another story by showing the growth in real wage costs being the nominal wage growth deflated by producer price inflation. Real wage developments do not seem to be excessive compared with the German ones for all countries under investigation, probably with the exception of Ireland. Moreover, most data points are below the 45° line implying that real wages were not excessively high, declining real unit labour costs, good corporate profitability and declining labour income shares. More generally, Figure 2 reveals the economic intuition that the results of the wage formation process in the European periphery countries should be characterized in terms of excessive nominal unit labour costs vis-à-vis Germany and not in terms of excessive real unit labour costs resulting from a negotiation disequilibrium between employees (/labour) and employers (/capital).

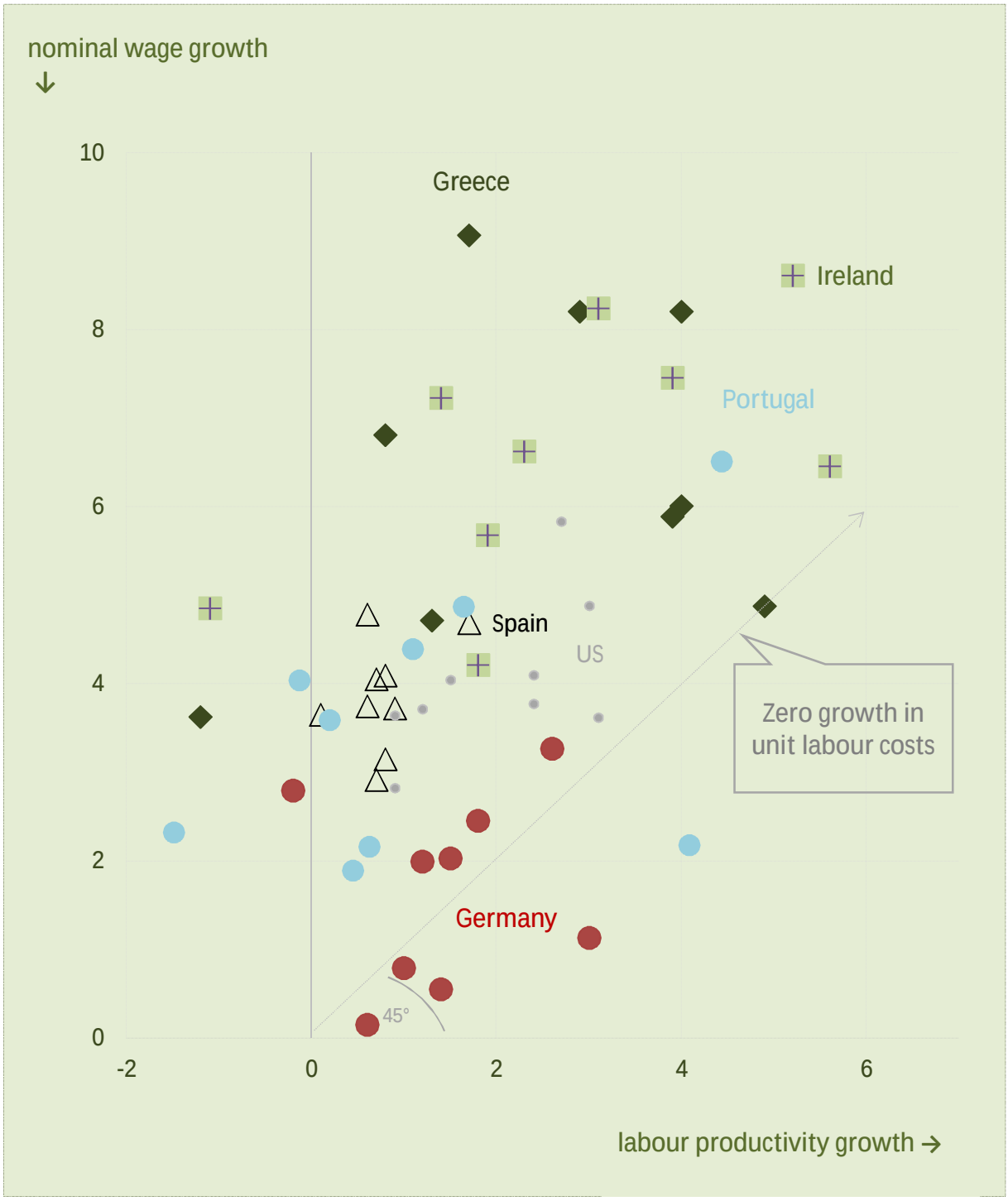
Figure 1 Unit labour costs 1975-2010
in annual growth rates, %



Source: Own calculations based on the KLEM European Commission and OECD databases, see appendix B.

Note: The unit labour cost is the gross hourly nominal wage rate of the whole economy, in euros for Germany, Greece, Ireland, Portugal and Spain and in US dollar for the US, divided by the production per hour. The dotted lines represent the unit labour costs deflated with producer prices.

Figure 2a Nominal wage growth in relation to labour productivity growth 2000-2008
annual %



Source: Own calculations based on the KLEM European Commission and OECD databases, see appendix B.
Note: Unit labour costs equal gross nominal wages per hour divided by labour productivity per hour. Therefore, the growth in unit labour costs equals by approximation the growth in nominal wages per hour (on the y-axis) minus the growth in labour productivity (on the x-axis). By consequence, in case nominal wage growth equals labour productivity growth, the growth in unit labour costs is zero as indicated by the 45° degrees line. Data points above the 45° line correspond with a gross hourly nominal wage growth that is higher than the productivity growth.

Figure 2b Real wage growth in relation to labour productivity growth 2000-2008
annual %

Source: Own calculations based on the KLEM European Commission and OECD databases, see appendix B.
Note: Real unit labour costs equal gross real wages per hour divided by labour productivity per hour. Therefore, the growth in real unit labour costs equals by approximation the growth in real wages per hour (on the y-axis) minus the growth in labour productivity (on the x-axis). By consequence, in case real wage growth equals labour productivity growth, the growth in unit labour costs is zero as indicated by the 45° degrees line. Data points below the 45° line correspond with a gross hourly real wage growth that is lower than the productivity growth. Nominal wages are deflated with producer prices.

3. WAGE BARGAINING MODEL

This section describes the specifications of the two-player Nash bargain between a representative employer and a representative employee about the gross nominal wage. Graafland and Huizinga (1999) introduced this model and applied it empirically to the Netherlands. Peeters and den Reijer (2008) adjusted the model and applied the model to the French, German, Spanish, Dutch and US labour markets over the period 1970-2001.

We start from a profit and a utility maximising function and derive first order conditions that render a nominal wage equation dependent on several factors. The optimal gross nominal wage of an employee is the nominal wage that maximises the combined objective Φ of the employer and the employee. It is specified as

$$max_w \, \Phi \stackrel{\text{def}}{=} \Pi^{\alpha} \Psi^{1-\alpha} \qquad (1)$$

where Π is the profit function of the employer and Ψ the utility function of the employee and α a parameter representing the relative bargaining power. This bargaining parameter is ranged between 0 and 1: the closer it is to 0 the employee has almost full power and the employer almost none during the negotiation process, while a value close to 1 indicates the opposite.[6]

We define profits as net revenues minus labour costs. Gross revenues equal the price (P) times the number of products sold. Net revenues, that is gross revenues minus value added taxes and capital costs (interest, depreciation) equal P^{ω} with ω a parameter that we will estimate. The number of goods sold differs from the production by the change in inventories. Costs only consist of nominal wage costs that equal the gross nominal wage per employee W times the number of hours worked L. The specification of profits per labour hour is therefore

$$\Pi \stackrel{\text{def}}{=} P^{\omega} q^{\rho} - W \qquad (2)$$

[6] We interpret this negotiation power also as the value the employer or employee attaches to profits and utility, respectively (see also Figure 3).

where sales per hour equals q^{ρ} with q being labour productivity. In case $\rho = 1$, production equals sales. In case $\rho < 1$, labour productivity does not fully translate into an equal increase in sales (*cf.* Bell *et al.*, 2000).[7] A part of the inventory of goods is devalued or never sold, such as for instance often happens with perishable food products or out-of-date computers or cell phones. We allow the parameter ω, which is related to the producer price P to deviate from 1. The representative employer´s aim in *(2)* is the maximisation of profits per employee Π, by adjusting labour input. A precondition of the maximisation is that the objective function is concave in W.

