TOTAL FACTOR PRODUCTIVITY CONVERGENCE IN EUROPEAN REGIONS: NATIONAL, LOCAL AND SECTORAL EFFECTS

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D-2015-01

May, 2015

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The authors gratefully acknowledge the financial support of the ERDF.

This document is available at: http://www.sepg.pap.minhap.gob.es/sitios/sepg/es-ES/Presupuestos/Documentacion/Paginas/Documentacion.aspx

Resumen: En este trabajo se realiza un análisis desagregado de la convergencia en productividad total de los factores para una muestra de 121 regiones europeas (NUTS 2) durante el periodo 1995-2007. Para ello, se calculan los niveles de productividad total de los factores a partir de las series de la base de datos BD.EURS, utilizando participaciones del trabajo y del capital, específicas para cada región y sector. Este enfoque desagregado se utiliza para analizar la relación entre la productividad total de los factores de los sectores y la global y en qué medida el cambio estructural ayuda a explicar las diferencias en las tasas de crecimiento de la productividad en las diferentes regiones. El trabajo realiza un análisis shift-share, tomando como referencia los 9 países de la Unión Europea donde se encuentran situadas las regiones. Nuestros resultados muestran evidencia de que la convergencia absoluta en productividad total de los factores entre las regiones europeas es muy diferente, en función del sector de la producción de que se trate. Además muestran que el crecimiento de la productividad total de los factores entre las regiones del norte y del sur, y más particularmente en aquellas objetivo 1 las regiones del norte y del sur, ha sido muy diferente en este período. En primer lugar, el efecto determinante es siempre el diferencial (o efecto competitivo), esto indica la existencia de factores competitivos locales como determinantes de la dinámica de la productividad. En segundo lugar, el crecimiento de la productividad total de los factores sectorial es muy importante; se observa una alta correlación entre el crecimiento de la productividad en la industria y el crecimiento en productividad de las regiones europeas.

Palabras Clave: Productividad total de los factores, shift-share, cambio estructural, regiones Europeas.

Abstract: This paper analyses a disaggregated analysis of convergence in total factor productivity for a sample of 121 European regions (NUTS 2) during the period 1995-2007. To do so, total factor productivity levels from BD.EURS database using a specific labour and capital income share for each region and sector are calculated. This disaggregated approach is used to analyze the relationships between total factor productivity of industries and overall and to what extend structural change helps to explain differences in productivity growth rates in the different regions. The paper performs a shift-share analysis, using as a reference the 9 countries of the European Union where the regions are located. Our results show evidence that the total factor productivity absolute convergence rate among European regions is very different, depending on the production sector concerned. Moreover, total factor productivity growth between the northern and southern regions, and more particularly in those Objective 1 northern and southern regions, has been very different in this period. Firstly, the most determinant effect is always the differential (the competitive effect), this indicates the existence of local competitive factors as determinants of the productivity trend dynamic. Secondly, total factor productivity growth of sectors is very important; a high correlation is observed between productivity growth in industry and European regions productivity growth.

Keywords: Total factor productivity, shift-share, structural change, European regions.

JEL Classification: O52; R11; R12

1. Introduction

Productivity dynamics is the determinant element to maintaining sustainable regional growth. Since the mid–nineties, productivity growth in Europe has shown signs of weakness. In 2007, productivity in the U.S. was 39% higher than in the European Union (EU) in terms of GDP per person employed, and 26% higher in terms of GDP per hour worked. Total factor productivity (TFP hereafter) growth has contributed more to growth in labour productivity than has growth of capital per worker. Indeed, TFP has been the main cause of the different productivity trends in the EU and the U.S in the period 1995-2007[1].

The convergence or divergence of regional incomes has been widely studied in the regional science literature since works of Barro and Sala–i–Martin (1991, 1992) and Mankiw, Romer and Weil (1992). European integration has stimulated numerous studies using European regions sample (EU-12 to EU-27) and using a variety of approaches (see Eckey and Türk (2007) for a survey and Le Gallo and Dall'erba (2008) and Bartkowska and Riedl (2012) more recent papers). All works cited analyze the convergence in labor productivity. Some studies provide evidence for convergence and others for divergence in European regions. Moreover, some studies show evidence of polarization and convergence clubs.

Despite the multitude of existing work on convergence in labour productivity in European regions, contributions focused on measuring and analysing the convergence in TFP is scarce. The main reason is the lack of regional data on capital stock. In existing works on TFP for European regions, Dettori, Marrocu and Paci (2012) and Ladu (2012), TFP is computed using the capital stock calculated by the authors from the gross fixed capital formation (GFCG hereafter) series come from Cambridge Econometrics. Even more scarce is the literature addressing to the disaggregate TFP's behavior. In Schergell, Fischer and Reismann (2007) and Marrocu, Paci and Usai (2013) a disaggregation of 13 industries are used, calculating the capital stock from the series of GFCF which were replaced by a much lower disaggregation in a later version of the database Cambridge Econometrics at the lack of robustness the series. Derbyshire, Gardiner and Waigths (2013) estimate capital stock series for European regions from 1995 to 2007, but their estimate of capital and their results on TFP are both questionable[2]. Nowadays, Cambridge Econometrics maintains the European Regional Database that includes gross fixed capital formation by three sectors only.

This article contributes to the debate with an analysis disaggregate (six sectors) of TFP for a sample of 121 regions in the European Union using capital stock series come from BD.EURS (NACE Rev1) database[3]. In the few studies that analyze the behaviour of TFP at the regional level, there are some authors like Esteban (2000) and Ezcurra et al. (2005) that argue

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[1] See in more detail these reflections extracted from the 2007 report by the European Commission on Competitiveness (SEC, 2007). Easterly and Levine (2001) have already showed that, for countries, more than 90% of the differences in growth rates were explained by TFP rather than factors accumulation. Many other authors such as Hall and Jones (1999) and Parente and Prescott (2000) also obtained similar results for countries. In fact, in all the 121 regions that we have included in this paper and in this period, we have obtained a correlation both in growth and in levels of labour productivity and TFP of more than 90%. Boldrin and Canova (2001) already found for 101 European regions that GDP per capita is much more correlated with TFP than with capital-labour ratios.

[2] Their estimates of capital stock in Escribá and Murgui (2014b) are discussed.

[3] For more details see Appendix 1 and Escribá and Murgui (2014a). This regional database is the only one that facilitates capital stock series and is available free on the following web page:
http://www.sepg.pap.minhap.gob.es/sitios/sepg/es-ES/Presupuestos/Documentacion/Paginas/BasededatosBDEURS.aspx

the irrelevance of disaggregated approaches. Conversely, O'Leary (2006), Batog and Batog (2007) and De Gallo and Kamerianakis (2011) advocate the use of disaggregated approaches and the importance of structural change to capture the regional dynamics of productivity.

In this article a disaggregated sectoral approach is used to analyze the relationships between TFP of industries and overall TFP and to what extend structural change helps to explain differences in TFP growth rates in the different regions, in the same way as sectoral composition helps to explain the regional differences in TFP levels. The sectoral structure, in particular the weight of the manufacturing sector, is critical of the behavior of productivity. The European Commission recently considers that a strong industrial base will be of key importance for Europe's economic recovery, productivity and competitiveness[4].

Moreover, this disaggregated approach to the dynamics of the TFP is used in this work to analyze to what extent a convergence of the TFP gap between northern and southern European regions has taken place in this period and whether there is a convergent dynamic regarding productivity in Objective 1 regions[5] as compared to the more developed regions.

This paper introduces important contributions with regard to the empirical literature on productivity convergence in European regions and show evidence on regional and sectoral disparities in TFP across a set of 121 European regions in the 1995-2007 period. Firstly, TFP is used directly as the variable to be explained. To do so, we calculate TFP levels from BD.EURS database using a specific labour and capital income share for each region and sector. In European regions there are substantial differences between sectoral and regional (and country) shares that are indicative of technological differences and they are essential to determine the behavior of TFP. The date used to calculate TFP levels and growth rates for six sectors and 121 regions come from the BD.EURS. This database is compiled by the Budget General Directorate of the Spanish Ministry of Economic and Financial Affairs. The data provided by BD.EURS are mainly based on information supplied by REGIO, the EUROSTAT regional database, so ensuring its compatibility with AMECO and EU-KLEMS, for this reason it commences in 1995. The lack of homogeneous data for the remainder of the European regions, especially for data relating to the GFCF, determined the complete set of regions that are included in this database, 121 regions by 9 European countries: Belgium, France, Germany, Spain, Netherlands, Austria, Italy, Portugal, and Sweden. The availability of disaggregated capital stock data for six sectors at NUTS 2 level in the work of Escribá and Murgui (2014b)[6] makes it possible to use a standard procedure to estimate TFP for each industry in each region.

