The wage inflation-unemployment curve at the macroeconomic level

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Abstract

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1 Introduction

The most popular approach to capture the way in which unemployment and other real disturbances affect wages is the ubiquitous Phillips Curve. This empirical and macroeconomic proposition suggests a stable relationship between unemployment and nominal wage growth, with higher unemployment restraining wage changes. However, the original relationship and the empirical applications that followed are usually criticized for lacking any microeconomic theoretical foundation, except the principle that "when demand for labour is high and there are very few unemployed we should expect employers to bid wage rates up quite rapidly" (Phillips (1958)).

Recently, this debate has been revisited with Gali (2011) and Gali, Smets, and Wouters (2011) providing plausible theoretical foundations to the dynamic relation between wage inflation and unemployment. Indeed, by reformulating the New Keynesian (NK) wage equation, Gali (2011) introduces unemployment to an otherwise standard NK model with staggered wage setting. Their reformulation has the advantage of the observability of the associated driving force (i.e. the unemployment rate), which contrasts with the unobservability of the wage markup or the output gap, which are the driving forces in typical NK models. Under some assumptions, the proposed relation takes a form similar to the empirical applications of the Phillips curve. Nonetheless, contrary to the purely empirical proposition, the so-called New Keynesian Wage Phillips Curve (NKWPC) is a microfounded structural relation between wage inflation and unemployment, with coefficients that are functions of parameters that have a structural interpretation. In particular, the slope of the curve is decreasing in the degree of wage rigidity. In the limit, when wage rigidity approaches zero, i.e. the case of full flexibility, the curve becomes vertical (Gali (2011)).

Based on this framework, we add to the literature by estimating reduced form equations of the NKWPC. By doing so, we provide estimates of the slope of the implied wage inflation-unemployment curve (given expected wage inflation) for several advanced countries over the 1985q1-2014q3 period. To our knowledge, our investigation is the first attempt to provide measures of wage rigidity at the macroeconomic level for several countries. This is an important contribution given the importance of wage rigidity not only for the validity of several theoretical models but also given its perceived role as a factor of macroeconomic stability.

Indeed, measuring wage rigidity is important for several reasons. First, The New Keynesian Phillips curve, which has quickly become the principal workhorse model in monetary economics, is based on the optimizing behavior of price setters in the presence of nominal rigidities. Therefore, the existence of such "imperfections" has been pointed to by many authors as an aspect needed to account for a number of labor market characteristics. Furthermore, the introduction of real wage rigidities overcomes a well known empirical weakness of the standard NK model, namely, its lack of inflation inertia.[1] Second, rigidities and frictions in the labor market might be crucial for understanding sluggishness in firms' marginal cost and their price setting behavior. As such, rigidities have important implications for price competitiveness. Third, the presence of sufficiently flexible wages and prices is seen as a factor of macroeconomic stability, in particular in economies that have joined a currency union or adopted any other form of hard peg, for in those cases the exchange rate is no longer available as an adjustment mechanism.[2] Moreover, even in countries with flexible exchange rate systems, rigidity is believed to cause unemployment by limiting the adjustment of wages.

Albeit its importance, the empirical literature on wage rigidity at a macroeconomic level is very scarce. Indeed, most of the contributions are based on individual and firm level data. Some of this literature rests on the idea that wage rigidity can be estimated based on the assumption that there is a hypothetical distribution of wage changes that would prevail if there was no rigidity (notional distribution). Measures of wage rigidity can then be obtained from

[1] See, for instance, Hall (2005) and Blanchard and Gali (2007a).

[2] Wage rigidity was put forward as one of the explanations of high and persistent unemployment in Europe when compared to the US (Grubb, Jackman, and Layard (1983)).

the comparison of the notional and observed distribution as in Dickens et al. (2007) or Altonji and Devereux (1999). More recent contributions capture rigidity by looking at asymmetries in the wage change distribution.[3]

Even though vast, this literature has provided inconclusive results so far. The reported degree of downward wage rigidity varies not only across different approaches and countries but also between different datasets referring to the same country. Furthermore, much of the previously cited studies focus on the effect on the wage change distribution, whether the lower part of the distribution is compressed from below due to a nominal or real lower bound. Thus, by concentrating mainly on the shape of the distribution, this literature does not explore to what extent wages are affected by unemployment but only the effect on the shape of the distribution. Furthermore, micro studies derive wage rigidity from wage changes of individuals engaged in ongoing employment relationships. However, if there are high worker turnover rates, wage rigidity for job stayers may not translate into similar levels of rigidity at higher levels of aggregation. Measuring wage rigidity at the macroeconomic level is thus particularly acute.

In this paper, we go beyond the existing literature by analyzing the wage-unemployment relationship at the aggregate level. Together with estimating

[3]See Altonji and Devereux (1999) for the first type of studies and Dickens et al. (2007), Holden and Wulfsberg (2008), Holden and Wulfsberg (2009) or Messina et. al (2010) for the second case.

the reduced form NKWPC, we are able to provide measures of wage rigidity for our sample of countries. We pay special attention to European countries. Indeed, the European Monetary Union has brought to the fore traditional questions related to the Optimum Currency Area (OCA) theory. These questions concern the role played by relative price adjustment mechanisms and the difficulties due to asymmetric evolutions among member countries. As mentioned before, wage flexibility is proposed as a substitute to exchange rates adjustment, at least partially. Moreover, it is argued that the current situation in the euro area is mainly a current account deficit crisis and not only a public finance crisis (Wasmer (2012)). In this context, the euro area will need huge price and wage adjustments to ensure the stability of the Euro.

However, contrary to the classical logic, recent contributions suggest that the impact of wage rigidity actually depends on the monetary policy rule in place and notably the central bank's response to inflation. Thus, this literature questions the classical view that wage flexibility is particularly recommended in a currency union (see Gali (2013) and Gali and Monacelli (2014)). Moreover, during the recent crises and in a low and stable inflation environment, many observers have highlighted the risk of wage deflation and the stagnation of the economy, i.e. the experience of Japan between 1997 and 2003. In order to save their jobs, many workers accepted downward revisions of their salaries or benefits. This mechanism, which can be seen as judicious at the individual level, can prove disastrous when adopted at a large scale. In this context, downward rigidity of wages can be seen as a way to prevent deflationary spirals.

Our results point to a substantial differences in the nature of wage rigidities in our sample of countries. In particular, we detect countries with high and low real wage rigidity at the aggregate level and different degree of wage indexation. We also evidence that the inflation wage-unemployment relationship have exhibited profound shifts during our sample period. Indeed, our analysis reveals an indexation easying as disinflation took place in most of the countries. Moreover, wage rigidity have changed over time. Finally, we present evidence that wage rigidity is not linked to the labor institutional environment at the macroeconomic level.

The rest of the paper is organized as follows. Section 2 presents the model and the estimation methodology. Section 3 briefly describes the data set and display the results. Finally, section 4 concludes.

2 From Theory to Estimation

At the aggregate level, the relationship between wages and unemployment can be captured from the Phillips curve, that focuses on the relation between the growth of nominal wage and the unemployment rate. This traditional Phillips curve is seen as a simple ad hoc macroeconomic model without micro-founded relationships. In turn, Medium-scale New Keynesian Dynamic Stochastic General Equilibrium (DSGE) models, which are microfounded structures widely used by central banks and other policy institutions, lack of a reference to unemployment. This is unfortunate because unemployment is an important indicator of economic activity and a central focus of the policy debate (Gali, Smets, and Wouters (2011)).