The employee bargains about the nominal net nominal wage, which consists of the gross nominal wage after deduction of taxes and social contributions, t, and considers this in deviation of the reservation wage represented as $W_{reservation}$:

$$\Psi \stackrel{\text{def}}{=} W(1-t) - W_{reservation} \qquad (3)$$

We distinguish an official and an informal sector in the economy. In the official sector people work and earn an official nominal wage $W_{official}$. People in the informal sector have an informal "opportunity" nominal wage, $W_{informal}$. The reservation wage, as mentioned in (3), represents the employee's outside opportunity wage or benefit that we define as a weighted average of this official and informal wage, with relative weight β between 0 and 1,

$$W_{reservation} \stackrel{\text{def}}{=} \beta W_{official} + (1-\beta) W_{informal}. \qquad (4)$$

The nominal wage in the official sector equals the after-tax gross average market wage $W(1-t)$ in case of the absence of unemployment u, which implies that $u = 0$. In the other extreme case of maximum unemployment ($u = 1$) the official gross nominal wage equals the unemployment benefit,

[7] In the original wage bargaining model of Graafland and Huizinga (1999), constant returns to scale were assumed, implying that $\rho = 1$. Empirically, this restriction was later rejected for all countries under investigation (see Peeters and den Reijer, 2008), for which reason we introduced the flexibility that ρ can deviate from 1. This parameter could even exceed 1, as argued by some referees, in which case the optimization of the wage bargaining model would fail due to non-convexity of the objective function. However, yet, we have never found any empirical evidence for this in countries that we analyse (see also our empirical analyses in section 4 here).

which equals the replacement rate R times the gross nominal wage as $R * W$. The replacement rate R equals the average unemployment benefit divided by the average gross nominal market wage ($0 \leq R \leq 1$). In sum, we have thus defined the official nominal wage as

$$W_{official} \stackrel{\text{def}}{=} u\,R\,W(1-t) + (1-u)W(1-t) \qquad (5)$$

The nominal wage obtained in the informal sector depends on the household production function:

$$W_{informal} \stackrel{\text{def}}{=} P_c^{\upsilon}\,(\gamma q)^{\mu}. \qquad (6)$$

The employee addresses in this case his labour to work at home. He avoids expenditures such as the costs of childcare, home cleaning or house maintenance. The informal nominal wage therefore depends on the consumer price P_c. Parameter υ determines to what extent taxes, insurances and possible capital costs have to be paid ($0 \leq \upsilon \leq 1$) while parameter μ determines to what extent there is a difference between the labour input for household production and the eventual usable production ($0 \leq \mu \leq 1$). Parameter γ takes account of a possible lower labour productivity of the informal vis-à-vis the official sector ($0 \leq \gamma \leq 1$). In the case where the employee is non-productive at home, that is $\gamma = 0$, no nominal wage is earned in the informal sector and therefore β in (4) should logically equal 1.

Optimising the profits and utility functions simultaneously, as follows from Appendix A, the optimal nominal wage results as,

$$\log W = \rho \log q + \omega \log P + \log\left\{1 + \frac{\alpha(1-\beta)\gamma^{\mu}}{1-\alpha} * \frac{P_c^{\upsilon} q^{\mu-\rho}}{P^{\omega}(1-t)}\right\}$$
$$- \log\left\{1 + \frac{\alpha}{1-\alpha}\left[1 - \beta\left(1 - u(1-R)\right)\right]\right\} \qquad (7)$$

For wage coordination implying alignment of nominal wage growth and productivity growth, parameter ρ is crucial[8]. Ideally, it should not exceed one and it should be positive and significant, entailing that decreases in productivity depress nominal wages and increases in productivity push nominal wages upward. Moreover, according to the Euro-Plus Pact it should hold that

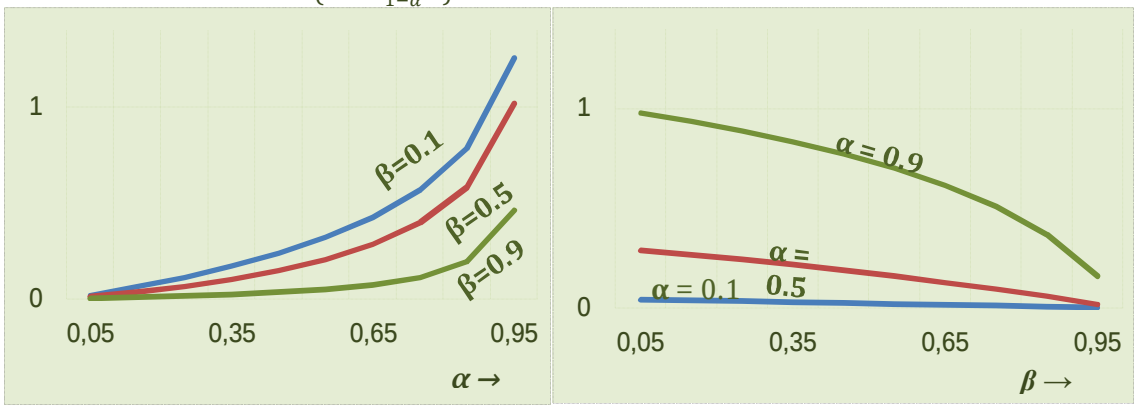
$$log\, W = \rho\, log\, q \;\Leftrightarrow\; log\, ulc = (\rho - 1)\, log\, q \qquad (7^*)$$

where $ulc \overset{\text{def}}{\equiv} W/q$ is the nominal unit labour cost. Perfect alignment of nominal wage growth with productivity growth occurs if and only if $\rho = 1$ implying that there are no other explanatory factors in the nominal wage equation *(7)*. This situation will only occur if the negotiation power of the employer is weak ($\alpha \to 0$), so that neither unemployment nor the replacement rate plays a role and price compensation does not take place ($\omega = 0$).[9]

The non-linearity of the wage equation *(7)* allows for non-constant semi-elasticities with respect to the unemployment rate *u* and the replacement rate *R*. This implies that the response of nominal wages to a decrease in the unemployment rate of 1%-point may differ from a nominal wage change in response to an increase in the unemployment rate of 1%-point, apart from the change in sign. As follows from equation *(7)*, the semi-elasticity with respect to the unemployment rate is negative. Therefore, as expected, a higher unemployment rate negatively affects the nominal wage and a lower unemployment rate positively affects the nominal wage (see equation *(A6)* in appendix A for the derivation). The extent to which unemployment affects the nominal wage depends on the replacement rate (*R*) and the unemployment rate (*u*). *Ceteris paribus*, an increase in the unemployment rate depresses the nominal wage more in case of sober unemployment benefits (*R* is small) than abundant unemployment benefits (*R* closer to 1). The unemployment elasticity is close to zero in case the replacement rate is close to one. Moreover, the nominal wage elasticity of unemployment is lower if the level of unemployment is higher, implying a lower degree of nominal wage flexibility. In sum, nominal wages are more flexibly reacting to changes in unemployment in case of a less generous welfare state of the economy or a tighter labour market.

[8] In the literature more definitions of wage coordination are around, see Acocella and Bartolomeo (2004) or Stockhammer (2008), but we stick strictly to the one specified in equation *(7*)* with $\rho = 1$.
[9] In the case of no negotiating power for the employer, implying $\alpha = 0$, the profit function plays no role and the utility function is linear. Therefore the after tax wage of the employee can be unlimited.

