Wage Leadership Models: a country-by-country analysis of the EMU

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Mariam Camarero
Departamento de Economía
Universidad Jaume I
e-mail: camarero@eco.uji.es

Gaetano D’Adamo
Departamento de Economía Aplicada II
Universidad de Valencia
e-mail: gaetano.dadamo@uv.es

Cecilio Tamarit
Departamento de Economía Aplicada II
Universidad de Valencia
e-mail: cecilio.tamarit@uv.es

Abstract

According to the theory of wage leadership, if there is free labor mobility across sectors in the economy, changes in the level of the (real) wage in the sector acting as the “leader” cause changes in the same direction in the level of the wage in other sectors. Therefore, depending on which sector leads wage determination, the outcome in the aggregate wage will be different and this may affect the cost competitiveness of a country. According to the “Scandinavian Model” of wage leadership, the traded sector (Industry) should be the leader, because it would be conducive to wage restraint. Using quarterly data on four macro sectors (Industry, Services, Construction and the Public Sector) for ten EMU countries, we find significant differences across countries. Interestingly, countries that recently experienced a construction bubble such as Spain and Ireland show wage leadership of the construction sector. Moreover, in half of the countries included in the dataset, wages in different sectors are, to some extent, set autonomously, which would suggest a low degree of inter-sectorial labor mobility.

Jel Classification: C32, E62, J51
Keywords: Wage Leadership, Cointegrated VAR, Labor Market

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1. Introduction

According to the theory of wage leadership (Aukrust 1970; Smith 1996), if there is labor mobility across sectors in the economy, changes in the level of the (real) wage in the sector acting as the “leader” cause changes in the same direction in the level of the wage in other sectors. These changes need not be proportional, and the adjustment across sectors will ultimately depend on the degree of cross-sectorial labor mobility.

First of all, which sector should lead wage determination? According to Aukrust’s (1970) “Scandinavian Model”, it should be the internationally traded sector. The reason is that the latter is affected by international competitive pressure, which may help wage restraining: put it another way, in the traded sector, firms should increase wages in step with labor productivity; if wages increased faster, in fact, firms can either reduce their profit margins (which, in a highly competitive market, are not large), or have to increase prices, although this measure will hurt their competitiveness. Therefore, a country where the traded sector is the leader in wage determination will be, in principle, in a better competitive position than a country where the non-traded sector leads wage determination. In the latter sector, in fact, due to the lack of international competitive pressure, unions have more bargaining power and can extract a mark-up over productivity. Based on this principle, in several European countries it is established that each year, the first sector to sign the agreements for collective bargaining is the manufacturing sector (Knell and Stiglbauer 2009).

Secondly, why do wages in different sectors co-move? There are three explanations. The first is the labor supply channel. If wages in, say, the services sector increase relative to the industry sector, workers will move to the former, as long as inter-sectorial labor mobility is possible, and the shrinking labor supply in the latter will force the employers to increase wages (see Demekas and Kontolemis, 2000). Alternatively, we can see the co-movement of wages in different sectors as a Stackelberg game with one sector playing as the leader, and internalizing the moves of other sectors, and the others following (Calmfors and Larsson, 2011). Finally, if the welfare of an agent, or a social group, depends on the welfare of others due to social comparison, co-movement in wages across sectors may be due to “envy effects” (Oswald 1979), whereby workers in one sector do not want to lose purchasing power relative to the others.

The issue of wage leadership is important because it is potentially related, as we have already described, to the development of real wages in a country. According to the Scandinavian model, leadership of the traded sector is consistent with wage moderation, for the reasons described above; however, Calmfors and Larsson (2011) challenged this approach, suggesting that in a Monetary Union, leadership of the non-traded sector is conducive to wage restraint. In other words, the wage leadership structure of the labor market should influence the level of the aggregate wage, but the economic literature is not unanimous towards the direction of this effect.

