

Benito, Juan Miguel; Ezcurra, Roberto

Conference Paper

Spatial disparities in productivity and industry mix: The case of the European regions

44th Congress of the European Regional Science Association: "Regions and Fiscal Federalism", 25th - 29th August 2004, Porto, Portugal

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Benito, Juan Miguel; Ezcurra, Roberto (2004) : Spatial disparities in productivity and industry mix: The case of the European regions, 44th Congress of the European Regional Science Association: "Regions and Fiscal Federalism", 25th - 29th August 2004, Porto, Portugal, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/116992>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Spatial disparities in productivity and industry mix. The case of the European regions*

Juan Miguel Benito and Roberto Ezcurra[†]

Department of Economics
Universidad Pública de Navarra

Abstract

This paper applies nonparametric techniques to examine the evolution of the entire distribution of regional productivity in the European Union between 1977 and 1999. Likewise, we study the strength of the respective roles played by regional and sectoral factors in the convergence of productivity observed in the European context. To achieve this aim, we consider a new methodology involving a modification of conventional shift-share analysis and various results reported in the literature on personal income distribution. Our results suggest that regional inequality in productivity in the European Union is closely linked to *intrinsic* differences between regions. Likewise, the analyses reveal the major role played by the national component and spatial dimension in the explanation of regional disparities in product per worker in the European Union. In addition, our findings support the relevance of one-sector growth models for analysing regional disparities in per capita income.

Key words: Regional disparities, productivity, European Union.

JEL Code: R10, R11, R58.

*The authors wish to acknowledge the comments and suggestions of Pedro Pascual and Manuel Rapún. Roberto Ezcurra is also grateful for the financial support from MCYT (BEC2002-03941) and the Fundación BBVA.

[†]Postal address: Department of Economics, Universidad Pública de Navarra, Campus de Arrosadia s/n. 31006 Pamplona (Spain). E-mail address: jon.benito@unavarra.es and roberto.ezcurra@unavarra.es.

1 Introduction

In recent years, the issue of territorial imbalances in the European Union has been examined in numerous studies from a variety of different approaches¹. There are various reasons for the amount of interest surrounding this issue. Among them is the fact that economic growth theory has advanced greatly over the last fifteen years, coinciding with the introduction of endogenous growth models in the mid eighties. Another, the need to reduce disparities in terms of development levels across the various European regions, is directly related to some of the basic principles behind the forming of the Union, especially since the introduction of the Single Act and the Maastricht agreements. In particular, one of the specific assumptions of the European integration programme is that it will drive the growth of all Member States, thereby increasing economic and social cohesion².

Against this background, Esteban (1994) and Ezcurra (2003) have shown that regional differences in productivity are the main reason for regional inequality in per capita income in the European Union³. It therefore seems that the logical procedure would be to analyse the regional distribution of product per worker and try to pinpoint the causes of spatial differences in productivity in order to gain a deeper understanding of the per capita income disparities between European regions. In fact, this is the issue that the present study aims to address.

One possible cause of regional inequality in aggregate productivity might be related to significant differences in product per worker across the various sectors⁴. If this were the case, significant longstanding disparities in regional productivity might well be perfectly compatible with processes of regional convergence in production per worker in each of the various sectors⁵. In other words, this would mean

¹A review of this literature and the principle findings obtained can be found in Armstrong (2002) or Terrasi (2002).

²Specifically, article 2 of the Treaty of the European Union states that “The Community shall have as its task to promote (...) a harmonious and balanced development of economic activities (...), a high degree of convergence of economic performance (...)”.

³In contrast to the situation in Europe, Browne (1989) and Carlino (1992) report the main cause of regional disparities in per capita income in the United States to be regional variability in unemployment rates.

⁴There is a general trend in the literature on economic convergence to include in the convergence equation structural variables relating to the industry mix (Barro and Sala-i-Martin, 1991). In this respect, see also Fagerberg and Verspagen (1996) or Paci and Pigliaru (1997, 1999).

⁵In fact, Paci (1997) detects convergence in the secondary and tertiary sectors in 109 European regions over the 1980-1990 period.

that regional differences in per capita income might basically be due to variability in the industry mix across the European regions. In fact, as the European Commission (1999) reports, regions specialising in dynamic, high growth sectors tend to perform better in terms of per capita income. The industry mix in each region meanwhile would, in theory, be mainly a consequence of some kind of comparative advantage or circumstances in history.

On the other hand, however, disparities in productivity may be related to *intrinsic* differences between regions. If this were the case, the main determinants of regional inequality in productivity would be those basic aggregate factors, such as infrastructure, human capital and R&D, that have an uniform impact on productivity in all sectors.

The aim of this study, therefore, is to analyse the regional distribution of product per worker in the European Union between 1977 and 1999. Likewise, we study the impact of the respective roles played by regional and sectoral factors in the convergence of productivity observed in the European context. In the process, it is also hoped that some new light will be shed on the characteristics of regional inequality and that, ultimately, some type of inference will emerge that might prove useful when it comes to designing regional policy and determining how to increase productivity in more backward regions. Our findings will also help to assess the theoretical relevance of one-sector growth models in attempting to account for regional per capita income disparities.

Most of the studies that have analysed regional disparities in per capita income in the European context apply the concepts of sigma convergence and beta convergence, introduced by Barro and Sala-i-Martin (1991, 1992), combining the information provided by various dispersion statistics with the estimate of convergence equations. However, as Quah (1993, 1996a, 1997) has repeatedly pointed out, not only does this approach raise a number of econometric problems, it also fails to capture a series of potentially interesting features of the dynamics of the distribution in question. In particular, this type of analysis provides only a partial view of the observed distribution, since it neglects to consider, for example, the fact that the various regions may shift their relative positions over the study period; thus it completely ignores the possibility of intradistributional mobility. This conventional approach also fails to inform about the possible existence of distinct clusters of regions with distinguishing features that set them apart from the rest of the population. To address some of the limitations of conventional convergence

analysis, this paper adopts the nonparametric approach proposed by Quah (1996a, 1997) to examine the evolution of the entire cross-section distribution. Moreover, we explore the causes of regional productivity by means of a new methodology involving a combination of shift-share analysis and various results reported in the literature on personal income distribution. This enables us to assess the impact of various factors in regional disparities in product per worker in the European context.

A conditioning factor in all studies of regional disparities in the European Union is lack of regional data. Some authors [Barro and Sala-i-Martin (1991), Sala-i-Martin (1996), Fagerberg and Verspagen (1996)] decided to limit the number of countries included in their studies in order to obtain a longer study period. Others [Esteban (1994), Neven and Gouyette (1995), Quah (1996b), López Bazo et al. (1999)] preferred to increase the number of countries, even at the expense of restricting the study period. In this respect, our study makes a major break from previous literature on the subject. The use of data supplied by Cambridge Econometrics has enabled us to work with figures for 197 NUTS2 regions from all of the member states. This includes a sectoral breakdown of employment and value added at market prices for the period 1977 to 1999. Monetary variables have been converted into constant 1990 euros, by applying the necessary deflators, thus enabling us to compare data for different years in real terms⁶.

The paper is organised as follows. The next section examines the dynamics of the distribution of product per worker in the European Union. To further round off the results obtained thus far, section 3 analyses the roles of the national component and the spatial dimension in territorial imbalances observed in the European context. Section 4 investigates the factors that lead to region-specific differentials. Finally, the main conclusions of the paper are summed up in section 5.

⁶The data provided by Cambridge Econometrics are based mainly on information supplied by REGIO, the Eurostat regional database. REGIO, however, is seriously lacking in some respects, especially when it comes to data relating to the late seventies and early eighties. For this reason, and because of the need for complete series of regional data for a sufficient number of NUTS2 regions over time, Cambridge Econometrics has opted to complete REGIO data with alternative national statistics and interpolation methods. Lack of complete data, however, has obliged us to exclude from our study the new German Länder, French overseas departments and Spanish territories in North Africa.

2 The distribution dynamics of regional productivity

We will begin by examining the evolution of spatial disparities in productivity in the European Union over the 1977 to 1999 period. In contrast to the procedure adopted in conventional convergence analysis, this paper will approach the issue by calculating a series of indicators traditionally used to study personal income distribution. However, since our unit of reference is the region and not the individual, we will then introduce into the analysis the relative frequencies of each observation. Thus, all the indicators calculated will be statistics weighted by the employment share of the different regions. With a few exceptions, studies that focus on the convergence hypothesis tend to ignore differences in population, income or employment across the various regions considered. This omission has particular repercussions in the European context, since it means assigning the same weight in the analysis to widely differing regions⁷.

Within the literature on personal income, it is a well-known fact that results may differ, at times substantially, according to which measures are used in the analysis. Given the obvious difficulty arising from the fact that different indicators may give different orderings of the distributions to be compared, it would seem reasonable to check the robustness of our results against different inequality measures. In accordance with this procedure, in this paper we have examined regional disparities in productivity in the European Union by means of the information provided by the Gini index, $G(x)$, and the two measures proposed by Theil (1967) within the information theory context, $T(0)$ and $T(1)$. We also take into account the coefficient of variation and the standard deviation of the logs, two measures of dispersion that are common in descriptive statistics and widely used in the convergence literature to capture the concept of sigma convergence⁸. All the indices selected are independent of scale and size of population and, except for the standard deviation of the logs, they all fulfil the Pigou-Dalton transfer principle⁹.

Figure 1 presents the evolution of the inequality indices just mentioned¹⁰.

⁷In employment terms, for example, 1999 figures ranged between 16.000 employed in the Finnish region of Åland and over 5 million in Île de France.

⁸In contrast to the procedure adopted in conventional convergence analyses, for the purposes of this paper, both statistics were calculated after including the corresponding weightings.

⁹Chakravarty (1990) and Cowell (1995), among others, make a detailed analysis of these and other normative properties that should be satisfied by an inequality index.

¹⁰In order to detect the possible existence of significant differences in the evolution of the

The results indicate that the dispersion of the distribution analysed decreased between 1977 and 1999. Indeed, the various indices values fell between 32% and 14% over the twenty-three years considered. This does not imply a steady rate of reduction in disparity throughout the period, however. In fact, by whichever measure of inequality it is viewed, the main reduction in inequality is seen to have taken place in the late seventies, followed by a period of stagnation in the two decades that followed. The standard deviation of the logs, moreover, though it is not the ordinal equivalent of the remaining measures, can be seen to behave in a qualitatively similar fashion. Note, also, that the Theil indices do not appear to be particularly sensitive to the shares used to weight inequality. This is simply an indication of high positive correlation between regional employment and income shares in the European Union¹¹. Indeed, the average of the correlation coefficient between the two variables for the 1977 to 1999 period is 0.95.