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[4] "The crisis has underlined the importance of the real economy and a strong industry. Industry's interactions with the rest of Europe's economic fabric extend far beyond manufacturing, spanning upstream to raw materials and energy and ownstream to business services (e.g. logistics), consumer services (e.g. after-sales services for durable goods) or tourism. Industrial activities are integrated in increasingly rich and complex value chains, linking flagship corporations and small or medium enterprises across sectors and countries". See European Commission (2014).

[5] Objective 1 regions includes areas NUTS 2 whose per capita (GDP) Gross Domestic Product is less than 75% of the EU average.

[6] In Escribá and Murgui (2014b) the methodology used in the construction of capital stock series is explained. These series remain important discrepancies with Cambridge Econometrics. Currently, Cambridge Econometric not provides capital stock series.

Secondly, a sectoral disaggregation analysis is carried out, which allows the extent to which the specific dynamics of each TFP sector contribute to aggregate regional TFP growth to be determined, as well as the extent due to structural change and intersectoral factor reallocation. To relate the overall growth based on the dynamics of individual sectors, a dynamic shift-share decomposition related to the European Union (EU9)[7] is done. The regional effects with respect to the EU9 are decomposed, to determine what aspects are due to national behaviour that the region belonged to, with respect to the EU9, and to what extent they are due to regional behaviour with respect to national. Moreover, the analysis is conducted by grouping the regions based on two criteria: whether they belong or not to the Objective 1 regions, and whether they are located in northern or southern Europe.

Our results show that, TFP growth between the northern and southern regions, and more particularly in those Objective 1 northern and southern regions, has been very different in this period. Firstly, our findings show that, behind the regional disparities in TFP dynamics, there are regional competitive advantages that are highly related to nationality and also to strictly geographical location factors that affect productivity across all sectors. Secondly, TFP growth of sectors is very important; a high correlation is observed between TFP growth in industry and regional TFP growth.

This paper is structured as follows: in the following section, we describe the database used and the regional groups. In the third section, we provide the basic statistics concerning growth accounting. In the fourth section, we provide information on regional disparities in TFP levels. The next section discusses β convergence in TFP. The sixth section discusses in detail the dynamics of regional TFP, structural change and TFP growth in each of the sectors and a dynamic shift-share analysis is performed. Finally the most important results are discussed and some indications of regional development policy are proposed.

2. The database and regional groups.

The database used is BD.EURS when referring to all the variables. This database, in year 2000 euros, is disaggregated into six sectors for 121 regions (NUTS 2) for the period 1995-2007. The TFP series of European sectors and regions used in this paper were obtained from the GVA series in PPS (Purchasing power standards), employment, capital income share and labour income share come from the BD.EURS. In the following section we describe the measure of TFP growth by sectors and regions.

In accordance with the EUROSTAT disaggregation, each region (NUTS 2) is disaggregated in to six major sectors: agriculture and fisheries, industry (manufacturing and energy), construction, wholesale and retail trade services including hotels and restaurants and transport, financial, real estate and other business services, and finally, public administration.

For the shift-share analyses that were conducted for this paper, the identification of different European regional groups that were proposed in the studies by other authors was

[7] Used as reference are the 9 countries of the European Union which the 121 regions under analysis belong to.

utilised. Ertur, Baumont and Le Gallo (2006) (given the "enduring pattern of polarization between the rich regions in the north and the poor regions in the south" and that poor regions surrounded by rich regions are more likely to progress) propose the north - south distinction. Bartkowska and Riedl (2012) identify five convergence clubs: the first two correspond to the non Objective 1 northern regions, the latter three to Objective 1 regions. Brasili, Bruno and Sagnatti (2012) consider two convergence clubs: Objective 1 and non Objective 1. Accordingly, in this paper, the following classification of four groups will be followed, based upon which the results will be presented in more detail [8]:

- Regions classified as Objective 1 in 1994 that can be sub-divided into:
  - Regions Objective 1 in the north.
  - Regions Objective 1 in the south.
- Remainder of the Regions:
  - Remainder of the regions in the north.
  - Remainder of the regions in the south.

3. Growth Accounting: regional and sectoral level.

In economic growth studies, the usual way of measuring TFP growth originates with the paper of Solow (1957), where a residual is obtained from a Cobb-Douglas function production with Gross Value Added (Q) and two productive factors (capital (K) and labour (L)), with a Hicks-neutral technical change, that, by taking logarithms and differentiating, leads to the TFP growth rate to be expressed as:

$$\hat{TFP}_t = \hat{Q}_t - \alpha\hat{K}_t - (1-\alpha)\hat{L}_t \quad (1)$$

Under the assumptions of perfect competition and of factor remuneration according to their marginal productivity, α and (1-α) are both the capital and labour income share as well as income elasticities with respect to the factors.

This expression can be written at a disaggregated level thus:

$$\hat{TFP}_{ij,t} = \hat{Q}_{ij,t} - \alpha_{ij}\hat{K}_{ij,t} - (1-\alpha_{ij})\hat{L}_{ij,t} \quad (2)$$

where *i* are the sectors (agriculture and fisheries; industry [manufacturing and energy]; construction; wholesale and retail trade services, hotels and restaurants and transport; financial, real estate and other business services; and finally, public administration), *j* refers to the regions and α_{ij} refers to the average capital share across all years for region *j* and industry *i*. The information on α_{ij} is extracted from the accounts available in the BD.EURS database.

[8] In Appendix 2, the regions belonging to each group are detailed.

The sources of GVA growth for all activities in the 121 European regions can be summarize as follow. Across all regions, a positive contribution of capital and labour is seen (except in 3 regions in the former East Germany whose contribution is zero, and indeed highly negative in the case of Sachsen-Anhalt), as well as of TFP, with the exception of a few regions, mainly in Spain, Portugal and Italy and Berlin. However, a marked difference in trends across the regions can be seen; the contribution of labour in all Spanish regions is particularly high in the period, whilst, conversely, it is very low in most German, French and Swedish regions.

Whilst in some regions, in this period, the quantitative growth of factors is responsible for GVA growth, in others, developments mainly occurred in total factor productivity. These results are considerably more pronounced or changed for each of the individual sectors.[9]

4. Regional disparities in total factor productivity levels.

Unlike the relative levels of labour (or capital) productivity between regions, where it is not difficult to establish a ranking, including at intersectoral level, in the case of total factor productivity, the comparisons between levels are much more problematic. The reason lies in the inclusion of differences in factor shares by sector and region. There are substantial differences between sectoral and regional shares that are indicative of technological differences and they are very important in TFP's behavioural. In the researches with regard to European regions: Dettori, Marrocu and Paci (2012) and Ladu (2012) estimate the parameters of aggregate production function and calculate TFP for 199 during 1985-2006 period and 115 European regions during 1976-2000 period respectively , using series come from Cambridge Econometrics. Derbyshire, Gardiner and Waights (2013) get estimates of TFP levels from the new version of Cambridge Econometrics series (see Figure 8 and Equation 10 in pages 1145 and 1147, respectively) with an important assumption: factor share identical (equal to 2/3 for labour income share) for all sectors and for all European countries and regions.

In this paper, different factor shares ($(1-\alpha_{ij})$ and α_{ij}) for region j and industry i are used and the initial TFP levels are calculated in each regional industry following the methodology in Bernard and Jones (1996b) and Harrigan (1999).

To calculate the initial TFP levels, the first step consists of evaluating the level of aggregate TFP in each region j relative to a common reference point– the Brussels region[10] (subindex N)–. To do this, we assume that $\left(Q_N / L_N\right) = \left(Q_N / K_N\right) = 100$, so that[11]:

[9] For space reasons, figures and tables corresponding have not been included, but they are available to the reader upon request from the authors.

[10] Brussels region has the highest level of TFP in 1995. We employ other reference points as the mean of the TFPs of EU-9 countries and the results are similar.

[11] This expression is identical to Harrigan (1999, page 273) in the special case when labour share are constant over time.

$$RTFP_{j,N} = \frac{\left(\frac{Q_j}{K_j}\right)^{\alpha_j}\left(\frac{Q_j}{L_j}\right)^{1-\alpha_j}}{\left(\frac{Q_N}{K_N}\right)^{\alpha_N}\left(\frac{Q_N}{L_N}\right)^{1-\alpha_N}} = \frac{Q_j}{Q_N}\left(\frac{K_N}{K_j}\right)^{\alpha_j}\left(\frac{L_N}{L_j}\right)^{1-\alpha_j} \quad (3)$$

So, we can expressed the initial TFP in a region as $TFP_j = RTFP_{j,N} \cdot 100$

The second step consists of relating sector (*i*) and regional (*j*) levels. Therefore, the initial levels of TFP in each region-industry relative to the reference point are expressed as:

$$RTFP_{ij,iN} = \frac{Q_{ij}}{Q_{iN}}\left(\frac{K_{iN}}{K_{ij}}\right)^{\alpha ij}\left(\frac{L_{iN}}{L_{ij}}\right)^{1-\alpha ij} \quad (4)$$

Thus, we can compute TFP levels for each sector and region as:

$$TFP_{ij} = RTFP_{ij,iN} \cdot RTFP_{j,N} \cdot 100 \quad (5)$$

In Figure 1a the TFP level of all activities is shown. As can be seen, there are considerable differences in the starting level of TFP across the different regions. There is a very close relationship between Objective 1 regions and those that in 1995 show the lowest TFP levels. The opposite is observed in the remaining regions and those with the highest TFP levels.