Which sector leads wage determination is ultimately an empirical issue. Several works have tested wage leadership since Aukrust’s (1970) seminal work. Evidence in favor the
Scandinavian Model was found by Aukrust (1977) for Norway, the U.S. and France, while Bemmels and Zaidi (1990) successfully applied it to Canada. However, this model has been found to be at odds with more recent data. Ultimately, the results seem to be country-dependent but there are also conflicting results for the same country. Demekas and Kontolemis (2000) find weak exogeneity of government wages over private wages in Greece. Jacobsson and Ohlsson (1994), in a Vector Error Correction Model for Sweden, find long-run wage leadership of the private sector, thus confirming the predictions of the Scandinavian model, a result which is shared by Lindquist and Vilhelmsson (2006) who use a bivariate Vector Error Correction Model for Sweden. However, Friberg (2007), using a broader sectoral decomposition, does not find evidence of the Scandinavian model for Sweden.

Lamo et al. (2011) used several empirical methods to study the co-movement and causality relationship between private and public wages using annual data for 18 OECD countries (plus the Euro Area as a whole), finding that private and public wages generally do not decouple and the former seem to exert a stronger influence on the latter than the reverse.

With respect to previous work on the issue, the present paper uses a broader sector decomposition to analyze wage leadership for EMU countries. We consider four different sectors, namely Industry, Services, Construction and the Public Sector. Industry proxies the traded sector, Services and Construction are non-traded sectors, and finally the Public sector is a non-market non-traded sector, where the wage is not related to the marginal product of labor. This distinction is important, but the empirical literature on wage leadership so far has generally focused on the distinction between public and private sector wages, ignoring the role of the non-traded sector (with the exception of Friberg, 2007 and D’Adamo, 2011), although the theoretical models of reference clearly state the importance of the leadership of the traded private sector vis-à-vis the non-traded sector.

The paper is structured as follows: section 2 briefly discusses the theoretical framework of reference. Section 3 presents the data used in the analysis; Section 4 shows the empirical approach adopted, which is a Vector Error Correction Model; in Section 5 we discuss the results. Section 6 concludes.

2. The theoretical framework

A stylized framework of wage setting may show how alternative wage leadership models can affect the aggregate wage.

In a world with perfect competition, wages adjust to clear the labor market. The observed real wage is thus the result of the bargaining process between employees’ unions and employers.

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2 In particular, he distinguishes between private sector, manufacturing sector, construction, wholesale and retail trade, financial sector, central government and county/municipal government.

3 Theoretical models of public sector wage setting generally assume wages for public employees to be set exogenously. Alternatively, Demekas and Kontolemis (2000) assume the government maximizes an objective function in public goods provision and public wages. In this sense, wage bargaining in the public sector is affected by the pressure that public employees are able to exert on the government.
On the one hand, employees’ unions tend to push for wage increases above productivity; however, their bargaining power depends on the unemployment rate and in particular it will be lower when unemployment is high. Thus, on the labor supply side, we have

\[ w_t - p_t = f(prod_t, U_t) \]

where \( w_t - p_t \) is the (log) real wage, \( prod_t \) is (log) labor productivity and \( U_t \) is the unemployment rate.

On the other hand, employers tend to constrain the real wage, maximizing their mark-up on unit labor cost, where the latter is defined as \( w_t - p_t - prod_t \). The mark-up that employers will be able to extract from the real wage will in turn be related to the real exchange rate, as a real exchange rate appreciation is generally expected to reflect in higher wages (see Phelps, 1994). On the demand side, we can therefore write

\[ w_t - p_t = g(prod_t, q_t) \]

where \( q_t \) is the real exchange rate.

However, the economic literature (to name but a few, Alesina and Perotti 1997; Nickell, 1998; Nunziata 2005) has shown that the observed wage is a result of additional wage pressure factors, which can be classified as wage setting institutions. The literature has considered various types of institutions, basically related to the degree of employment protection, the bargaining power of unions, the level of the minimum wage and the degree of coordination in wage bargaining.\(^4\)

However, the evolution of the aggregate wage is likely to be influenced by inter-sectorial co-ordination in wage setting as well. In other terms, when labor is freely mobile across sectors, the level of wages in the economy will tend to equalize in the traded and the non-traded sectors, as well as the public sector. In this sense, finding out which sector leads the process of wage setting is important: economic theory (Aukrust, 1977; Froot and Rogoff, 1995) suggests that the traded sector should lead wage determination, since productivity tends to grow faster than in the non-traded sector, and international competition would foster wage moderation. However, Calmfors and Larsson (2011) challenged this approach, suggesting that in a Monetary Union, leadership of the non-traded sector is conducive to wage restraint.