However, recent contributions implant in the basic New Keynesian model various theories of unemployment based on the presence of labor market frictions. In particular, by reformulating the standard version of the NK wage equation in terms unemployment, Gali (2011) shows that the staggered wage setting model à la Calvo imply a dynamic relation between wage inflation and the unemployment rate. Under certain assumptions, the New Keynesian Wage Phillips Curve takes the same form as the original equation of Phillips. Furthermore, in the presence of wage indexation to past inflation, the resulting wage dynamics are consistent with a specification often used in applied work. This model, which allows for involuntary unemployment while preserving the convenience of the representative household paradigm, asserts the Phillips curve once more in the academic debate.

More in detail, Gali (2011) and Gali, Smets, and Wouters (2011) introduce a variant of the staggered wage setting model originally developed in Erceg, Henderson, and Levin (2000), where workers (or unions) supplying a labor service of a given type get to reset their nominal wage with probability $1 - \theta$ each period and a fraction of workers θ keeping their wage unchanged in any given period. The parameter θ, which follows the formalism of **?**, is then a natural index of nominal wage rigidity.

As in Erceg, Henderson, and Levin (2000), Gali (2011) derives the following baseline wage inflation equation:

$$\pi_t^w = \beta E_t\{\pi_{t+1}^w\} - \lambda(\mu_t - \mu) \tag{1}$$

where where π_t^w is wage inflation, μ_t denotes the average wage markup and μ is the desired level of μ_t. In Eq. 1, the parameter λ is defined as follows:

$$\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta(1+\epsilon\varphi)} \tag{2}$$

with θ denoting the index of wage rigidity (i.e. the Calvo wage rigidity parameter), β the usual utility discount factor, ϵ the (constant) wage elasticity of demand for the services of each labor type and φ is defined latter on.

As seen, Equation (1) implies that wage inflation is a forward looking variable, which depends positively on expected one period ahead wage inflation and negatively on the deviation of the average wage markup from its desired value. Solving Equation (1) forward, the baseline wage inflation equation in the NK framework is expressed as follows:

$$\pi_t^w = -\lambda \sum_{k=0}^{\infty} \beta^k E_t\{(\mu_{t+k} - \mu)\} \tag{3}$$

The previous Equation implies that wage inflation is proportional to the discounted sum of expected deviations of current and future average wage markups from their desired levels. Therefore, variations in wage inflation are driven by deviations of average wage markup from its natural level, because those deviations generate pressure on workers currently setting wages to adjust those wages in one direction or another.

The model can be further extended to allow for automatic indexation to price inflation of the wages that are not reoptimized in any given period. In that case and with the indexation rule, the following wage inflation equation can be derived:

$$\pi_t^w - \gamma\bar{\pi}_{t-1}^p = \alpha + \beta E_t\{\pi_{t+1}^w - \gamma\bar{\pi}_{t-1}^p\} - \lambda(\mu_t - \mu) \tag{4}$$

where $\bar{\pi}_t^p$ is the price inflation variable to which wages are indexed.

Now, since the wage markup is not directly observed in actual time series data, Gali (2011) replaces this variable with the unemployment rate by assuming that households find it optimal to participate in the labor market in period

t if and only if the real wage prevailing in his trade is above his disutility from working. Under this scenario, real wages depend positively on the aggregate participation rate.[4] Indeed, since unemployment is defined as the difference between the participation rate and employment, it is straightforward to find a simple linear relation between the wage markup, μ_t, and the unemployment rate, u_t:

$$\mu_t = \varphi u_t \tag{5}$$

where φ is the inverse Frisch labor supply elasticity.[5]

Finally, we can define the natural rate of unemployment as the rate of unemployment that would prevail in the absence of nominal wage rigidities. With a constant desired wage markup, u_t^n is then a linear function of the desired wage markup:

$$u^n = \frac{\mu}{\varphi} \tag{6}$$

By combining Equations (3), (4) and (5), we obtain the following augmented New Keynesian Wage Phillips curve (NKWPC):

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[4]See also Gali (1996) and Blanchard and Gali (2007b).

[5]The Frisch labor supply elasticity refers to the substitution effect associated with a change in the wage rate. It is the percent change in a person's labor supply in response to a change in the real wage, holding the marginal utility of consumption fixed.

$$\pi_t^w = \alpha + \gamma\bar{\pi}_{t-1}^p + \beta E_t\{\pi_{t+1}^w - \bar{\pi}_{t-1}^p\} - \lambda\varphi(u_t - u^n) \quad (7)$$

As in the original Phillips curve, the augmented NKWPC outlines the existence of an inverse relation between wage inflation and the unemployment rate. However, unlike the original Phillips curve, the NKWPC is a microfounded structural relation with coefficients that are functions of structural parameters. In particular, note that the slope of the curve (given expected wage inflation) is decreasing in the degree of wage rigidity θ (i.e. the proportion of workers changing wage each period, which is inversely related to λ).[6]In addition, expectations play an important role for wage setting in the NKWPC. Indeed, by solving (7) forward we obtain:

$$\pi_t^w = \alpha + \gamma\bar{\pi}_{t-1}^p - \lambda\varphi \sum_{k=0}^{\infty} \beta^k E_t\{(u_{t+k} - u^n)\} \quad (8)$$

which implies that wage inflation is a forward looking variable inversely related to the discounted sum of the current and future unemployment rates.

To derive a reduced form representation of the previous NKWP, Gali (2011) considers an exogenous and stationary AR(2) as follows:

$$\hat{u}_t = \phi_1\hat{u}_{t-1} + \phi_2\hat{u}_{t-2} + \epsilon_t \quad (9)$$

[6]This slope is also decreasing in the size of the Frisch labor supply elasticity which in inversely related to φ.

where $\hat{u}_t = u_t - u^n$. Combining (9) with the augmented NKWPC yields the following reduced form representation of the wage inflation equation:

$$\pi_t^w = \alpha + \gamma \bar{\pi}_{t-1}^p + \psi_0 \hat{u}_t + \psi_1 \hat{u}_{t-1} \tag{10}$$

where the parameters ψ_0 and ψ_1 are defined as:

$$\psi_0 \equiv -\frac{\lambda\varphi}{1 - \beta(\phi_1 + \beta\phi_2)}$$

$$\psi_1 \equiv -\frac{\lambda\varphi\beta\phi_2}{1 - \beta(\phi_1 + \beta\phi_2)}$$

It is important to remark that the previous reduced form equation holds if the cross-equation restriction $\psi_1 = \psi_0\beta\phi_2$ is verified. In this case, the wage inflation equation should have a negative coefficient on the current unemployment rate and a positive one on its lag, in addition to a positive coefficient on lagged price inflation in the presence of indexation. Within this context, the slope of the wage inflation equation corresponds to $\lambda\varphi$ in Equations (7) and (8) where $\lambda\varphi = -\psi_0(1 - \beta(\phi_1 + \beta\phi_2))$.

