Labour Cost Convergence in the EU: Spatial Econometrics Approach

RESEARCH PAPER

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Abstract

This paper investigates spatial dispersion and the process of convergence of labour costs across NUTS2 EU regions in the period 1996-2006. While spatial relations have long been overlooked in the standard empirical work and most studies still treat regions as isolated in space, recent evidence shows that regional data cannot be regarded as independently generated, due to the presence of spatial dependencies among the neighbouring regions. As a consequence, the standard estimation procedures, employed in many empirical studies, can be invalid and lead to serious biases and inefficiencies in the estimates of the convergence rate. To deal with this issue, in this paper we use methods based on the concept of spatial dependence in order to augment the standard β-convergence measure. Our results confirm absolute convergence of wages within the EU, and reveal narrowing in the wage gap between high- and low- wage regions even after controlling for their different productivity growth rates. This is an important signal to firms seeking location for production and at the same time bad news for regions relying on labour costs as the main source of their competitiveness to attract new firms.

Keywords: convergence, labour market, European Union, spatial econometrics, regional competitiveness
JEL classification: E24, C21, R12

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1 Introduction[1]

Do poorer economies "catch up" with the richer ones? The debate on economic convergence is usually concerned with the dynamic movements of income (GDP per capita) and productivity (GDP per worker) between countries or regions, which has been a flourishing field of research during the last decades.[2] In general, a modest convergence process has been confirmed at best, while many researchers find the results inconclusive: "This attention has however led to many different interpretations of convergence and to a wide array of empirical results, so much so that a feeling of exasperation is now not uncommon" (Islam, 2003: 309). But even in the presence of absolute convergence in labour productivity, so commonly studied in the literature, its source remains unclear, as it can be accounted for by absolute convergence in real wages, or by relative convergence in factor endowments or in factor prices (O'Rourke, Taylor and Williamson, 1995: 2). It has also been pointed out by Williamson (1995: 142) that factor prices generally, and real wages specifically, "are the better yardstick for assessing sources of long-run convergence". He further argues that wage convergence is likely to be far more dramatic than output per worker convergence.

We focus our attention on the process of labour cost convergence across the regions of the European Union, which have been subject to substantial national and regional integration processes for more than five decades. While the issue of income convergence within the EU has received considerable attention in regional economic analysis (for example, López-Bazo et al., 1999; Florax, de Groot and Heijungs, 2002; Magrini, 2004), the dynamics of factor prices, and labour costs in particular, is not so well documented, although we can find an exception in Mora, Lopez-Tamayo and Suriñach (2005). They find convergence between eleven Euro-area countries during 1981 and 2001 for unit labour costs (defined as nominal wages per employee and productivity in PPP terms) and nominal wages, but not for real wages

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[2] *See Islam (2003), Durlauf, Johnson and Temple (2004) and Abreu, de Groot and Florax (2005a) for recent overviews.*

or labour productivity, thus concluding that "productivity does not follow the same pattern as unit labour costs" and that "high growth rates of unit labour costs are the consequence of high levels of inflation" (Mora, Lopez-Tamayo and Suriñach, 2005: 2003).

In our convergence analysis, we pay attention to the important, but largely overlooked effects of spatial dependencies. While most authors still consider the economies as being isolated in space, recent evidence shows that, in particular in the analysis of regions, *space matters*. Examples include the division: rich North-poor South (and West-East since 2004) within the EU (Magrini, 2004; Le Gallo and Ertur, 2003), or the core-periphery results of New Economic Geography (Krugman, 1991). Due to spatial interactions (e.g., mobility of factors, interregional trade, diffusion of technology and knowledge, regional spillovers) the growth of a region will partially be determined by growth of its neighbouring regions (Rey and Montouri, 1999; Arbia, 2006; Debarsy and Ertur, 2006; Rey and Le Gallo, 2009), and, by way of extension, we can expect the regional wages and wage growth to be partially determined by their values in the neighbouring regions.

The aim of our paper is threefold. Firstly, to see if the old and new concepts of real factor price convergence, in particular in the labour market, have any ground in our sample of EU regions. Secondly, to prove that space matters and introduce the appropriate spatial econometric tools into the analysis. And thirdly, to explore nominal labour cost convergence, determining the dynamics of the competitiveness of regions in their role as production locations.

Section 2 reviews the theoretical background of the labour cost convergence process, while Section 3 explains data and methodology used in this study followed by the basics of spatial analysis in Section 4. The results of the empirical analysis are discussed in Section 5, while Section 6 concludes.