Figure 3 Negotiation power and employee's preference parameter
Vertical axis represents $log\left\{1+\frac{\alpha(1-\beta)}{1-\alpha}\right\}$, *see the third term in equation (7)*



Source: Authors based on the wage bargaining model, see equation (7).
Note: We illustrate the interaction of the negotiation power of the employer versus the negotiation power of the employee, that is α versus $(1-\alpha)$, and the preference parameter of the employee for working in the official sector (β) versus working in the informal sector $(1-\beta)$. The left graph shows that a higher preference for working in the informal sector pushes nominal wages up at a given negotiation power, *ceteris paribus*, because a lower β increases the term $log\left\{1+\frac{\alpha(1-\beta)}{1-\alpha}\right\}$ which is represented at the vertical axis and equivalent to the third term in wage equation *(7)*. The right graph shows that at a given preference of the employee, *ceteris paribus*, a lower value attached to profits by the employer pushes nominal wages less up than a higher value. In this case unemployment and the replacement rate depress nominal wages less, as follows from the fourth term in wage equation *(7)* that also contains the factor $\frac{\alpha}{1-\alpha}$. Interesting is further the fact that a small β drives up wages fast as the employee's preference for working in the informal sector weakens the power of the employer, who therefore has to pay a higher nominal wage. In contrast, if β is close to one, there is hardly a difference in nominal wage increases between a low or a high negotiation power of the employer ($\alpha = 0.1$ or $\alpha = 0.9$), respectively.

While the wage bargaining equation *(7)* represents a long-term model equilibrium, our empirical analyses will include also short-term dynamics as the gross nominal wage may deviate from the equilibrium nominal wage in the short term. In the empirical analyses, we therefore estimate Error Correction Model (ECM) specified as

$$\Delta\, log\, W = \sum_{x_i \in \{P,P_c,q,R,t,u\}} \varphi_i log\, x_i + \vartheta\,(log\, W_{-1} - log\, W^*_{-1}) \qquad (8)$$

where $log\, W^*$ equals the non-linear equilibrium *(7)* at time *t-1* and $x_i \in \{P, P_c, q, t, u, R\}$. We call the parameters $\alpha, \beta, \gamma, \rho, \omega\ \upsilon$ and μ the deep parameters, that we aim to estimate in the empirical analysis, along with the adjustment speed parameter ϑ and the short-term effects φ_i's. The determinants in the wage equation, that is the producer price P, the consumer price P_c, the productivity q, the tax rate t, the unemployment rate u and the replacement rate R are observed at the national level.

In the empirical analyses, we also provide the contributions of these determinants to the nominal wage growth. Based on the wage equation *(7)*, we quantify the long-run model contributions of all determinants to the gross nominal wage growth in those analyses,

$$\Delta \log W^* = \sum_{xi \in \{P, P_C, q, R, t, u\}} \in_{x_i} \frac{\Delta x_i}{x_i}$$

where the elasticity of a determinant x_i is defined as

$$\in_{x_i} \stackrel{\text{def}}{\equiv} \frac{\partial \log W^*}{\partial \log x_i} \qquad (9)$$

or similarly, the multiplication by Δx_i instead of $\frac{\Delta x_i}{x_i}$ for the semi-elasticities of *t*, *u* and *R*. (see appendix A). Unlike most other models in the literature, all elasticities are time varying and the model thus explicitly takes downward wage rigidity into account and thereby allows for analysing wage flexibility.

4. ECONOMETRIC ESTIMATION RESULTS

The model is estimated with annual data over the sample period 1980-2010 for Germany and the United States. Although we have a longer full database for these countries, we prefer to align the samples and not to include the 1970s that were characterised by two oil crises en hence a high inflation period. Moreover, in view of the democratic developments in the other countries we stick to the period 1980-2010 or the longest times series available thereafter. In addition, as no consistent up-to-date information on nominal wages is available for Greece for the years 2009-10, we extrapolated these series.[10]

We estimate the wage equation as specified in equation *(8)*, by means of 2-Stage-Least-Squares (2-SLS). In order to correct for endogeneity between the gross nominal wage and the price variables P and P_c, we employ the instrument variable estimator. The instruments are the three and four year lagged exogenous variables. We follow Peeters and Den Reijer (2008), but have generalised the model by the introduction of three additional parameters. The non-linearity and thus interrelation of parameters has therefore become more complicated. Table 1 reports the estimation results. Before discussing the estimation results, we describe the road followed for obtaining starting values for the structural or deep parameters in the estimation strategy. We impose all non-linear restrictions according to *(7)* in the long-run relationship for each of the countries. However, we need suitable starting values for these seven parameters, as the high degree of non-linearity of these parameters can trap us into a local optimum. For this reason, we search the full grid of possible combinations of $\alpha, \beta, \gamma, \mu$ and υ making steps of 0.01, starting at 0.00 and ending at 1.00. In theory, these parameters should be in this range. We perform the search on the full grid for the maximum value of the objective function for each of the six equations. The productivity parameter and producer price parameter in the long run (ρ, ω), the adjustment parameter (ϑ) and the short run parameters (φ_i) for the first lag of nominal wages, productivity, prices, unemployment and the replacement rate are estimated freely, if possible . For each combination on this grid the sum of squared residuals (SSR) is calculated. After searching the full grid, we use the combination of these parameters that provides the smallest SSR,

[10] See appendix A of a description of the database of time series and the previous section for graphs.

along with the associated estimated other parameters, as the starting values in the estimation of the system of equations by 2-SLS.

The results in Table 1 reveal that the adjusted R^2 varies from 0.58 for Ireland to 0.92 for Portugal. The adjustment parameters of the long-run equilibrium are all significant. Further test statistics on autocorrelation in the residuals (the here presented *Q(2)*) as well as on normality of residuals do not reject the hypothesis of autocorrelation and normality at the 5%-level, respectively. Therefore, the overall estimation results are satisfactory. The productivity parameters for Germany, Ireland, Portugal and the US were insignificantly different from 1, so they were fixed at 1. Most of the other parameter estimates in the long run relationship differ across countries. These differences become more apparent when studying the elasticities and nominal wage contributions.

Table 1 Two-Stage-Least-Squares estimation results of the wage bargaining model

	Germany	Greece	Ireland	Portugal	Spain	US
Long-run parameter estimates						
α	0.68	0.82	0.83	0.74	0.88	0.68
β	0.84	0.89	0.77	0.85	0.89	0.89
γ	0.33	0.92	0.93	0.90	0.99	0.59
ρ	1.00	0.11	1.00	1.00	0	1.00
ω	0.10	0.71	0.24	1.00	0.13[11]	1.00
μ	0.99	0.22	0.51	0.69	0.99	0.51
υ	0.99	0.14	0.51	0.11	0.20	0.61
ϑ	-0.20 *(-4.05)*	-0.11 *(-6.14)*	-0.07 *(-2.38)*	-0.35 *(-9.09)*	-0.06 *(-4.00)*	-0.12 *(-1.97)*
Short-run parameter estimates						
$\Delta \log W_{-1}$	0.33 *(3.59)*		0.46 *(3.71)*		0.34 *(2.19)*	
$\Delta \log q$				0.78 *(3.42)*		
$\Delta \log P_c$						0.45 *(3.70)*
$constant$	0.04 *(6.47)*	0.14 *(12.8)*	0.04 *(3.61)*	0.13 *(8.78)*	0.06 *(3.76)*	0.04 *(4.95)*
R^2_{adj}	0.77	0.59	0.58	0.92	0.89	0.77
Sample period	1980-10	1988-10	1981-10	1991-10	1980-10	1980-10
Standard error*100	1.02	3.16	2.47	1.47	1.41	0.87
p-value Q(2)	0.15	0.38	0.07	0.33	0.32	0.05
p-value J-Bera	0.31	0.25	0.37	0.79	0.62	0.88
Instruments	13	13	13	13	13	13

Note: These are the estimates of equation *(8)* with the long-run relationship as specified in equation *(7)*. Instruments used are three and four years lagged exogenous variables (of the country under consideration but also from Germany or the US). Q(2) is the statistic for third-order autocorrelation. The figures in brackets are HAC *t*-statistics. Insignificant parameters are set to 0 and ρ's and ω's insignificantly different from *1* are imposed to be *1*. A dummy for Germany is included to capture the change due to the unification in 1990.

