POLARIZATION TRENDS ACROSS THE EUROPEAN REGIONS

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***Abstract** - This paper examines the level of polarization in the distribution of GDP per capita in 263 European regions over the period 1995-2008. To that end I have completed the non-parametric analysis of the external shape of the distribution with the information provided by a series of measures proposed by Esteban and Ray (1994) and Esteban et al. (2007). The results show a reduction in the degree of polarization across the European regions throughout the study period. This conclusion does not depend on the specific number of groups considered in the analysis and the value assigned to the polarization sensitivity parameter. The analysis carried out also shows that polarization and spatial autocorrelation have followed a similar trend between 1995 and 2008, which reveals the importance of the geographical location of the various regions in explaining the variations registered by the distribution of GDP per capita over time.*

Key-words: POLARIZATION, GDP PER CAPITA, REGIONS, EUROPEAN UNION

JEL Classification: R11, R12, F15

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1. INTRODUCTION

Over the last two decades there have been numerous studies on spatial disparities in the European Union (EU) using a variety of different approaches. This increasing interest has to do with the important advances that have taken place in economic growth theory, coinciding with the introduction of endogenous growth models in the mid-1980s (Barro and Sala-i-Martin, 1995). The assumptions underlying these models ultimately allow for the reversal of the neoclassical prediction of convergence, and lead to the conclusion that the faster growth of rich economies leads to increase regional disparities. In fact, the self-sustained and spatially selective nature of economic growth is also highlighted by the models of the so-called "new economic geography" developed since the seminal contribution by Krugman (1991). According to these theories, increasing returns and agglomeration economies explain the accumulation of economic activity in the more dynamic areas, which causes ultimately spatial divergence. Academic debate aside, however, the increasing relevance of this topic in the EU is closely related to the strong emphasis placed on achieving economic and social cohesion in the context of the process of integration currently underway (European Commission, 2007).

Against this background, the analysis of regional convergence or divergence trends in the EU has received considerable attention in the literature. Nevertheless, the methodological approximations employed in most of these studies tend to ignore the fact that a reduction in the cross-sectional dispersion of the distribution may be compatible with a process of polarization into several internally homogeneous regional clusters (Esteban and Ray, 1994; Anderson, 2004). In view of this, various authors have addressed the analysis of regional polarization in the EU using the non-parametric approach popularized by Quah (1996, 1997) to investigate the distribution dynamics (Le Gallo, 2004; Ezcurra et al., 2005; Fotopoulos, 2008). However, it is important to note that these approximations do not enable to obtain a precise quantification of the changes in the degree of polarization over time. Taking this into account, in this paper I have employed alternatively the set of measures proposed by Esteban and Ray (1994) and Esteban et al. (2007) to examine the degree of polarization in the regional distribution of GDP per capita in the EU.

There are a few earlier studies that have used these polarization measures in the European context, although the samples used are, at best, limited to the EU15 countries (Le Gallo, 2004; Ezcurra et al., 2006, 2007). Accordingly, these previous contributions do not allow us to assess to what extent the results are affected by the inclusion in the analysis of the new member states incorporated into the EU in 2004 and 2007, which is particularly relevant for the design of the European regional policy. In order to fill this gap, the present paper aims to extend the results obtained so far in the literature by investigating this issue in a sample of regions belonging to the EU27 countries.

The rest of the paper is organized as follows. After this introduction, section 2 describes the data used and provides some preliminary evidence. Section 3 presents the polarization measures proposed by Esteban and Ray (1994) and

Esteban et al. (2007). The results obtained when these measures are calculated to quantify the level of regional polarization in the EU are discussed in section 4. In order to complete the analysis, section 5 explores the relationship between polarization and spatial autocorrelation. The final section offers the main conclusions from the paper.

2. DATA AND PRELIMINARY EVIDENCE

This paper is based on data drawn from the Cambridge Econometrics regional database. The sample covers a total of 263 NUTS-2 regions belonging to the 27 EU member states.[1] In order to maximize the number of regions included in the analysis, the study period goes from 1995 to 2008.[2] NUTS-2 regions are used instead of other possible alternatives for various reasons. First, NUTS-2 is the territorial unit most commonly employed in the literature to investigate the determinants of regional growth in Europe, which facilitates the comparison of the results with those obtained in previous papers. Second, NUTS-2 regions have been particularly relevant in terms of the EU regional policy since the 1989 reform of the European Structural Funds. The key variable throughout the paper is the GDP per capita of the various regions expressed in purchasing power standards (PPS).