5. TFP Convergence Analyses.

Having described the differences in the levels of total factor productivity in the European regions, the next step is to analyze whether these differences remained or reduced over time. To do so, analysis is conducted in to whether the European regions experienced TFP convergence during the period under analysis.

The majority of the analysis on convergence between European regions has focused on analyzing the σ and/or β convergence in labour productivity or per capita income. In this paper we go one step further in the analysis of regional convergence in Europe and analyze, for the aggregate and for each of the sectors, if evidence exists of TFP convergence among the 121 European regions.

Firstly, a regression model was estimated following Barro (1991) and Barro & Sala-i-Martin (1991). This attempts to show whether the regions that initially had lower TFP values are those with higher growth rates (absolute β convergence), such that they become closer or converge to steady state TFP levels of the most productive regions.

Both for the aggregate of all the activities as well as for each of the sectors analyzed, the expression that is estimated is as follows:

$$\hat{g}_{TFP} = \alpha + \beta Ln\, TFP_{1995} + \varepsilon$$
$$\varepsilon \rightarrow N(0, \sigma^2 I) \quad (6)$$

where $\hat{g}_{TFP}$ denotes TFP growth rate in the period 1995-2007 and $LnTFP_{1995}$ is the logarithm of the initial level of total factor productivity.

There are many studies that demonstrate the existence of spatial dependence in this type of analysis.[12] Some studies that analyze the β convergence in labour productivity taking into account the spatial interdependence between European regions show differences in the obtained convergence rate.[13]

Therefore, we present below a brief exploratory analysis of the initial TFP level (exogenous variable) and of the TFP growth rate (endogenous variable).[14] Figures 1a and 1b show the maps detailing the TFP levels of the 121 European regions in 1995, as well as their average growth rates for the period 1995-2007. They are separated in to five quartiles, shown from light to dark colours, depending on the initial TFP level (or their growth rates, according to the chart). Thus, regions that appear lighter in colour belong to the lowest initial TFP quartile (or lower growth rate) and those that are darker belong to the higher levels (or rates).

From observation of the figures it can be deduced that the distribution of both variables cannot be considered random. Overall, it appears that neighbouring regions have similar values of variables. Therefore, there seems to be some degree of spatial dependence[15]. Except for northern Italy, the regions that show higher TFP levels in 1995 tend to be relatively isolated, that is, they have a higher TFP level than their neighbouring regions. In contrast, regions with lower TFP levels are characterized by them having similar TFP levels to those regions geographically adjacent to them. However, what is more interesting than what can be observed from these levels concerns TFP growth rates; it is quite normal for groups of geographically proximate regions to evolve in a similar manner. What stand out are the opposite trends of the (northern) Objective 1 regions of the former East Germany and the Objective 1 regions of the south. The German regions started out from the lowest levels and grew at the highest rates. In the next section we will return to this topic.

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[12] See Flingleton and Mc Combie (1998); López-Bazo et al (1999); Vayá et al. (2004) and Badinger, Müller and Tondl (2004) for European regions.

[13] See Vayá et al. (2004), Carrington (2003), Baumont, Ertur and Le Gallo (2003) or Le Gallo and Dall'erba (2008), studies which analyse β convergence including the spatial dependence in a cross section analysis for the European regions.

[14] To carry out this exploratory analysis, the GeoDa 0.9.5-i program is used.(See Anselin, Syabri and Kho, 2006)

[15] As shown in Moreno and Vayá (2000), p.55, the results that can be interpreted from these graphs are sensitive to the number of defined intervals, so it is necessary to carry out spatial autocorrelation contrasts to confirm the existence or otherwise of spatial autocorrelation that is statistically significant in the spatial distribution of the variables. In our case, the Moran's I value is 0.438 and 0.406 for the initial TFP level and growth rate, respectively. The Moran scatterplot can be seen for each of the variables in graphs A3.1 and A3.2 in Appendix A3, where the positive spatial dependency can be seen.

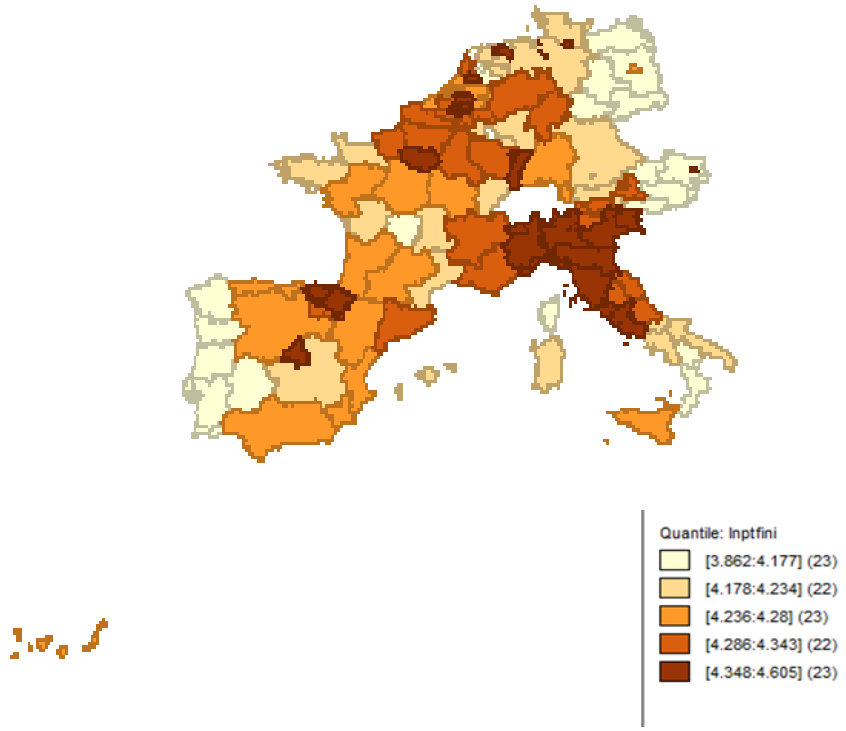

Figure 1a. TFP levels in 1995 in European Regions. Total Activities.

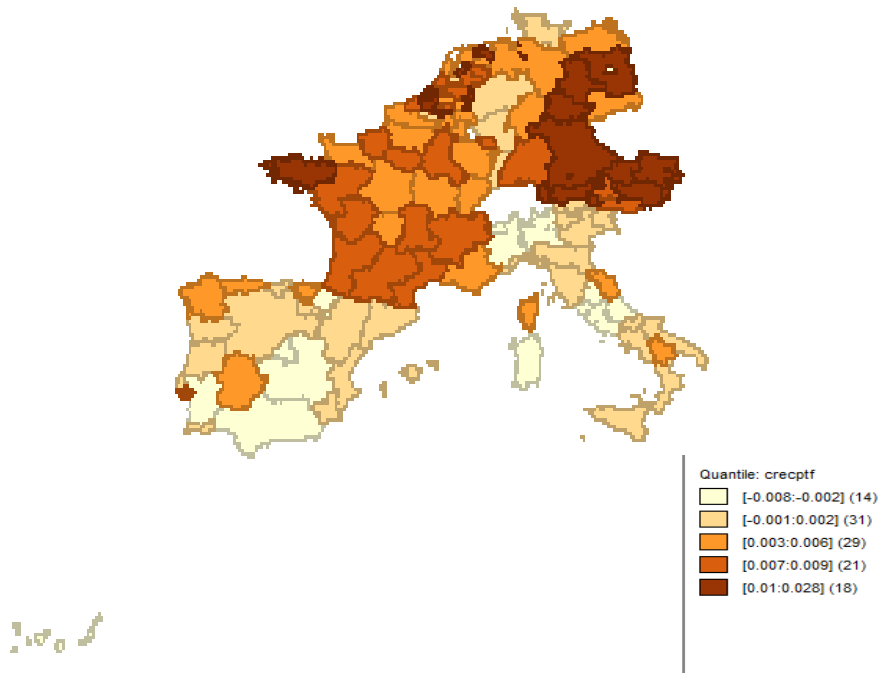

Figure 1b. Average TFP growth rate in European Regions, 1995-2007. Total Activities.