[INSERT FIGURE 1 AROUND HERE]

The various statistics calculated so far do not provide an accurate description of the regional per capita income distribution. We will now, therefore, estimate the density functions of the distribution analysed. Following common practice in the literature, we will use non-parametric estimation techniques, thus avoiding the need to specify any particular functional form beforehand. This kind of approach undoubtedly offers major advantages in the present context, where parametric approximations are lacking in generality and flexibility.

Figure 2 shows the density functions, both simple and weighted by share of employment, of the regional distribution of product per worker¹². The x axis represents regional productivity normalised (taking 100 as the European average) and the y axis shows the distribution of probability associated. Estimates are based on calculations using Gaussian kernel functions. The optimal smoothing

inequality over time, in Figure 1 the various measures have been normalised by giving a value of 100 to the level corresponding to the year 1977.

¹¹Recall that in this context the only difference between $T(0)$ and $T(1)$ is the interchanging roles played by the employment and income shares.

¹²Though density functions were estimated for each year of the period analysed, to save space, we present only those of 1977, 1980, 1985, 1990, 1995 and 1999. The rest are available from the authors upon request.

parameter value is also determined in each case, following Silverman (1986)¹³.

[INSERT FIGURE 2 AROUND HERE]

The results obtained reveal the presence of significant differences in the external shape of the distribution analysed between 1977 and 1999, showing that the initial situation does not remain stable throughout time. As Figure 2 shows, the probability mass concentrated around the community average has increased during the twenty-three years considered. Simultaneously, there has been a reduction in the distance between the extreme values of the distribution. These findings are also consistent with the evolution of regional inequality in productivity described earlier.

Likewise, the analysis carried out suggests the existence of some degree of polarisation in the regional distribution of product per worker in the European context. In 1977 the density functions estimated are characterised by the existence of a single mode around the European average. However, in the following years, the external shape of the distribution changes and, at the end of eighties, it is possible to appreciate a timid polarisation into two groups. Indeed, in the second part of the period, as well as the usual cluster of regions around the European average, there is a new local maximum, formed by regions situated at the bottom of the distribution. This result can be interpreted as an indication of the difficulties faced by some regions with relatively low levels of productivity to improve their relative positions. Finally, there are signs that suggest the possible formation of a third pole, integrated in this case by regions situated at the top of the distribution.

The density functions estimated in Figure 2 give a first impression of the external shape of the distribution for each year considered. This type of analysis, however, is based on a series of cross-sections of the distribution examined, and does not, therefore, take into account, for example, that, over time, the different economies may shift their relative positions in terms of productivity. To address this shortcoming and to complete the results obtained so far, we will now take a look at intra distributional mobility in the distribution of product per worker in the European Union between 1977 and 1999.

¹³See Silverman (1986), section 2.10. Readers interested in the methodological details might consult, the monographs of Scott (1992), Wand and Jones (1994) or Simonoff (1996), among others.

Most of the studies that have addressed this issue are based on the discrete transition matrix, obtained by a process that divides the distribution into a series of mutually exclusive classes¹⁴. This approach entails a problem, however, since the results it yields are sensitive to the way in which the observed distribution is divided up. Nevertheless, since there is no procedure for determining the optimum number of classes in each case, the researcher must decide arbitrarily. To address this problem, Quah (1996a, 1997) suggests substituting the transition matrix with a stochastic kernel to reflect the probabilities of transition between a hypothetically infinite number of classes, reducing their size infinitesimally. According to Quah (1996a, 1997) the stochastic kernel can be reached by estimating the density function of the distribution over a given period, $t + k$, conditioned on the values corresponding to a previous period, t . In other words, the joint density function at moments t and $t + k$ is estimated and then divided by the implicit marginal distribution in order to obtain the corresponding conditional probabilities.

Before discussing the results obtained when we apply this instrument to the analysis of distribution dynamics, some clarification of the methodology is required. Thus, Gaussian kernel functions are used in all cases. The smoothing parameter has been selected following Silverman (1986). Finally, all estimations are made in Gauss, using the the code proposed by Shuetrim (1999) to obtain the bivariate density function.

Figure 3 shows the stochastic kernel estimated for the whole sample period ($t = 1977$ and $t + k = 1999$). This three-dimensional graph can be interpreted as a transition matrix with an infinite number of classes, that informs about the probabilities associated with each pair of values in the first and last years of the study period. In other words, the stochastic kernel gives us, as does a discrete transition matrix, the probability distribution of 1999 product per worker for regions with a given value in 1977. High levels of probability are of course represented by the peaks on the graph. Thus, if the probability mass is concentrated around the main diagonal, the intradistributional dynamics are characterised by a high level of persistence in the relative positions of the regions over time and therefore low mobility. If, on the other hand, the density is located mainly on the opposite diagonal to the main diagonal, this would indicate some regions overtaking others

¹⁴For the European case Fingleton et al. (1996) and Cuadrado et al. (2002) estimates various transition matrices to analyse regional mobility in terms of per capita income. Likewise, López-Bazo et al. (1999) apply this instrument to the examination of regional mobility in the distribution of product per worker.

in the ranking. Finally, the probability mass could, in theory, accumulate parallel to the t axis. This would reflect the convergence of regional product per worker towards the European average. In order to aid interpretation of the graph, Figure 3 also includes contour plots on which the lines connect points at the same height on the three-dimensional kernel.

[INSERT FIGURE 3 AROUND HERE]

Figure 3 shows the probability mass concentrated around the main diagonal. This indicates that the level of mobility of the distribution analysed is relatively low. European regions, therefore, tend generally to maintain their relative positions over the twenty-three years considered. However, this general pattern again Figure 3 reveals the existence of a pronounced turn at the top of the distribution. It suggests that the reduction of regional disparities in productivity observed in the European context between 1977 and 1999 was due mainly to the dynamics of those regions with high levels of product per worker.

[INSERT FIGURE 4 AROUND HERE]

We now estimate the corresponding ergodic distribution by iteration of the stochastic kernel until to reach the convergence of the process. Given that this is, by definition, a continuous distribution, it can be represented graphically (Figure 4). As shown, the corresponding ergodic distribution is characterised by a single local maximum located around the community average (unimodality). This situation contrasts with the information yielded by the density functions estimated in Figure 2 for various years within the 1977-1999 period. According to these, regional productivity distribution at the end of the nineties features various modes, which appears to suggest a tendency of the European regions to cluster into different productivity classes. At this point, however, a word of warning is required: comparisons between Figure 4 and the density functions estimated previously should be based only on the shape of the distribution, since there is no point in comparing the level of density that appears on the vertical axis. Also, the fact that the greater part of the density of the probability mass in4 is concentrated around the European average points to future development opportunities that might help to reduce existing territorial imbalances in terms of productivity in the European context.

3 Determinants of the distribution dynamics of regional productivity: the national component and the spatial dimension

To enhance the results achieved so far, in this section we will examine the role of the national component and the spatial dimension in the dynamics of regional productivity in the European Union between 1977 and 1999. In a break from the standard practice in the literature, we will approach this issue using a series of instruments proposed by Quah (1996b, 1997) and introduced in the preceding pages of this paper, which will provide a fairly accurate estimation of the change that occurs in the distribution that concerns us when various factors, in addition to regional product per worker, are introduced into the analysis. The intuitive idea of this methodology is quite simple. It is a matter of comparing product per worker in a given region with that of other regions with which it ought to bear some relation.

Since the pioneer study by Molle, Van Holst and Smit (1980), the literature on spatial inequality in the European context has emphasised the importance of the specific features of individual countries in regional growth processes¹⁵. It is therefore reasonable to assume that the national component may play a major role in the evolution of the distribution of regional product per worker in Europe throughout the period of observation. In order to analyse the importance of the so-called *country effect*, following Quah (1996b), we construct a conditioned distribution, obtained by normalising product per worker of each region according to the average productivity of the country to which it belongs, excluding the region in question.

So far, we have considered the various regions only as isolated units, and have thereby disregarded the strictly spatial dimension. No major problems should arise when using this approach, as long as the evolution of each region, in economic terms, is independent of the behaviour of the remaining regions over time. However, this does not seem a very realistic assumption within the context of the integration process currently underway in Europe, which is characterised overall by the decreasing relevance of national frontiers and a continual increase in the degree of interaction among regions. It is, therefore, reasonable to suppose, for example, that the productivity level of a given region might be linked to that of

¹⁵See also Barro and Sala-i-Martin (1996) or Rodriguez-Pose (1999), among others.

another or several other geographical areas. Indeed, a detailed analysis of productivity levels confirms the truth of such an assumption. Specifically, a clear positive spatial relationship among neighbouring areas is evident in both 1977 and 1999, indicating an overall similarity in productivity levels between physically adjacent regions¹⁶. The traditional literature on economic convergence has tended to examine this undeniably interesting question by applying a set of techniques adopted from spatial econometrics¹⁷. In this paper, however, we base our analysis of the subject on a new, conditioned distribution, obtained by normalising the product per worker of each region, this time dividing it by the average productivity of its immediate neighbours.

The two conditioned distributions that we have defined can be intuitively interpreted as that part of the initial distribution that remains unexplained by the national component and the various factors relating to the spatial location of the regions considered. For a more precise understanding of this idea, let us first imagine a situation in which the *country effect* and the spatial dimension have no impact at all on the distribution dynamics of regional product per worker, so that regions that are less (more) productive than the European average will also be less (more) productive than their national average and their neighbouring regions. In this hypothetical scenario, the initial distribution would coincide with the conditioned distributions. If, on the other hand, the national component and the spatial variable were to play a significant role, we might expect less (more) productive regions to register a level of product per worker similar to the average of the regions with which they are grouped by political or geographical criteria.

The proposal made by Quah (1996b) is to analyse these issues by estimating various transition matrices. The shortcomings of this approach are well known, however; the researcher must first group the sample regions into an arbitrary number of classes. To overcome the problems involved in using discrete transition matrices, we have opted in this paper to use stochastic kernels and contour plots instead¹⁸.

Before going on to discuss the outcomes obtained, it might be worth clarifying

¹⁶See Benito and Ezcurra (2003).

¹⁷See, for example, Fingleton and McCombie (1998), Lopez-Bazo et al. (1999) or Fingleton (1999).