The study begins by examining the external shape of the EU regional distribution of GDP per capita. This issue is addressed by means of non-parametric techniques, thus avoiding the need to specify any particular functional form beforehand. There are several major advantages to using this approach in the context that concerns us, given the lack of generality and flexibility associated with parametric methods.

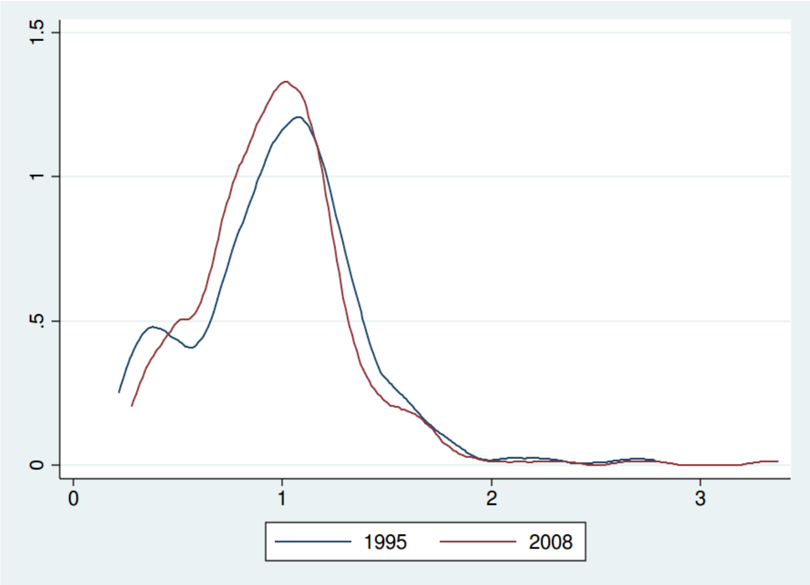
The non-parametric approach requires to select a method to smooth the data. As is usual in the literature, I use kernel smoothing for the analysis. Specifically, the estimates are based on Epanechnikov kernel functions. Likewise, I employ the data-based automatic smoothing parameter proposed by Silverman (1986). I checked that there is practically no difference in the estimates, irrespective of the kernel function considered. From a theoretical point of view, however, the choice of the smoothing parameter is much more important than that of the kernel function. For this reason, I repeated the analysis using alternatively the smoothing parameter proposed by Sheater and Jones (1991) and based on the solve-the-equation plug-in method. Nevertheless, the results were in all cases very similar[3].

[1] NUTS is the French acronym for "Nomenclature of Territorial Units for Statistics", a hierarchical classification of subnational spatial units established by Eurostat. In this classification NUTS-0 corresponds to country level and increasing numbers indicate increasing levels of subnational disaggregation.

[2] The lack of data has obliged me to exclude from the study the French overseas departments and territories, and the Portuguese islands in the Atlantic, as well as the Spanish autonomous cities in North Africa.

[3] The estimates obtained from alternative kernel functions and smoothing parameters are available upon request.

Figure 1. Kernel density estimates of the regional distribution of GDP per capita



The kernel density estimates are shown in Figure 1[4]. When reading the graph it should be noted that, in order to facilitate comparisons and remove from the analysis the influence of absolute changes over time, each region's GDP per capita is normalized according to the sample average. Figure 1 confirms clearly that there are important differences in terms of GDP per capita across the European regions. The estimated density function for 1995 is characterized by the presence of two modes[5]. Thus, besides the main mode, which is located slightly above the EU average, the estimates show a second mode situated at about 50% of the EU average, which is formed mainly by Central and Eastern European regions belonging to the countries incorporated into the EU in the last enlargements. In that respect, it should be recalled that the integration of the new member states contributed to a substantial increase in the magnitude of regional disparities within the EU, to the point that the traditional North/South divide has been replaced by a new North-West/East polarization pattern (Ertur and Koch, 2006; Ezcurra and Rapún, 2007). Nevertheless, Figure 1 reveals that

[4] Though I have obtained estimates of the density functions for each year of the period, to save space, I present only those of 1995 and 2008. The rest are available upon request.