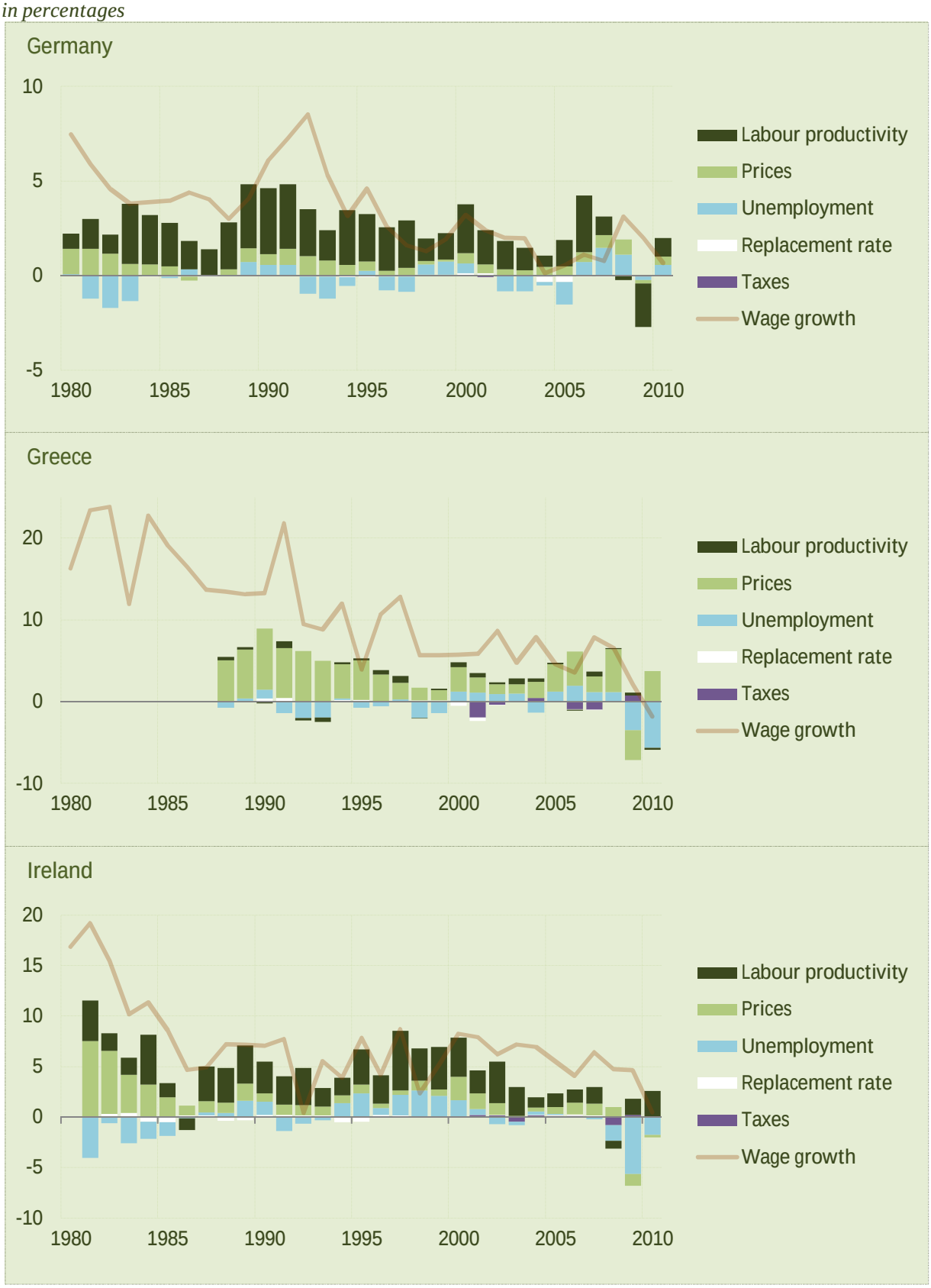
[11] As pointed out by a referee, the value for this parameter is remarkably low given that Spain is the only country in the sample with automatic wage indexation. See Peeters & den Reijer (2008) for related estimation results with indexation (υ=ω=1).

5. WAGE FLEXIBILITY AND PRODUCTIVITY GROWTH

Based on the estimated model, Figure 4 shows the contributions of the determinants to the nominal wages. While the first decade of the 21st century and the 1990s were marked by much lower inflation than the 1980s, inflation was in most countries still a main contributor to nominal wage growth due to price indexation. The reduction in unemployment however pushed up nominal wages until the global recession started. In Germany, Portugal, the United States, and in particular in Spain, unemployment played a major role in the wage formation processes. For Germany, Ireland, Spain and the US these results corroborate earlier findings (see Peeters and den Reijer (2008).

Our focus is however on productivity, which played a prominent role in Germany, Ireland, Portugal and the United States. Interesting is in this respect the case of Ireland. While productivity growth contributed positively to nominal wage growth in most years, apart from the recession years, other factors (prices, unemployment) drove nominal wage growth down. Vice versa, the same holds. In years where productivity went down, other factors (prices, unemployment) pushed nominal wages upward. There is however a large residual part that we cannot explain. Figure 5 illustrates the relative impact of productivity, unemployment, prices and other factors. It follows that productivity explains nominal wage growth for 40% in the period 1998-2010. Germany ranks highest in this respect. In Ireland and the US productivity only explained 32% and 28% of nominal wage growth, respectively, while this was much less for Portugal (18%), Spain (8%) and Greece (5%). Developments in German productivity thus significantly and largely influenced German nominal wages. Nonetheless, developments in unemployment and prices counted in this period for 19% and 12%. The remainder of 30% is unexplained. As follows further, in Spain the main nominal wage determinant was unemployment (even at 42%). Prices counted most in Portugal, Greece and the US, for more than 35%. Positive inflation and low unemployment are important determinants that tend to push up nominal wages. These factors may have been driving up nominal wages in times of low productivity growth. High inflation and low productivity occurred occasionally in Germany, Portugal, Greece and Ireland in the decade 2000-10. From the data also follows that Germany, Portugal, and Greece ran into situations where productivity growth fell below zero, while unemployment decreased which may have put upward pressure on nominal wages.

Figure 4 Contributions to nominal wage growth based on the wage bargaining model
in percentages