¹⁸Stochastic kernels and contour plots are used by Overman and Puga (2002) to investigate the origin of the disparities in regional unemployment rates in the European Union. See also Lamo (2000).

a few points relating to the interpretation of stochastic kernels and contour plots in this context. Within this framework, these instruments provide information concerning the probabilities of transition between the initial distribution and the conditioned distribution, and not between two moments of time as in the previous case. Thus, if the factors considered do not help to explain distribution dynamics, the probability mass should cluster around the main diagonal¹⁹. If, on the other hand, the national component and the spatial dimension are determinant in explaining the evolution of the distribution analysed, the density will tend to cluster parallel to the axis corresponding to the initial distribution and around the average.

[INSERT FIGURE 5 AROUND HERE]

Figure 5 reports the results obtained when this method is used to examine the impact of the *country effect* on the distribution dynamics of regional productivity in Europe between 1977 and 1999. To construct the stochastic kernel and the contour plot, we have considered the total information from data on all twenty-three years of the period between 1977 and 1999. The results thus obtained highlight the importance of the national component in this context. Though with certain exceptions, the empirical evidence generally points to relatively substantial differences in the distribution of productivity between a typical country and the European Union as a whole. However, close analysis of the graphs in Figure 5 provide a detailed breakdown of this conclusion. Indeed, the *country effect* appears to have more impact among regions with low or medium levels of productivity, given that their levels of product per worker generally tend to coincide with the national average. However, at the top the distribution, the probability mass appears to be approaching the main diagonal. This suggests that regional productivity tends to be less removed from the national average in regions with high levels of product per worker.

[INSERT FIGURE 6 AROUND HERE]

¹⁹In the discrete case, the corresponding transition matrix ought to coincide with the identity matrix.

We now use this same method to determine the impact of spatial factors relating to the geographical location of the various regions considered. We again estimate the stochastic kernel and the contour plot for the initial and conditioned distributions over the whole of the twenty-three year sample period. The results, shown in Figure 6, are largely consistent with those reported earlier for the national component. They clearly highlight the major role played by the spatial dimension in the dynamics of regional product per worker over the 1977-1999 period. As in the previous case, regions with low or medium productivity levels are characterised by sharing a similar level of product per worker with adjacent regions. In any case, for high productivity values, the probability mass again appears to be approaching the main diagonal. Thus, regions situated at the top of the distribution tend, with certain exceptions, to have a higher level of product per worker than their neighbours. Therefore, the empirical evidence suggests that regions with low and medium levels of productivity have a greater tendency to cluster geographically than regions with high levels of productivity.

4 Productivity and industry mix

As we have already mentioned in the introduction to this paper, the results from various studies suggest that regional inequality in productivity is the main explanation for regional disparities in per capita income in the European Union. This makes it all the more crucial to identify and examine the causes that lead to regional differences in product per worker. In fact, this is the issue that will be studied in the section that follows.

It is well known that the aggregate product per worker of a region or a nation can be expressed as the weighted average of productivity across its sectors. Thus, for region i we can write:

$$y_i = \frac{X_i}{E_i} = \sum_{j=1}^m \left(\frac{X_{ij}}{E_{ij}} \right) \left(\frac{E_{ij}}{E_i} \right) = \sum_{j=1}^m y_{ij} s_{ij} \quad (1)$$

where the indices i , $i = 1, 2, \dots, n$, and j , $j = 1, 2, \dots, m$, denote regions, and industrial sectors respectively²⁰. Likewise, X stands for value added, and E stands for employment.

Expression (1) states that regional productivity differences can be attributed to two causes (or a combination of them both). A first possible cause of regional

²⁰Obviously, $\sum_{j=1}^m s_{ij} = 1$, for all $i = 1, 2, \dots, n$.

disparities in productivity might have to do with differences in production per worker in the m sectors considered. Therefore, even if there were no regional disparities in each individual sector, regions specialising in more productive sectors would attain higher than average aggregate productivity. Alternatively, regional disparities in product per worker may also be a direct result of the differences in regional endowments of certain aggregate factors that exert the same influence on productivity in all the various sectors²¹.

In order to assess the relevance of each of these possible explanations to the European situation, it will be necessary to obtain a break-down of the productivity gap between each of the regions considered and the European average. According to Esteban (2000), a useful technique for an initial exploration of the issue is shift-share analysis. Though this technique was originally proposed by Dunn (1960), it has since been subjected to intense criticism and thorough revision which have led to a considerably improved reformulation of the original. Shift-share analysis was originally designed as a technique for analysing growth in regional employment. It can, however, be directly applied to the study of production per worker. The idea is quite simple. For our case, it is a question of decomposing the productivity gap between a given region and the European average so as to capture the respective roles of three factors: industry mix, region-specific factors with an equal effect on all sectors and, finally, interaction between the first two.

Thus, using the same expression as in the case above, average productivity at European level can be written as:

$$y = \sum_{j=1}^m s_j y_j \quad (2)$$

where s_j e y_j denote respectively sector j 's employment share and its productivity at the European level²². In order to isolate the role played by the region's industry mix from that of its productivity, expression (1) can be rewritten as:

$$y_i = \sum_{j=1}^m s_{ij} y_{ij} = \sum_{j=1}^m [(s_{ij} - s_j) + s_j] [(y_{ij} - y_j) + y_j] \quad (3)$$

With some algebra, the above expression will give the difference between the productivity of region i and the European average in any given year, which can

²¹Benito and Ezcurra (2003) present a model of endogenous growth where regional disparities in productivity can be explained by means of the existence of structural differences among regions.

²²Therefore, $\sum_{j=1}^m s_j = 1$.

be written as:

$$\begin{aligned}
y_i - y &= \sum_{j=1}^m (s_{ij} - s_j) y_j + \sum_{j=1}^m (y_{ij} - y_j) s_j + \\
&\quad + \sum_{j=1}^m (s_{ij} - s_j) (y_{ij} - y_j)
\end{aligned} \tag{4}$$

Or alternatively,

$$\gamma_i = \varepsilon_i + \rho_i + \alpha_i \tag{5}$$

In other words, the productivity gap between each of the regions considered and the European average, γ_i , can be expressed as the sum of three factors. The first of these, ε_i , is known as the structural component, which measures the impact of the difference between the region's industry mix and the European mean, assuming that production per worker in each sector is the same across all regions. Specifically, ε_i takes positive values if the region is relatively more specialised ($s_{ij} > s_j$) in sectors with high product per worker at the European level. In fact, ε_i reaches its highest value when a region specialises exclusively in the sector with the highest average productivity. The regional or differential component, ρ_i , meanwhile, captures that part of γ_i that can be attributed to sector by sector productivity gaps between region i and the European level. In this case the region is assigned an industry mix equal to the European mean. Therefore, ρ_i takes positive values if region i 's sectoral productivity is higher than the European average ($y_{ij} > y_j$). Lastly, the allocative component, α_i , captures the interaction between ε_i and ρ_i , which in turn indicates the region's degree of specialisation in sectors where productivity is higher than the European mean. It is easy to appreciate that α_i takes positive values if the region is relatively specialised in sectors with a productivity level above the European mean. Thus, α_i can be taken as an index of the efficiency of the region in allocating resources among the various sectors of industry.

However, according to the results obtained in the preceding section, it may be useful to provide some precise quantitative data concerning the impact of the *country effect* on the evolution of regional disparities in product per worker in the European environment. In addressing this issue we have adopted a new approach based on an alternative version of shift-share analysis in order to distinguish how much of the influence of each component is actually due to a regional effect and how much to the national effect.

Indeed, it is possible rewrite expression (1) as follows:

$$y_i = \sum_{j=1}^m s_{ij} y_{ij} = \sum_{j=1}^m (s_{ij} + s_j^k - s_j^k + s_j - s_j)(y_{ij} + y_j^k - y_j^k + y_j - y_j) \quad (6)$$

where the subscript k refers to the country to which region i belongs, with $k = 1, 2, \dots, H$.

With some algebra in the above expression, the difference in productivity between region i and the European average can now be written as:

$$\begin{aligned} y_i - y &= \sum_{j=1}^m (s_{ij} - s_j^k) y_j^k + \sum_{j=1}^m (s_j^k - s_j) y_j + \\ &\quad + \sum_{j=1}^m (y_{ij} - y_j^k) s_j^k + \sum_{j=1}^m (y_j^k - y_j) s_j + \\ &\quad + \sum_{j=1}^m (s_{ij} - s_j^k) (y_{ij} - y_j^k) + \sum_{j=1}^m (s_j^k - s_j) (y_j^k - y_j) \end{aligned} \quad (7)$$

which in turn can be written as follows:

$$\gamma_i = \varepsilon_i^I + \varepsilon_i^E + \rho_i^I + \rho_i^E + \alpha_i^I + \alpha_i^E \quad (8)$$

Likewise, it can also be easily verified that:

$$\sum_{j=1}^m (s_{ij} - s_j) y_j = \sum_{j=1}^m (s_{ij} - s_j^k) y_j^k + \sum_{j=1}^m (s_j^k - s_j) y_j \quad (9)$$

$$\sum_{j=1}^m (y_{ij} - y_j) s_j = \sum_{j=1}^m (y_{ij} - y_j^k) s_j^k + \sum_{j=1}^m (y_j^k - y_j) s_j \quad (10)$$

and

$$\begin{aligned} \sum_{j=1}^m (s_{ij} - s_j)(y_{ij} - y_j) &= \sum_{j=1}^m (s_{ij} - s_j^k)(y_{ij} - y_j^k) + \\ &\quad + \sum_{j=1}^m (s_j^k - s_j)(y_j^k - y_j) \end{aligned} \quad (11)$$

That is,

$$\varepsilon_i = \varepsilon_i^I + \varepsilon_i^E \quad (12)$$

$$\rho_i = \rho_i^I + \rho_i^E \quad (13)$$

and

$$\alpha_i = \alpha_i^I + \alpha_i^E \quad (14)$$

Therefore, according to expressions (12), (13), and (14), the structural, regional and allocative components that concern us may be expressed as the sum of an internal factor and an external factor, the interpretation of which is straightforward. The internal factor represents differences between a particular region and the national average in that country, while the external factor is found by comparing the national average with the European average²³.

Our purpose in this section is to examine the contribution of each of the summands in expression (7) to global inequality in European regional productivity differentials. However, in order to determine how much of this inequality is attributable to each component, it is necessary to assign to each not only its direct impact on global inequality, but also its indirect effects, (which may be either positive or negative). However, since there is more than one way of assigning indirect effects, if a particular measure of inequality is at all decomposable, there will normally be more than one possible outcome to the process²⁴.