[5] As is usual in the literature, this finding depends on the visual examination of the estimated density functions. In order to confirm formally the presence of various modes in the distribution, a multimodality test based on the notion of "critical bandwidth" introduced by Silverman (1981) should be applied (Bianchi, 1997). Nevertheless, this test uses different bootstrap samples to calculate the critical bandwidth, which might raise problems in this context due to the presence of spatial dependence in the sample. For further details on this issue, see section 5.

the initial situation has not remained stable during the time span considered. In fact, between 1995 and 2008, there has been an increase in the density concentrated around the average. This trend has led to the disappearance at the end of the study period of the second mode located at the lower end of the distribution. In any case, the results show that in 2008 there were still numerous regions whose GDP per capita is below 75% of the EU average, which indicates the difficulties faced by these regions to improve their relative situation in terms of development.

3. MEASURING REGIONAL POLARIZATION

The non-parametric approach used in the previous section presents a major limitation as it does not provide precise quantitative information about the changes experienced by the level of polarization over time. To overcome this shortcoming one can resort to some of the polarization indices derived by various authors during the last two decades (e.g. Esteban and Ray, 1994; Wolfson, 1994; Wang and Tsui, 2000). Within this framework, in this paper I use the measures proposed by Esteban and Ray (1994) and Esteban et al. (2007), since this approach allows the researcher to incorporate into the analysis the error generated when partitioning the original distribution into various groups in order to quantify the level of polarization. In addition, these measures are particularly useful in our context since they can be applied not only to the study of bipolarization (polarization into two groups), but also to the analysis of polarization in general.

According to Esteban and Ray (1994), the degree of polarization of a distribution *f* into a given number of groups can be obtained by means of the following expression:

$$P^{ER}(\alpha,\rho) = \sum_{i=1}^{n}\sum_{j=1}^{n} p_i^{1+\alpha} p_j \left|\mu_i - \mu_j\right| \qquad (1)$$

where μ_i and p_i, respectively, denote the average GDP per capita and the population share of group *i*. Likewise, α is a parameter that captures the degree of sensitivity of P^{ER} to polarization, the value of which falls in the interval [1, 1.6] in order to be consistent with a set of axioms proposed by Esteban and Ray (1994). Before going any further, it is worth noting that the proposed measure of polarization bears an obvious likeness to one of the indicators most commonly used in the traditional literature on inequality, the Gini index, *G*. Nevertheless, the fact that in expression (1) p_i is raised to (1+α) means that the measure of polarization will, in practice, follow a different pattern from that of the Gini index. In particular, the higher the value adopted by α, the greater the conceptual division between inequality and polarization measures.

Before applying this measure, however, it is first necessary to define a simplified representation of the original distribution into a set of *n* exhaustive and mutually exclusive groups, $\rho = (z_0, z_1, \dots, z_n; \mu_1, \dots, \mu_n; p_1, \dots, p_n)$, the boundaries of which are given by GDP per capita intervals of the form

$[z_{i-1}, z_i]$. This will involve a certain degree of error, however, as this partition will generate some loss of information, depending on the level of income dispersion within each of the various groups considered. Taking this into account, the generalized measure of polarization proposed by Esteban et al. (2007) is obtained after correcting the P^{ER} index applied to the simplified representation of the original distribution with a measure of the grouping error, $\varepsilon(f,\rho)$. That is,

$$P^{EGR}(f,\alpha,\rho,\beta) = P^{ER}(\alpha,\rho) - \beta\varepsilon(f,\rho) \quad (2)$$

where $\beta \geq 0$ is a parameter representing the weight assigned to the error term in expression (2).