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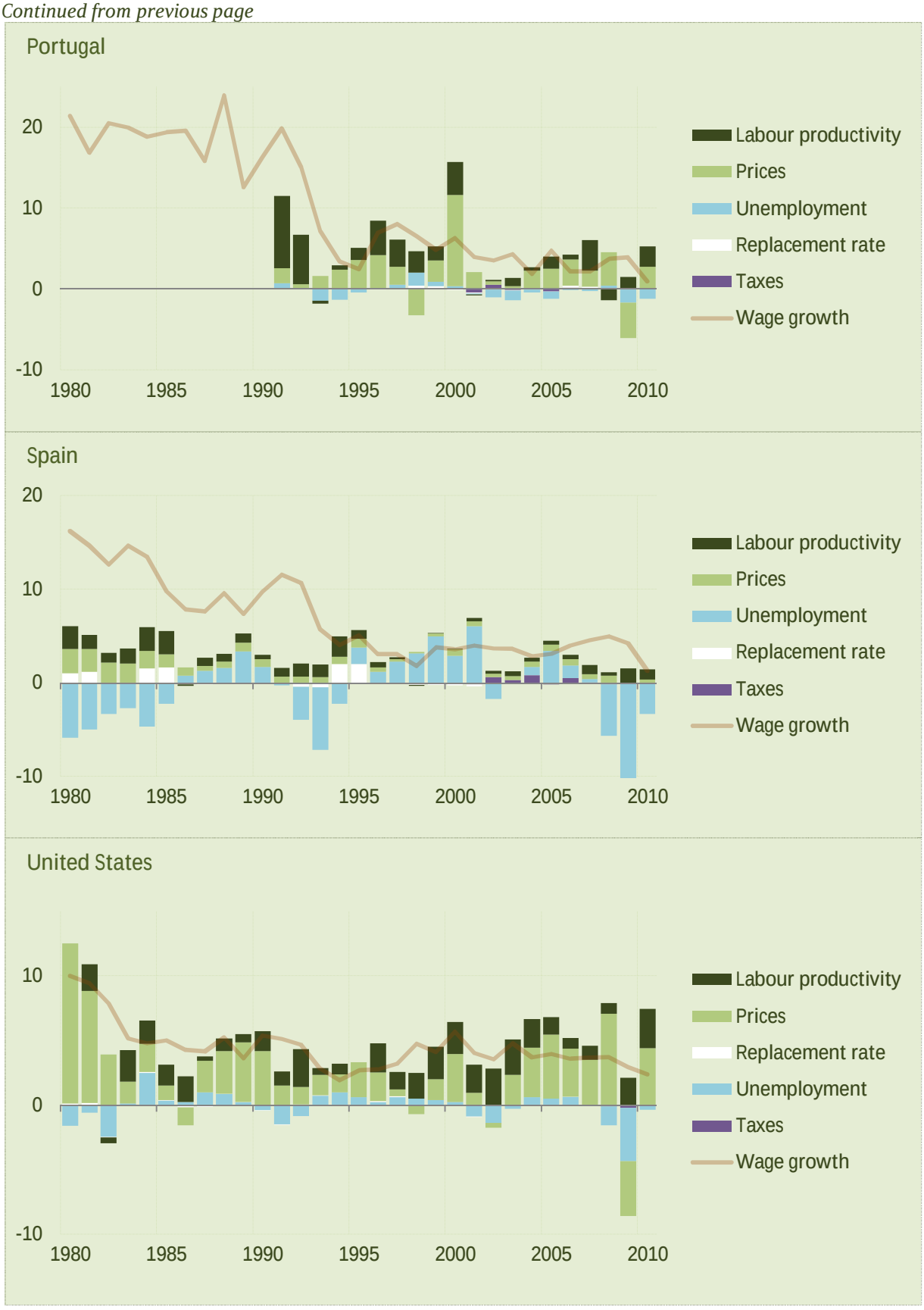
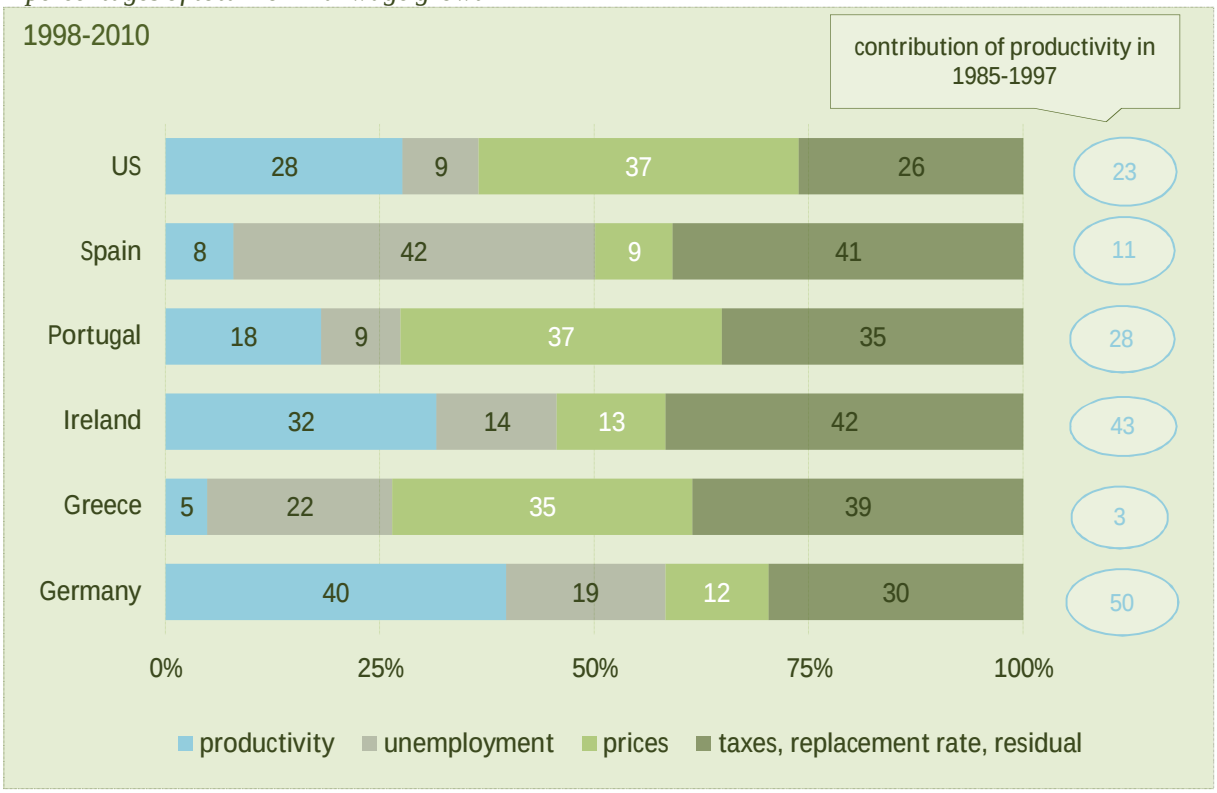


Source: Own calculations based on the econometrically estimated wage bargaining model (see Table 1).

Figure 5 Explanatory power of productivity, prices and unemployment
in percentages of total nominal wage growth



Source: Own calculations.
Note: For each country and each year we calculated the absolute value of the contribution of productivity (see figure 4) as a percentage of the sum of the absolute value of the contributions of productivity, of prices, of unemployment and of the residual. We calculate the latter as the nominal wage growth minus the contributions of productivity, prices, and unemployment. This graph illustrates the simple averages during the 13 years periods mentioned (from 1998-2010 and 1985-1997).

High nominal wage growth accompanied with low productivity growth, and consequently high unit labour costs, potentially cause real exchange rate misalignment. To investigate this further, we focus on years where low productivity growth did not drive nominal wage growth down in each of the countries under investigation. We are interested to find out what was hampering the flexibility of nominal wage growth to adjust downwardly. The extent to which price inflation and the change in unemployment put upward pressure on nominal wages in times of low productivity growth depends on their nominal wage elasticities. We therefore investigate, based on the elasticities computed from the estimated wage bargaining model, the distributions of the contributions of prices and unemployment to nominal wage growth considering the whole sample period. Figure 6 presents the results. It marks the situations where nominal wage growth did not exceed productivity growth by