Keeping this in mind, then, we now proceed to decompose variance in regional productivity gaps, in accordance with the results obtained in the previous section. At this point, however, it is worth recalling that variance is not a conventional measure of inequality. Indeed, although it fulfils the condition of independence with respect to population size and the Pigou-Dalton transfer principle, variance is not independent of scale. This could prove to be a major drawback if, as in our case, the aim is to obtain comparisons over time. In order to overcome this problem, it was decided to modify expressions (4) and (7), by dividing each side

²³In fact, notice that:

$$y_i - y^k = \sum_{j=1}^m (s_{ij} - s_j^k) y_j^k + \sum_{j=1}^m (y_{ij} - y_j^k) s_j^k + \sum_{j=1}^m (s_{ij} - s_j^k) (y_{ij} - y_j^k)$$

and

$$y^k - y = \sum_{j=1}^m (s_j^k - s_j) y_j + \sum_{j=1}^m (y_j^k - y_j) s_j + \sum_{j=1}^m (s_j^k - s_j) (y_j^k - y_j)$$

²⁴For a more detailed analysis of this and other related issues, see, for example, Lerman (1999).

of the equation by $y = \sum_{j=1}^m s_j y_j$, such that:

$$\begin{aligned}
\frac{y_i - y}{y} &= \frac{\sum_{j=1}^m (s_{ij} - s_j) y_j}{y} + \frac{\sum_{j=1}^m (y_{ij} - y_j) s_j}{y} + \\
&\quad + \frac{\sum_{j=1}^m (s_{ij} - s_j) (y_{ij} - y_j)}{y} = \\
&= \frac{\sum_{j=1}^m (s_{ij} - s_j^k) y_j^k}{y} + \frac{\sum_{j=1}^m (s_j^k - s_j) y_j}{y} + \\
&\quad + \frac{\sum_{j=1}^m (y_{ij} - y_j^k) s_j^k}{y} + \frac{\sum_{j=1}^m (y_j^k - y_j) s_j}{y} + \\
&\quad + \frac{\sum_{j=1}^m (s_{ij} - s_j^k) (y_{ij} - y_j^k)}{y} + \frac{\sum_{j=1}^m (s_j^k - s_j) (y_j^k - y_j)}{y} \tag{15}
\end{aligned}$$

For the sake of simplicity, the above expression can be rewritten as:

$$\begin{aligned}
\gamma_{iN} &= \varepsilon_{iN} + \rho_{iN} + \alpha_{iN} = \\
&= \varepsilon_{iN}^I + \varepsilon_{iN}^E + \rho_{iN}^I + \rho_{iN}^E + \alpha_{iN}^I + \alpha_{iN}^E \tag{16}
\end{aligned}$$

Thus, the index value remains unaltered, if product per worker in each region is modified in the same proportion. It is also well known that the various regions of the European Union differ widely in terms of employment. We have therefore weighted regional productivity values by relative employment.

We are now ready to analyse the contribution of each of the summands in expression (15) to regional productivity disparities with respect to the European average. Specifically, by applying the inequality measurement just described, we have:

$$\begin{aligned}
Var_{\omega l}(\gamma_N) &= Var_{\omega l}(\varepsilon_N) + Var_{\omega l}(\rho_N) + Var_{\omega l}(\alpha_N) + 2[Cov_{\omega l}(\varepsilon_N, \rho_N) \\
&\quad + Cov_{\omega l}(\varepsilon_N, \alpha_N) + Cov_{\omega l}(\rho_N, \alpha_N)] = \\
&= Var_{\omega l}(\varepsilon_N^I) + Var_{\omega l}(\varepsilon_N^E) + Var_{\omega l}(\rho_N^I) + \\
&\quad + Var_{\omega l}(\rho_N^E) + Var_{\omega l}(\alpha_N^I) + Var_{\omega l}(\alpha_N^E) + \\
&\quad + 2[Cov_{\omega l}(\varepsilon_N^I, \varepsilon_N^E) + Cov_{\omega l}(\varepsilon_N^I, \rho_N^I) + Cov_{\omega l}(\varepsilon_N^I, \rho_N^E) + \\
&\quad + Cov_{\omega l}(\varepsilon_N^I, \alpha_N^I) + Cov_{\omega l}(\varepsilon_N^I, \alpha_N^E) + Cov_{\omega l}(\varepsilon_N^E, \rho_N^I) + \\
&\quad + Cov_{\omega l}(\varepsilon_N^E, \rho_N^E) + Cov_{\omega l}(\varepsilon_N^E, \alpha_N^I) + Cov_{\omega l}(\varepsilon_N^E, \alpha_N^E) +
\end{aligned}$$

$$\begin{aligned}
& + Cov_{\omega l}(\rho_N^I, \rho_N^E) + Cov_{\omega l}(\rho_N^I, \alpha_N^I) + Cov_{\omega l}(\rho_N^I, \alpha_N^E) + \\
& + Cov_{\omega l}(\rho_N^E, \alpha_N^I) + Cov_{\omega l}(\rho_N^E, \alpha_N^E) + Cov_{\omega l}(\alpha_N^I, \alpha_N^E)]
\end{aligned} \tag{17}$$

As can be appreciated from the above expression, global inequality will tend not to coincide exactly with either the simple or weighted sum of the inequality of each of the components considered, even though the contribution of each component to global inequality is equal to the sum of its direct and indirect effects. Indeed, only if there were no correlation among the various components, would expression (17) become:

$$\begin{aligned}
Var_{\omega l}(\gamma_N) & = Var_{\omega l}(\varepsilon_N) + Var_{\omega l}(\rho_N) + Var_{\omega l}(\alpha_N) = \\
& = Var_{\omega l}(\varepsilon_N^I) + Var_{\omega l}(\varepsilon_N^E) + Var_{\omega l}(\rho_N^I) + \\
& + Var_{\omega l}(\rho_N^E) + Var_{\omega l}(\alpha_N^I) + Var_{\omega l}(\alpha_N^E)
\end{aligned} \tag{18}$$

then, the contribution of each component would be given by its corresponding variance. Indeed it is the correlation among the various factors that gives rise to the problems associated with the type of decomposition to which we have been referring. It is necessary, for example, to determine how interaction among the various components (expressed in terms of their corresponding covariance) is to be distributed over their individual contributions. Therefore, since there are several ways of making that distribution, it is not possible to find a single factorial decomposition of $Var_{\omega l}(\gamma_N)$.

Therefore, to determine the contribution of each component to global inequality it is necessary to establish a rule whereby to distribute the effects of interaction among the various components over their individual contributions. Given that we have no further information in this respect, we have opted to assign to each component half the covariance by which it is affected, as stated in expression (17). According to this rule, the role of the structural component in global inequality in regional productivity gaps will be given by:

$$\begin{aligned}
\overline{Var_{\omega l}(\varepsilon_N)} & = Var_{\omega l}(\varepsilon_N) + Cov_{\omega l}(\varepsilon_N, \rho_N) + Cov_{\omega l}(\varepsilon_N, \alpha_N) = \\
& = Cov_{\omega l}(\varepsilon_N, \varepsilon_N) + Cov_{\omega l}(\varepsilon_N, \rho_N) + Cov_{\omega l}(\varepsilon_N, \alpha_N) = \\
& = Cov_{\omega l}(\varepsilon_N, \gamma_N)
\end{aligned} \tag{19}$$

Likewise,

$$\overline{Var_{\omega l}(\varepsilon_N)} = \overline{Var_{\omega l}(\varepsilon_N^I)} + \overline{Var_{\omega l}(\varepsilon_N^E)} \tag{20}$$

with:

$$\overline{Var_{\omega l}(\varepsilon_N^I)} = Cov_{\omega l}(\varepsilon_N^I, \gamma_N) \quad (21)$$

and

$$\overline{Var_{\omega l}(\varepsilon_N^E)} = Cov_{\omega l}(\varepsilon_N^E, \gamma_N) \quad (22)$$

By analogy, for the regional component we will have:

$$\begin{aligned} \overline{Var_{\omega l}(\rho_N)} &= Var_{\omega l}(\rho_N) + Cov_{\omega l}(\varepsilon_N, \rho_N) + Cov_{\omega l}(\rho_N, \alpha_N) = \\ &= Cov_{\omega l}(\rho_N, \rho_N) + Cov_{\omega l}(\varepsilon_N, \rho_N) + Cov_{\omega l}(\rho_N, \alpha_N) = \\ &= Cov_{\omega l}(\rho_N, \gamma_N) \end{aligned} \quad (23)$$

Additionally,

$$\overline{Var_{\omega l}(\rho_N)} = \overline{Var_{\omega l}(\rho_N^I)} + \overline{Var_{\omega l}(\rho_N^E)} \quad (24)$$

with:

$$\overline{Var_{\omega l}(\rho_N^I)} = Cov_{\omega l}(\rho_N^I, \gamma_N) \quad (25)$$

and

$$\overline{Var_{\omega l}(\rho_N^E)} = Cov_{\omega l}(\rho_N^E, \gamma_N) \quad (26)$$

Finally, for the allocative component:

$$\begin{aligned} \overline{Var_{\omega l}(\alpha_N)} &= Var_{\omega l}(\alpha_N) + Cov_{\omega l}(\varepsilon_N, \alpha_N) + Cov_{\omega l}(\rho_N, \alpha_N) = \\ &= Cov_{\omega l}(\alpha_N, \alpha_N) + Cov_{\omega l}(\varepsilon_N, \alpha_N) + Cov_{\omega l}(\rho_N, \alpha_N) = \\ &= Cov_{\omega l}(\alpha_N, \gamma_N) \end{aligned} \quad (27)$$

In which case,

$$\overline{Var_{\omega l}(\alpha_N)} = \overline{Var_{\omega l}(\alpha_N^I)} + \overline{Var_{\omega l}(\alpha_N^E)} \quad (28)$$

with:

$$\overline{Var_{\omega l}(\alpha_N^I)} = Cov_{\omega l}(\alpha_N^I, \gamma_N) \quad (29)$$

and

$$\overline{Var_{\omega l}(\alpha_N^E)} = Cov_{\omega l}(\alpha_N^E, \gamma_N) \quad (30)$$