Nonetheless, it is important to bear in mind that when dealing with income distributions, there are no unanimous criteria for establishing the precise demarcation between the different groups. To address this problem, Esteban et al. (2007) use the algorithm proposed by Davies and Shorrocks (1989) in order to find the optimal partition of the original distribution into a given number of groups, ρ^*. This means selecting the partition that minimizes the Gini index value of within-group inequality, $G(f) - G(\rho^*)$. Given that $\varepsilon(f,\rho^*) = G(f) - G(\rho^*)$, the generalized measure of polarization proposed by Esteban et al. (2007), therefore, can be expressed as:

$$P^{EGR}(f,\alpha,\rho^*,\beta) = P^{ER}(\alpha,\rho^*) - \beta[G(f) - G(\rho^*)] \quad (3)$$

4. REGIONAL POLARIZATION IN THE EU

According to the above methodology, I estimate the level of polarization registered by the EU regional distribution of GDP per capita, using the information provided by various partitions of the original distribution into two and three groups. In order to check the robustness of the results, different degrees of sensitivity to polarization are considered in the analysis. Specifically, α=1,1.3,1.6. Likewise, as in Esteban et al. (2007), in all cases β=1.[6] To respect the scale invariance principle, we normalize beforehand the GDP per capita of the various regions by the sample average. In addition, in the results presented below the values of the generalized measure of polarization proposed by Esteban et al. (2007) are divided by two to make its interval between 0 and 1 when α=1.

4.1. Regional bipolarization

According to the algorithm proposed by Davies and Shorrocks (1989), in the optimal two-group partition of the distribution the cut-off income between the two groups is equal to the average GDP per capita. When the various regions are divided into two groups using this criterion, it is possible to explain

[6] This choice is due to the fact that, as mentioned above, the formulation of P^{ER} is similar to that of the Gini index. The second term in expression (3) is in fact the difference between two Gini indices. It is therefore reasonable to select in empirical analyses a value of β equal to one (Duro, 2005).

around 69% of the overall inequality measured by the Gini index. Accordingly, this would leave about 31% of internal inequality unexplained by the partition.

Table 1. Generalized measures of polarization: The two-group case

		P^{EGR}	
Year	α=1	α=1.3	α=1.6
1995	0.096	0.065	0.040
1996	0.095	0.064	0.039
1997	0.094	0.063	0.039
1998	0.094	0.063	0.038
1999	0.093	0.063	0.038
2000	0.093	0.062	0.037
2001	0.090	0.060	0.036
2002	0.087	0.057	0.033
2003	0.084	0.055	0.032
2004	0.083	0.054	0.032
2005	0.080	0.053	0.030
2006	0.079	0.052	0.030
2007	0.077	0.051	0.029
2008	0.077	0.051	0.030

Table 1 presents the evolution of the generalized measure of polarization over time in the two-group case (bipolarization). Taking the study period as a whole, the results obtained reveal a decrease in the bipolarization of the EU regional distribution of GDP per capita. In particular, the values of P^{EGR} fell by between 19% and 26% over the study period, depending on the value assigned to the parameter α. This trend was the result of the gradual reduction registered by the index throughout the time span considered, particularly since 2001.

Nevertheless, according to expression (3), the value of P^{EGR} depends on two factors: the bipolarization of the simplified distribution and the degree of within-group dispersion weighted by the parameter β. In order to complete the results obtained so far, Table 2 provides information relating to these two components of the measure of generalized bipolarization. Regarding the evolution of regional bipolarization in the simplified distribution, the results show a decrease of about 16% in the value of the P^{ER} index between 1995 and 2008 for the different values adopted by the parameter α. In overall terms, however, P^{ER} followed a similar evolution to that of P^{EGR} described above.

To complete these results, Table 3 reveals how the average GDP per capita and the population shares of each of the two groups into which I have divided the distribution evolved over time. The results reveal the existence of a process of convergence in average GDP per capita levels between the two groups throughout the study period, which contributes to explaining the observed decrease in the degree of bipolarization of the simplified distribution. Thus, in 1995, the average GDP per capita in the poor regions stood at around 49% of that of the rich ones. Fourteen years later, however, this percentage had increased to 56%. This is consistent with the improvement achieved by some of the regions initially located at the lower end of the distribution, as shown in the non-parametric analysis performed in the preceding section (Figure 1). With respect to the population shares of the two groups, Table 3 indicates that the differences between the two groups decreased over the study period. Neverthe-less, Table 3 shows that the influence of this factor on the evolution of P^{ER} was offset by the observed process of convergence in the average GDP per capita of the two groups.