2 Why would Labour Costs Converge?

The traditional economic theory suggests goods trade and factor mobility to be the most powerful mechanisms in factor price convergence among countries (and even more so among regions within a country), which has lately been complemented by theories on the role of outsourcing for cross-country wage differentials (Deardorff, 2001). In the context of the neoclassical trade theory, Heckscher (1919) first argued that in a model with more than one factor, free international trade will result in the equality of factor returns across countries. Ohlin (1933) later argued for only a partial equalization, while Samuelson (1948) and Lerner (1952) developed a model in which international trade leads to complete factor price equality (Rassekh and Thompson, 1993). As Rassekh and Thompson (1993: 12-14) note, there was very little empirical work on the factor price equalization (FPE) theorem before the 1980s, which was partly due to the fact that the leading trade theorists actually expressed doubts about its empirical validity. For example, Caves (1960: 92) refers to FPE as "a supreme example of non-operational theorizing". Samuelson (1971) thus later introduced an empirically testable dynamic version of FPE, showing that with identical homothetic preferences across countries, the process of *factor price convergence* (FPC) will result from the expansion of trade. This also has an implication for the empirical testing, since FPC indirectly provides support for the existence of FPE (the equivalence of static factor returns across countries).

In its early stage, empirical research predominantly concentrated on the impact of international trade in general on the labour markets, providing inconclusive results (Tovias, 1982; Mokhtari and Rassekh, 1989; O'Rourke and Williamson, 1994). Bernard et al. (2003: 3) find that even within the UK, there are large differences in skill premium in wages between different regional labour markets, and Duranton and Monastiriotis (2000: i) conclude that "data on average regional earnings point at a worsening of UK regional inequalities and a rise in the North-South gap". But it has recently been argued that while trade in final goods alone cannot account for the entire dynamics in factor price differences, it is cross-border outsourcing of production processes and trade in intermediate goods that seems to be more important as a mechanism of factor price convergence and equalization (Feenstra and Hanson, 1999; 2001; Egger and Egger, 2001; Egger and Pfaffermayr, 2004). Deardorff (2001: 135) states that "to the extent that factor prices are not equalized internationally without fragmentation, fragmentation may be a force toward factor price equalization".

3 Data and Methodology

We test for the existence of absolute convergence in the price of labour between 1996 and 2006 in the sample of 210 regions in the following EU member states: Austria, Belgium, Bulgaria, the Czech Republic, Germany, Estonia, Spain, Finland, France, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Portugal, Sweden, Slovenia, Slovakia and the United Kingdom, as well as for the existence of conditional convergence in the subsample of 115 regions[3] for which data were available. Data on compensation per employee, obtained from Eurostat, were used for the price of labour. In the regressions below, the initial values refer to the year 1996. We have tested several specifications of models for convergence in labour costs, which are expressed either in real values to account for the inflation and standard of living, or as nominal labour cost (in current EUR), which are the prices, faced by firms (rather than real consumption wages), which affect their economic decisions, i.e., where to locate their production.

On the methodological level, following Barro and Sala-i-Martin (1992; 1995), we adopt their traditional concept of *β-convergence*, which was initially inspired by the neoclassical growth model (Solow, 1956), but is designed to analyse any dynamic adjustment process with one-way cross-sectional units (countries, regions).

[3] *In the subsample of 115 regions for which we test conditional convergence, there are 9 regions in Austria, 11 regions in Belgium, 21 regions in Germany, 15 regions in Spain, 22 regions in France, 3 regions in Greece, 2 regions in Ireland, 18 regions in Italy, 1 region in Luxembourg and 2 regions in Portugal.*

The process of β-convergence requires a negative relation between the growth rate of a variable and its initial level. The convergence hypothesis was initially intended to explain income disparities between nations, but it later proved to be more useful in the study of regional disparities within a country or group of countries (Arbia, 2006: 8). We will be able to conclude that there is β-convergence in the cross-section of EU regions if the price of labour in low-wage regions tends to grow faster than the one in high-wage regions. This could be the result of any of the previously discussed convergence drivers: free trade (FPE theorem), cross-border outsourcing or interregional migration.

β-convergence in labour costs is presented by the following nonlinear equation (see Barro and Sala-i-Martin, 1995: 90 for details):

$$\frac{1}{T}\ln\left[\frac{LC_{T,i}}{LC_{0,i}}\right] = \alpha S_N - \frac{\left(1-e^{-\beta T}\right)}{T}\ln LC_{0,i} + \varepsilon_i \ , \tag{1}$$

where the variable LC represents labour costs, S_N is a (Nx1) unit vector where N is the number of observations and T stands for the time period under investigation.