Note also that under certain conditions, the reduced form NKWPC takes the same form as the original equation of Phillips. Indeed, it is easy to verify that if the unemployment rate follows an AR(1) model such as:

$$\hat{u}_t = \phi_1 \hat{u}_{t-1} + \epsilon_t \tag{11}$$

Combining (11) with the augmented NKWPC gives the following reduced form equation for wage inflation:

$$\pi_t^w = \alpha + \gamma \bar{\pi}_{t-1}^p + \psi_0 \hat{u}_t \qquad (12)$$

where the parameter ψ_0 is defined as:

$$\psi_0 \equiv -\frac{\lambda\varphi}{1-\beta\phi_1}$$

In this particular case, $0 < \phi_1 < 1$ and $\psi_0 < 0$ must be verified.

Therefore, a successful application of Eq.(10) to data requires the following steps:

1. Define the suitable autoregressive process for the unemployment rate; in particular, the following properties must be verified in Eq (9): $\phi_1 > 1$ and $-1 < \phi_2 < 0$;

2. Test for the hypothesis $0 < \phi_1 + \phi_2 < 1$ in Eq (9), a requirement for stationarity;

3. Estimate the system formed by Equations (9) and (10) and verify that $\psi_0 < 0$, $\psi_1 > 0$ and $-(\psi_0 + \psi_1) > 0$;

4. Test the cross-equation restriction $\psi_1 = \psi_0\beta\phi_2$ in the previous system by OLS

5. Compute the implied estimates of the slope of the wage-unemployment curve and Calvo wage rigidity parameter, conditional on calibrated values for φ and ϵ. The Calvo wage rigidity parameter is obtained, conditional on calibrated values for β, φ and ϵ, by solving for θ in the expression of the parameter λ.[7] In this case, β and φ are set to 0.99 and 1, as it is usually the case in the literature, and ϵ is such that it is a value consistent with the average unemployment rate over the sample period considered.

3 Data Definition and Results

3.1 Data definition

We use quarterly data on unemployment rate, consumer price index (CPI) and hourly manufacturing wages from the OECD Economic Outlook Database for the 1985q1-2014q3 period. Wage and price inflation correspond to year-to-year change of the (log) wage and CPI, respectively. The countries covered are: Austria, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, the UK and the USA. Regarding our

[7] More precisely, the expression of ψ_0 allows us to calculate the parameter λ and solve for θ in the following equation: $1 - \theta(\beta + 1 + (1 + \epsilon\varphi)\lambda) + \beta\theta^2 = 0$.

measures of labour market rigidity, we consider the average Employment Protection Legislation (EPL) provided by the OECD for the 1985-2014 period. This index measures the strictness of employment protection for individual and collective dismissals and for regular contracts. The EPL index scores from 0 to 6 with higher values representing stricter regulation.

We also consider the adjusted bargaining coverage rate for the 1985-2011 period, provided by the Data Base on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts (ICTWSS) from the Amsterdam Institute for Advanced Labour Studies (University of Amsterdam). This indicator has the advantage of providing data on employees covered by wage bargaining agreements as a proportion of all wage and salary earners in employment with the right to bargaining (expressed as percentage), adjusted for the possibility that some sectors or occupations are excluded from the right to bargain (removing such groups from the employment count before dividing the number of covered employees over the total number of dependent workers in employment).

From the same source, we also used a wage bargaining coordination index, which is a categorical variable taking the value of 1 (fragmented bargaining, mostly at company level) to 5 (economy-wide bargaining, based on enforceable agreements between the central organizations of unions and employers affecting the entire economy or entire private sector, or on government imposition of a wage schedule, freeze, or ceiling). Our last indicator for labor market institution is the government intervention in the wage bargaining process, with the lowest value indicating that the government influences wage bargaining by providing an institutional framework of consultation and information exchange, etc. The higher value, on the contrary, implies that the government imposes private sector wage settlements, places a ceiling on bargaining outcomes or suspends bargaining.

3.2 Estimation results

Table 1 presents the system estimated coefficients of the reduced form NKWPC equations for the 1985q1-2014q3 period.[8] As mentioned before, conditional on lagged price inflation and with an AR(2) process for the unemployment rate, the reduced form wage inflation equation should have a negative coefficient on the current unemployment rate and a positive one on its first lag. Besides, this model involves the cross-equation restriction $\psi_1 = \psi_0.\beta.\phi_2$, which is tested conditional on values for β (set to 0.99). Conversely, with an AR(1) process for the unemployment rate, the equation becomes the traditional augmented Phillips curve.

[INSERT table 1]

[8] The system equations consists of two equations, the simple autoregressive process for the unemployment rate and the wage inflation equation.

As seen in the table 1, in Austria, Germany and the United States the autoregressive process for the unemployment rate is an AR(1). Moreover, ψ_0 and ψ_1 in Eq.(10) do not have the correct sign in Germany and the USA.[9] In the rest of countries the system is estimated with an AR(2) process, with any further lags of the unemployment rate not being significant.

Turning to the wage inflation equation, the results show that real wage rigidities, introduced through implicit indexation of wages to prices (γ in table 1), appear to be more relevant in Europe than in Japan or the United States. Indeed, while this coefficient is close to unity in Finland, Italy or Spain, wage indexation is bellow 0.3 in non European countries.

The results also show that the coefficients on the unemployment rate have the predicted signs.[10] Indeed, for most of the countries, the estimated coefficients are negative and significant for current unemployment (ψ_0) and positive for its first lag (ψ_1). Moreover, the conditions $-(\psi_0 + \psi_1) > 0$ and $0 < \phi_1 + \phi_2 < 1$ are both satisfied for all the countries which have an AR(2) process.[11][12]

[9] Muto and Shintani (2014) confirm this result for the case of the United States. In Austria, an AR(1) process for the unemployment rate results in a better fit than the AR(2).

[10] To have a better fit, in Ireland the price inflation variable is π^p_{t-4} instead of π^p_{t-1} as in the rest of the countries.

[11] Except for Finland, where $\psi_0 + \psi_1$ is not statistically significant.

[12] Since $\phi_1 < 1$ in Denmark, an AR(1) process would be also pertinent for this country. The results also indicate that the case of Germany should be taken with caution since ϕ_1 is higher than one in the AR1, implying that the process is not stationary.

As mentioned above, the slope of structural-form NKWPC is decreasing in the degree of wage rigidity, which is inversely related to λ. Also, it is decreasing in the size of the Frisch labor supply elasticity which is the inverse of φ. As can seen in Table 1, the slope of estimated NKWPC is substantial in Austria, Japan and Norway, implying a low nominal wage rigidity. Conversely, it is clearly flat, i.e the value of $\lambda\varphi$ is very small, in Spain, Ireland and, surprisingly, in the USA.

Table 1 also reports the point estimates for the Calvo parameter, θ, which are obtained by conditioning on calibrated values for β, φ and ϵ.[13] As the Calvo parameter is the fraction of workers keeping their wage unchanged in any given period, the higher this parameter, the higher the wage rigidity.

[INSERT table 2]

It is interesting to see that there are large divergences in the estimated wage rigidity parameter across countries –even among European countries– that is usually not considered in the theoretical literature.[14] Indeed, the Calvo parameter ranges from 0.14 (Japan) to 0.86 (Spain). The countries that appear

[13]Recall that φ, the inverse of Frisch labor supply, is set to 1 in the benchmark equation and ϵ is set to a value consistent with the average unemployment rate over the sample period estimated. We acknowledge that the value of φ is controversial. Therefore, we also calibrate the models for an inverse Frisch labor supply elasticity equal to 5 (see table 2). Regarding ϵ, it is obtained given the mean unemployment rate and the fact that $\epsilon = (1 - \exp\{-\varphi u^n\})^{-1}$.