No attempt has been done so far in the literature, to our knowledge, to measure empirically the impact of wage leadership on the aggregate wage, which is our objective of a companion paper. In order to do that, however, it is first necessary to identify consistently which sector(s) lead wage determination.

The wage leadership structure of the labor market should therefore influence the level of the aggregate wage, but the economic literature is not unanimous towards the direction of this effect. The observed wage equation will therefore have a more general form like:

\[ w_t - p_t = \gamma_0 + \gamma_1 prod_t + \gamma_2 U_t + \gamma_3 q_t + \gamma_4'Z_t + \gamma_5'X_t + \varepsilon_t \tag{1} \]

\(^4\) See Calmfors and Driffill (1988), Nunziata (2005), Boeri et al. (2001), among others.
Where $\gamma_1, \gamma_3 > 0$ and $\gamma_2 < 0$; $Z_t$ and $X_t$ are vectors of variables defining respectively wage setting institutions, more generally institutions which exert upward pressure on the aggregate real wage, and wage leadership.

As it was pointed out by Friberg (2007), non-traded sector firms operate in a less competitive environment, since they are not subject to international competition: therefore, wage bargaining in non-traded sectors may lead to higher outcomes, ceteris paribus. On the other hand, wage setting in the public sector may follow a different pattern. Theoretical models of public sector wage setting generally assume that wages for public employees are set exogenously or, as in Demekas and Kontolemis (2000), that the government maximizes an objective function in public goods provision and public wages (a form of political patronage). In this sense, also wage bargaining in the public sector may lead to higher outcomes, depending on the political pressure that public employees are able to exert on the government. If the mobility of labor across sectors is high and therefore wages tend to equalize, a leading role in wage setting of a non-traded sector (services, construction, or Public Administration) can harm international competitiveness.

To see why this is the case, consider a sector breakdown of (1) assuming, for simplicity, that we only have two sectors, a leader L and a follower F. Then, we can represent wage setting as:

$$w_{L,t} - p_t = \delta_0 + \delta_1 prod_{L,t} + \delta_2 U_t + \delta_3 q_t + \delta_4' Z_t + \varepsilon_{L,t}$$

(2)

$$w_{F,t} - p_t = \alpha + \beta w_{L,t} + \varepsilon_{F,t}$$

(3)

In other terms, wage setting in F will not result from the evolution of productivity in that sector, but rather adjust to the level of the wage in L. The aggregate wage will then be a weighted average of the two. According to the Scandinavian Model, if L is identified with the Traded sector (Industry excluding construction), this would be conducive to wage restraint, meaning that the impact of the variables in Z will be limited. However, if a non-traded sector leads wage determination, since unions have a higher bargaining power there, they may extract a higher mark-up on productivity, and therefore the impact of variables in Z will be larger. As a result, if L is a non-traded sector, the aggregate wage will be higher. Equation (3) will be our empirical reference to estimate long-run wage leadership relations, as it will be clarified in section 4.

Although highly stylized, this model shows why testing wage leadership is important in search of a wage setting model that ensures wage moderation.

3. Data and series definition

We use quarterly data on the group of countries generally referred to as EMU-12, excluding Luxembourg due to lack of data and Portugal because only annual data are available: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands and Spain. The length of the sample differs across countries: Austria, Belgium and Netherlands

Indeed, for some countries the series are quite short, as we can see. However, there are reasons why we can still consider the cointegration analysis reliable. First, we can reasonably expect that it takes a shorter time for the relations we will estimate to go back to equilibrium with respect to other business cycle relations. D'Adamo (2011) shows that, in the case of Central and Eastern Europe, it takes 2 to 6 quarters for a disequilibrium to be corrected in a wage leadership model. Second, we estimate the VECM progressively, adding one variable at a time to the system, exploiting the property of superconsistency of cointegration relations. This allows us to estimate the model parsimoniously maintaining the same restrictions. Third, again to save on degrees of freedom, we will gradually restrict to zero all insignificant coefficients in the short run matrices, using a general-to-specific approach. Nevertheless, we acknowledge that the results obtained for Greece must be taken with caution.