This equation can further be log-linearized to yield the model, which can be estimated by ordinary least squares (OLS):

$$\ln\left[\frac{LC_{T,i}}{LC_{0,i}}\right] = \alpha S_N - \beta \ln LC_{0,i} + \varepsilon_i \tag{2}$$

$$\varepsilon \sim \text{iid}\left(0, \sigma^2_\varepsilon \text{I}\right) \ ,$$

where a negative β coefficient means that the data show presence of absolute β-convergence of labour costs within the sample. The (annual) speed of convergence is given by:

$$b = \frac{-\ln(1-\beta)}{T} \ . \tag{3}$$

Regions converge with speed b, inversely related to the distance from a steady state. We can also calculate the half-life of convergence, which is the time needed for wage disparities to diminish by half-life:

$$T_{half-life} = \frac{\ln(2)}{b} = 0.69b^{-1} \cdot \quad (4)$$

The β-convergence approach has been criticized both on theoretical and methodological levels, because of concerns such as heterogeneity and endogeneity issues as well as the assumption of isolated economies (Quah, 1996), which clearly does not resemble the reality of any regional analysis, where spillovers between regions are more than likely. Nevertheless, serious methodological problems of taking space into account have for a long time been prohibitive, leaving room for the emergence of spatial econometric methods. When neighbouring economic units are not isolated from each other, this must be taken into account in econometric analysis (see, for example, Abreu, De Groot and Florax, 2005b; Fingleton and López-Bazo, 2006; Fischer and Stumpner, 2008; Le Gallo and Dall'erba, 2008), which we do by making use of the appropriate spatial models.

4 The Basics of Spatial Analysis

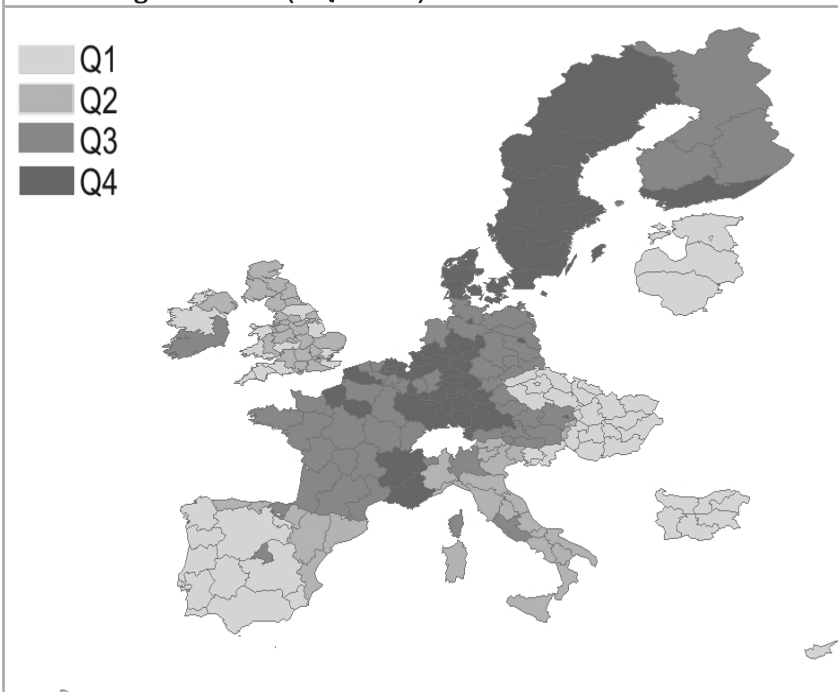
Factor price equalization/convergence has, to our knowledge, so far been analysed in the context of a "neoclassical world", in which countries and regions exist independently from one another, ignoring any international and interregional linkages, although spatial interactions among the neighbouring regions (interregional trade and factor mobility, diffusion of technology and knowledge, regional spillovers) are a reality. The models of regional science are based on the importance of location and distance, spatial interaction and spillovers in the economic decision-making (LeSage, 1997).

4.1 Spatial Patterns in Regional Labour Costs

In examining spatial patterns in regional labour costs, the *spatial dependence or autocorrelation* have been defined by Anselin and Bera (1998: 241) as "the coincidence of value similarity with locational similarity". This means that positive autocorrelation is revealed by high-wage (or low-wage) regions clustered in space, while negative autocorrelation would refer to clustering of dissimilar values, rather than a random spatial distribution of wages.