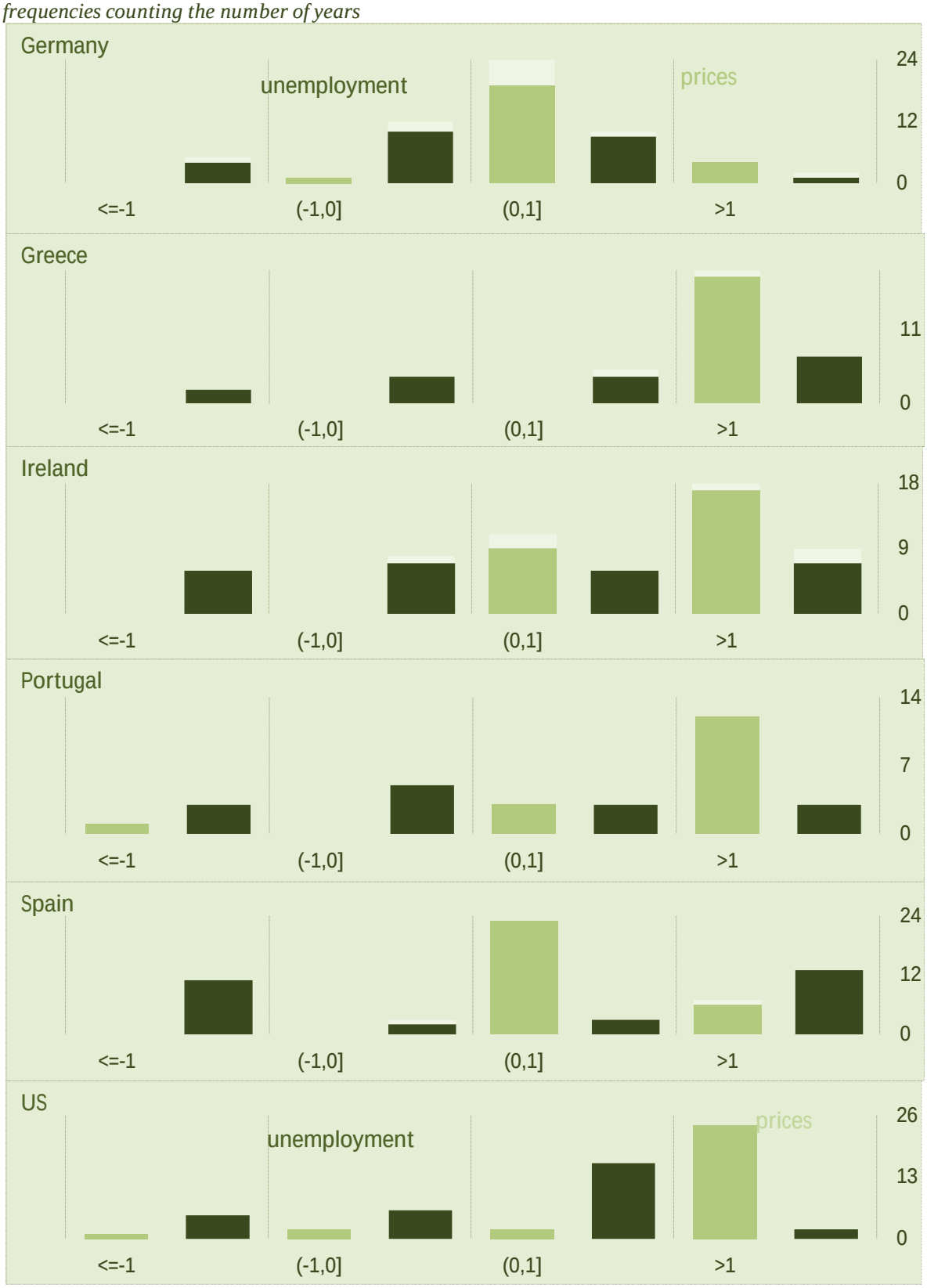
white parts. All other cases are of interest to us here, as nominal wage growth was too high in comparison with labour productivity (not in agreement with the Euro-Plus Pact). The distribution is in frequencies, so for Spain for instance, there were twelve years in which nominal wages dropped more than 1% due to unemployment and there were thirteen years in which unemployment pushed up nominal wages by more than 1%.

Figure 6 shows that the distribution of the contribution of prices is skewed to the left (implying peaks to the right) in Germany, Greece, Ireland, Portugal, Spain and the US. In many years, inflation pushed up nominal wages more than 1 percent. For the Greece, Ireland, Portugal (apart from one year), Spain and Germany, there are no downward adjustments in nominal wages due to prices, pointing at downward price rigidities. In contrast, the distribution of the unemployment contributions is more symmetric, implying that changes in unemployment not only pushed nominal wage growth upward but also downward. The degree of flexibility of nominal wages to changes in unemployment was thus relatively high.

We draw two lessons here. First, both prices and unemployment have been driving up nominal wages in times of low productivity and prices did this even more often than unemployment. Second, downward price rigidities exist in Greece, Ireland, Portugal and Spain but also in Germany. Especially in Greece, apart from some rare exceptions, nominal wages even *only* moved upwardly. This downward rigidity of nominal wages is thus likely to hamper swift falls in nominal wages, also in times of low productivity.

This downward rigidity in nominal wages, as it concerns the nominal wage responsiveness to changes in consumer price inflation and unemployment enters the wage bargaining model via the replacement rate. The relatively generous unemployment benefits drive up nominal wages, as the employee wants to have a higher nominal wage to obtain enough utility (see equation *(1)*). At the same time, the employer is willing to pay this nominal wage, in particular when the labour market is tight or consumer prices are high (as follows from equation *(7)*). A direct policy instrument to influence the wage formation is therefore the unemployment benefit, being the nominator of the replacement rate.

Figure 6 Distribution of nominal wage contributions of prices and unemployment
frequencies counting the number of years



Source: Own calculations based on nominal wage contributions.
Note: White cases mark where nominal wage growth did not exceed productivity growth and consequently unit labour costs fell. Recession years 2009-2010 are not included.

Table 2 shows that the growth rate of the estimated reservation wage (see equation *(4)*) has been lagging somewhat behind the growth rate of the nominal wages during the decade 2000-2007 in Ireland, Portugal and the US, though it has kept good pace with the nominal wage growth. Irish reservation wages grew 5.8%, only 0.4%-points lower than nominal wages. In the other countries, the reservation wage has followed the nominal wage growth even more closely. In Greece and Spain, the reservation wage grew as fast as nominal wages (with 7.4 and 3.2%-points, respectively). The role of the reservation wage is in this respect interesting, in particular for Portugal and Spain, but also Ireland, as these economies record the highest replacement rates (at 41.1, 36.1 and 33.0%, see Table 2) of this group of economies. In Portugal and Ireland, the reservation wage has even increased 5%-points in comparison with a decade ago. This contrast sharply with other countries, such as Germany and Greece as they have brought their replacement rates down during this period.

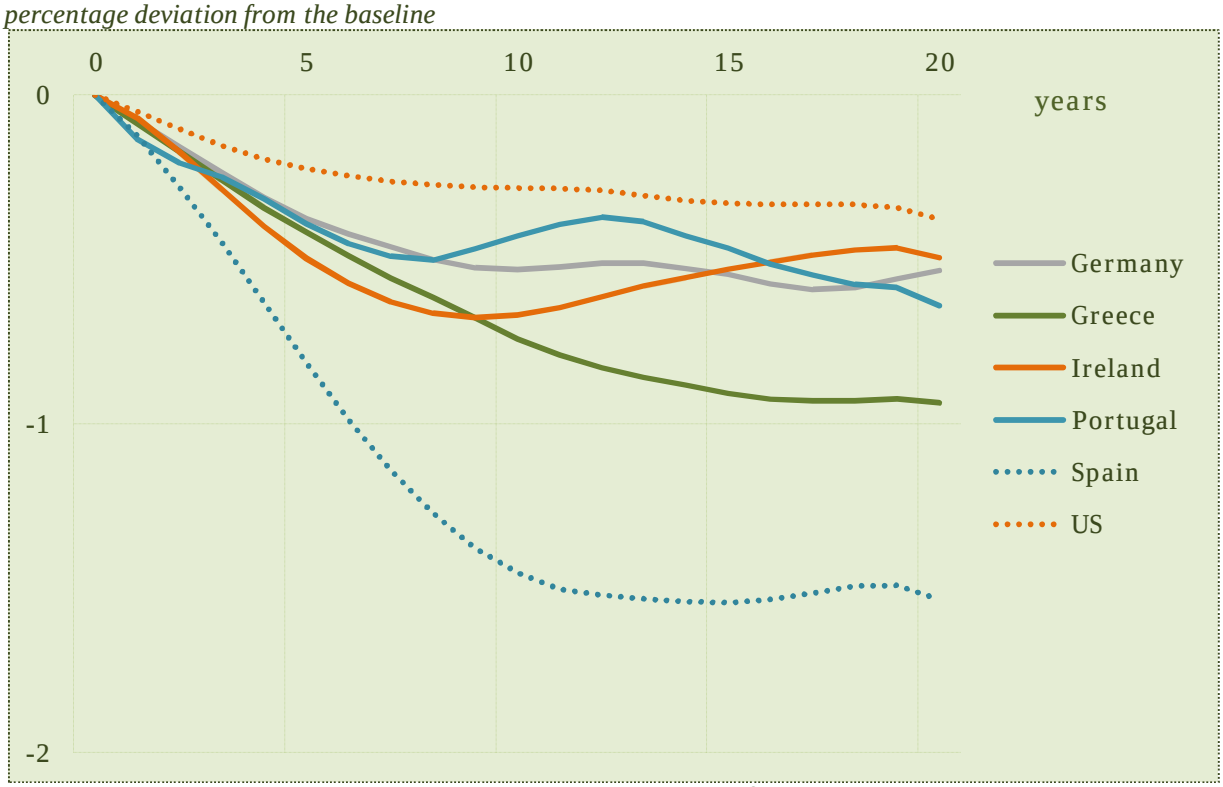
To explain this feature of the model, we analyse the impact of a 5%-point reduction of the replacement rate on nominal wages with our estimated wage bargaining model (see Table 1). We do this for each of the countries in order to be able to make a comparison of the effects. Figure 7 shows the result.