The results of the estimation are presented in Table 1 for the cross-section of the 121 European regions in equation (6). When comparing model specifications we use likelihood ratio or Lagrange multiplier statistics as is the case with most of the spatial econometric literature. Specifically, we are comparing the OLS model against the SAR (equation 7), SEM (equation 8) and SLX (equation 9) models for cross sectional data which may capture possible spatial interactions across spatial units.[16] The results of estimation when is considered spatial dependence in European regions are presented in Table 2.

If we suppose a spatial autoregressive model (SAR), convergence equation can be expressed as:

$$\begin{aligned} &\hat{g}_{TFP} = \alpha + \rho W \hat{g}_{TFP} + \beta Ln\,TFP_{1995} + \varepsilon \\ &\varepsilon \to N(0, \sigma^2 I) \end{aligned} \tag{7}$$

Where W is the spatial weights matrix, usually containing contiguity relations or functions of distance. A first-order contiguity matrix has zeros on the main diagonal, rows that contain zeros in positions associated with non-contiguous observational units and ones in positions reflecting neighbouring units that are (first-order) contiguous.

However, if we assume a spatial autocorrelation in the error process (SEM), convergence equation can be written as:

$$\begin{aligned} &\hat{g}_{TFP} = \alpha + \beta Ln\,TFP_{1995} + \varepsilon \\ &\varepsilon = \lambda W \varepsilon + u \qquad u \to N(0, \sigma^2 I) \end{aligned} \tag{8}$$

Finally, if we assume that $\hat{g}_{TFP}$ is affected by spatial lags of the explanatory variables, this gives the spatial lag of X model (SLX) and convergence equation would be:

$$\begin{aligned} &\hat{g}_{TFP} = \alpha + \beta Ln\,TFP_{1995} + \theta W\, Ln\,TFP_{1995} + \varepsilon \\ &\varepsilon \to N(0, \sigma^2 I) \end{aligned} \tag{9}$$

We estimate equation (6), in the first instance, using an ordinary least squares regression (Table 1). The estimates do not suffer from non-normality and heteroskedasticity as can be observed in the lower part of Table 1. Spatial tests were performed on the residuals of the OLS thus were used for the test the spatial weights matrix *W*. Lagrange Multiplier tests for spatial error (LM ERR) and spatial lag (LM LAG) are obtained. As can be seen, the null hypothesis of absence of spatial dependence is accepted in columns [2], [3] and [5] corresponding to agriculture sector, industry and private services, respectively.

[16] We use the acronyms most commonly used in the spatial econometrics literature to refer to the model specifications (see LeSage and Pace, 2009)

Table 1. Estimation Results. OLS Estimation

Dependent variable	$\partial_{TFP,1998-2007}$			OLS Estimation		
	TOTAL	**Agriculture**	**Industry**	**Construction**	**Private Services**	**Financial-Real state**
	[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**
$\hat{\alpha}$	0.064***	0.093***	0.087***	0.073**	0.180***	0.114***
	(0.015)	(0.012)	(0.031)	(0.038)	(0.021)	(0.015)
$\hat{\beta}$	-0.013***	-0.014***	-0.015**	-0.017**	-0.040***	-0.027***
	(0.003)	(0.003)	(0.007)	(0.008)	(0.004)	(0.003)
Convergence speed (b)	0.014	0.023	0.016	0.019	0.051	0.032
R^2	0.12	0.24	0.51	0.035	0.36	0.32
Sample Size	121	121	121	121	121	121
Shapiro-Wilk Test	[0.602]	[0.270]	[0.026]	[0.050]	[0.538]	[0.581]
Breusch-Pagan	[0.519]	[0.480]	[0.103]	[0.010]	[0.022]	[0.653]
Robust LM Error	5.563	1.932	2.115	14.157	5.195	23.424
(p-value)	(0.001)	(0.165)	(0.146)	(0.000)	(0.063)	(0.000)
Robust LM Lag	0.491	1.325	0.208	7.771	0.314	7.250
(p-value)	(0.483)	(0.250)	(0.648)	(0.005)	(0.575)	(0.007)

Note: Standard errors in brackets. *** Significant values at 1%; ** Significant values at 5% and * significant at 10%. Robust LM Error and Robust LM Lag stands for the Robust Lagrange Multiplier test respectively for residual spatial autocorrelation (Ho: $\lambda = 0$) and spatially lagged endogenous variable (Ho: $\rho = 0$). The null hypothesis for Shapiro-Wilk test is that the data are normally distributed. Breusch-Pagan/Cook-Weisberg tests the null hypothesis that the error variances are all equal versus the alternative that the error variances are a multiplicative function of one or more variables. The implicit convergence speed is obtained thus: $b = -\ln\left(1-\hat{\beta}T\right)/T$. Where T is the length of the period.

The estimated β parameter is negative and significant in all cases, which shows a TFP convergence process in the 121 European regions both for the total of activities, with a convergence speed of 1.4%, as well as for the sectors although with different rates. When spatial interdependence is taken into account (in columns [1], [4] and [6] in Table 2), estimates of convergence parameters change. In Table 2, the modelling strategy for specifying a spatial econometric model is used. The commonly adopted procedure is to test the OLS model against the SAR, SEM and SLX models for an exogenously specified spatial weights matrix W. Tests (likelihood ratio) in the lower part of Table 2 in each column show if the null hypothesis $(\rho = 0)$, $(\lambda = 0)$ and $(\theta = 0)$ in equation (7), (8) or (9), is accepted, respectively. For the construction sector and the financial services the SLX model has been used (equation (9)) and SEM model (equation (7)) for the total of activities.

To simplify the presentation of the results, only the results of the model suggested by LR test are presented.

All the estimated variables have coefficients with a high level of significance. The spatial dependence parameter is positive and significant in all cases where is introduced. Regarding convergence, the estimated β parameter is negative and significant in all cases, which demonstrates a TFP convergence process in the 121 European regions both for the total of activities, with a rate of 0,9% annually, as well as for the sectors. The sectors that have the fastest converged are private productive services (5.1%) and the construction sector (4.8%), followed by financial and real estate (4.2%).

The industrial sector has the slowest convergence among all sectors and private services sector has the fastest. In an economic integration with specialization in relation to the processes of technological diffusion, these are more plausible in the non-tradable goods production, where the spatial division of labour makes no sense. This would lead one to expect, as happens for countries, (Bernard and Jones, 1996 a & b) catch up effects to occur in the service sector. Our results confirm that the highest convergence speeds are in the private service and construction sectors.

Table 2. Estimation Results. Spatial regression model.

Dependent variable	$\vartheta_{TFP,1995-2007}$					
Spatial Regression Model	**TOTAL** **[SEM]**	**Agriculture**	**Industry**	**Construction** **[SLX]**	**Private Services**	**Financial-Real state [SLX]**
$\hat{\alpha}$	0.0044*** (0.014)			0.057*** (0.059)		0.079*** (0.019)
$\hat{\beta}$	-0.008*** (0.003)			-0.038*** (0.010)		-0.034*** (0.004)
Convergence speed (*b*)	0.009			0.048		0.042
R^2	0.34			0.20		0.36
λ	0.361*** (0.089)					
ρ				0.049*** (0.017)		
θ						0.015*** (0.005)
LR Test SEM vs. OLS ($\lambda = 0$)	16.274[0.000]			1.463 [0.211]		1.160 [0.281]
LR Test SAR vs. OLS ($\rho = 0$)	1.431 [0.231]			0.853 [0.721]		0.318 [0.572]
LR Test SLX vs. OLS ($\theta = 0$)	16.274[0.482]			8.03 [0.004]		7.48 [0.006]

Note: Standard errors in brackets. *** Significant values at 1%; ** Significant values at 5% and * significant at 10%. The coefficient λ reflects residual special correlation, (see equation (7)). The coefficient ρ represents the spatial lag of endogenous variable, (see equation(8)) and the coefficient θ reflects average or typical spillovers, where averaging takes place across all observations, (see equation (9).

6. Total Factor Productivity dynamic.

The convergence that is generally observed in TFP between the 121 regions has occurred across the majority of sectors, albeit at different speeds, so it is interesting to analyze the role played by structural change and TFP sectoral dynamic in this convergence process.