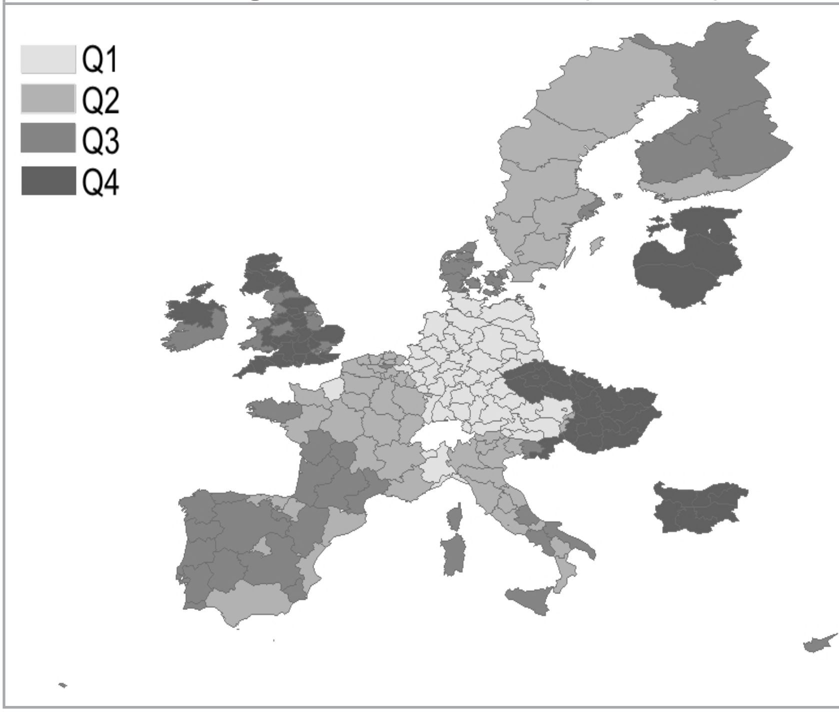
The spatial characteristics can be distinguished in Figure 1, showing the distribution of initial 1996 values of labour costs per worker, as well as in Figure 2, showing spatial distribution of labour cost growth rates in the 1996-2006 period, where similar regional values of wage levels and growth rates (represented as the same shade of regions, belonging to the same quartile of the distribution) can be said to be clustered in space, which gives us reasonable doubt about the randomness of spatial distribution of labour costs within the EU, as well as about the validity of standard econometric methods, as will be explored below.

Figure 1 **Distribution of Initial Average Labour Costs per Worker for EU NUTS2 Regions in 1996 (in Quartiles)**



Source: Eurostat, authors' presentation.

Figure 2 **Distribution of Average Labour Costs per Worker Growth Rates for EU NUTS2 Regions in the Period 1996-2006 (in Quartiles)**



Source: Eurostat, authors' presentation.

4.2 Spatial Models

Spatial models have been developed to deal with dependencies, taking place in space. Interactions among spatial units (in our case NUTS2 regions) are modelled by introducing the connectivity (or spatial weight) matrix, W, which imposes the structure of spatial interactions.

In our W matrix, we define neighbours by selecting k-nearest neighbours, with k=7, 12 or 15 neighbours[4] [5].

[4] *We chose the minimum of 7 neighbours following Dall'erba and Le Gallo (2006: 275) who argue that "in the European context, the minimum number of nearest neighbours that guarantee international connections between regions is k=7".*

[5] *All variable coefficients presented in Section 4 were robust to the choice of the weight matrix.*

In the context of spatial econometrics, the weight matrix is transformed into a spatial lag, which is the average of the neighbouring regions if the weight matrix is row standardized. Row standardization means that:

$$w_{ij}^{*} = \frac{w_{ij}}{\sum_j w_{ij}} = \frac{w_{ij}}{\eta_i} \quad \text{where} \quad \sum_j w^{*}_{ij} = 1 \,. \tag{5}$$

4.2.1 Spatial Autoregressive (SAR) Model

In the specification of the spatial autoregressive (SAR) model, also called the spatial lag model, spatial dependency concept means that the dependent variable is not defined only by the set of exogenous explanatory variables, but also by the value of the dependent variable in surrounding regions, and this spatial dependence is given by the parameter on endogenous spatial lag in the dependent variable *Wy*. The SAR model for convergence to be estimated becomes:

$$\ln\left[\frac{LC_{T,i}}{LC_{0,i}}\right] = \alpha S_N - \beta \ln LC_{0,i} + \rho \sum w_{ij} \ln\left[\frac{LC_{T,i}}{LC_{0,i}}\right] + u_i \,, \tag{6}$$

where w_{ij} represents elements of connectivity matrix W and ρ is the autoregressive spatial parameter, corresponding to the intensity of interregional wage interactions.