Data come from Eurostat. We define the real wage as real compensation per hour worked\(^5\), and calculate it as:

\[
rcomh = \ln\left(\frac{\text{Total Compensation of employees in sector } i}{\text{Hours worked in sector } i}\right) - \ln(\text{CPI})
\]

We think this definition is preferable to compensation per employee, which is used for example in Lamo et al. (2011), because the latter measure may be affected by the increased relevance of part-time contracts, which may impact sectors differently.

We include four sectors in our empirical model: Construction; Industry except Construction; Services of the Business Economy; Public Administration, Defense, Compulsory Social Security. In a preliminary analysis, Agriculture and Fishing was also included; however, in most cases it was long-run excludable from the system or the corresponding real compensation appeared to be stationary. Given the peculiarities related to the agriculture sector (the effect of price controls on the products of the sector due to the CAP, the progressive loss of relative purchasing power of the sector, and so on) it may make sense to exclude it from the analysis.

From the point of view of tradability, Industry can be identified with the traded sector; services is a mixed traded and non-traded market sector, but mainly non-traded; construction is a market non-traded sector; public administration is a non-market non-traded sector.

The graphs of nominal compensation per hour worked for the four sectors included in the analysis are reported in Figure 1. Already from a descriptive point of view, we can see close co-movement of the four wage series in the case of Belgium, Finland, Spain, Germany and the Netherlands, while in the case of Italy and Austria in particular the picture appears more blurred.

\(^5\) For Spain, thousands of hours worked were only available from 2000; thus, the real wage is calculated there as real compensation per full-time equivalent, and the denominator is “thousands of full time equivalents”.
4. Empirical approach

In order to test wage leadership, as in previous studies in this field (see Lamo et al. 2011, Lindqvist and Vilhelmsson 2006, Friberg 2007, among others), we use a Vector Error Correction model (VECM). In fact, as it will be clear shortly, the VECM is a natural candidate to test empirically the predictions of alternative models of wage leadership, since they make precise statements on the long-run relations as well as the causal links between wages in different sectors. Given the vector of variables $x_t$, a VECM of order $n$ can be written as

$$\Delta x_t = \Pi \bar{x}_{t-1} + \Gamma_1 \Delta x_{t-1} + \cdots + \Gamma_n \Delta x_{t-n} + \phi D_t + \mu + \varepsilon_t; \varepsilon_t \sim Niid(0, \Omega)$$

(4)

where $D$ is a vector of dummy variables (seasonals and other unrestricted dummies), $\mu$ is a vector of constant terms and $\Omega$ is the (p×p) covariance matrix of (white noise) residuals. $\Gamma_j$, $j=1,\ldots,n$ are the matrices of the short-run coefficients. When the variables in $x_t$ are I(1) and cointegrated, the matrix $\Pi$ will be of rank $r < p$, where $r$ is the number of (long-run) cointegration relations. Therefore, the $\Pi$ matrix can be decomposed as:

$$\Pi = \alpha \bar{\beta}; \bar{\beta} = [\beta_0 \beta_d \beta_t]; \beta = [\beta_c \beta_l \beta_s \beta_p]$$

$$\bar{x}_{t-1} = [x_{t-1} 1 D_s t]; x_{t-1} = [w_{c,t-1} w_{l,t-1} w_{s,t-1} w_{p,t-1}]$$

where the elements in $\bar{\beta}$ are $r \times 1$ vectors, 1 represents a constant restricted to lie in the cointegration relation, $D_s$ are dummies capturing shocks that do not cancel in the cointegration relations and $t$ is a linear trend. The matrix $\alpha$ is called the matrix of loadings, which show how the variables in $x_t$ adjust to the cointegration relations.