6.1. TFP growth decomposition.

We define the TFP of a region –following Bernard and Jones (1996a)– as:

$$TFP_j = \frac{Q_j}{L_j^{1-\alpha_j} K_j^{\alpha_j}} = \sum_i \frac{Q_{ij}}{L_{ij}^{1-\alpha_{ij}} K_{ij}^{\alpha_{ij}}} \cdot \left[\frac{L_{ij}^{1-\alpha_{ij}}}{L_j^{1-\alpha_j}} \cdot \frac{K_{ij}^{\alpha_{ij}}}{K_j^{\alpha_j}} \right] = \sum_i TFP_{ij} \cdot \omega_{ij} \tag{10}$$

each of the $\omega_{ij,}$ that is, $\left[\frac{L_{ij}^{1-\alpha_{ij}}}{L_j^{1-\alpha_j}} \cdot \frac{K_{ij}^{\alpha_{ij}}}{K_j^{\alpha_j}} \right]$, is approximating the relative concentration of factors in sector *i*, with respect to the joint utilisation of resources by that region. Therefore, each of the ω_{ij} will be used to measure the relative participation of sector *i* in region *j*. The complete set of ω_{ij} is a proxy on the productive structure of each region *j* and the structural change is understood to be the modification of ω_{ij} in the different regions.

Thus, the TFP growth of each region (Total Effect, TE) can be decomposed between a structural change effect (SCE) and a productivity growth effect (PGE), based on equation (10), as

$$\hat{TFP}_j = \frac{\dot{TFP}_j}{TFP_j} = \sum_i \left(\hat{TFP}_{ij}\right)\left(\frac{TFP_{ij}}{TFP_j}\right)\left(\omega_{ij}\right) + \sum_i \left(\dot{\omega}_{ij}\right)\left(\frac{TFP_{ij}}{TFP_j}\right) \tag{11}$$

where the average growth rate for the 1995-2007 period is indicated by the circumflex accent, and the variation by the points.

The first term on the right is equivalent to the contribution of regional sectoral TFP dynamics to TFP growth, assuming that the initial productive structure does not change; the second term is equivalent to the structural change contribution.

Both effects are calculated for each of the 121 European regions. In order to better present the results, regions are grouped in to the four groups. As can be seen in Table 3, the results show the importance of geographical location (north or south) in the regional TFP growth. Within the northern regions or the southern are not present significant differences in TFP growth between Objective 1 regions and the rest.

On average, the group of regions in which TFP grows the fastest in this period are in the north (0.8% , see last row of the table). The southern regions grow between 0.2% and 0.1% -Objective 1 or not-, respectively.

In northern regions, the key role is played by growth effects (between 100% and 85%) and the structural change effects are less relevant. However, in the southern regions, the growth

effects are negative (-0.1 %) and TFP grows only slightly due to the structural shift towards construction and private services.

The disaggregated analysis of growth effects and structural change is essential to see the importance of the performance of the industrial sector in TFP growth in European regions. As can be observed in Table 3, the strong positive growth effect of the industrial sector in all regional groups very important is. This is the sector that has been major advances in TFP, although it has lost ground in all regional groups, as can be observed in the structural change effect. This loss is much higher in the southern regions, and this is what largely marks the difference between the northern and southern regions.

Structural change has occurred in the same direction in the different groups of regions, albeit at different intensities; in general, the share of agriculture has declined and the share of the industrial sector in all regions has also fallen. This period has also seen a higher transfer of productive resources to the financial and real estate sector (as well as to other private services, especially in the southern regions) in Objective 1 regions. In the southern regions, this has also occurred towards the construction sector. Structural change has been directed towards sectors where TFP grows less, that is, those with negative growth effects, but where technological diffusion is higher between regions, as seen in the previous section.

Table 3. Productivity Growth and Structural Change Effects. Groups of European Regions 1995-2007. Average Percentage contribution

SECTOR	Objective 1 Northern Regions			Remaining Northern Regions			Objective 1 Southern Regions			Remaining Southern Regions		
	PGE	SCE	TE	PGE	SCE	TE	PGE	SCE	TE	PGE	SCE	TE
Agriculture	15.84	-9.56	6.28	3.66	-3.70	-0.04	33.46	-77.43	-43.98	-6.57	-47.87	-54.44
Industry	78.00	-15.91	62.10	71.36	-40.06	31.30	77.29	-84.10	-6.81	110.51	-202.17	-91.66
Construction	-15.44	-35.69	-51.13	0.12	-0.86	-0.73	-71.77	112.42	40.65	-112.97	246.99	134.02
Priv Sect Prod	31.26	3.85	35.11	26.00	3.24	29.25	-31.88	59.71	27.83	-112.41	99.08	-13.34
Fin / Real Est.	-4.90	61.23	56.33	-11.14	59.54	48.40	-57.22	155.61	98.38	90.77	55.48	146.25
Public Admin	-4.23	-4.46	-8.69	-5.02	-3.15	-8.17	-1.21	-14.86	-16.07	-40.79	19.95	-20.83
Total Activity	**100.54**	**-0.54**	**100**	**84.98**	**15.02**	**100**	**-51.34**	**151.34**	**100**	**-71.45**	**171.45**	**100**
Total Activity	*0.008*	*-0.000*	*0.008*	*0.007*	*0.001*	*0.008*	*-0.001*	*0.003*	*0.002*	*-0.001*	*0.002*	*0.001*

Note: With the exception of the last row, where the value of productivity growth, structural change and total effects are shown, in the rest of the table, the percentages are shown that represent each of the effects with respect to the total activity. PGE: Productivity Growth Effect. SCE: Structural Change Effect. TE: Total Effect.

6.2. Catch-up in TFP.

To analyze the effect of sectoral TFP growth and structural change in convergence, we define TFP growth of the EU9 ($\hat{TFP}_P$) in a similar way to equation (11) and we measure the growth of the relative productivity of each region with respect to the EU9 which we define as overall net effect (NE).

$$NE = \hat{TFP}_j - \hat{TFP}_P = NPGE + NSCE \tag{12}$$

This overall net effect can be decomposed as the sum of a net productivity growth effect (NPGE) and a net structural change effect (NSCE). In turn, the productivity growth effect, using a shift-share analysis[17], can be expressed as a sectoral or industry mix effect (SE), a differential or competitive effect (DE) and an allocation effect (AL). The overall net effect can be expressed as:

$$NE = \sum_i \hat{TFP}_{iP} \frac{TFP_{iP}}{TFP_P} \omega_{iP} \left[\sigma_{ij} - 1\right] + \sum_i \omega_{iP} \left[TFP_{ij} \frac{TFP_{ij}}{TFP_j} - \hat{TFP}_{iP} \frac{TFP_{iP}}{TFP_P} \right] +$$

$$+ \sum_i \omega_{iP} \left[\sigma_{ij} - 1\right] \left[\hat{TFP}_{ij} \frac{TFP_{ij}}{TFP_j} - \hat{TFP}_{iP} \frac{TFP_{iP}}{TFP_P} \right] + \left[\sum_i \dot{\omega}_{ij} \frac{TFP_{ij}}{TFP_j} - \sum_i \dot{\omega}_{iP} \frac{TFP_{iP}}{TFP_P} \right] \tag{13}$$

The first expression to the right of the equals sign, the sectoral or industry mix effect, depends exclusively on the regional productive specialization (σ_{ij}) [18]. The second is a competitive or differential effect in the strict sense, a consequence of the different TFP sectoral dynamics in the region with respect to the EU9 and independent of the sectoral structure, and reflects the competitiveness of the industries in the region with respect to the EU9. The third contains the suitability for specialization (or not) in the sectors in which the region shows a higher (or lower) dynamic than the EU9 average across the different sectors, and the last term reflects the structural change effect in relation to the EU9.

The results of the shift-share decomposition can be seen in Table 4. The north-south distinction is again essential. Regardless of whether the regions are Objective 1 or not, in the northern regions, TFP grows more (values between 0.26 and 0.29) than in the EU9 and in the southern regions it grows less (values between -0.33 and -0.38) as can be seen in column [1].

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[17] The shift-share analysis applied to the study of European regions has been heavily utilised, although not applied to TFP, but rather to labour productivity. See Esteban (2000), Ezcurra, Pascual and Rapún (2005), O´Leary (2006) and Oguz and Knight (2010). There is also literature which includes spatial structure in the shift share analysis, see Nazara and Hewings (2004).

[18] Based in each of the ω_{ij} it is possible to immediately obtain the localization or specialisation coefficients (σ_{ij}) of a productive activity *i* in region *j* with respect to the country it belongs to, and also with respect to the EU9, $\sigma_{ij} = \frac{\omega_{ij}}{\omega_{iP}}$ with ω_{iP} the relative concentration of factors in sector *i* in the EU9 with respect to the complete utilisation in the EU9 Total Activities.

These results show no evidence of convergence between different groups of regions. The TFP of the northern regions have grown faster than the average of the EU-9 and the South much less, so there is no evidence of catch-up in TFP between the northern and southern regions. However, within each group the differences in TFP levels have decreased[19] differently depending on the group. Primarily, convergence or catch-up in northern and mainly in Objective 1 regions is observed.