Note that the different terms in $\overline{Var_{\omega l}(\cdot)}$ are the sums of the elements in each of the rows (columns) of the matrix of variances and covariances for the various factors into which regional productivity gaps have been disaggregated. Obviously,

$$\begin{aligned} Var_{\omega l}(\gamma_N) &= \overline{Var_{\omega l}(\varepsilon_N)} + \overline{Var_{\omega l}(\rho_N)} + \overline{Var_{\omega l}(\alpha_N)} = \\ &= \overline{Var_{\omega l}(\varepsilon_N^I)} + \overline{Var_{\omega l}(\varepsilon_N^E)} + \overline{Var_{\omega l}(\rho_N^I)} + \\ &\quad + \overline{Var_{\omega l}(\rho_N^E)} + \overline{Var_{\omega l}(\alpha_N^I)} + \overline{Var_{\omega l}(\alpha_N^E)} \end{aligned} \quad (31)$$

such that the sum of the contributions of the various components is equal to $Var_{\omega l}(\gamma_N)$. This is what Shorrocks (1982, 1983) termed the *natural* decomposition of variance. In this case, the relative impact of a particular component on global inequality is given by the quotient obtained when that individual contribution is divided by $Var_{\omega l}(\gamma_N)$. In other words, for the structural, regional and allocative components respectively, we have:

$$\frac{\overline{Var_{\omega l}(\varepsilon_N)}}{Var_{\omega l}(\gamma_N)} = \frac{Cov_{\omega l}(\varepsilon_N, \gamma_N)}{Var_{\omega l}(\gamma_N)} = \frac{\overline{Var_{\omega l}(\varepsilon_N^I)}}{Var_{\omega l}(\gamma_N)} + \frac{\overline{Var_{\omega l}(\varepsilon_N^E)}}{Var_{\omega l}(\gamma_N)} \quad (32)$$

$$\frac{\overline{Var_{\omega l}(\rho_N)}}{Var_{\omega l}(\gamma_N)} = \frac{Cov_{\omega l}(\rho_N, \gamma_N)}{Var_{\omega l}(\gamma_N)} = \frac{\overline{Var_{\omega l}(\rho_N^I)}}{Var_{\omega l}(\gamma_N)} + \frac{\overline{Var_{\omega l}(\rho_N^E)}}{Var_{\omega l}(\gamma_N)} \quad (33)$$

and

$$\frac{\overline{Var_{\omega l}(\alpha_N)}}{Var_{\omega l}(\gamma_N)} = \frac{Cov_{\omega l}(\alpha_N, \gamma_N)}{Var_{\omega l}(\gamma_N)} = \frac{\overline{Var_{\omega l}(\alpha_N^I)}}{Var_{\omega l}(\gamma_N)} + \frac{\overline{Var_{\omega l}(\alpha_N^E)}}{Var_{\omega l}(\gamma_N)} \quad (34)$$

Naturally,

$$\frac{\overline{Var_{\omega l}(\varepsilon_N)}}{Var_{\omega l}(\gamma_N)} + \frac{\overline{Var_{\omega l}(\rho_N)}}{Var_{\omega l}(\gamma_N)} + \frac{\overline{Var_{\omega l}(\alpha_N)}}{Var_{\omega l}(\gamma_N)} = 1 \quad (35)$$

Likewise, it is important to note, that $\overline{Var_{\omega l}(\cdot)}$ are not true indices of inequality. Indeed, the contribution of an individual component may take a negative value when $Cov_{\omega l}(\cdot) \leq 0$. In these cases, the component in question would be exerting a compensatory effect on regional productivity gaps generated by the remaining components.

It is also worth underlining the fact that the results obtained by applying this methodology are directly related with the number of productive activities considered in the analysis. In fact, the outcomes are not independent of the sectorial decomposition used. In this sense, a small number of sectors would tend to emphasise similarity between the productive structures of the different regions,

thus underestimating the importance of the structural component in accounting for regional productivity dispersion, while decomposition into numerous sectors would have the opposite effect. In accordance with these considerations, we have decided to take 17 sectors (Table A1).

The Figures 7, 8, 9 and 10 show the results that emerge from the natural decomposition of variance in regional productivity gaps in the European Union over the period 1977-1999²⁵. Globally speaking, regional disparities in product per worker decreased over the twenty-three year observation period; the value of $Var_{\omega l}(\gamma_N)$ falling from 0,1084 in 1977 to 0,0793 in 1999, which represents a 27% reduction. The process was not regular throughout the period, however. In fact, the reduction of the disparities was concentrated into the period between 1977 and the early eighties. Subsequently, a slight increase in regional productivity differences occurred, but this was not enough to compensate for the reduction that had taken place previously. This evolution of $Var_{\omega l}(\gamma_N)$ is consistent with the outcomes achieved in the preceding paragraphs.

[INSERT FIGURE 7 AROUND HERE]

[INSERT FIGURE 8 AROUND HERE]

[INSERT FIGURE 9 AROUND HERE]

[INSERT FIGURE 10 AROUND HERE]

The structural and regional components shared a similar evolutionary pattern as that of $Var_{\omega l}(\gamma_N)$, which means a reduction in inequality over the whole of the period observed. Indeed, the values for $\overline{Var_{\omega l}(\varepsilon_N)}$ and $\overline{Var_{\omega l}(\rho_N)}$ decreased

²⁵We have omitted Denmark and Luxembourg from this analysis, because both these countries are made up exclusively of NUTS2 regions, for which the regional and national averages obviously coincide.

respectively by 29% and 33% between 1977 and 1999. The overall trend of these two components conceals the different dynamics involved in each case, however. In the case of the structural component, in fact, inequality due to the internal factor diminished by 50% over the twenty-three year period. Meanwhile, inequality generated by the external factor also decreased, though to a lesser extent. In particular, the value of $\overline{Var_{\omega l}(\varepsilon_N^E)}$ dropped by 10% over the observed period. Findings reveal, furthermore, that with such an evolutionary trend, the external factor goes some way to explaining the 67% of global inequality that was attributable to the structural component in 1999, when in 1977 it had been only 53%.

As far as the regional component is concerned, the values of $\overline{Var_{\omega l}(\rho_N^I)}$ and $\overline{Var_{\omega l}(\rho_N^E)}$ decreased by 16% and 34% respectively between 1977 and 1999. In spite of this trend, however, the results show that the greater part of $\overline{Var_{\omega l}(\rho_N)}$ is to be attributed to the external factor. In fact, despite the fact that its relative importance fell by 4% over the observed time period, in 1999 it still represented over three quarters of the inequality attributable to the regional component.

The allocative component, meanwhile, deserves further comment. In particular, $\overline{Var_{\omega l}(\alpha_N)}$ decreased by 61% in absolute terms over the twenty-three year observation period. However, its negative sign suggests that the allocative component had a compensatory effect on the productivity differences resulting from the remaining factors. Logically, such an evolution was the final outcome of the dynamics displayed by $\overline{Var_{\omega l}(\alpha_N^I)}$ and $\overline{Var_{\omega l}(\alpha_N^E)}$, the values of which also decreased in absolute terms by 61% in both cases over the period analysed. As in the cases described earlier, the external factor is the main cause of inequality attributable to the allocative component. Specifically, $\overline{Var_{\omega l}(\alpha_N^E)}$ accounted for 79% of $\overline{Var_{\omega l}(\alpha_N)}$ in 1999.

Relatively speaking, the strongest impact on global inequality in productivity came from the regional component. In fact, although the relative importance of $\overline{Var_{\omega l}(\rho_N)}$ decreased by 5% over the time period considered, in 1999 it still accounted for 98% of global inequality. The effect on regional productivity gaps played by the structural component, meanwhile, remained practically the same throughout the whole of the 1977-1999 period, and stood at 8% by the late nineties. Finally, the relative weight of the allocative component decreased in absolute terms by 6% over the twenty-three years considered, finishing the period at -7%. The negative sign is a result of negative correlation between γ_N and α_N and shows the allocative component to have generated a decrease in regional productivity gaps

of around 7% in 1999.

The results obtained so far indicate regional inequality in Europe to be determined mainly by the regional component. This underlines the importance of factors whose effect on productivity is uniform across all sectors when attempting to account for spatial disparities in product per worker. In the final instance, however, what factors help us to explain the regional component? In an attempt to answer this question, we now investigate the role of a series of variables such as infrastructure endowment, human capital stock, and degree of technological development, all of which have been repeatedly emphasised for their importance in the theoretical literature on economic growth²⁶.

Having reached this point, and before going on to comment on the results obtained, it is essential to point out that in order to conduct this kind of analysis it is necessary to obtain data on the above mentioned variables for a sufficient number of NUTS2 regions over reasonably extended time period. Faced, as we were, with the problem of lack of data for most of the regions and years considered, we opted to approach the issue at national level. This change in the territorial unit of reference does not constitute a major drawback, however, since, as testified by the results summarised in the Table 9, the external factor accounts for most of the inequality attributable to the regional component in productivity in the European context.

On the basis of the above considerations, therefore, we construct a panel of data that covers 13 member states over the period from 1980 to 1995, such that the final model is given by²⁷:

$$\rho_{Nit}^E = \beta_0 + \beta_1 I_{it} + \beta_2 H_{it} + \beta_3 ID_{it} + u_{it} \quad (36)$$

where I_{it} denotes the stock of physical capital in the country in question normalised by its production, H_{it} is the percentage of the population with a secondary education, while ID_{it} denotes expenditure on research and development as a share of GDP²⁸.

[INSERT TABLE 1 AROUND HERE]

²⁶A summary of this literature can be found in Barro and Sala-i-Martin (1995).

²⁷It was necessary to exclude Germany from our analysis, because data for 1990 onwards include the East German Lander. Luxembourg was also excluded because of insufficient data. These circumstances also obliged us to reduce the sample period and consider biannual data.

²⁸The data used has been obtained from Eurostat, OECD and World Bank.

The above model is estimated by the generalised least squares method and the results are summarised in Table 1. From the table it can be seen that, I_{it} and ID_{it} are statistically significant, indicating that both the stock of physical capital and expenditure on research and development have a positive effect on the external factor of the regional component. The growth literature in fact includes several studies that emphasise the importance of the impact of these variables on aggregate growth in Europe²⁹. The empirical evidence also suggests variations in the dependent variable to be unrelated to H_{it} . It is worth noting, however, that this may be due to lack of precision in the variable which, for lack of data enabling us to approximate the level of human capital in the various European member states, we were obliged to use³⁰

5 Conclusions

In this paper we have examined the evolution of the distribution of regional productivity in the European Union between 1977 and 1999. The results obtained reveal an overall reduction in regional inequality throughout the study period. The greater part of this reduction took place at the end of seventies and was due to the dynamics displayed by those regions situated at the bottom of the distribution. Nevertheless, the level of intradistributional mobility is relatively low. This suggests that the European regions have tended generally to maintain their relative positions in terms of productivity over the twenty-three years considered.

The analyses performed reveal the major role played by the national component in the explanation of regional disparities in product per worker in the European Union. Thus, productivity growth patterns in the European context are closely linked to country-specific features relating, for example, to historical, social and institutional factors. Our findings, meanwhile, confirm that there is a clear spatial association between neighbouring areas, evidenced by the fact that adjacent regions tend on the whole to share similar product per worker levels. Moreover, regions with relatively low and medium productivity levels have a greater tendency towards geographical clustering than regions at the top of the distribution.