[14]Most of the literature assumes a Calvo parameter of 0.75. For instance, **?** consider a Calvo parameter of about 0.75 for a φ equal to 5 for the Euro Area, which is higher than our estimated mean for these countries (0.61). Moreover, their assumed parameter does not take into account the important differences in terms of wage rigidity among European countries.

less rigid are Austria, Japan, Netherlands, Norway and Portugal.These results confirm the very low wage rigidity in Japan, at least when compared to the United States and to the majority of the European countries (see for instance, Muto and Shintani (2014)). Indeed, it is well know that in Japan, labour market adjustments take place through wage variations rather than in the employment for the "core workers". Given that national wages are indexed to wages of these workers, we observe flexibility at the aggregate level. Under this scenario, an important implication of this flexibility is that periods of deflation cannot be mitigated by the rigidity of nominal wages in this country.

A second group of European countries (Sweden, France, Denmark and Finland) is in an intermediate position, with a parameter ranging from 0.54 (France) to 0.63 (Denmark). Finally, the USA is among the countries with higher wage rigidity, with a Calvo parameter equal to 0.74.[15] Surprisingly, wage rigidity in the USA appears to be much higher than in many European countries, even if the labor market in the USA is considered to be much more flexible. For instance, our results suggest that wages in France are less rigid than in the USA, even though labor market institutions in the first country are stronger than in the USA. This result confirms previous studies on macroeconomic wage curves that conclude that the United States in no more flexible than some European countries (see for instance Heyer, Reynes, and Sterdy-

[15]Our estimated parameter is similar to the 0.79 in Gali (2011) for the 1964-2010 period.

niak (2007)). Thus, the link between institutions and wages rigidity is not straightforward at the macroeconomic level.

In the context of the Euro, an internal devaluation mechanism (through relative price adjustment) may be a substitute to an external devaluation. In particular, wage flexibility is often proposed as a substitute to exchange rates adjustments, at least partially to ensure stability of the euro zone. However, the Calvo parameter appears very high in Spain and Italy, implying a substantial rigidity of nominal wages, strengthening adjustment problems in the Monetary Union.

With this in mind, we analyzed if wage rigidity can be explained by the labour market institutional setting. Indeed, the heterogeneity of individual country experiences are often explained by the interaction between adverse shocks, such as the slowdown of labour productivity, rises in real interest rates, oil price shocks, etc, and labour market institutions (e.g. Blanchard and Wolfers (2000), Bertola, Blau, and Kahn (2001), Nickell, Nunziata, and Ochel (2005)). Thus, the standard policy recommendation to fight the poor employment performance is labour market flexibilization, supplemented with expansionary monetary policy in some cases (Blanchard (2006)).

Taking into account the results by previous authors, we considered the role of the employment protection legislation (EPL), union coverage, wage coordination and government intervention in the bargaining process. Figure 1 shows the slope of the structural-form NKWPC and the Calvo wage rigidity parameter versus these institutional indicators. As seen, no clear relationship can be found between labour market institutions and wage rigidity, confirming previous results at the macroeconomic level (Mazier and Saglio (2008)). For instance, even with very low employment protection legislation in the United States and Ireland, nominal wage rigidity at the aggregate level is relatively high compared to other European countries. In contrast, Netherlands and Portugal have very high EPL although wage rigidity is well below the average of the sample. The relationship between the (adjusted) coverage rate, the government intervention and wage coordination is no more clear.[16]

[INSERT figure1]

A further interesting question that emerges when dealing with wage rigidity is its link with the unemployment rate. Indeed, if wage flexibility is an adjustment mechanism to absorb external shocks and accommodate employment variations, countries with low wage rigidity should exhibit low unemployment rates. Our motivation to address this issue is that some labour market theo-

[16]Results based on micro-data are no less conclusive. For instance, Holden and Wulfsberg (2008) show that downward nominal wage rigidity in OECD countries is higher in cases where employment protection legislation is stricter and union density and inflation higher. Holden and Wulfsberg (2008) also show that lower unemployment is associated with lower nominal wage rigidity. Dickens, et. al (2007), in turn, find a positive but weak correlation coefficient between EPL and nominal rigidity and even lower correlation between rigidity and union density.

ries explain the persistence of unemployment by the presence of wage rigidities, particularly downward wage rigidity, that hinders the adjustment of wages to labour market disequilibria (see for instance, Layard, Nickell, and Jackman (1991)). As such, the high and persistent levels of unemployment rate in the European countries since the 1980s generated a large literature that concluded that the main cause of this unemployment was the ill-adapted labour market institutions that prevented complete adjustment in the labour market (Layard, Nickell, and Jackman (1991)).

At this respect, Figure 1 also plots the slope of the structural-form NKWPC versus the mean unemployment rate for the period. In addition, the correlation between the slope or the Calvo parameter and the mean unemployment rate is quite high (-0.59 with the slope and 0.73 with the Calvo parameter). Yet, the last correlation is difficult to interpret since the Calvo parameter is linked to the average unemployment rate through ϵ. In contrast, the slope of the structural-form NKWPC depends on wage stickiness (λ) and labor supply elasticity (φ), but not on the average unemployment rate on the estimated period. As seen in the figure, a lower mean unemployment rate is associated with a steeper slope (see Austria, Japan, Norway and Netherlands). Conversely, Spain and Ireland have a high average unemployment rate and a flat slope. The most notably exception is the United States, where low unemployment is associated with a very low slope and thus a substantial wage stickiness at the macroeconomic level.

Finally, we assess the model's stability over time through a rolling analysis with windows of 60 observations. The idea behind this exercise is threefold. First, we want to shed some new light on the link between wage dynamics and the monetary policy regime. Indeed, there is in fact evidence supporting the conjecture that wage indexation has not been constant over time and could be linked to the inflation regime (?). Second, there is a large literature suggesting that the slope of the Phillips curve has flattened over time. This proposal implies that wages have become less responsive to the unemployment rate.[17] Third, the institutional setting has changed in most of the countries under analysis, becoming less rigid. If rigid labor market institutions prevent the adjustment of wages to demand or supply shocks, we should expect higher nominal wage flexibility in recent years. In other words, as the steepness of the slope is decreasing in the degree of wage rigidity, the curve should become vertical.

Figure 2 illustrate significant time variation in the estimated coefficient of the lagged inflation term that is coherent with the conjecture that wage

[17] One argument is that globalization may lead to higher labor mobility. This could lead to flattening of the Phillips curve if it results in declining sensitivity of service sector wages and prices to domestic demand shifts. In particular, workers may not press for higher wages when the domestic labor market tightens for fear that their jobs may be taken by foreign labor.

indexation could be linked to the monetary policy regime. Specifically, the figures show that, in most countries, the impact of lagged price inflation on wage inflation was relatively high at the beginning of our sample period, after which we observe a decline to an insignificant impact in the last windows. Hence, the pegging of nominal wage growth to the rate of inflation seems to fall steadily as inflation stabilizes at lower levels. At the extreme, drastic price drops or even deflation in some countries in recent years seem to be associated with a sharp movement away from wage indexation.