Overall the most determining effect is always the differential or competitive effect (column [3]). In all regional groups, the global net effect coincides in sign and practically in size with the differential effect (see Table 4, column [5]). This result points to the existence of regional factors as determinants of TFP dynamic[20]. That is, even if each region had a productive structure similar to the EU9, the same behaviour would be observed in the regional TFP dynamics. The sectoral effects and the initial specialization of regions (column [2]) play a very minor role. The same holds true regarding the allocation effects can be seen in column [4].

Regarding the role played by the sectors in the size and sign of the differential effect of all activities, the results show that this in turn depends heavily on the size of the differential effect on the industrial sector and in the private services sector. If, in a region, the competitive effect in these sectors evolves positively (negatively) then the TFP in the region grows more (less). However, the major differences between regions occur in the differential effect of the industrial sector. The economic importance of industrial activities is much greater than suggested by the share of manufacturing in GVA. As Rueda-Cantuche et al, (2013) indicate: "Industry accounts for over 80% of Europe's exports and 80% of private research and innovation. Nearly one in four private sector jobs is in industry, often highly skilled, while each additional job in manufacturing creat 0.5-2 jobs in other sectors".

Structural change has had a positive and much more important effect across all the southern regions where it has softened the fall in TFP. This has been a result of the fact that, although the industrial sector has decreased, it has done so less rapidly than the EU9 (i.e. less than -0.31 %,) the construction sector has greatly increased (in the EU9 it does not change) as has the production services sector (0.05 % above the EU9), from the agricultural sector to other private and public services.

Since the more determinant effects are the differential, we decompose this effect to take into consideration the nation to which the region belongs. Thus the total differential effect (DE) will be

$$DE = \sum_i \omega_{iP} \left[\hat{TFP}_{ij} \frac{TFP_{ij}}{TFP_j} - \hat{TFP}_{iN} \frac{TFP_{iN}}{TFP_N} \right] + \sum_i \omega_{iP} \left[\hat{TFP}_{iN} \frac{TFP_{iN}}{TFP_N} - \hat{TFP}_{iP} \frac{TFP_{iP}}{TFP_P} \right] \qquad (14)$$

[19] As shown in Figure A4.1 Appendix 4. In this figure convergence-σ is represented for four groups during the period 1995-2007.

[20] This result, of the dominant differential effect, agrees with those results obtained previously by Esteban (2000) and Ezcurra, Pascual and Rapún (2005) for earlier periods in the EU, although these authors use a static shift share analysis.

The first expression on the right represents the regional differential effect (RDE) with respect to the nation and the second expression represents the differential effect of the nation with respect to the EU9 (NDE).

Table 4. Sources of convergence and catch-up in TFP. Regional group average in relation to EU9.

REGION	SECTOR	GLOBAL NET EFFECT [1]	NET PRODUCTIVITY GROWTH EFFECT				NET STRUCTURAL CHANGE EFFECT [6]
			Sectoral Effect [2]	Differential Effect [3]	Allocation Effect [4]	Sum [5]	
Objective 1 Northern Regions	Agriculture	0.06	0.01	0.05	0.03	0.09	-0.03
	Industry	0.41	-0.07	0.39	-0.09	0.23	0.19
	Construction	-0.35	-0.02	-0.01	-0.04	-0.07	-0.28
	Priv Sec Prod	0.07	-0.01	0.12	-0.02	0.09	-0.02
	RE & Fin S.	0.09	0.01	-0.06	0.07	0.02	0.07
	Public Sec	-0.03	-0.00	0.00	-0.00	-0.01	-0.02
	Total Activ.	**0.26**	**-0.08**	**0.49**	**-0.06**	**0.35**	**-0.08**
Remaining Northern Regions	Agriculture	0.01	0.01	-0.01	0.00	-0.00	0.02
	Industry	0.18	-0.01	0.22	-0.02	0.19	-0.01
	Construction	0.04	0.00	0.05	-0.00	0.05	-0.01
	Priv Sec Prod	0.03	0.00	0.05	-0.00	0.05	-0.02
	RE & Fin S.	0.04	0.00	-0.05	0.01	-0.03	0.07
	Public Sec	-0.03	-0.00	-0.01	-0.00	-0.02	-0.01
	Total Activ.	**0.29**	**0.01**	**0.25**	**-0.00**	**0.25**	**0.04**
Objective 1 Southern Regions	Agriculture	-0.07	0.04	-0.00	-0.01	0.03	-0.10
	Industry	-0.08	-0.06	-0.24	0.06	-0.24	0.15
	Construction	0.13	-0.01	-0.06	-0.01	-0.09	0.21
	Priv Sec Prod	-0.15	0.01	-0.23	0.00	-0.22	0.07
	RE & Fin S.	-0.16	0.02	-0.16	0.09	-0.05	-0.11
	Public Sec	0.01	-0.00	0.02	0.00	0.02	-0.01
	Total Activ.	**-0.33**	**0.00**	**-0.68**	**0.14**	**-0.54**	**0.21**
Remain Southern Regions	Agriculture	-0.06	0.01	-0.04	-0.00	-0.04	-0.02
	Industry	-0.20	0.05	-0.27	-0.01	-0.23	0.04
	Construction	0.23	-0.00	-0.10	-0.00	-0.10	0.34
	Priv Sec Prod	-0.22	0.01	-0.29	-0.03	-0.31	0.09
	RE & Fin S.	-0.15	0.01	0.18	-0.00	0.18	-0.33
	Public Sec	0.01	0.00	-0.03	-0.00	-0.03	0.04
	Total Activ.	**-0.38**	**0.08**	**-0.56**	**-0.06**	**-0.54**	**0.15**

In Table 5 can be seen the results of shift-share decomposition. In the differential effect, the national competitive component with respect to EU9 -Column [2] in each group of regions- is what determines the overall differential effect. It is mainly national factors that make regional TFP more or less dynamic. The national competitive effect is positive in the northern regions, irrespective of them being Objective 1 or not, and especially so if they are Objective 1. It is negative in the southern regions and similar in size, irrespective of them being Objective 1.

Table 5. Regional and National Effects. Differential effect decomposition.

SECTOR	Objective 1 Northern Regions			Remaining Northern Regions			Objective 1 Southern Regions			Remaining Southern Regions		
	Regional Effect	National Effect	Total	Regional Effect	National Effect	Total	Regional Effect	National Effect	Total	Regional Effect	National Effect	Total
Agriculture	0.00	0.05	0.05	-0.02	0.01	-0.01	0.01	-0.02	-0.00	-0.03	-0.02	-0.04
Industry	0.11	0.29	0.39	0.01	0.20	0.22	0.00	-0.25	-0.24	0.02	-0.29	-0.27
Construction	-0.05	0.04	-0.01	0.01	0.04	0.05	-0.02	-0.05	-0.06	-0.04	-0.07	-0.10
Priv Sect Prod	-0.03	0.14	0.12	-0.05	0.10	0.05	-0.01	-0.22	-0.23	-0.03	-0.27	-0.29
Fin / Real Est.	0.00	-0.06	-0.06	-0.04	-0.01	-0.05	-0.23	0.07	-0.16	0.06	0.12	0.18
Public Admin	-0.01	0.01	0.00	-0.00	-0.01	-0.01	0.07	-0.05	0.02	-0.00	-0.03	-0.03
Total Activity	**0.02**	**0.46**	**0.49**	**-0.09**	**0.34**	**0.25**	**-0.17**	**-0.51**	**-0.68**	**-0.01**	**-0.55**	**-0.56**

7. Conclusions and final observations.

In this paper, European regions levels TFP from a disaggregated approach are calculated. To do so, different factor shares for region and industry are used. Although the type of analysis carried out in this paper has been mainly descriptive, it has led to some important conclusions. Our results show evidence that the TFP absolute convergence rate among European regions is very different, depending on the production sector concerned. It is very slow in industry (tradable goods) and the technological diffusion processes between regions are higher in the private services and construction sectors.

When we consider the four different groups of regions barely can be seen a catch-up process each other. This is indicative that the absolute convergence observed among European regions has considerable spatial component, and probably occurs between neighboring regions, ie mainly within each group. In fact the northern regions have reduced disparities in levels of TFP especially Objective 1 regions.

Our results agree with O'Leary (2006), Batog and Batog (2007) and De Gallo and Kamerianakis (2011) who advocate using multi-sectoral approaches. By analyzing not only the level but also the growth of TFP and relating them to each other, for example by studying convergence, the disaggregated approaches become fully relevant.