Likewise, the empirical findings supplied by this paper suggest regional inequality in productivity in the European Union to be closely linked to intrinsic

²⁹See, for example, Vanhoudt *et al.* (2000) or Paci and Pigliaru (2002).

³⁰A more detailed analysis about this question can be found in Lodde (1999).

differences between regions. This being the case, the main factors in determining regional inequality in productivity would be basically those which have a uniform effect on productivity in all sectors. Industry mix, therefore, appears to have contributed relatively little to regional dispersion in average productivity over the twenty-three years covered by the study. Thus, the relatively minor role played by the structural component supports the relevance of one-sector growth models for analysing regional disparities in per capita income.

In order to complete the analysis, we have also investigated the role played by several variables on variations in the regional component over time. Problems arising from lack of statistical data on a sufficient number of NUTS2 regions for a long enough period of time obliged us to approach the issue at national level. It is worth noting, however, that, according to our results, this change in the unit of reference does not constitute a major drawback. In this way, the empirical evidence provided suggests the regional component of each country to be positively related to its stock of physical capital and the percentage of GDP allocated to research and development. These results give rise to certain implications that could be of use to regional policy designers in search of ways to increase productivity in backward regions.

References

- Armstrong, H.W. (2002): 'European Union Regional Policy: Reconciling the Convergence and Evaluation Evidence', in J.R. Cuadrado and M. Parellada (eds.) *Regional Convergence in the European Union, Facts, Prospects and Policies*, pp. 231-272. Berlin: Springer-Verlag.
- Barro, R. and Sala-i-Martin, X. (1991) 'Convergence across States and Regions', *Brooking Papers on Economic Activity* 1: 107-182.
- Barro, R. and Sala-i-Martin, X. (1992) 'Convergence', *Journal of Political Economy* 100: 407-443.
- Barro, R. and Sala-i-Martin, X. (1995) *Economic Growth*. New York: McGraw-Hill.
- Benito, J.M. and Ezcurra, R. (2003) 'Distribucin espacial de la productividad in la Unin Europea', Department of Economics, Mimeo. Universidad Pblica de Navarra.

- Browne, L.E. (1989) 'Shifting Regional Fortunes: the Wheel Turns', *New England Economic Review*. Federal Reserve Bank of Boston: 27-40.
- Carlino, G.A. (1992) 'Are Regional Per Capita Earnings Diverging?', *Business Review*: 3-12. Federal Reserve Bank of Philadelphia.
- Chakravarty, S.R. (1990) *Ethical Social Index Numbers*. Berlin: Springer Verlag.
- Cowell, F. (1995) *Measuring Inequality*, 2nd Edition, LSE Handbooks in Economics. London: Prentice Hall.
- Cuadrado, J.R., Mancha, T. and Garrido, R. (2002) 'Regional Dynamics in the European Union: Winners and Losers', in J.R. Cuadrado and M. Parellada (eds.) *Regional Convergence in the European Union, Facts, Prospects and Policies*, pp. 23-52. Berlin: Springer-Verlag.
- Dunn, E.S. (1960) 'A Statistical and Analytical Technique for Regional Analysis', *Papers and Proceedings of the Regional Science Association* 6: 97-112.
- Esteban, J. (1994) 'La desigualdad interregional en Europa y en España: descripción y análisis', in J. Esteban and X. Vives (eds.) *Crecimiento y convergencia regional en España y Europa*, 2, pp. 13-82. Barcelona: Instituto de Análisis Económico.
- Esteban, J. (2000) 'Regional convergence in Europe and the industry mix: a shift share analysis', *Regional Science and Urban Economics* 30: 353-364.
- European Commission (1999) *Sixth Periodic Report on the Social and Economic Situation of the Regions in the European Union*. Brussels.
- Fagerberg, J. and Verspagen, B. (1996) 'Heading for Divergence. Regional Growth in Europe reconsidered', *Journal of Common Market Studies* 34: 431-448.
- Fingleton, B. (1999) 'Estimates of time to economic convergence: an analysis of regions of the European Union', *International Regional Science Review* 22: 5-35.
- Fingleton, B., Lewney, R. and Pinelli, D. (1996) 'Regional Growth and Convergence', *The Single Market Review*, subseries VI (1). London: Kogan Page-Earthscan.
- Fingleton, B. and McCombie, J. (1998) 'Increasing returns and economic growth: some evidence for manufacturing from the European Union regions', *Oxford Economic Papers* 50: 89-105.
- Lamo, A. (2000) 'On convergence empirics: some evidence for Spanish regions', *Investigaciones Económicas* XXIV (3): 681-707.
- Lerman, R.I. (1999) 'How Do Income Sources Affect Income Inequality', in J. Sil-

- ber (ed.) *Handbook of Income Inequality Measurement*, pp. 341-362. Boston: Kluwer Academic Publishers.
- Lodde, S. (1999): 'Human capital and growth in the European regions: does allocation matter?', in J. Adams and F. Pigliaru (eds.) *Economic Growth and Change. National and Regional Patterns of Convergence and Divergence*. Cheltenham: Edward Elgar.
- López-Bazo, E., Vaya, E. Mora, A. and Suriñach, J. (1999) 'Regional Economic Dynamics and Convergence in the European Union', *The Annals of Regional Science* 33 (3): 343-370.
- Molle, W., Van Holst, B. and Smit, B. (1980) *Regional Disparity and Economic Development in the European Community*. Farnborough: Saxon House.
- Overman, H. and Puga, D. (2002) 'Regional unemployment clusters', *Economic Policy* 34: 115-147.
- Paci, R. (1997) 'More Similar and Less Equal: Economic Growth in the European Regions', *Weltwirtschaftliches Archiv* 133: 609-634.
- Paci, R. and Pigliaru, F. (1997) 'Structural change and convergence: an Italian regional perspective', *Structural Change and Economic Dynamics* 8: 297-318.
- Paci, R. and Pigliaru, F. (1999) 'European Regional Growth: Do Sectors Matter?', in J. Adams and F. Pigliaru (eds.) *Economic Growth and Change. National and Regional Patterns of Convergence and Divergence*, pp. 213-235. Cheltenham: Edward Elgar.
- Paci, R. and Pigliaru, F. (2002): 'Technological Diffusion, Spatial Spillovers and Regional Convergence in Europe', in J.R. Cuadrado and M. Parellada (eds.) *Regional Convergence in the European Union, Facts, Prospects and Policies*, pp. 273-292. Berlin: Springer-Verlag.
- Quah, D. (1993) 'Empirical cross-section dynamics in economic growth', *European Economic Review* 37: 426-434.
- Quah, D. (1996a) 'Empirics for Economic Growth and Convergence', *European Economic Review* 40: 1353-1375.
- Quah, D. (1996b) 'Regional convergence clusters across Europe', *European Economic Review* 40: 951-958.
- Quah, D. (1997) 'Empirics for Growth and Distribution: Stratification, Polarization and Convergence Clubs', *Journal of Economic Growth* 2: 27-59.
- Rodríguez-Pose, A. (1999) 'Convergence or Divergence? Types of Regional Responses to Socio-Economic Change in Western Europe', *Tijdschrift voor Eco-*

- nomische in Sociale Geografie* 90 (4): 363-378.
- Sala-i-Martin, X. (1996) 'Regional Cohesion: Evidence and Theories of Regional Growth and Convergence', *European Economic Review* 40: 1325-1352.
- Scott, D.W. (1992) *Multivariate Density Estimation: Theory, Practice and Visualization*. New York: John Wiley and Sons.
- Shorrocks, A.F. (1982) 'Inequality decomposition by factor components', *Econometrica* 50: 193-211.
- Shorrocks, A.F. (1983) 'The Impact of Income Components on the Distribution of Family Incomes', *Quarterly Journal of Economics* 98 (2): 311-326.
- Shuetrim, G. (1999) 'Gauss Routines to Estimate Univariate and Bivariate Kernel Densities', <http://ideas.repec.org/c/apr/aprsft/cd0003.html>.
- Silverman, B.W. (1986) *Density Estimation for Statistics and Data Analysis*, Monographs on Statistics and Applied Probability 26. London: Chapman and Hall.
- Simonoff, J.S. (1996) *Smoothing Methods in Statistics*. Berlin: Springer-Verlag.
- Terrasi, M. (2002) 'National and Spatial Factors in EU Regional Convergence', in J.R. Cuadrado and M. Parellada (eds.) *Regional Convergence in the European Union: Facts, Prospects and Policies*, pp. 185-209. Berlin: Springer-Verlag.
- Theil, H. (1967) *Economics and Information Theory*. Amsterdam: North Holland.
- Vanhoudt, P., Matha, T. and Smid, B. (2000): "How productive are capital investments in Europe?", *EIB Papers* 5: 81-106.
- Wand, M.P. and Jones, M.C. (1994) *Kernel Smoothing*. London: Chapman and Hall.

Figures and Tables

Figure 1: Regional inequality in productivity, 1977-1999.

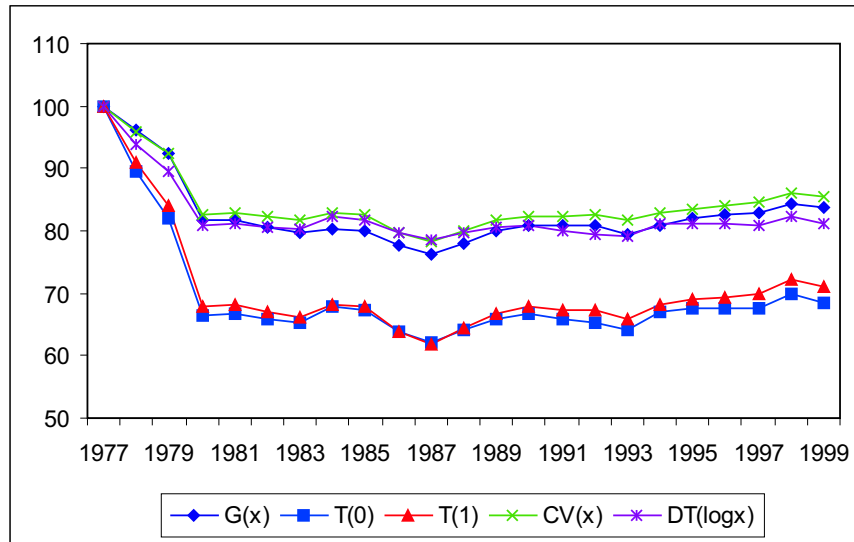


Figure 2: Density functions of the regional distribution of the product per worker.