Table 2. Simplified polarization and internal dispersion: The two-group case

		P^{ER}		Error
Year	α=1	α=1.3	α=1.6	ε(*f*,ϱ)
1995	0.166	0.135	0.110	0.070
1996	0.164	0.134	0.109	0.070
1997	0.163	0.133	0.108	0.069
1998	0.163	0.133	0.108	0.070
1999	0.164	0.133	0.108	0.070
2000	0.164	0.133	0.108	0.071
2001	0.161	0.131	0.107	0.071
2002	0.157	0.128	0.104	0.070
2003	0.153	0.125	0.101	0.069
2004	0.150	0.122	0.099	0.067
2005	0.148	0.120	0.098	0.068
2006	0.145	0.118	0.096	0.066
2007	0.141	0.115	0.093	0.064
2008	0.140	0.114	0.092	0.063

Table 3. Average GDP per capita and relative size of the two groups

	Average GDP per capita		Population shares	
Year	Group 1	Group 2	Group 1	Group 2
1995	0.634	1.305	0.455	0.545
1996	0.649	1.308	0.468	0.532
1997	0.653	1.308	0.471	0.529
1998	0.651	1.307	0.469	0.531
1999	0.656	1.313	0.476	0.524
2000	0.649	1.308	0.468	0.532
2001	0.651	1.300	0.463	0.537
2002	0.670	1.300	0.476	0.524
2003	0.669	1.286	0.463	0.537
2004	0.689	1.290	0.482	0.518
2005	0.678	1.273	0.458	0.542
2006	0.705	1.285	0.492	0.508
2007	0.717	1.283	0.499	0.501
2008	0.719	1.279	0.498	0.502

Finally, I will examine the second component of the generalized polarization measure: the error term that captures the degree of within-group dispersion in the two groups considered. As can be observed in Table 2, internal cohesion increased during the study period. Specifically, the value of ε experienced an 11% decrease between 1995 and 2008. According to expression (3), this rise in the level of internal cohesion suggested by the evolution of ε should, *ceteris paribus*, favor an increase in P^{EGR}, as the polarization forecast based on the simplified distribution has improved in absolute terms. Nevertheless, this finding must be treated with some reservation since, as pointed out earlier, the value of ε depends ultimately on the weight assigned to the parameter β. In any case, the results indicate that the impact of the error term was offset by the reduction experienced by P^{ER} over the study period.

4.2. Regional polarization: The three-group case

So far I have examined the degree of bipolarization registered by the regional distribution of GDP per capita over the period 1995-2008. As the previous analysis shows, the two-group representation of the original distribution allows us to examine a series of issues of undeniable interest without any disproportionate loss of information. It is important to note, however, that when examining the evolution of polarization in a bimodal distribution, one runs the risk of interpreting a decrease in polarization, when what is actually taking place is a division of the distribution into three poles (Esteban and Ray, 1994). Likewise, the dualized view of the spatial distribution of GDP per capita in the EU underlying the above analysis may be an oversimplification in more than one respect. As a first step toward addressing these potential problems, I now consider an alternative classification of the European regions into three groups: one made up of regions with GDP per capita around the EU average, and two extreme groups.

Table 4. Generalized measures of polarization: The three-group case

		P^{EGR}	
Year	α=1	α=1.3	α=1.6
1995	0.104	0.066	0.039
1996	0.101	0.064	0.038
1997	0.100	0.063	0.037
1998	0.101	0.064	0.038
1999	0.101	0.063	0.037
2000	0.102	0.065	0.039
2001	0.102	0.065	0.039
2002	0.099	0.064	0.039
2003	0.095	0.060	0.034
2004	0.093	0.059	0.034
2005	0.092	0.058	0.033
2006	0.089	0.056	0.033
2007	0.088	0.056	0.033
2008	0.086	0.054	0.032

When the original distribution is simplified into three groups using the methodology developed by Davies and Shorrocks (1989), it is possible to account for an average of around 86% of the overall inequality measured in terms of the Gini index. The remaining 14% corresponds to the internal dispersion unexplained by this partition. Anyway, it is interesting to note that the three-group partition provides a 17% increase in explanatory power in comparison with the two-group case.