Industry is the sector that plays the most determinant positive role in regional TFP growth in all the regional groups, and largely marks the difference in the dynamic between the north and south regions; it contributes with a growth effect of 0.6 % in all the northern regions

and only 0.1 % in the south. The manufacturing sector generates significant demand for research and qualified services. It is little wonder that today the EU executive's 20-20-20 strategy will be used to revive the industrial sector in the twenty-seven European countries, such that by 2020 it reaches 20% of total activity.

Our findings show distinctly different trends between northern and southern Europe. Note that the TFP growth in the northern regions (0.8 %) is independent of whether they are Objective 1 or not, and in the southern regions, it is either 0.2 and 0.1% depending on whether they are Objective 1 or not. That is, regardless of whether the regions are Objective 1 or not, in the northern regions, TFP growth is approximately about 0.3 more than in the EU9 and in the south it is some 0.3 less. Overall, the most determinant effect is always the differential (the competitive effect); in all regional groups, the overall net effect agrees in sign and practically in size with the differential effect. This indicates the existence of local competitive factors as determinants of the TFP trend dynamic. That is, even if each region had a productive structure similar to the EU9, the same trends would be observed in the regional TFP dynamic.

In addition, structural change has seen positive and much bigger trends in all the southern regions where it has softened the fall in TFP (they would have had a net negative effect without the structural change effect) as the industrial sector reduced at a slower rate than in the EU9. Perhaps this is related to the much higher relocation and restructuring levels of the industrial sector in northern regions, and the continued use of medium and low industrial technology in the south.

The aggregate approach, although it is not sufficient, is of the utmost importance, not only because it should clearly be related to regional infrastructure and human and technological capital provision policies, but also because very global geographic and national aspects influence the regional differential effects. This points to policies decided at multiregional and trans-frontier level that take into account the existing geographical imbalances and that reduce barriers and distances between regions regarding these provisions, as well as to structural reforms in countries that promote competitiveness and the correct functioning of factor and product markets. This is about generating the necessary incentives to improve productivity performance in the most under developed regions of Europe.

The importance of these domestic factors (regulatory framework in both the goods as well as the factors market, quality of institutions etc.) on the productivity trends in the European regions will direct our research in the future.

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APPENDIX 1. BD.EURS Database (NACE Rev. 1)

The basic data for the 121 European regions and the period 1995-2007, are taken from the BD.EURS database (NACE Rev.1) base year 2000. This basis is the result of analyzing the quality and consistency of the different statistical sources available on the basic macroeconomic variables - GVA in current and constant prices, employment, gross fixed capital formation and capital stock- for countries and at level NUTS-2. The level of regional disaggregation corresponds to NUTS2 in the Eurostat nomenclature of statistical territorial units and the level of industry disaggregation corresponds to six major sectors: agriculture and fisheries, industry (manufacturing and energy), construction, wholesale and retail trade services including hotels and restaurants and transport, financial, real estate and other business services, and finally, public administration.

In this version of the database, only information about 121 regions from 9 European countries is presented. These are those regions which provide higher quality and quantity of information for the period 1995-2007. They are: the regions of Belgium, Germany, France, Italy, Netherlands, Austria, Portugal, Sweden and Spain. The basic source of information is the regional series of EUROSTAT and also using as a reference the existing information for countries especially in databases, AMECO and EU-KLEMS.

The TFP series of European sectors and regions used in this paper were obtained from the GVA series, employment, capital income share and labour income share, and are:

Gross value added. GVA at current prices from EUROSTAT includes production of goods and services at factor costs produced in the region by the six sectors. GVA deflactors are obtained from EU-KLEMS. Series in PPS (Purchasing power standards)

Number of employees. National information from the series provided by AMECO and EUROSTAT, sectoral disaggregation from EUROSTAT and EU-KLEMS and the regional disaggregation from EUROSTAT.

Gross earnings of each regional industry. The gross earnings of each regional industry is calculated using the EU-KLEMS and EUROSTAT as a reference.

Capital stock. Net stock of capital in the region by the six branches of activity for 121 regions in nine European countries for the period 1995-2007. They are calculated using the Perpetual Inventory Method (PIM). Regional series of GFCF taken from EUROSTAT are the basic inputs of the estimation, while the criteria followed to prioritise regional comparability consists, on the one hand, of using the same sectoral depreciation rates for all the countries and regions in the sample and, on the other, of constructing sectoral regional capital stocks under identical criteria for all the regions in the different countries. Capital stock series provide a sectoral disaggregate similar to the used by EUROSTAT (NACE Rev. 1) for regional GFCF.

Currently, the majority of the European countries are immersed in a process of adapting their national and regional accounts to the NACE Rev.2 norms, to harmonise them with other EU members and involves significant changes from the base 2000 (NACE Rev.1). There are serious difficulties in linking both regional bases, the availability of the new NACE Rev.2 is going at different rates in different countries, with considerable delays. Besides the inherent difficulties in being able to directly link the national and sectoral magnitudes of Rev.1 with Rev.2, the necessary and sufficient base information is not currently available to be able to address a satisfactory link of the accounts to a sufficiently disaggregated NUTS2 level. This is why this work is limited to the 1995-2007 period.

APPENDIX 2. European Regions and Groups

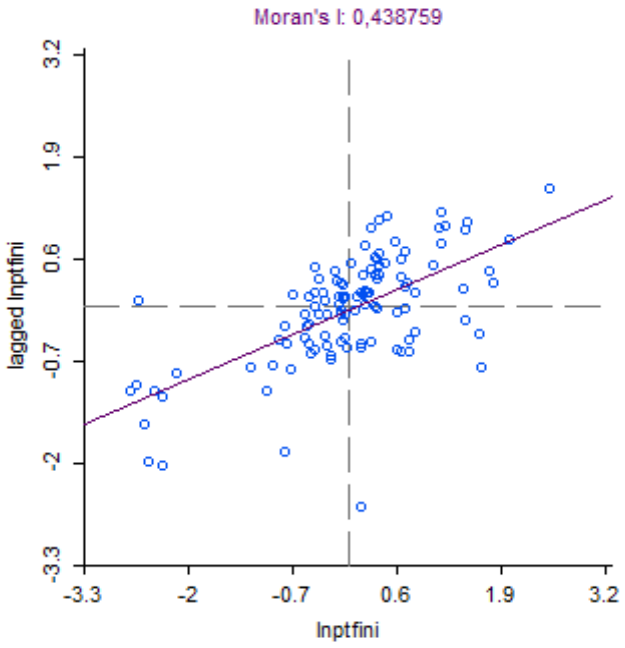
Table A2.1. NUTS2 Codes and Regional Groupings

Code	Group	Region	Code	Group	Region
Be1	North	Région de Bruxellest	Fr71	North	Rhône-Alpes
Be21	North	Prov. Antwerpen	Fr72	North	Auvergne
Be22	North	Prov. Limburg	Fr81	North	Languedoc-Roussillon
Be23	North	Prov. Oost-Vlaanderen	Fr82	North	Alpes-Côte d'Azur
Be24	North	Prov. Vlaams Brabant	Fr83	O1 North	Corse
Be25	North	Prov. West-Vlaanderen	Itc1	North	Piemonte
Be31	North	Prov. Brabant Wallon	Itc2	North	Valle d'Aosta
Be32	O1 North	Prov. Hainaut	Itc3	North	Liguria
Be33	North	Prov. Liège	Itc4	North	Lombardia
Be34	North	Prov. Luxembourg (B)	Itd1	North	Bolzano-Bozen
Be35	North	Prov. Namur	Itd2	North	Prov. Trento
De1	North	Baden-Württemberg	Itd3	North	Veneto
De2	North	Bayern	Itd4	North	Friuli-Venezia Giulia
De3	O1 North	Berlin	Itd5	North	Emilia-Romagna
De4	O1 North	Brandenburg	Ite1	North	Toscana
De5	North	Bremen	Ite2	South	Umbria
De6	North	Hamburg	Ite3	South	Marche
De7	North	Hessen	Ite4	North	Lazio
De8	O1 North	Mecklenburg-Vorpom	Itf1	O1 South	Abruzzo
De9	O1 North	Niedersachsen	Itf2	O1 South	Molise
Dea	North	Nordrhein-Westfalen	Itf3	O1 South	Campania
Deb	North	Rheinland-Pfalz	Itf4	O1 South	Puglia
Ded	O1 North	Sachsen	Itf5	O1 South	Basilicata
Dec	North	Saarland	Itf6	O1 South	Calabria
Dee	O1 North	Sachsen-Anhalt	Itg1	O1 South	Sicilia
Def	North	Schleswig-Holstein	Itg2	O1 South	Sardegna
Deg	O1 North	Thüringen	Nl11	North	Groningen
Es11	O1 South	Galicia	Nl12	North	Friesland (NL)
Es12	O1 South	Asturias	Nl13	North	Drenthe
Es13	O1 South	Cantabria	Nl21	North	Overijssel
Es21	South	País Vasco	Nl22	North	Gelderland
Es22	South	Navarra	Nl23	O1 North	Flevoland
Es23	South	La Rioja	Nl31	North	Utrecht
Es24	South	Aragón	Nl32	North	Noord-Holland
Es3	South	Comunidad Madrid	Nl33	North	Zuid-Holland
Es41	O1 South	Castilla y León	Nl34	North	Zeeland
Es42	O1 South	Castilla-la Mancha	Nl41	North	Noord-Brabant
Es43	O1 South	Extremadura	Nl42	North	Limburg (NL)
Es51	South	Cataluña	At11	O1 North	Burgenland (A)
Es52	O1 South	Comunidad Valenciana	At12	North	Niederösterreich
Es53	South	Illes Balears	At13	North	Wien
Es61	O1 South	Andalucía	At21	North	Kärnten
Es62	O1 South	Región de Murcia	At22	North	Steiermark
Es7	O1 South	Canarias	At31	North	Oberösterreich
Fr1	North	Île de France	At32	North	Salzburg
Fr21	North	Champagne-Ardenne	At33	North	Tirol
Fr22	North	Picardie	At34	North	Vorarlberg
Fr23	North	Haute-Normandie	Pt11	O1 South	North
Fr24	North	Centre	Pt15	O1 South	Algarve
Fr25	North	Basse-Normandie	Pt16	O1 South	Centro (PT)