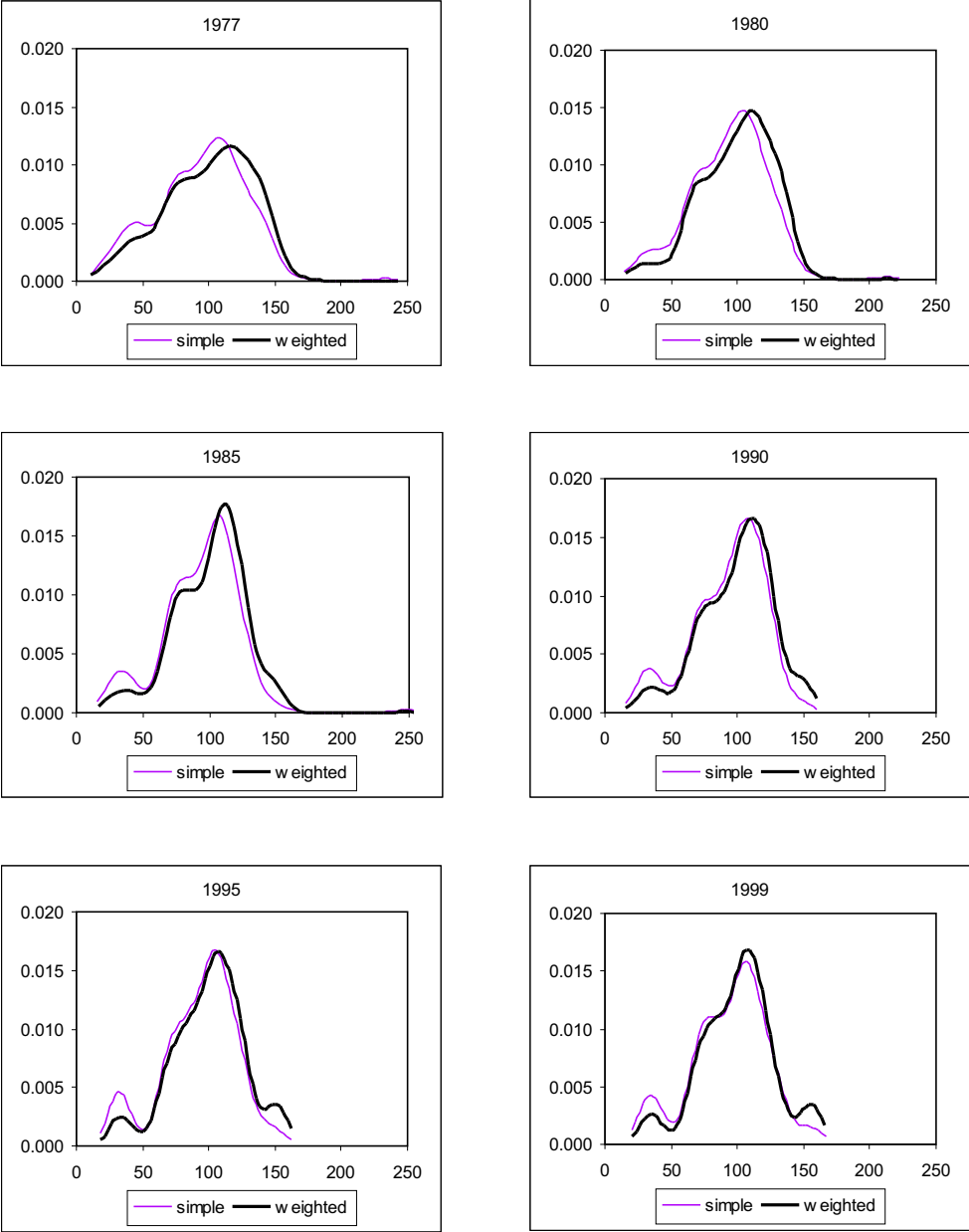


Figure 3: Stochastic kernel and contour plot of the regional distribution of the product per worker, 1977-1999.

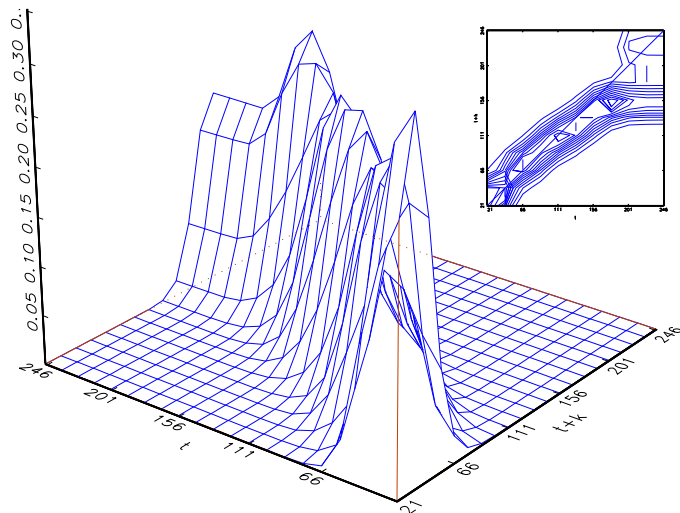


Figure 4: Ergodic distribution of regional productivity.

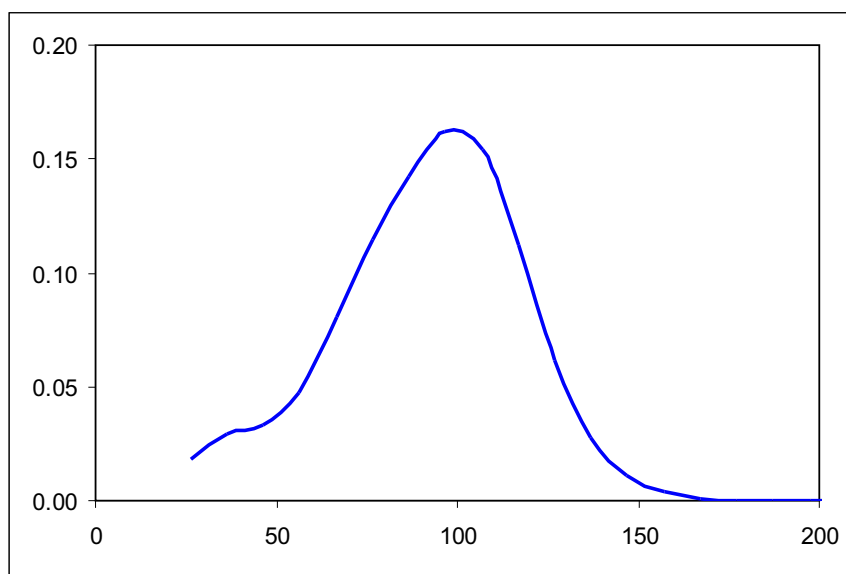


Figure 5: The national component and the distribution dynamics of regional productivity.

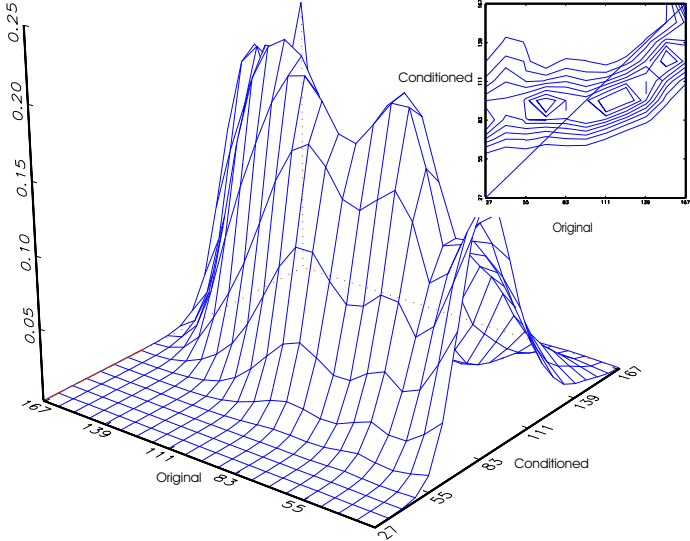


Figure 6: The spatial dimension and the distribution dynamics of regional productivity.

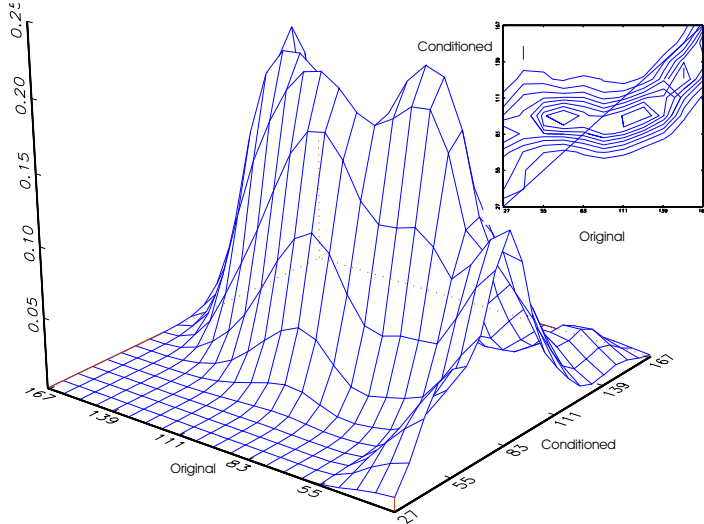


Figure 7: Decomposition of the regional inequality in productivity.

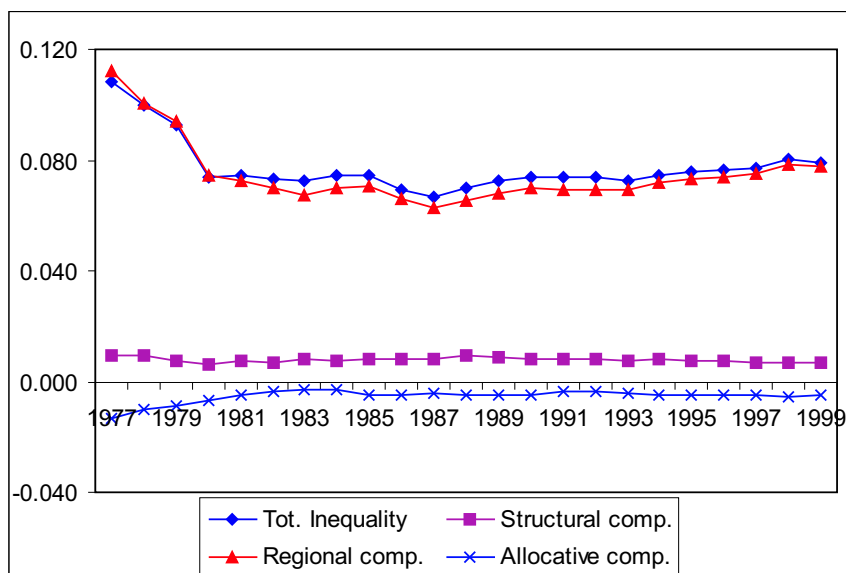


Figure 8: Decomposition of the inequality corresponding to the structural component.