Table 4 shows the measure of generalized polarization in the three-group case for different values of the parameter α. The results reveal a reduction in polarization for the period as a whole. The P^{EGR} values, in particular, decreased in this case by between 17% and 18% from 1995 to 2008, depending on the weight assigned to the polarization sensitivity parameter. Although this is in line with the information provided by Table 1, it should be noted that the degree of reduction experienced by regional polarization when the original distribution is partitioned into three groups is lower than in the two-group case. In any case, the evolution of P^{EGR} was not a uniform throughout the study period. In fact, two distinct phases can be observed, irrespective of the degree of sensitivity to polarization considered. Thus, regional polarization remained virtually stable during the first years of the study period. This trend was to change since 2002, however, when a gradual reduction in the values of P^{EGR} took place.

Table 5. Simplified polarization and internal dispersion: The three-group case

		P^{ER}		Error
Year	α=1	α=1.3	α=1.6	ε(*f*,ϱ)
1995	0.135	0.097	0.070	0.032
1996	0.133	0.096	0.070	0.032
1997	0.132	0.095	0.069	0.032
1998	0.133	0.096	0.069	0.032
1999	0.133	0.096	0.070	0.033
2000	0.134	0.097	0.071	0.032
2001	0.133	0.097	0.070	0.031
2002	0.131	0.095	0.070	0.031
2003	0.126	0.091	0.065	0.031
2004	0.123	0.089	0.064	0.030
2005	0.122	0.088	0.064	0.030
2006	0.119	0.086	0.062	0.030
2007	0.117	0.085	0.062	0.029
2008	0.115	0.084	0.061	0.029

Next, I examine regional polarization in the simplified three-group distribution. Table 5 reveals a decrease in polarization in the simplified distribution for the study period as a whole. The values of the corresponding indices fell by about 14% between 1995 and 2008, regardless of the value assigned to the polarization sensitivity parameter. As can be observed, P^{ER} follows a similar trend to that of P^{EGR} described earlier.

To further complete these results, I now examine the evolution of the average GDP per capita and the relative sizes of each of the three groups considered. In this respect, the information displayed by Table 6 shows the low income group to be shifting toward the EU average. Specifically, in 1995 the average GDP per capita of this group was equivalent to 50% of that of the middle income group, and 35% of that of the high income group. Fourteen years later, however, the above percentages had increased to 60% and 42%, respectively. This, however, should not obscure the fact highlighted in the analysis performed in the preceding section, which is the difficulties faced by some of the less developed regions of the Union to improve their relative situation in this context. Meanwhile, the distance between the high income group and the middle income group remained virtually constant throughout the period. These trends, therefore, contributed, in the three-group case, to the observed decrease in regional polarization detected in the EU over the study period. With respect to the relative sizes of the different groups, Table 6 reveals the existence of some changes between 1995 and 2008. In particular, the different groups tended to be less homogeneous in terms of size during the study period. Such changes in relative group size should, in theory, lead to a reduction in regional polarization. Accordingly, in the three-group case the two factors that explain the dynamics of the simplified distribution work in the same direction, which contrasts with the results obtained in the two-group case.

Table 6. Average GDP per capita and relative size of the three groups

	Average GDP per capita			Population shares		
Year	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
1995	0.525	1.043	1.505	0.325	0.403	0.272
1996	0.532	1.045	1.506	0.324	0.412	0.264
1997	0.532	1.042	1.492	0.322	0.407	0.271
1998	0.541	1.050	1.509	0.331	0.410	0.259
1999	0.541	1.047	1.512	0.332	0.409	0.260
2000	0.534	1.050	1.523	0.328	0.420	0.252
2001	0.548	1.058	1.536	0.337	0.424	0.239
2002	0.545	1.058	1.542	0.323	0.455	0.222
2003	0.553	1.021	1.458	0.318	0.390	0.292
2004	0.566	1.032	1.466	0.321	0.408	0.271
2005	0.574	1.032	1.470	0.322	0.415	0.264
2006	0.578	1.023	1.465	0.312	0.426	0.262
2007	0.599	1.035	1.491	0.323	0.446	0.231
2008	0.622	1.036	1.488	0.341	0.426	0.233

Lastly I focus on the evolution of the error term, which accounts for internal dispersion in the three groups considered. According to Table 5, internal cohesion increased over the study period. Specifically, the value of ε decreased by around 8%. From a theoretical point of view, this rise in internal cohesion should help to increase the level of generalized polarization, even though the ultimate effect of ε on P^{EGR} depends, as we are already aware, on the value assigned to the parameter β.