Now in the VECM, if a variable is found to be weakly exogenous, i.e. it does not adjust to any cointegrating relation, then shocks to that variable are identified as one of the common stochastic trends of the system. Thus, following Lindquist and Vilhelmsson (2006) and Lamo et al. (2011), we define wage leadership in the empirical model as:

**Definition 1. Wage Leadership in the Long-Run Model.** Sector $i$ is wage leader in the model defined by equation (4) if $\alpha_{ij} = 0 \ \forall j = 1, \ldots, r$, i.e. if Sector $i$ is weakly exogenous in (3).

**Definition 2. Wage Leadership in the Short-Run Model.** Sector $i$ is wage leader in the short run model:

$$\Delta x_t = \Gamma_1 \Delta x_{t-1} + \cdots + \Gamma_n \Delta x_{t-n} + \phi D_t + \mu + \varepsilon_t; \varepsilon_t \sim Niid(0, \Omega)$$

If lagged values of $w_i$ can be used to predict current values of the wage in sector $j$ and the reverse is not true, i.e. if $\Delta w_i$ Granger-causes $\Delta w_j$.

Thus, we allow for more than one wage leader in both the long-run and the short-run model, which is clearly possible in our case as we include four sectors in our model.

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6 This amounts to testing that the corresponding row in the $\alpha$ matrix is zero.
Note that the number of cointegrating vectors is a proxy of inter-sectorial labor mobility. If we find, in our case, less than 3 vectors (i.e. more than 1 common stochastic trend), it means that, to a certain extent, sectors can fix wages autonomously, and the labor supply channel is not working fully.

Finally, as we anticipated in the introduction, while we expect co-movement (i.e. cointegration) among wages in different sectors, adjustment after a change in the wage in the leading sector need not be proportional: therefore, we follow Friberg (2007) to introduce the concept of full wage adaptability, which will be tested as a restriction on the cointegration space:

**Definition 3. Full Wage Adaptability.** There is full wage adaptability between $w_i$ and $w_j$ if the former is weakly exogenous in system (4) and a restriction to, respectively, -1 and 1 of the coefficients in the pairwise cointegration vector of $w_i$ and $w_j$ cannot be rejected.

5. Results

The results are, as we would expect, quite different across countries. We begin the analysis with the results of the choice of the cointegration rank in Table 1 and the specification of the long-run matrix, as well as the results on the sectors that were identified as “leaders”, in Table 2.

As far as the choice of the rank is concerned, we took three elements into consideration: the results of Johansen's trace test; the modulus of the largest unrestricted root of the characteristic polynomial; and the largest t-value in the r-th vector. We do this in order to make sure that, by excluding a cointegration relation, albeit persistent, we are not throwing away potentially important information. These criteria need not suggest the same rank, as it is the case in Table 2, and in this sense some room for judgment is left.

First of all, the rank of the long-run matrix determines the number of cointegration relations and, therefore, the number of stochastic trends. As shown in Table 1, only 5 countries out of 10 have a rank equal to three and therefore just 1 stochastic trend: Belgium, Finland, Germany, Greece and Spain.

France and Austria show only one cointegration vector (CV henceforth) to which Construction is adjusting. Public Sector and Industry are long-run excludable. In other words, we have three distinct stochastic trends that can be identified with shocks to wages in Industry, the Public Sector and Services and only the last one has a long-run impact on another sector, namely Construction.

Belgium presents three CV, one common stochastic trend identified with shocks to Public sector wages. Thus, the Public sector is long-run leader in wage determination.

Finland as well has three CV; the model includes a restricted broken trend, with a break in 1992Q1. The linear trend was found to be excludable from the system. The trend break appears at the beginning of the Finnish deep economic and financial crisis of the early 1990s;
a recursive estimation of our system (first sample: 1975Q1-1990Q4) shows a remarkable stability of our estimates over the whole sample, except for the years 1992-1994 which were exactly the years of the crisis. Industry is weakly exogenous and therefore is the leading sector. Therefore, Finland confirms Aukrust's (1977) Scandinavian Model.