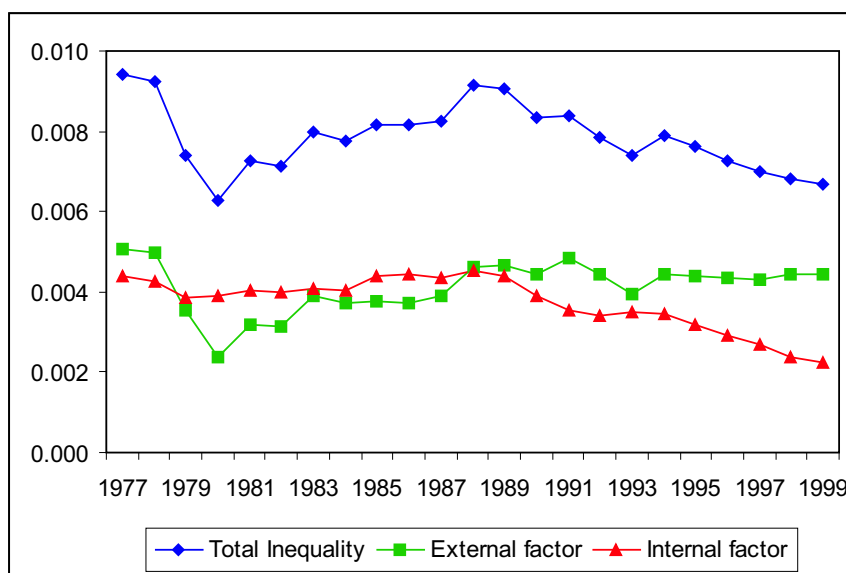


Figure 9: Decomposition of the inequality corresponding to the regional component.

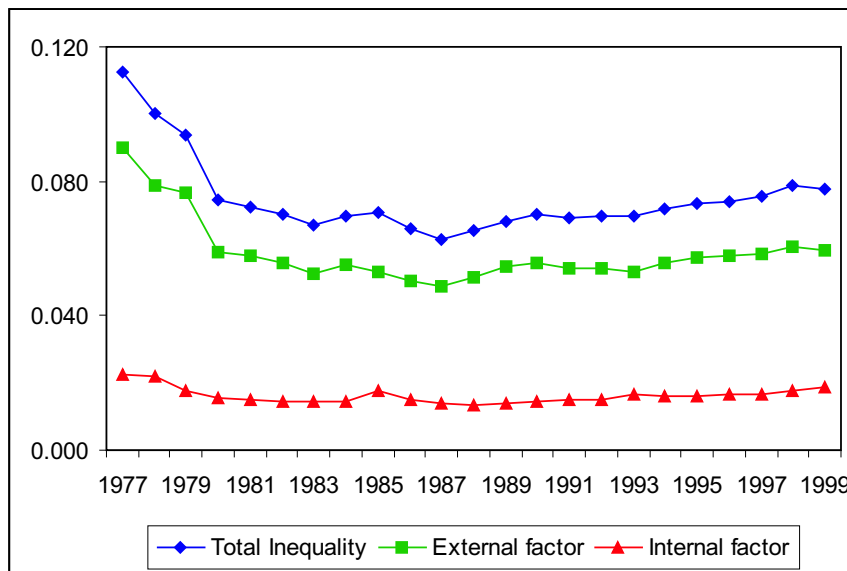


Figure 10: Decomposition of the inequality corresponding to the allocative component.

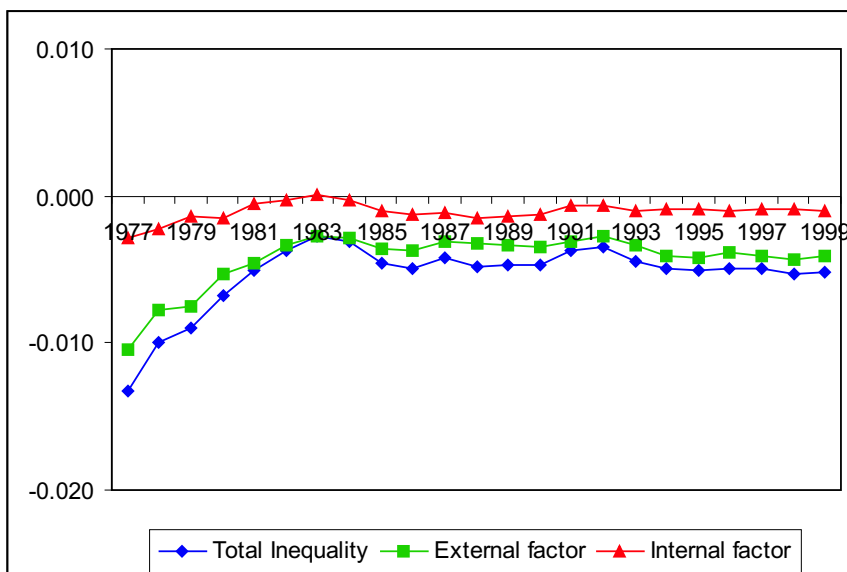


Table 1: Explaining variables of the external factor of regional component.

Dependent variable	ρ_{Nit}^E
<i>Constant</i>	−0.2927*** (−3.591)
<i>I_{it}</i>	0.0474* (1.733)
<i>H_{it}</i>	0.0004 (0.853)
<i>ID_{it}</i>	0.0744*** (6.381)
F Test	19.85***
\bar{R}^2	0.3859
Observations	91

Note: Figures that appear in brackets refer to Student's t statistics. * Statistically significant at the 10% level. ** Statistically significant at the 5% level. *** Statistically significant at the 1% level. Standard errors have been calculated by means of White's robust heteroscedasticity corrected covariance matrix.

Table A1: Sectors (NACE-CLIO R17).

Sector 1	Agricultural, forestry and fishery products.
Sector 2	Fuel and power products.
Sector 3	Ferrous and non-ferrous products.
Sector 4	Non-metallic minerals and mineral products.
Sector 5	Chemicals products.
Sector 6	Metal products and machinery.
Sector 7	Transport equipment.
Sector 8	Food, beverages and tobacco.
Sector 9	Textiles and clothing, leather and footwear.
Sector 10	Paper and printing products.
Sector 11	Other manufactured products.
Sector 12	Building and construction.
Sector 13	Recovery, repair, trade, lodging and catering services.
Sector 14	Transport and communication services.
Sector 15	Services of credit and insurance institutions.
Sector 16	Other market services.
Sector 17	Non-market services.

Appendix

The 197 territorial units considered in the paper are:

Belgium: Bruxelles-Brussel, Antwerpen, Limburg, Oost-Vlaanderen, Vlaams Brabant, West-Vlaanderen, Brabant Wallon, Hainaut, Liège, Luxembourg y Namur. *Denmark*. *Germany*: Stuttgart, Karlsruhe, Freiburg, Tübingen, Oberbayern, Niederbayern, Oberpfalz, Oberfranken, Mittelfranken, Unterfranken, Schwaben, Berlin, Bremen, Hamburg, Darmstadt, Giessen, Kassel, Braunschweig, Hannover, Lüneburg, Weser-Ems, Düsseldorf, Köln, Münster, Detmold, Arnsberg, Koblenz, Trier, Rheinhessen-Pfalz, Saarland and Sch.-Holstein. *Greece*: Anatoliki Makedonia, Kentriki Makedonia, Dytiki Makedonia, Thessalia, Ipeiros, Ionia Nisia, Dytiki Ellada, Sterea Ellada, Peloponnisos, Attiki, Voreio Aigaio, Notio Aigaio and Kriti. *Spain*: Galicia, Asturias, Cantabria, País Vasco, Navarra, La Rioja, Aragón, Madrid, Castilla-León, Castilla-la Mancha, Extremadura, Cataluña, Com. Valenciana, Baleares, Andalucía, Murcia and Canarias. *France*: Île de France, Champagne-Ard., Picardie, Haute-Normandie, Centre, Basse-Normandie, Bourgogne, Nord-Pas de Calais, Lorraine, Alsace, Franche-Comté, Pays de la Loire, Bretagne, Poitou-Charentes, Aquitaine, Midi-Pyrénées, Limousin, Rhône-Alpes, Auvergne, Languedoc-Rousillon, Provence-Alpes-Côte d'Azur and Corse. *Ireland*: Border-Midland and Western and Southern and Eastern. *Italy*: Valle d'Aosta, Piemonte, Liguria, Lombardia, Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia, Emilia-Romagna, Toscana, Umbria, Marche, Lazio, Abruzzi, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia and Sardegna. *Luxembourg*. *Netherlands*: Groningen, Friesland, Drenthe, Overijssel, Gelderland, Flevoland, Utrecht, Noord-Holland, Zuid-Holland, Zeeland, Noord-Brabant and Limburg. *Austria*: Burgenland, Niederöster., Wien, Kärnten, Steiermark, Oberösterreich, Salzburg, Tirol and Vorarlberg. *Portugal*: Norte, Centro, Lisboa e Vale do Tejo, Alentejo, Algarve, Açores and Madeira. *Finland*: Itä-Suomi, Väli-Suomi, Pohjois-Suomi, Uusimaa, Etelä-Suomi and Aland. *Sweden*: Stockholm, Östra Mellansverige, Sydsverige, Norra, Mellansverige, Mellersta Norrland, Övre Norrland, Smaland med oarna and Västsverige. *United Kingdom*: Tees Valley and Durham, Northumberland et al., Cumbria, Cheshire, Greater Manchester, Lancashire, Merseyside, East Riding, North andorkshire, South Yorkshire, West andorkshire, Derbyshire, Leicestershire, Lincolnshire, Hereford et al., Shropshire, West Midlands, East Anglia, Bedfordshire, Essex, Inner London, Outer London, Berkshire et al., Surrey, Hampshire, Kent., Avon et al., Dorset, Cornwall, Devon, West Wales, East Wales,

North East Scotland, Eastern Scotland, South West Scotland, Highlands and Islands and Northern Ireland.