At this point it is interesting to discuss briefly how to select the optimal partition of the original distribution to investigate regional polarization in the EU. To explore this question, in addition to the two classifications adopted in this section, an alternative four-group partition using the methodology proposed by Davies and Shorrocks (1989) is also considered[7]. Following Esteban et al. (2007), the optimal number of groups can be found by selecting the partition which provides the maximum value of the measure of generalized polarization. This criterion is based on the idea that the distribution is partitioned in such a way as to capture its polarization as fully as possible. Therefore it appears reasonable to select the simplified distribution which provides the highest value of the phenomenon under study. According to the results, the highest level of generalized polarization is obtained on average for the three-group partition of the original distribution.

5. POLARIZATION AND SPACE

In the analysis carried out so far, the different regions have been considered as isolated units, thus ignoring the spatial characteristics of the data. This should raise no major problems, as long as each economy evolves independently of the rest. However, this does not seem a very realistic assumption in the context of the economic integration process currently underway in Europe. On the contrary, the importance of interregional trade, and technology and knowledge transfer processes suggests that geography plays an important role in explaining regional growth patterns in the European setting (e.g. Magrini, 2004; Creszenci, 2005; Fingleton and López-Bazo, 2006).

Nevertheless, the different polarization measures calculated in the previous section do not take into account the geographical location of the various regions in accounting for the formation of homogeneous groups linked by similar levels of GDP per capita. In view of this, and in order to complete the results, I proceed to calculate the Moran's I test to examine the possible presence of spatial autocorrelation in the EU regional distribution of GDP per capita (Cliff and Ord, 1981). To do so I use different spatial weights matrices (W) based on the inverse of the geographical distance between the centroids of the sample regions. In order to check the robustness of the results, the spatial weights matrices are defined using different cut-off parameters above which spatial interactions are assumed negligible. In particular, the cut-off parameters used coincide with the various quartiles of the distance distribution (Le Gallo and Dall'erba, 2008). As is usual in the literature, the spatial weights matrices

[7] The results of the four-group partition are not reported for lack of space, but are available upon request. In any case, it should be noted that the evolution of generalized polarization does not appear to depend on the number of groups considered in the analysis, since the P^{EGR} value decreased in all cases between 1995 and 2008.

are row standardized, so that it is relative, and not absolute, distance which matters.

Table 7. Spatial autocorrelation (Moran's I test)

Year	$W(Q_1)$	$W(Q_2)$	$W(Q_3)$	$W(Q_4)$
1995	0.460	0.342	0.246	0.198
1996	0.449	0.337	0.244	0.195
1997	0.441	0.335	0.244	0.194
1998	0.434	0.330	0.241	0.191
1999	0.425	0.323	0.237	0.187
2000	0.427	0.329	0.243	0.190
2001	0.416	0.322	0.239	0.186
2002	0.403	0.315	0.236	0.183
2003	0.386	0.301	0.226	0.174
2004	0.380	0.297	0.223	0.172
2005	0.366	0.287	0.216	0.166
2006	0.347	0.272	0.205	0.157
2007	0.334	0.260	0.195	0.151
2008	0.319	0.246	0.183	0.144

Note : All the statistics are significant at the 1% level.

The results are presented in Table 7. It should be noted that, regardless of the specific spatial weights matrix used in the analysis, all the statistics calculated are positive and statistically significant at the 1% level. This indicates the existence of a pattern of positive spatial association in this context, which confirms the results obtained in the literature (e.g. Le Gallo and Ertur, 2003; Ertur and Koch, 2006). Nevertheless, the value of the statistic decreased over the study period. Indeed, it is important to stress that the evolution of Moran's I is similar to that registered by P^{EGR}. This impression is confirmed by the various correlation coefficients calculated in Table 8, which suggests that physical-geography spillover effects play a relevant role in explaining the changes registered by the EU regional distribution of GDP per capita.