The results for Germany and Greece confirm those of previous studies (respectively Lamo et al., 2011 and Demekas and Kontolemis 2000) that used a different empirical model, in particular only distinguished between private and public sector wages. In both countries, we find three CVs, with the Public sector weakly exogenous\(^7\). Exogeneity of other sectors is rejected at all significance levels.

Ireland presents two CV, where Industry and Construction weakly exogenous. The former cointegrates with the Services wages and the latter with Public Sector's.

Italy and the Netherlands present similar results with two CV, where Industry and Services are weakly exogenous. However, in both cases, in the Moving Average representation we see that only the former has a significant long-run impact on Public Sector and Construction.

Finally, Spain has 3 CV, where Construction is weakly exogenous and the other sectors are significantly adjusting to those CVs. The over-identified model could not be rejected with a p-value of 0.05 which is quite borderline; however, a recursive estimation has shown a remarkable stability of the results.

While results are, as we have already stated, country-dependent, and notwithstanding the short data sample for some of the countries, we have some interesting insights: (1) for some countries, they confirm results in previous works that were using a different framework and dataset; (2) the countries that had a construction bubble, Spain and Ireland, show weak exogeneity of the Construction sector.

Next, following Definition 2, we test for wage leadership in the short-run model. In other words, we estimate the VAR in first differences:

\[
\Delta x_t = \Gamma_1 \Delta x_{t-1} + \cdots + \Gamma_n \Delta x_{t-n} + \mu + \Phi D_t + \epsilon_t
\]

Then, if we reject \(\Gamma_{h,ij} = 0\) \(\forall h = 1, \ldots, n\) while we cannot reject \(\Gamma_{h,ji} = 0\) \(\forall h = 1, \ldots, n\) we say that wages in sector \(i\) lead wages in sector \(j\) in the short run. This is basically a test of Granger causality. Results of the short-run wage leadership analysis are reported in table 3. In most of the cases, no significant short-run leadership is actually present. In Austria, the Industry sector leads the other three sectors in the short run while in Belgium Services leads Industry and Construction. In Spain, Industry is short-run leader with respect to Construction and Services.

6. Conclusions

This work has analyzed wage leadership models in 10 EMU countries. With respect to previous literature, we have used a broader sector decomposition including Industry,

\(^7\) In the case of Greece, we had to add two step dummies in 2002Q1 and 2009Q1.
Construction, Services and the Public Sector. While Industry is traditionally identified with the traded sector, the other sectors are, to different extents, sheltered. While the economic literature is not unanimous on which sector should lead wage determination in order to ensure wage restraint, the Scandinavian Model of wage leadership, suggesting that the traded sector should act as a leader, traditionally received the favor of both policymakers and economists.

Using a Cointegrated VAR model for each of the countries in our dataset, we have shown that a significant heterogeneity across countries is present. In 5 out of ten countries, more than one common stochastic trend was found, meaning that sectors have been setting wages autonomously, up to a certain extent. This may suggest a limited degree of inter-sectorial labor mobility in those countries.

Moreover, in the case of Belgium, Germany, Greece and Spain, Industry was not found to be weakly exogenous, i.e. the wage there adjusts to the wage in sheltered sectors, which goes against the prediction of the Scandinavian Model.

Interestingly, in Spain and Ireland, the countries in the sample which experienced a construction bubble, Construction is weakly exogenous.

In three countries out of ten, i.e. Germany, Greece and Belgium, it was the Public sector which acted as a leader in wage setting. While the results for Greece have to be taken with caution due to the shortness of the data sample, in the case of Belgium and Germany they were robust and showed stability in a recursive estimation. Moreover, for both Germany and Greece, they confirm results of previous studies which used different empirical specifications.

No current empirical work, to our knowledge, has tested empirically the effect of alternative wage leadership models on the aggregate wage, while economic theory has not come to a unanimous conclusion on the matter. Therefore, an extension on this line of research is to apply these results to a standard wage setting model, in order to see how wage leadership, together with other wage setting institutions, affects the outcome of the aggregate wage.