[INSERT Figure 2]

The results of the rolling regression also show that the value of the slope ($\lambda\varphi$) is not stable in most countries (see Figure 3). At the end of the period, the slope is much steeper in Japan, Norway and Sweden.[18] In France, the estimated coefficient shows a downward trend since the mid of the 1990's, pointing to a pronounced wage flexibility. Remark that even if it declines since the end of the 1990's, its level (in absolute value) remains very low in the USA. Similarly, the estimated coefficients of the slope in Spain and Finland are very low and even become positive since the mid of the 1990's, implying a positive relation between wage inflation and unemployment. The rolling coefficients for the Calvo wage rigidity parameter, presented in Figure 4 are in

[18]Note that the estimated coefficient of the slope in absolute value is particularly high in Japan.

line to those of the slope.[19]

[INSERT Figure 3]

[INSERT Figure 4]

3.3 Robustness tests

In the NKWPC, the growth of productivity is taken into account in the indexation rule but with the assumption that labor productivity grows at a constant rate in the long run. We relax this assumption by subtracting the trend component of labor productivity growth from wages.[20] Table 3 shows the results of this exercise. As seen, most of the findings appear to be robust to the use of the alternative specification. In particular, there is no noticeable difference between the point estimates for the Calvo parameter in both cases.[21]

[INSERT Table 3]

We also estimate the reduced-form NKWPC equation with four periods lagged inflation terms. Table 4 shows the main results: the estimated inflation indexation ($\sum \gamma$), the value of the slope ($\lambda.\varphi$) and the Calvo parameter (θ).

[19]When the discriminant of the quadratic equation is negative there is no solution for θ, explaining the discontinuity of the Calvo rolling parameters in Finland, Italy, Netherlands, Spain, Sweden and the United States.

[20]The trend component is calculated using a Hodrick Prescott filter.

[21]We also verify the direct the potential influence of changes in labor productivity growth on wage inflation by introducing labor productivity growth as an explanatory variable in the equation. The results, not presented here to save space, remain similar, pointing to the robustness of our findings.

Even though one lag is sufficient to capture the dynamics in the system in most cases, adding the first four quarters to the indexation shows that the results remain robust, except in Japan, Portugal and the UK. In particular, indexation becomes stronger in the last two countries and negative in Japan. The effect on the slope and on the Calvo parameter is also important in the UK, where rigidity increases substantially. However, in most countries, there is no noticeable difference between the NKWPC estimates with one or four lagged period(s) as an indexing variable.

[INSERT Table 4]

Finally, we estimate the system equations for the 1985q1-2007q4 period. The objective in this case is to prevent our estimates from being distorted by binding downward nominal wage rigidities during the most recent recession. Table 5 reports the main results for this period. Note that the coefficients on price indexation, current and lagged unemployment remain unaffected in most of the countries. Interestingly, however, the point estimates of θ, the Calvo wage rigidity parameter, are higher than those obtained in the previous section. This result suggest that during the Great Recession nominal wages became more flexible. The rapid increase in unemployment during these years probably means that more workers were pushed to adjust wages (downward).

[INSERT Table 5]

4 Conclusions

In this paper we assess quantitatively the wage inflation-unemployment relationship. By relying on the New Keynesian Wage Phillips Curve, we provide estimates of wage rigidity at the macroeconomic level for European countries, Japan, and the USA and for the 1985q1-2014q3 period.

A number of key results emerge from our analysis. First, the estimated coefficients in the implied wage equation have the predicted signs and are significant for all countries. Thus, the reduced form NKWPC equation can be seen as an empirically plausible model which provides an inverse relationship between wage inflation and the unemployment rate that is determined by structural parameters such as wage stickiness and labor supply elasticity.

Second, we find international structural differences in the wage determination process at the macroeconomic level. Regarding real wage rigidity, we identify three groups of countries. The first group includes countries with relatively flexible nominal wages (Austria, Japan, Netherlands, Portugal and Norway). In the Netherlands, the so-called "Dutch miracle" relies in part on its strong wage moderation. Quite paradoxically, Norway, which has the highest downward wage flexibility in Europe, does not belong to the European Monetary Union and, thus, it can adjust relative prices through its nominal exchange rate. The second group includes countries with relatively high real wage rigidity (Ireland, Spain and the USA). Finally, the rest of countries are in an intermediate position. Yet the nature of wage rigidity seems to be different across countries: whereas in the US there is substantial resistance to nominal wage cuts, stronger wage indexation translates into downward real wage rigidity in Europe.

Third, a rolling analysis reveals that the value of the slope of NKWPC and, thus, wage rigidity, is instable in most countries. For instance, our results suggest that during the Great Recession nominal wage became more flexible in a group of countries. Moreover, wage indexation appears to be linked to the monetary policy regime. In particular, disinflation is associated with a sharp movement away from wage indexation.

Finally, no clear relationship seems to appear between institutional indicators of the labor market and nominal wage rigidity. In contrast, in most cases, a lower mean unemployment rate is associated with a steeper slope of the implied wage equation. One of the exceptions is the USA where low unemployment is associated with a flat slope.

Table 1: The wage inflation-unemployment curve. 1985q1-2014q3

	ϕ_1 Coeff. (t-stat)	ϕ_2 Coeff. (t-stat)	$\phi_1+\phi_2$ Coeff. (t-stat)	γ coeff. (t-stat)	ψ_0 Coeff. (t-stat)	ψ_1 Coeff. (t-stat)	$\psi_0+\psi_1$ coeff. (t-stat)	$\psi_1=\psi_0.\beta.\phi_2$ Wald test P-value	$-\lambda.\varphi$ Coeff.	θ coeff.
Austria	0.91 (22.58)	–	–	0.75 (5.85)	−0.97 (−4.58)	–	–	–	−0.0991	0.22
Denmark	1.28 (5.85)	−0.30 (−1.42)	0.98 (19.52)	0.74 (10.77)	−0.42 (−2.96)	0.12 (0.98)	−0.30 (−5.98)	0.02	−0.0113	0.63
Finland	1.95 (35.76)	−0.97 (−21.86)	0.98 (30.63)	0.85 10.07)	−0.92 (−3.85)	0.88 (3.61)	−0.89 (−0.03	0.02	−0.0177	0.62
France	1.89 (46.32)	−0.92 (−34.76)	0.98 (31.00)	0.61 (16.76)	−1.35 (−6.62)	1.23 (6.01)	−0.12 (−3.91)	0.02	−0.0320	0.54
Germany	1.00 (64.23)	–	–	0.57 (6.46)	−0.21 (−3.34)	–	–	–	−0.0021	0.74
Ireland	1.75 (8.70)	−0.76 (−3.81)	0.99 39.97	0.72 (13.90)	−0.20 (−1.16)	0.15 (0.92)	−0.05 (−2.05)	0.69	−0.0026	0.84
Italy	1.48 (5.30)	−0.49 (−1.76)	0.99 (17.41)	0.91 (21.58)	−0.34 (−1.73)	0.17 (0.90)	−0.17 (−3.24)	0.65	−0.0065	0.74
Japan	1.88 (14.12)	−0.90 (−32.98)	0.98 (7.50)	0.31 (1.75)	−8.60 (−8.72)	7.66 (7.63)	−0.94 (−4.46)	0.00	−0.1797	0.14
Netherlands	1.86 (32.18)	−0.88 (−22.20)	0.98 23.36	0.66 11.19)	−1.35 (−5.00)	1.18 (7.63)	−0.17 (−3.92)	0.34	−0.0326	0.43
Norway	1.52 (9.41)	−0.56 (−4.91)	0.95 (8.21)	0.84 12.79)	−2.12 (−4.28)	1.18 (2.37)	−0.93 (−7.46)	0.14	−0.1042	0.21
Portugal	1.74 (7.97)	−0.75 (−3.40)	0.98 (26.64)	0.78 5.84)	−3.04 (−7.61)	2.86 (7.14)	−0.18 (−3.37)	0.00	−0.0620	0.40
Spain	1.93 (46.60)	−0.95 (−48.90)	0.99 (33.64)	1.02 14.53)	−0.19 (−1.13)	0.14 (0.90)	−0.05 (−1.66)	0.72	−0.0024	0.86
Sweden	1.65 (12.73)	−0.66 (−5.35)	0.98 (25.32)	0.33 6.15)	−0.92 (−3.31)	0.60 (2.11)	−0.31 (−5.41)	0.91	−0.0189	0.56
UK	1.89 (24.10)	−0.91 (−28.80)	0.98 (13.62)	0.88 (10.13)	−2.65 (−4.65)	2.40 (4.38)	−0.25 (−2.99)	0.092	−0.0524	0.41
USA	0.98 (56.34)	–	–	0.16 2.80)	−0.15 (−2.97)	–	–	–	−0.0045	0.74