Table 8. Correlation between regional polarization and spatial autocorrelation

	Generalized measures of polarization (P^{EGR})					
	Two groups			Three groups		
Moran's I	α=1	α=1.3	α=1.6	α=1	α=1.3	α=1.6
$W(Q_1)$	0.869	0.872	0.862	0.865	0.941	0.873
$W(Q_2)$	0.835	0.833	0.804	0.861	0.946	0.890
$W(Q_3)$	0.798	0.840	0.716	0.859	0.941	0.892
$W(Q_4)$	0.850	0.827	0.843	0.832	0.950	0.894

Note : All the correlation coefficients are significant at the 1% level.

6. CONCLUSIONS

In this paper I have examined the level of polarization of the GDP per capita distribution in 263 European regions over the period 1995-2008. Taking into account that the non-parametric techniques used so far to study this issue do not enable to obtain a precise quantification of the changes in the degree of polarization over time, I have employed in this context the different measures proposed by Esteban and Ray (1994) and Esteban et al. (2007).

Although the relatively short time span considered implies that the findings of the paper should be treated with some caution, the results reveal a reduction in polarization across the EU regions throughout the study period as a whole. This conclusion does not depend on the specific number of groups considered in the analysis and the value assigned to the polarization sensitivity parameter. The analysis carried out also shows that polarization and spatial autocorrelation have followed a similar trend between 1995 and 2008, which reveals the importance of the geographical location of the various regions in explaining the variations registered by the distribution of GDP per capita over time.

The results indicate that the observed reduction in the degree of polarization throughout the study period is the final outcome of various factors, sometimes working in opposite directions. For example, in the two-group case the process of convergence in terms of average GDP per capita between the various groups outweighs the reduction in the differences in their relative sizes, which explains the observed decrease in polarization in the simplified distribution. According to the approach developed by Esteban and Ray (1994) and Esteban et al. (2007), the evolution of generalized polarization also depends on within-group dispersion. In all the cases considered, within-group dispersion decreased in the EU over the study period, which should, in theory, give rise, *ceteris paribus*, to an increase in generalized polarization. This factor appears, nevertheless, not to have caused any substantial alteration in the evolution displayed by the simplified distribution.

The findings of the paper are compatible with different theoretical explanations. For example, the reduction in the degree of polarization and spatial autocorrelation detected during the study period may be related to the existence of diseconomies of agglomeration prevailing after some level of concentration, core-periphery spread effects, technological diffusion processes, or transport infrastructures that affect the locational choice of private capital. Likewise, the important amount of funds devoted over the last two decades by the European regional policy to promoting economic and social cohesion and reducing disparities in the level of development of the various regions may have led to a more spatially balanced growth and, consequently, to a lower degree of polarization. In any case, the analysis carried out in the paper does not allow us to disentangle the specific role played by these factors in explaining the observed polarization trends. Future research should pay particular attention to the need to identify and study the various theoretical mechanisms which explain ultimately the changes experienced by the regional distribution of GDP per capita in the EU.

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L'ÉVOLUTION DU DEGRÉ DE POLARISATION DES RÉGIONS EUROPÉENNES

Résumé - *Cet article étudie le degré de polarisation de la distribution du PIB par habitant dans 263 régions européennes sur la période 1995-2008. Une analyse non paramétrique de la forme de la distribution est menée grâce à une série de mesures proposées par Esteban et Ray (1994) et Esteban et al. (2007). Les résultats montrent une diminution du degré de polarisation dans les régions européennes sur la période étudiée. Cette conclusion est indépendante du nombre de groupes considérés et de la valeur attribuée au coefficient de sensibilité à la polarisation. L'analyse montre également que la polarisation et l'autocorrélation spatiale ont suivi une même tendance entre 1995 et 2008. Ceci est révélateur de l'importance de la localisation des différentes régions comme élément explicatif de l'évolution de la distribution du PIB par habitant observée dans la période.*

Mots-clés : POLARISATION, PIB PAR TÊTE, RÉGIONS, UNION EUROPÉENNE