The spatial lag parameter in the dependent variable ρ determines the strength of the average (across all regions) association between growth of wages for a region *i* and the average of those rates of wage growth for their neighbouring regions (Fischer and Getis, 2010: 357).

The simultaneity between the spatially lagged variable *Wy* and the error term presents an obvious violation of the Gauss-Markov assumptions for the classical econometric methods (OLS), which means that alternative estimation methods (e.g., maximum likelihood) must be used.

4.2.2 Spatial Error (SER) Model

Spatial dependence can also be present in the form of spatially autocorrelated errors, which can be decomposed to

$$\varepsilon_i = \rho \sum w_{ij} \varepsilon_j + u_i \ , \tag{7}$$

where ρ is the spatial autoregressive coefficient and u is the vector of i.i.d. errors. Inserting the spatially lagged error term in the convergence equation leads to specification of the SER model:

$$\ln\left[\frac{LC_{T,i}}{LC_{0,i}}\right] = \alpha S_N - \beta \ln LC_{0,i} + \rho \sum w_{ij} \varepsilon_j + u_i \ . \tag{8}$$

The SER model may be preferred when the autocorrelation is viewed more as a nuisance than a substantial parameter, which means that a random shock in a region affects growth rates in that region and additionally impacts all other regions. The problem with the SER model is that it often only reflects a common reaction of regions due to undefined, spatially correlated omitted variables. Although the empirical studies of convergence largely prefer the SER specification, this model has a weaker theoretical and interpretational meaning than SAR (Fingleton and López-Bazo, 2006).

4.2.3 SARAR Models

In our econometric estimation of wage convergence, we combined the above models by employing the SARAR model specification (Kelejian and Prucha, 1998; Anselin and Florax, 1995), which simultaneously allows for spatial lag in the dependent variable as well as spatially autoregressive disturbances in addition to exogenous variables, giving the following convergence model:

$$\ln\left[\frac{LC_{T,i}}{LC_{0,i}}\right] = \alpha S_N - \beta \ln LC_{0,i} + \lambda \sum w_{ij} \ln\left[\frac{LC_{T,i}}{LC_{0,i}}\right] + \varepsilon_i \tag{9}$$

$$\varepsilon_i = \rho \sum w_{ij} \varepsilon_j + u_i \ . \tag{10}$$

We further allow for processes where the innovations in the disturbance process are assumed to be heteroskedastic of an unknown form:

$\varepsilon \sim N(0,\sigma_i)$

by estimating the SARAR models as a generalized spatial two-step least squares model, which is a two-step procedure, alternating the GM and IV estimators and giving a consistent and efficient estimator (see Arraiz et al., 2008; Kelejian and Prucha, 1998; Piras, 2010 for details).

5 Results from Econometric Models

In the econometric part of analysis, we have estimated several models to test for the presence of absolute convergence of labour costs for 210 NUTS2 EU regions and conditional convergence for the sample of 115 regions for which all data were available. The results are presented in Table 1.

First, we estimated a non-spatial, classical log-linear model to test for absolute convergence in real labour costs. The results, presented in Table 1 (AC-REAL-OLS), reveal a negative and highly significant β coefficient (-0.153), providing evidence of absolute convergence across EU regions. Regions in the sample seem to be converging to a common steady-state with the speed of 1.8 percent per annum, with the average half-life of 46 years, while the model is able to explain 22 percent of the variation in real labour costs between 1996 and 2006.

Given the insight on the spatial dependencies, normally expected to occur between regional units and presented above, we first check the OLS results for spatial dependence using the standard Moran and LM tests. One of the most popular tests to formally detect global spatial autocorrelation is Moran's I (1950). If significant, the sample is not randomly distributed, although it does not give any insight into the nature of the spatial dependence. The value of Moran's I of 0.7 confirms the presence of a positive autocorrelation between the neighbouring regions in the sample.