Table 2: NKWPC Calvo parameters with $\varphi = 1$ and $\varphi = 5$. 1985q1-2014q2

	θ with $\varphi = 1$	θ with $\varphi = 5$
Austria	0.22	0.23
Denmark	0.63	0.63
Finland	0.62	0.63
France	0.54	0.55
Germany	0.83	0.83
Ireland	0.84	0.84
Italy	0.74	0.75
Japan	0.14	0.36
Netherlands	0.43	0.44
Norway	0.21	0.21
Portugal	0.40	0.41
Spain	0.86	0.76
Sweden	0.56	0.57
UK	0.41	0.42
USA	0.74	0.86

Appendix

Table 3: NKWPC Calvo parameters subtracting labor productivity trend from wages. 1985q1-2014q2

	θ Coeff.	θ_g Coeff.
Austria	0.22	0.33
Denmark	0.63	0.59
Finland	0.62	0.60
France	0.54	0.56
Germany	0.83	0.70
Ireland	0.84	0.86
Italy	0.74	0.78
Japan	0.14	0.23
Netherlands	0.43	0.49
Norway	0.21	0.23
Portugal	0.40	0.43
Spain	0.86	0.76
Sweden	0.56	0.51
UK	0.41	0.41
USA	0.74	0.76

Notes: (1) θ and θ_g are the Calvo point estimates in the benchmark equation and subtracting labour productivity, respectively. In Austria and the USA, the specification is the reduced-form NKWPC with labor productivity growth introduced as an explanatory variable.

Table 4: Main NKWPC estimates with four-periods lagged inflation as an indexing variable. 1985q1-2014q2

	$\sum\gamma$ Coeff.	$-\lambda\varphi$ Coeff.	θ Coeff.
Austria	0.77 (5.74)	-0.0973	0.22
Denmark	0.79 (8.12)	-0.0111	0.63
Finland	0.94 (10.92)	-0.0268	0.56
France	0.59 (17.53)	-0.0384	0.51
Germany	0.57 (5.36)	-0.0020	0.83
Ireland	0.68 (7.94)	-0.0036	0.80
Italy	0.92 (22.68)	-0.0168	0.63
Japan	−0.63 (−3.37)	-0.1098	0.20
Netherlands	0.78 (12.64)	-0.0461	0.38
Norway	0.87 (12.56)	-0.1116	0.20
Portugal	0.14 (1.12)	-0.0774	0.36
Spain	1.07 (17.05)	-0.0031	0.84
Sweden	0.40 (6.99)	-0.0243	0.52
UK	0.13 (7.79)	-0.0114	0.65
USA	0.28 (4.28)	-0.0046	0.74

Notes: (1)$\sum\gamma$ is the sum of four lagged terms for inflation.

Table 5: The Phillips Curve. 1985q1-2007q4

	ϕ_1 Coeff. (t-stat)	ϕ_2 Coeff. (t-stat)	$\phi_1+\phi_2$ Coeff. (t-stat)	γ coeff. (t-stat)	ψ_0 Coeff. (t-stat)	ψ_1 Coeff. (t-stat)	$\psi_0+\psi_1$ coeff. (t-stat)	$\psi_1=\psi_0.\beta.\phi_2$ Wald test P-value	$-\lambda.\varphi$ Coeff.	θ coeff.
Austria	0.90 (19.38)	–	–	0.82 6.40)	−0.85 (−3.85)	–	–	–	−0.0957	0.23
Denmark	1.22 (4.37)	−0.23 (−0.83)	0.99 (17.83)	0.70 (9.53)	−0.25 (−2.27)	0.06 (0.63)	−0.20 (−3.63)	0.01	−0.0051	0.73
Finland	1.91 (33.38)	−0.93 (−19.42)	0.98 (30.81)	0.81 8.47)	−1.02 (−4.09)	0.94 (3.63)	−0.08 (−1.98)	0.05	−0.0180	0.62
France	1.87 (38)	−0.90 (−24.74)	0.99 (28.18)	0.58 (13.88)	−1.38 (−5.56)	1.21 (4.76)	−0.16 (−4.67)	0.10	−0.0203	0.61
Ireland	1.63 (4.77)	−0.63 (−1.85)	0.99 (46.36)	0.73 (11.29)	−0.04 (−0.60)	0.03 (0.50)	−0.01 (−0.72)	0.80	−0.0003	0.93
Italy	1.22 (2.88)	−0.21 (−0.50)	1.01 (11.97)	1.01 (19.44)	−0.38 (−1.75)	0.08 (0.39)	−.30 (−3.71)		−0.0003	0.92
Japan	1.88 (16.24)	−0.89 (−27.07)	0.99 (8.95)	0.33 2.17)	−6.40 (−6.26)	5.64 (5.48)	−0.76 (−4.33)	0.00	−0.0817	0.29
Neth.	1.93 (30.03)	−0.94 (−21.60)	0.98 (21.04)	0.75 11.34)	−1.27 (−3.69)	1.18 (3.44)	−0.08 (−1.61)	0.27	−0.0203	0.51
Norway	1.41 (6.83)	−0.46 (−2.70)	0.96 (7.50)	0.81 10.57)	−1.93 (−3.61)	0.87 (1.58)	−1.06 (−7.38)	0.36	−0.0847	0.24
Spain	0.99 (75.60)	()	–	1.11 9.29)	−0.01 (−0.15)	()	–		−0.0002	0.94
Sweden	1.62 (8.90)	−0.64 (−3.60)	0.98 (22.29)	0.33 5.58)	−0.75 (−2.42)	0.47 (1.49)	−0.28 (−4.38)	0.86	−0.0150	0.58
UK	1.93 (26.94)	−0.95 (−43.65)	0.98 (14.34)	0.90 (10.95)	−3.52 (−6.26)	3.32 (6.11)	−0.21 (−2.61)	0.01	−0.0696	0.37
USA	0.97 (47.71)	–	–	0.20 2.96)	−0.02 (−0.29)	–	–	–	−0.0009	0.86

Figure 1: **Slope and wage rigidity of the structural-form NKWPC versus institutional labour market indicators**