References


Figure 1. Nominal Compensation per hour worked

Austria

Finland

Belgium

France

Germany

Greece

Ireland

Italy

Netherlands

Spain

Legend:
- Construction
- Industry
- Public
- Services
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<td>r=0 0.384</td>
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<td>r=2 2.074</td>
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<td>r=3 0.828</td>
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</tbody>
</table>

Note: Model (a) unrestricted constant, no trend; (b) unrestricted constant, restricted trend.

(*) When deterministics (i.e. restricted or unrestricted dummies, restricted level shifts or trend breaks) are included in the model, we simulate the distribution of the trace test by bootstrapping.
Table 2. Cointegration vectors and long-run wage leadership*

<table>
<thead>
<tr>
<th>Country</th>
<th># of Coint. Vectors</th>
<th>Restriction/Normalization</th>
<th>weakly exogenous sector(s)</th>
<th>LR test statistic (p-val.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>1</td>
<td>$\hat{\beta}' = [0 \ 1 \ \beta_{1S} \ 0]'$</td>
<td>Public, Services and Industry</td>
<td>10.803 (0.055)</td>
</tr>
<tr>
<td>Belgium</td>
<td>3</td>
<td>$\hat{\beta}' = \begin{bmatrix} \beta_{1t} &amp; 0 &amp; 0 &amp; 1 \ 0 &amp; 1 &amp; \beta_{2S} &amp; 0 \ 1 &amp; 0 &amp; 0 &amp; \beta_{3P} \end{bmatrix}$</td>
<td>Public</td>
<td>4.801 (0.187)</td>
</tr>
<tr>
<td>Finland</td>
<td>3</td>
<td>$\hat{\beta}' = \begin{bmatrix} \beta_{1t} &amp; 1 &amp; 0 &amp; 0 \ 0 &amp; \beta_{2C} &amp; 1 &amp; 0 \ 0 &amp; 0 &amp; \beta_{3S} &amp; 1 \end{bmatrix}$</td>
<td>Industry</td>
<td>3.123 (0.373)</td>
</tr>
<tr>
<td>France</td>
<td>1</td>
<td>$\hat{\beta}' = [0 \ 1 \ \beta_{1S} \ 0]'$</td>
<td>Public, Services and Industry</td>
<td>5.391 (0.249)</td>
</tr>
<tr>
<td>Germany</td>
<td>3</td>
<td>$\hat{\beta} = \begin{bmatrix} 0 &amp; 1 &amp; 0 &amp; \beta_{1P} \ 0 &amp; 0 &amp; 1 &amp; \beta_{2P} \ 1 &amp; 0 &amp; 0 &amp; \beta_{3P} \end{bmatrix}$</td>
<td>Public</td>
<td>5.293 (0.152)</td>
</tr>
<tr>
<td>Greece</td>
<td>3</td>
<td>$\hat{\beta}' = \begin{bmatrix} \beta_{1t} &amp; 0 &amp; 1 &amp; 0 \ 0 &amp; 1 &amp; 0 &amp; \beta_{2P} \ 1 &amp; 0 &amp; 0 &amp; \beta_{3P} \end{bmatrix}$</td>
<td>Public</td>
<td>7.180 (0.208)</td>
</tr>
<tr>
<td>Ireland</td>
<td>2</td>
<td>$\hat{\beta}' = \begin{bmatrix} 0 &amp; \beta_{1C} &amp; 0 &amp; 1 \ \beta_{2t} &amp; 0 &amp; 1 &amp; 0 \end{bmatrix}$</td>
<td>Industry and Construction</td>
<td>11.189 (0.083)</td>
</tr>
<tr>
<td>Italy</td>
<td>2</td>
<td>$\hat{\beta}' = \begin{bmatrix} \beta_{1t} &amp; 0 &amp; 0 &amp; 1 \ \beta_{2t} &amp; 1 &amp; \beta_{2S} &amp; 0 \end{bmatrix}$</td>
<td>Industry and Services</td>
<td>8.719 (0.121)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2</td>
<td>$\hat{\beta}' = \begin{bmatrix} \beta_{1t} &amp; 1 &amp; 0 &amp; 0 \ \beta_{2t} &amp; 0 &amp; \beta_{2S} &amp; 1 \end{bmatrix}$</td>
<td>Industry and Services</td>
<td>6.675 (0.246)</td>
</tr>
<tr>
<td>Spain</td>
<td>3</td>
<td>$\hat{\beta}' = \begin{bmatrix} 1 &amp; \beta_{1C} &amp; 0 &amp; 0 \ \beta_{2t} &amp; 0 &amp; 0 &amp; 1 \ 0 &amp; 0 &amp; 1 &amp; \beta_{3P} \end{bmatrix}$</td>
<td>Construction</td>
<td>7.804 (0.050)</td>
</tr>
</tbody>
</table>