Table 1 **Results of Various Specifications for Absolute and Conditional Convergence in Labour Costs for 210 (115) EU Regions between 1996 and 2006**						
	AC-REAL-OLS	**AC-REAL-SARAR**	**AC-NOM-SARAR**	**CC-NOM-OLS**	**CC-NOM-SARAR**	**CC-REAL-SARAR**
α	0.611*** (0.000)	0.593*** (0.000)	1.197*** (0.000)	0.457*** (0.000)	0.398*** (0.000)	0.285** (0.016)
β	-0.153*** (0.000)	-0.191*** (0.000)	-0.302*** (0.000)	-0.197*** (0.000)	-0.206*** (0.000)	-0.164*** (0.000)
VA				0.612*** (0.000)	0.569*** (0.000)	0.583*** (0.000)
Capital intensity				0.004*** (0.000)	0.005*** (0.000)	0.004*** (0.000)
Unemployment				-0.070*** (0.000)	-0.065*** (0.000)	-0.048*** (0.000)
Agriculture				-0.065* (0.092)	-0.077*** (0.000)	-0.014 (0.275)
VA*agriculture				0.286** (0.032)	0.273*** (0.000)	0.240** (0.035)
Lambda (spatial lag in LC)		0.707 (0.105)	0.045 (0.834)		0.282** (0.004)	0.483*** (0.000)
ρ		0.718*** (0.000)	0.824*** (0.000)		-0.235 (0.646)	-0.549 (0.461)
R^2	0.217	0.765	0.844	0.891	0.895	0.793
Number of observations	210	210	210	115	115	115
Convergence speed in %	1.8	1.9	3.0	2.0	2.1	1.6
Half-life	45.92	35.97	21.21	34.75	33.05	42.57
Diagnostics for spatial dependence						
MORAN'S I	0.69 (0.000)			0.224 (0.000)		
LM (LAG)	587.078 (0.000)			50.00 (0.000)		
RLM (LAG)	1.922 (0.166)			22.77 (0.000)		
LM (ERR)	760.135 (0.000)			43.51 (0.000)		
RLM (ERR)	174.058 (0.000)			16.28 (0.005)		

*Notes: AC-REAL-OLS corresponds to the results of OLS models for the absolute convergence in labour costs, measured in real (constant prices) terms, using the White heteroskedasticity consistent covariance matrix estimator. AC-REAL-SARAR corresponds to the results of SARAR model for the absolute convergence in real labour costs, while the CC-NOM-OLS are the results of the OLS estimates of conditional convergence specification. CC-NOM-SARAR and CC-REAL-SARAR correspond to the results for conditional convergence in nominal and real labour costs, estimated by the SARAR model, allowing for heteroskedastic innovations in the disturbance term. The numbers in brackets are p-values. MORANS'I is the Moran test for global spatial autocorrelation, LM(LAG) and LM (ERR) are the Lagrange multiplier statistics, testing for the presence of endogenous spatial lag and spatial autocorrelation in the error term, respectively. RLM (LAG) and RLM(ERR) are their robust versions. *** Significant at 1 percent, ** significant at 5 percent, * significant at 10 percent.*
Source: Authors' calculations.

The nature of spatial dependence is further explored by four additional LM tests, which suggest that the model of autocorrelated errors (SER) better captures the spatial patterns in the sample than the SAR model, which means that the autocorrelation is more of a nuisance parameter which needs to be accounted for, and that the OLS model provided biased results.[6] This is confirmed by the estimated spatial spillover parameters of the AC-REAL-SARAR model, where only spatial error correlation is significant. The results of this model suggest that the real labour costs in our sample of EU NUTS2 regions have been converging in the period 1996-2006 to a common steady-state at a rate of 1.9 percent per annum, yielding half-life of 36 years. This result is in fact similar to the many results of β-convergence in growth, which have been found to be around 2 percent (Quah, 1993; Abreu, de Groot and Florax, 2005a). It, however, does not confirm the prediction of Williamson (1995) of a relatively faster convergence in factor prices. Further, the result strongly confirms real factor price convergence in the labour markets of EU regions, which can be attributed to all three theoretically emphasized factors: international trade (providing indirect evidence of the factor price equalization theorem), fragmentation and cross-border outsourcing of production, as well as interregional migration.

We have also estimated the sample data for the presence of absolute convergence in *nominal* labour costs, where spatial dependencies are again best described by the SER model specification (shown by insignificant parameter on spatial lag of wages and significant spatial error correlation). The results of the model (AC-NOM-SARAR) in Table 1 show a somewhat faster pace of convergence (3.3 percent per annum with a half-life of 21.3 years), which is to be expected due to the nominal nature of data, in which the growth in wages is partly driven by price inflation. This does not correspond to the process of *real* factor price convergence of the standard of living, but is nevertheless an important result, as the nominal factor costs are one of the key factors for firms deciding upon their production location.