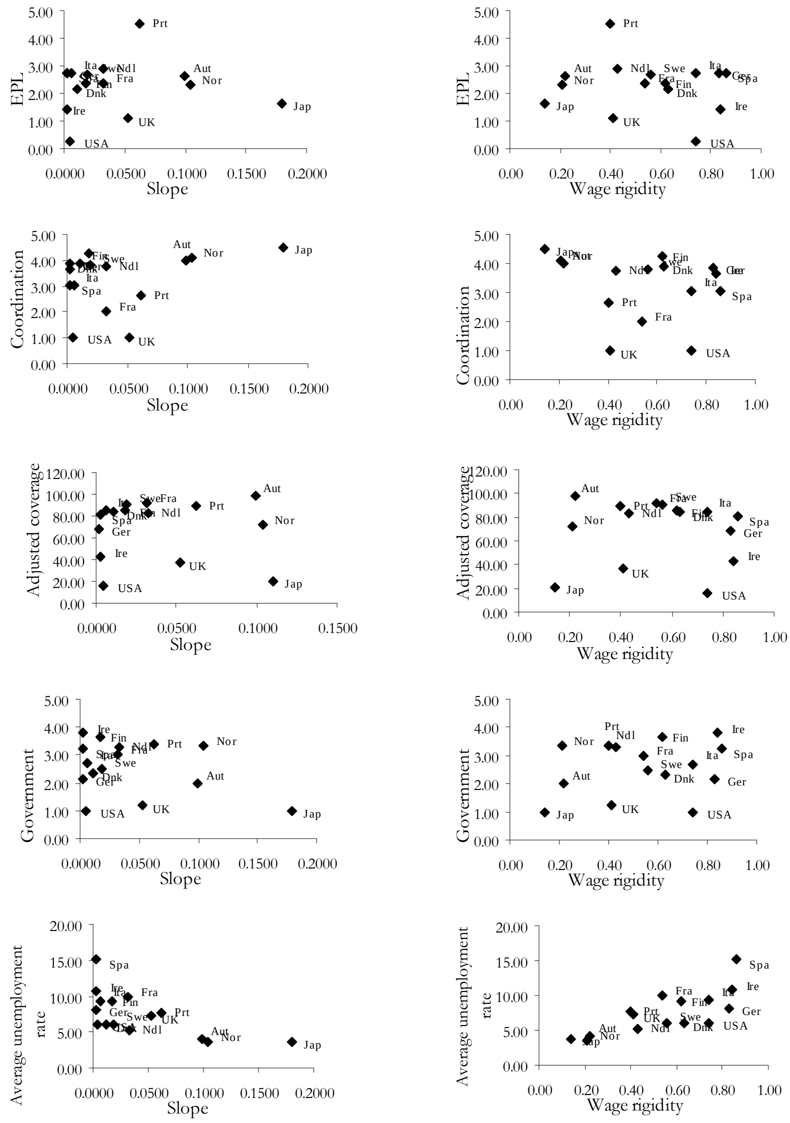


Figure 2: **Rolling estimation of the indexation term in the NKXPC**

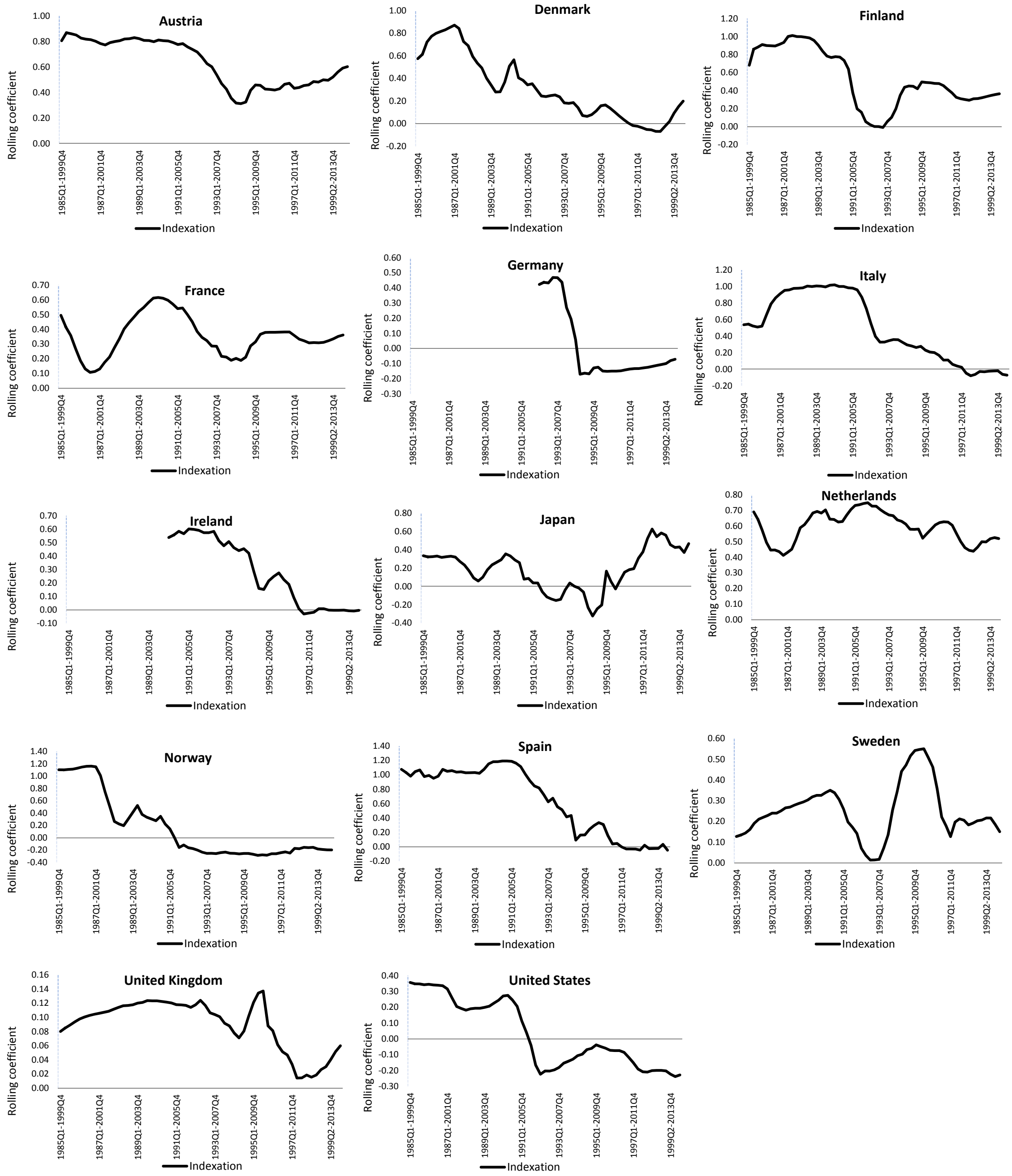


Figure 3: **Rolling estimation of the slope in the NKXPC**