Table 2 Actual replacement and unemployment rates 1981-2010

	Germany	Greece	Ireland	Portugal	Spain	US
Nominal wage growth and reservation wage growth 2000-2008						
after tax nominal wage ($W^*(1-t)$)	1.9	7.4	6.4	3.7	3.2	4.3
reservation wage ($W_{reservation}$)	2.1	7.4	5.8	3.2	3.2	4.0
difference	*-0.2*	*0.0*	*0.6*	*0.5*	*0.0*	*0.3*
Average actual replacement rate, in percentages						
1981-90	23.6	5.7	24.3	16.7	26.3	11.0
1991-00	27.1	14.6	28.9	36.9	36.1	12.5
2001-07	26.6	13.0	33.0	41.1	36.1	13.6
Average actual unemployment, in percentages						
1981-90	7.1	7.1	14.6	7.3	18.3	7.1
1991-00	8.1	10.1	11.2	5.5	19.5	5.6
2001-10	8.8	9.8	6.3	7.4	12.0	6.1

Source: Own calculations and OECD, see appendix B.
Note: We calculate the reservation wage according to equation *(4)*, where we use the estimated parameters β, γ, μ and υ as reported in Table 1. The reported figures are simple averages of the annual growth rates.

Figure 7 Nominal wage responses to 5%-point lower replacement rates according to the ECM
percentage deviation from the baseline



Source: Own calculations based on the wage bargaining model estimates of Table 1.
Note: At time 0 the replacement rate decreases 5%-points in comparison with the baseline in each country and is kept at that level for the rest of the period (20 years) and the figure presents the nominal wage response according to the Error-Correction-Model equation (8).

Table 3 Long-term nominal wage response to productivity, prices, unemployment and the replacement rate
percentage deviation from the baseline

	Germany	Greece	Ireland	Portugal	Spain	US
decrease in productivity of 1%						
minimum	-1.00	-0.14	-0.71	-0.87	-0.47	-0.90
maximum	-1.00	-0.16	-0.74	-0.93	-0.59	-0.93
decrease in prices of 1%						
minimum	-0.24	-0.45	-0.39	-0.62	-0.16	-0.92
maximum	-0.29	-0.56	-0.40	-0.80	-0.17	-0.94
increase in unemployment by 1%-point						
minimum	-0.87	-1.76	-0.97	-0.87	-1.46	-1.18
maximum	-0.95	-2.11	-1.19	-1.13	-1.94	-1.27
decrease in replacement rate by 5%-points						
minimum	-0.35	-0.81	-0.33	-0.33	-1.26	-0.29
maximum	-0.66	-1.31	-1.23	-0.84	-2.79	-0.65

Source: Own calculations based on the estimated wage bargaining model (see Table 1). Note: These estimates are the minimum and maximum of the computed elasticities over the sample periods 1980-2010.

It follows that the impact across the countries varies from a decrease in nominal wages of 0.5% to even 1.5% in the longer run. For Portugal and Ireland, for instance, their nominal wages would have been 0.5% lower in case they would have had replacement rates of 31.1 and 28%, respectively. This effect would already have materialised in 5 years. The effects for Spain are much bigger. Already in 5 years, nominal wages would have been 0.8% lower than in the baseline and after 10 years even 1.5%. The reason that the same policy measure works out differently for the economies comes from the non-linear character of the wage equation that we use and the differences in the estimated employees' preference parameters (see *(7)*). Lowering the unemployment benefits in a country with a relatively high unemployment, as in Spain, depresses nominal wages more than other countries. Spain recorded 12.1% unemployment in 2000-10, while Portugal and Ireland recorded respectively 7.4% and 6.3% in this period. Reducing replacement rate is thus an effective means for moderating nominal wages and it can help counteracting the upward nominal wage pressure from other determinants.

Table 3 presents the long-term nominal wage effects of a 5% decrease in the replacement rate (see last lines) along with the effect on nominal wages of changes in productivity, prices and unemployment. We present the minimum and maximum of the sample period as these elasticities vary due to the non-linear character of the model. As follows, the range between the minimum and maximum is sometimes quite big. For instance, a decrease of 5%-points in the replacement rate for Portugal (for example from 41% to 36%, see also Table 2) could have led to a fall in the Portuguese nominal wage in the long-term ranging from 0.33% to 0.84%. Its effect depends on the timing and in particular on the level of unemployment in Portugal. Comparing the sizes of the nominal wage responses across the determinants shows that the replacement rate is a powerful instrument. In Spain, a 5% decrease in the replacement rate could have affected nominal wages much more than a 1% decrease in productivity, a 1% decrease in prices and it is even larger than a 1%-point increase in unemployment. In case we assume that the future nominal wage formation in these countries continues as it happened in the past, these estimated long-term nominal wage responses can be used as a guide for policy makers.

6. SUMMARY AND CONCLUSION

In most developed countries, the settlement of nominal wages is a complicated process that is not describable in terms of linear equations. Not only labour productivity growth determines nominal wage growth, the stance of the business cycle, the negotiation power of the employees in relation to employers, fiscal and social security measures but also price developments are important determinants. This paper adopts a wage bargaining model, with the feature of asymmetric and time-varying elasticities of productivity, prices, unemployment and replacement rates. Based on its econometric estimates, we are able to compute the contributions of the different determinants of nominal wages for Germany, the EU-periphery countries Greece, Ireland, Portugal and Spain and the United States. We cover almost the full three decades, 1980-2010 for most of these economies. The empirical analysis shows that Greece, Ireland, Portugal and Spain are far from aligning nominal wage growth with productivity growth. Increases in unemployment and price inflation put upward pressure on nominal wages, even in times of low productivity. While increases in unemployment sometimes pushed nominal wages down, this hardly ever occurred for prices. Even though also Germany exhibits downward nominal wage rigidities, productivity growth is with 40% the main contributor to nominal wage growth.

The Euro-Plus Pact aims to ensure that nominal wage growth in a monetary union is conducive for competitiveness by requiring a coordination of wages such that nominal unit labour costs remain constant. One policy instrument to influence the wage bargaining process consists of the replacement rate. A 5%-point reduction in the replacement rate would decrease nominal wages in the range of 0.5% - 1.5% in the longer run.

APPENDIX A. DERIVATION OF THE WAGE EQUATION, THE WAGE ELASTICITIES AND THE WAGE CONTRIBUTIONS

Ai) Derivation of the wage equation

Substitution of (2) and (3) in the objective function (1) gives

$$\Phi = (Pq^{\rho} - W)^{\alpha}\,(W - T(W) - W_{reservation})^{1-\alpha}$$

where $T(W)$ is the tax paid by the employee as a function of W, and differentiate with respect to W:

$$\frac{\partial \Phi}{\partial W} = -\alpha(P^{\omega}q^{\rho} - W)^{\alpha-1}(W - T(W) - W_{reservation})^{1-\alpha}$$

$$+ (P^{\omega}q^{\rho} - W)^{\alpha}(1-\alpha)(W - T(W) - W_{reservation})^{-\alpha}\left(1 - \frac{\partial t}{\partial W}\right) = 0 \;\Leftrightarrow$$

$$-\alpha\,(W - T(W) - W_{reservation}) + (P^{\omega}q^{\rho} - W)(1-\alpha)(1-t_m) = 0 \;\Rightarrow$$

$$W\left\{\alpha\frac{1-t}{1-t_m} + (1-\alpha)\right\} = (1-\alpha)P^{\omega}q^{\rho} + \frac{\alpha}{1-t_m}W_{reservation} \qquad (A1)$$

where $t_m \overset{\text{def}}{\equiv} \frac{\partial T}{\partial W}$ and $W - T(W) = W(1-t)$.