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[6] *It has been shown (see López-Bazo, Vajá and Artis, 2004; Fingleton and López-Bazo, 2006) that the spatial error model is in general strongly preferred to the spatial lag specification in empirical convergence modelling, especially in models where the absolute β-convergence is considered, and that this is probably the result of* ad hoc *specifications and relevant variables, omitted from the estimated model and left in the error term.*

Our results provide evidence of a relatively rapid narrowing of the nominal labour cost gap between the EU NUTS 2 regions.

We want to explore this issue further and seek to find out if the narrowing wage gap is only a result of the convergence in technology and labour productivity. If the answer is yes, then the loss of the low-wage regions in their labour cost competitiveness is simply responding to their higher productivity growth rates. If the answer is no, then, from the standpoint of firms, the workers in low-wage regions are losing their cost competitiveness (compared to the high-wage regions) beyond their increasing marginal product. In other words, their average nominal wages are outrunning their labour productivity, which is bad news for regions relying on labour costs as a main source of their competitiveness to attract new firms.

The model to be estimated now becomes a version of conditional convergence, in which each economy tends to its own steady-state:

$$\frac{1}{T}\ln\left[\frac{LC_{T,i}}{LC_{0,i}}\right] = \alpha S_N - \beta \ln LC_{0,i} + \gamma \ln\left[\frac{X_{T,i}}{X_{0,i}}\right] + u_i \tag{11}$$

where *X* represents a vector of additional explanatory variables, which were defined with a consideration of Fingleton and López-Bazo (2006: 179), who advocate constructing structural growth models instead of modelling in *ad hoc* manner (and argue that "the preference for the nuisance case (spatial error) in a large number of studies is the result of the failure of standard spatial econometrics tools to detect the true externality mechanisms, especially when the growth model is underspecified"). We therefore apply a formal wage bargaining theory (Layard, Nickell and Jackman, 1990) to include the following control variables in our conditional convergence specification[7]:

[7] Layard, Nickel and Jackman (1990) also propose to include the index of output prices (the price that the producer can obtain for output influences the price at which labour can be purchased profitably) and consumer prices in a nominal wage equation, but because they are only available at the national and not regional level, they do not seem to add any additional information to the model (nevertheless, their inclusion in the model does not alter the estimated coefficients from Table 1).

- Unemployment rate: a Phillips curve effect which acts as a proxy for trade unions' bargaining power;
- Labour productivity (value added per employee; variable *VA* in Table 1): affects wages in the sense that workers strive to maintain their share in value added. This is a standard explanatory variable in equations explaining wage dynamics, since it is reasonable to expect that more productive workers with higher marginal products will be paid higher compensations. Previous results by Trefler (1993) even show that the international productivity differences can fully explain the observed factor prices differences across countries.

We additionally include a control variable for regional capital intensity of production (proxied by fixed capital formation per worker) as well as control for differences in regional production structures by including a dummy variable for regions with above-average share[8] of labour employed in the agricultural sector (variable *Agriculture* in Table 1). The last control variable is an interaction term between the agriculture dummy and labour productivity, accounting for the possibility that the growth of value added will be distributed to workers differently in regions with the highest agricultural share and hence possibly lower competition pressures.

In the column CC-NOM-OLS we first provide the results of the estimated OLS model on conditional convergence, giving the speed of convergence 2 percent per annum. The coefficient on labour productivity is large, positive and significant, as one would expect for a major determinant of wages. Nevertheless, the coefficient on the initial labour cost value remains negative (-0.197) and significant, meaning that even after controlling for their productivity growth, the labour costs in low-wage regions still increase at a higher rate than labour costs in high-wage regions.

The estimated coefficients on capital intensity and unemployment are of the expected signs, and the dummy for the agricultural regions shows a negative

[8] *We have tested several specifications of the agriculture dummy, and they did not affect the other reported coefficients. The results reported in Table 1 include an agriculture dummy which equals 1 if a region is within the 20 percent of regions with the highest agricultural share.*

(although not very significant) impact on wage growth. The interaction term with labour productivity, however, is positive and is well robust in all specifications of the model, which means that in the more agricultural regions, labour productivity growth is on average more generously reflected in growth of workers' wages than in the other regions in the sample. This can probably be attributed to the relatively less intensive competition pressures and stronger bargaining power of workers in these regions[9].