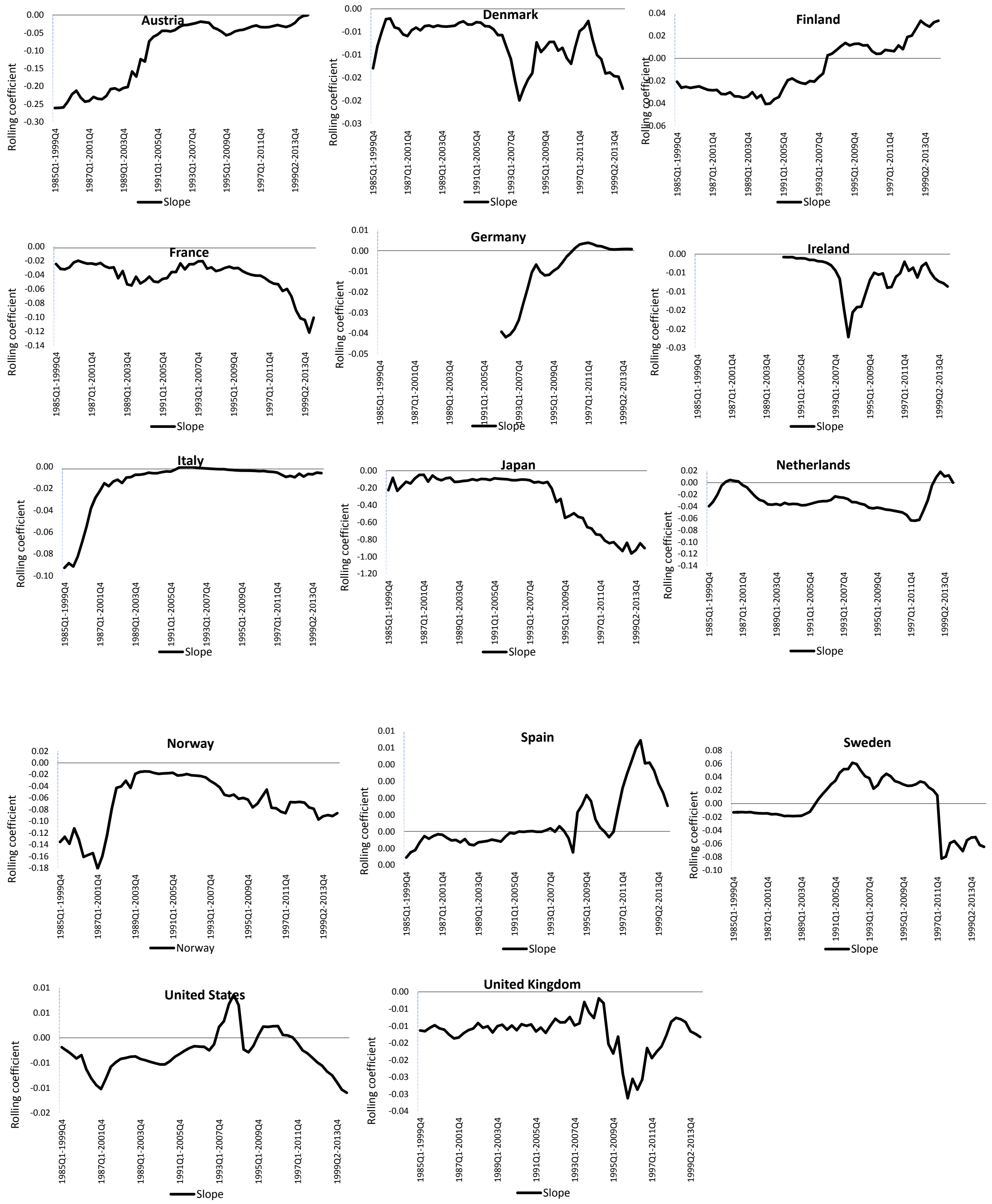
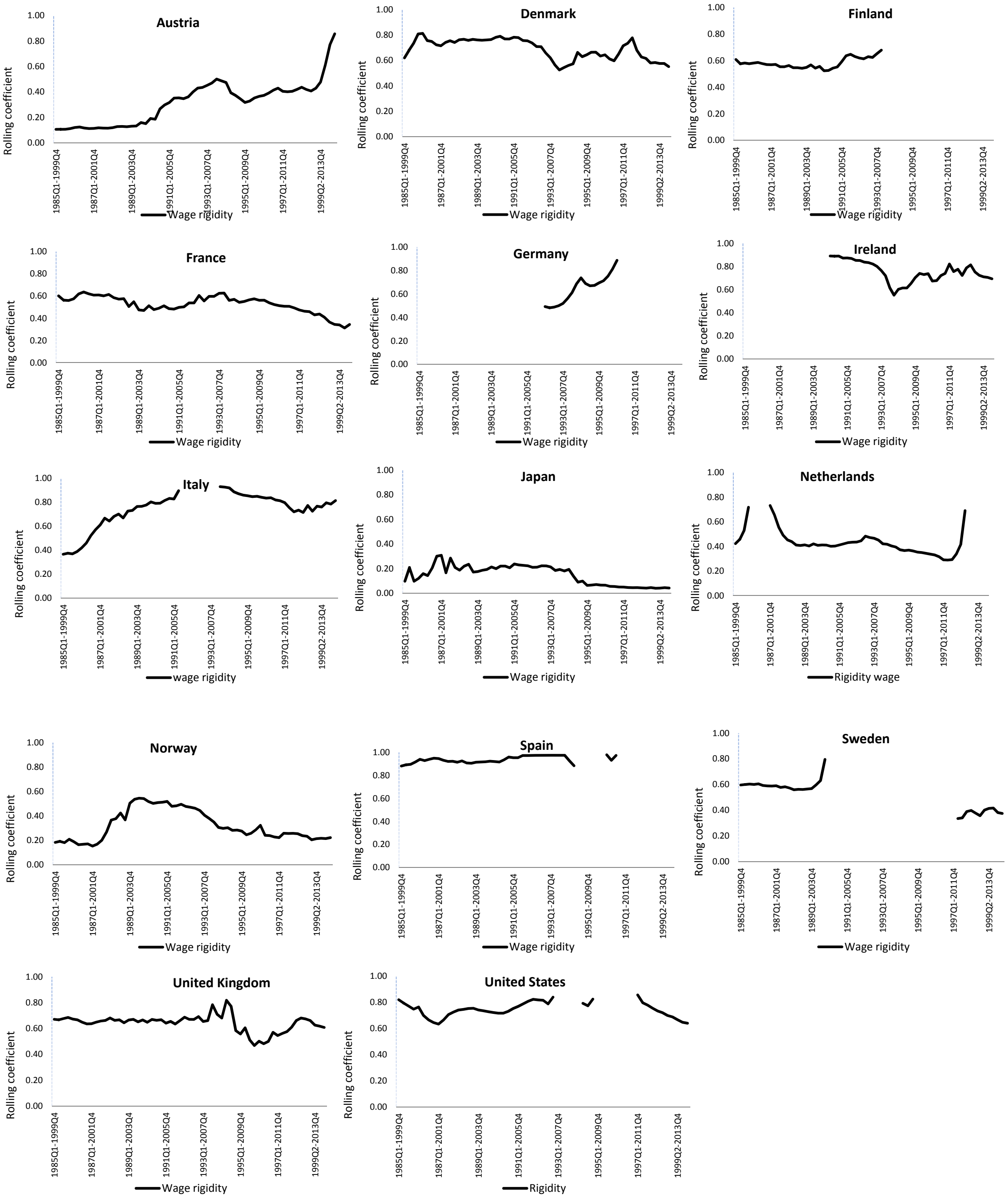


Figure 4: **Rolling estimation of the Calvo wage rigidity index**



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