Substitution of *(4)* and *(5)* in *(3)* gives

$$W_{reservation} = W(1-t)\beta[1 - u(1-R)] + (1-\beta)P_c^{v}(\gamma q)^{\mu} \;\ldots\ldots \qquad (A2)$$

Substitution of (A2) into (A1) gives

$$W\left\{\alpha\frac{1-t}{1-t_m} + (1-\alpha)\right\} = (1-\alpha)P^{\omega}q^{\rho} + \frac{\alpha}{1-t_m}\{W(1-t)\beta[1-u(1-R)] + (1-\beta)P_c^{v}(\gamma q)^{\mu}\} \;\Leftrightarrow$$

$$W\left\{1+\frac{\alpha}{1-\alpha}*\frac{1-t}{1-t_m}\left[1-\beta\left(1-u(1-R)\right)\right]\right\} = P^{\omega}q^{\rho}+\frac{\alpha(1-\beta)}{1-\alpha}*\frac{P_c^{v}(\gamma q)^{\mu}}{1-t_m} \Leftrightarrow$$

$$\log W = \omega \log P + \rho \log q + \log\left\{1+\frac{\alpha(1-\beta)\gamma^{\mu}}{(1-\alpha)}*\frac{P_c^{v}q^{\mu-\rho}}{P^{\omega}(1-t_m)}\right\}$$

$$-\log\left\{1+\frac{\alpha}{1-\alpha}*\frac{1-t}{1-t_m}\left[1-\beta\left(1-u(1-R)\right)\right]\right\}$$

This equals (7) where $t = t_m$ is imposed.[12]

[12] The lack of consistent time series on marginal tax rates across countries forces us to make this restriction. We leave analyzing the marginal and average tax impact on wages to future research.

Aii) Derivation of the nominal wage elasticities

Based on the long-run wage equation the elasticity of nominal wages with respect to productivity, producer and consumer prices, and the *semi*-elasticities of nominal wages with respect to unemployment and the replacement rate are respectively as follows.

$$\in_q \stackrel{\text{def}}{=} \frac{\partial \log W}{\partial \log q} = \rho + \frac{Y}{X} * \frac{P_c^{\upsilon}(\mu - \rho) q^{\mu-\rho}}{P^{\omega}} \tag{A3}$$

$$\in_P \stackrel{\text{def}}{=} \frac{\partial \log W}{\partial \log P} = \omega - \omega \frac{Y}{X} * \frac{P_c^{\upsilon} q^{\mu-\rho}}{P^{\omega}} \tag{A4}$$

$$\in_{P_c} \stackrel{\text{def}}{=} \frac{\partial \log W}{\partial \log P_c} = \upsilon \frac{Y}{X} * \frac{P_c^{\upsilon} q^{\mu-\rho}}{P^{\omega}} \tag{A5}$$

with

$$X \stackrel{\text{def}}{=} 1 + \frac{\alpha(1-\beta)\gamma^{\mu}}{(1-\alpha)(1-t)} * \frac{P_c^{\upsilon} q^{\mu-\rho}}{P^{\omega}}$$

and

$$Y \stackrel{\text{def}}{=} \frac{\alpha(1-\beta)\gamma^{\mu}}{(1-\alpha)(1-t)}$$

$$\in_u \stackrel{\text{def}}{=} \frac{\partial \log W}{\partial u} = -\frac{\alpha}{1-\alpha} \frac{\beta(1-R)}{1+Z} < 0 \tag{A6}$$

and

$$\in_R \stackrel{\text{def}}{=} \frac{\partial \log W}{\partial R} = \frac{\alpha}{1-\alpha} \frac{\beta\, u}{1+Z} > 0 \tag{A7}$$

where

$$Z \stackrel{\text{def}}{=} \frac{\alpha}{1-\alpha}\big[1 - \beta\big(1 - u(1-R)\big)\big].$$

All elasticities are time varying, unless specific parameter restrictions hold. For instance, the productivity elasticity *(A2)* will be non-time varying in case $\rho = \mu$, implying that the final output of labour at work (sold products) is as high as the final output of labour at home. In this case:

$$\in_q \stackrel{\text{def}}{=} \frac{\partial \log W}{\partial \log q} = \rho$$

Price homogeneity holds in case $\omega = \upsilon$, implying that the costs saved by one unity of household work equals the price that the employer earns for one unity of products sold. In this case:

$$\in_P + \in_{P_c} = \frac{\partial \log W}{\partial \log P} + \frac{\partial \log W}{\partial \log P_c} = \omega$$

Aiii) Derivation of the nominal wage contributions

It holds that the differential wage equation approximates the sum of the nominal wage contributions, that is

$$d\,log\,W \stackrel{\text{def}}{=} \sum_{x_i \in \{P, P_C, q, t, u, R\}} \frac{\partial\, log\, W}{\partial\, log\, x_i} \frac{\partial x_i}{x_i} \quad \stackrel{\Delta}{\rightarrow} \quad \Delta\, log\, W \;=\; \sum_{x_i \in \{P, P_C, q, t, u, R\}} \in_{x_i} \frac{\Delta x_i}{x_i}$$

where in case of semi-elasticities (for *t*, *u* and *R*) multiplication by Δx_i instead of $\frac{\Delta x_i}{x_i}$ takes place.

Figure 4 illustrates the five individual contributions according to the estimated wage equations for each individual country in our analysis.

APPENDIX B. DATA SOURCES

The time series used in our analyses are annual and come from the Organisation for Economic Co-operation and Development (OECD, Paris, see http://stats.oecd.org) and the KLEM- and AMECO-databases of DG Economics and Financial Affairs (European Commission, Brussels, see http://www.euklems.net and http://ec.europa.eu/economy_finance/ameco). They range from 1970 to 2010 for Germany and the United States. The data range for Greece from 1983 to 2010, for Ireland from 1977 to 2010, for Portugal from 1986 to 2010, for Spain from 1975 to 2010.

Nominal wages (*W*) are gross, per hour worked for the whole economy in the domestic currency. For the years 1970-2007 they come from the KLEM database (variable LAB_AVG). As these series stop in 2007 (in 2006 for Portugal), we use the gross hourly earnings growth rates of the private sector from the OECD for extrapolating the years up to 2010, except for Ireland and Greece. For Ireland, we use the hourly nominal wages of the manufacturing sector because the private sector data are not available for these years.

Remarkably, the OECD has no hourly wage data for Greece. We therefore use the best alternative, being the Greek compensation for the whole economy from the AMECO database from the European Commission and we divide these by the number of hours worked per Greek employee.

Labour productivity (*q*) is real growth per hour from the OECD database. We construct an index from these growth rates (1970=100). For those economies for which there is not yet a realisation for 2010, we use the projection from the Economic Outlook December 2010. The productivity series for Portugal only exists from 1986 onwards.

Producer prices (*P*) are the total manufacturing producer prices for Ireland and the United States and the domestic manufacturing producer prices for the other countries. All these series are part of the main economic indicators from the OECD. For Portugal, these only exist from 1990 onwards. We use the gross output price index from the KLEM database to estimate the prices for 1986-1989 for Portugal

to construct a longer series. This hardly affects our analyses as we use lags for the variables in the econometric estimations.

Consumer prices (P_c) come from the main economic indicators from the OECD.

Unemployment (u) is the harmonised unemployment rate from the macroeconomic indicators of the OECD.

The gross replacement rates (*RPR*) are two-year annual series from *Benefits and wages: OECD Indicators*, from the OECD (2007). We interpolated the data for the missing years by using the information for two adjacent years. For each country, we keep the rate for the years after 2008 constant at the rate of 2007.

Tax and social contributions (t and tm) are annual data from 2000 onwards from the OECD, while data before 2000 come from EUROMON (see Demertzis *et al*. 2006).

Our databases and estimation programmes are available upon request.

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