Tests for spatial dependencies of the structural model now seem to point to the SAR model specification, providing evidence that a convergence model that is not fully specified may indeed give biased results due to omitted variables (hence the preference for the SER specification in the absolute and *ad hoc* convergence specifications).

The conditional convergence equation is further estimated by a SARAR model (results in CC-NOM-SARAR column of Table 1), giving the convergence parameter of -0.2 with the yearly speed of convergence of 2.1 percent (to their own steady-states), even after controlling for the other labour cost determinants. The evidence of a strong wage convergence even after accounting for differences in productivity growth (and controlling for other factors) is an interesting result, suggesting that the increase in regional nominal labour costs has gone beyond the growth in labour productivity, and this convergence may be causing a decline in the competitive position of low-wage regions in their bid to attract new production. In other words, even when accounting for the relative dynamics in productivity, the labour cost differentials between EU regions are slowly diminishing, or at least have done so in the period 1996-2006.

Further, the results of the model not only confirm that a fully specified model will be more appropriate in providing unbiased estimates, but also give evidence that a region's wage growth will directly affect the growth of wages in the neighbouring regions through a positive and significant

[9] *The observed development of wages in the peripheral regions can perhaps also be explained by some variant of the economic geography models in the sense that the agricultural regions can be used as a proxy for the periphery (see, for example, Brakman et al., 2005; Forslid et al., 2002) but this is an interesting issue to be left for further research.*

lambda coefficient. Moreover, the parameter of spatial autocorrelation in the error term ρ is insignificant, which means that after including a spatial lag of wages (as well as other explanatory variables) in the labour cost convergence model, there is no residual spatial autocorrelation left in the error term, proving that the model is well specified and that neglecting the spatial interactions may lead to biased parameter estimates.

Finally, in the last column of Table 1 we present the results of a SARAR model of conditional convergence in real labour costs. As we can see, the estimated convergence coefficient is -0.16, which is somewhat lower than in the nominal wages specification, and it implies a convergence speed of real wages at 1.6 percent per annum (to their own steady-states) with a half-life of 23 years and again provides evidence that the gap of real labour costs between regions is closing at a rate which is faster than the rate at which their differences in labour productivity are diminishing. As in the previous model, the lambda coefficient of a spatial lag in labour costs is highly significant and positive, while the presence of residual spatial autocorrelation is not confirmed in the model, proving that the model is well specified.

6 Conclusion

Ever since the pioneering work of Heckscher (1919), the dynamics of factor prices has been among the relevant topics in the global research agenda. Nevertheless, the empirical work in this area has been scarce, in particular relative to the overwhelming bulk of work done on income and productivity convergence. The available empirical evidence on labour cost convergence is mixed, dependent on the sample of units and period under investigation. Our analysis of labour cost convergence across 115-210 EU NUTS2 regions between 1996 and 2006 is based on the concept of β-convergence, which we test by using spatial econometric models. These are able to take into account the fact that regions are not isolated islands, as the classical econometric models assume, thereby producing biased estimates. The correct specification for all of the estimated models has turned out to be the spatial error model, accounting for spatial dependencies in the error term.

The results reveal an absolute β-convergence process in real labour costs, which means that the labour costs in low-wage regions grow faster than in high-wage regions. This could have been expected, given the intensive integration processes within the European Union during the last five decades. The theoretical grounds for this result are at least tripartite: the first part can be traced back to the Heckscher-Ohlin-Samuelson theory of international trade (factor price equalization theorem), which has been recently supplemented by the findings on the effects of production fragmentation and intermediate goods trade on wage differentials, and the effects of labour migration. Since all three factors are even more forceful within than between countries, a regional labour cost convergence is a solid research hypothesis.

Our results further confirm the existence of absolute convergence in nominal labour costs, which are important to firms seeking production location. We have explored this issue further by estimating a version of conditional convergence. The results suggest that, even after accounting for labour productivity growth and controlling for other relevant factors, there is still scope for a negative and significant effect of initial wage levels on the wage growth rates, providing evidence of (conditional) β-convergence processes. This is indeed an interesting result, suggesting that the nominal as well as real labour cost growth has been outpacing the growth of labour productivity, which is an important signal to firms seeking location for production: the labour cost gap across EU regions, controlling for the differences in productivity, has been slowly narrowing; but it is also bad news for regions relying on labour costs as a main source of their competitiveness to attract new firms.

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