Note: the vectors are normalized on the variable which was found to be significantly adjusting. The order in which coefficients appear is always $\beta_{1t}, \beta_{2t}, \beta_{3s}, \beta_{IP}$. N.A. = not applicable. The LR-test of the restricted model is distributed as a $\chi^2_q$, where $q$ is the number of degrees of freedom.

* The order in which variables are inserted is Industry, Construction, Services, Public. $\beta_i = 1, 2, 3$ and $j = I, C, S, P$ indicates an unrestricted coefficient in vector $i$ for sector $j$. 
| Country | $w_1 \not\rightarrow w_C$ | $w_C \not\rightarrow w_I$ | $w_S \not\rightarrow w_I$ | $w_P \not\rightarrow w_I$ | $w_1 \rightarrow w_C$ | $w_C \rightarrow w_I$ | $w_S \rightarrow w_I$ | $w_P \rightarrow w_I$ | $w_1 \not\rightarrow w_S$ | $w_C \not\rightarrow w_S$ | $w_S \rightarrow w_C$ | $w_P \rightarrow w_C$ | $w_1 \not\rightarrow w_P$ | $w_C \not\rightarrow w_P$ | $w_S \rightarrow w_P$ | $w_P \rightarrow w_S$ |
|---------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Austria | 0.077 | 0.870 | 0.387 | 0.349 | 0.009 | 0.344 | 0.223 | 0.861 | 0.043 | 0.175 | 0.016 | 0.227 |
| Belgium | 0.543 | 0.077 | 0.009 | 0.043 | 0.464 | 0.870 | 0.043 | 0.009 | 0.469 | 0.888 | 0.469 | 0.246 |
| Finland | 0.188 | 0.120 | 0.382 | 0.043 | 0.534 | 0.782 | 0.120 | 0.043 | 0.296 | 0.823 | 0.782 | 0.974 |
| France | 0.880 | 0.077 | 0.009 | 0.043 | 0.651 | 0.870 | 0.077 | 0.009 | 0.784 | 0.898 | 0.945 | 0.543 |
| Germany | 0.058 | 0.120 | 0.382 | 0.043 | 0.313 | 0.782 | 0.120 | 0.043 | 0.938 | 0.823 | 0.782 | 0.974 |
| Greece | 0.279 | 0.120 | 0.382 | 0.043 | 0.345 | 0.782 | 0.120 | 0.043 | 0.027 | 0.823 | 0.782 | 0.974 |
| Ireland | 0.784 | 0.120 | 0.382 | 0.043 | 0.898 | 0.782 | 0.120 | 0.043 | 0.945 | 0.823 | 0.782 | 0.974 |
| Italy | 0.328 | 0.120 | 0.382 | 0.043 | 0.355 | 0.782 | 0.120 | 0.043 | 0.466 | 0.823 | 0.782 | 0.974 |
| Netherlands | 0.330 | 0.120 | 0.382 | 0.043 | 0.364 | 0.782 | 0.120 | 0.043 | 0.182 | 0.163 | 0.061 | 0.267 |
| Spain | 0.007 | 0.120 | 0.382 | 0.043 | 0.004 | 0.782 | 0.120 | 0.043 | 0.628 | 0.260 | 0.412 | 0.263 |

Note: P-values of the Granger non-causality F test. Null hypothesis: $w_i$ does not Granger-cause $w_j$. 

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