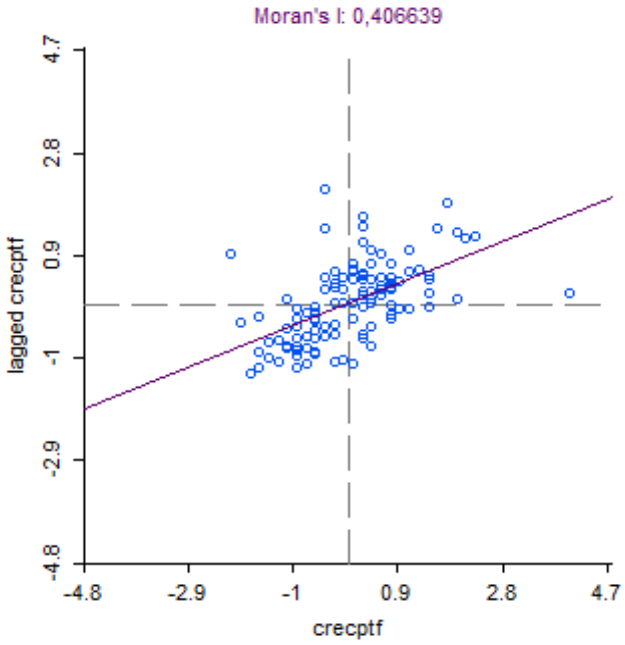
Fr26	Bourgogne	Pt17	O1 South	Lisboa
Fr3	Nord - Pas-de-Calais	Pt18	O1 South	Alentejo
Fr41	Lorraine	Se11	North	Stockholm
Fr42	Alsace	Se12	North	Östra Mellansverige
Fr43	Franche-Comté	Se21	North	Småland med öarna
Fr51	Pays de la Loire	Se22	North	Sydsverige
Fr52	Bretagne	Se23	North	Västsverige
Fr53	Poitou-Charentes	Se31	O1 North	Norra Mellansverige
Fr61	Aquitaine	Se32	O1 North	Mellersta Norrland
Fr62	Midi-Pyrénées	Se33	O1 North	Övre Norrland
Fr63	Limousin			

Note: O1 North: Northern Objective 1 Regions; O1 South: Southern Objective 1 Regions; North: Remaining Northern Regions; South: Remaining Southern Regions

APPENDIX 3. Spatial Dependence Exploratory Analysis.



Graph A3.1. Moran Scatterplot showing TFP in 1995.Total Activities



Graph A3.2. Moran Scatterplot showing TFP growth rates in the 1995-2007 period. Total Activities.

APPENDIX 4. Characteristics of the European Union 9

Table A.4. Main characteristics of the European Union of the 9 countries included in this paper.

Sectors	$\omega_{ij_{1995}}$	$\frac{Q_{ij}}{Q_{j\ 1995}}$	TFP_{1995}	$\hat{TFP}$	Growth Effect	Structural Change Effect	Total Effect
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Agriculture	0.040	0.025	44	0.013	0.0003	-0.0005	-0.0001
Industry	0.186	0.226	87	0.017	0.0039	-0.0031	0.0007
Construction	0.045	0.063	101	-0.008	-0.0005	0.0000	-0.0005
Private Productive Services	0.192	0.202	76	0.008	0.0016	0.0005	0.0020
Financial, Real Estate and business services	0.240	0.252	76	-0.002	-0.0006	0.0041	0.0035
Public administration	0.271	0.233	62	-0.001	-0.0002	-0.0002	-0.0004
Total Activities	1.000	1.000	72	0.004	0.0044	0.0008	0.0052

Note: The values in columns [4] to [7] correspond to the average of the 1995-2007 period.

In Percentages

Sectors	$\omega_{ij_{1995}}$	$\frac{Q_{ij}}{Q_{j\ 1995}}$	TFP_{1995}	$\hat{TFP}$	Growth Effect	Structural Change Effect	Total Effect
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Agriculture	4.0	2.5	44	1.28	0.03	-0.05	-0.01
Industry	18.6	22.6	87	1.71	0.39	-0.31	0.07
Construction	4.5	6.3	101	-0.80	-0.05	0.00	-0.05
Private Productive Services	19.2	20.2	76	0.77	0.16	0.05	0.20
Financial, Real Estate and business services	24.0	25.2	76	-0.24	-0.06	0.41	0.35
Public administration	27.1	23.3	62	-0.10	-0.02	-0.02	-0.04
Total Activities	100	100	72	0.44	0.44	0.08	0.52

Note: The values in columns [4] to [7] correspond to the average of the period 1995-2007.

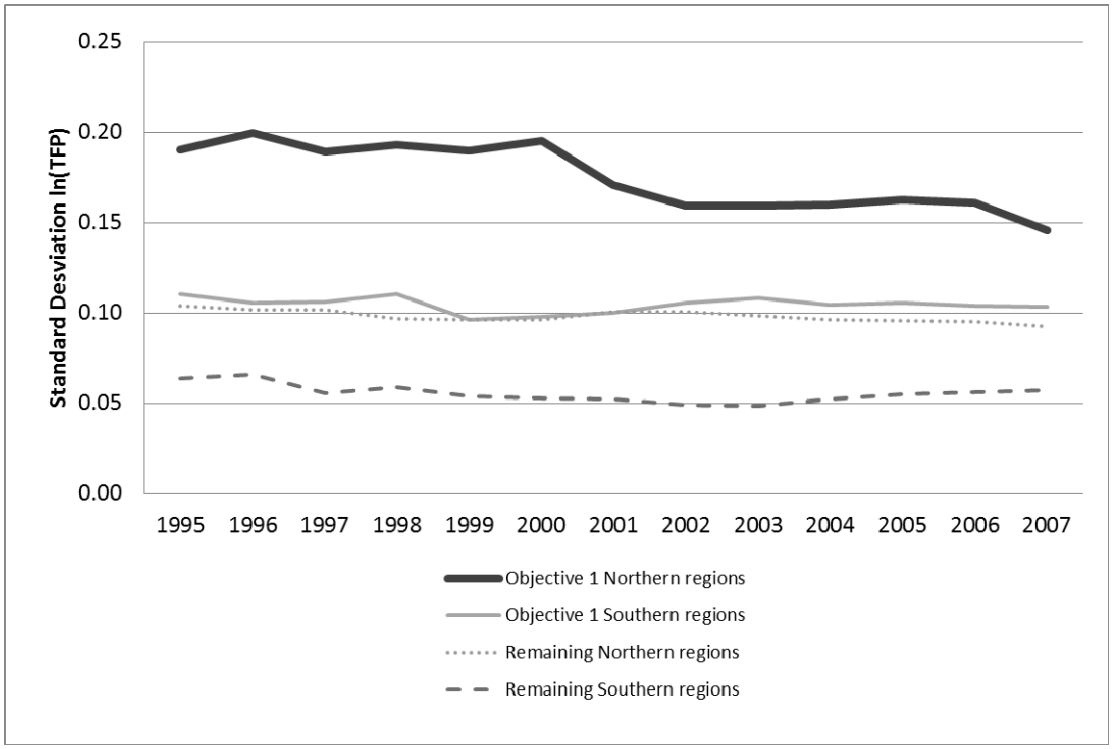


Figure A4.1. σ-Convergence in European regions.