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REGIONAL ECONOMIC DYNAMICS AND CONVERGENCE IN THE EUROPEAN UNION

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Abstract. Deepening in the European Union (EU) integration process has enhanced the question of economic disparities at a regional level. The convergence process observed until the late seventies was exhausted onwards in coincidence with important changes in the economic activity. The paper shows how these factors would have provoked a regional differenciated response that, despite being important, would have not strengthened the decrease in regional inequalities. We use an alternative and (in our opinion) richer approach to the traditional convergence analysis, where the evolution of the whole regional distribution is what matters and not that of a *representative* economy. Moreover, when analysing inequalities among regional economies, the geographical space acquire an outstanding role. Hence, we apply spatial association tests and relate them to the convergence analysis.

Resum. El avance en el proceso de integración ha aumentado el interés por la evolución de las disparidades económicas entre las regiones de la Unión Europea. El proceso de convergencia observado hasta finales de los setenta parece haberse agotado, coincidiendo con importantes cambios en el desarrollo de la actividad económica. El trabajo muestra como estos factores habrían provocado una respuesta regional diferenciada que, pese a ser importante, no habría contribuido a la disminución de las disparidades. En el trabajo se utiliza una aproximación alternativa a la empleada en el tradicional análisis de convergencia, donde lo que se considera es la evolución de la totalidad de la distribución y no unicamente aquélla de una economía *representativa*. Adicionalmente, cuando se estudian las disparidades entre economías regionales, el espacio adquiere un papel destacado. Por ello se aplican contrastes de asociación espacial y se relacionan con el análisis de convergencia.

KEY WORDS: Convergence, EU regions, Distribution dynamics

JEL classification: O40, O52, R12

1. Introduction

The topic of regional economic convergence has generated considerable interest in recent years. In the case of the EU this interest has been enhanced by the deepening and widening in the integration process. It is well known that the question of regional economic disparities acquired a relevant status both from an economic and political point of view with the accession of Greece, Spain and Portugal. The performance of these economies since then, as a whole as well as that of each one of their regions, might be seen as an empirical evidence of the impact of the integration process. In this sense, the implementation of the Single European Market and the Economic and Monetary Union might play an important role in the evolution of regional disparities, even though a consensus of their effects is far from being achieved from a theoretical point of view (Abraham and Van Rompuy 1995). In any case, there is a general agreement in the existence of a decrease in regional inequalities (ie convergence) from the fifties to the seventies and a relative stagnation afterwards (Molle and Broeckhout 1995; Suarez-Villa and Cuadrado-Roura 1993). Armstrong (1995) observe ß and s convergence in the period from 1950 to 1990, even though at a higher rate in a first subperiod up to 1970. Neven and Gouyette (1994) show the insignificance of the s convergence process since 1980, in spite of a slight decrease in disparities since 1984. This latter work also shows that the homogeneity is higher among the Northern regions of the EU than among the Southern ones and even the possibility of the existence of different patterns in the evolution of the disparities in both groups throughout the eighties. The decrease and even stagnation in the regional convergence process from the late seventies has also been observed in other economies. Sala-i-Martin (1996) sum up this pattern for the USA, Japan and some of the European national economies, Andrés and Doménech (1995) observe a similar pattern for the OECD economies while Mas et al. (1995) conclude the temporal instability of the convergence process and the exhaustion of such a process from the early eighties among the Spanish provincies (NUTS3 desaggregation level). In any case an eminent fact remains clear, that is the disparities among nations and regions in the EU at the present are significantly greater than those among the states in the United States or the regions of Canada (Esteban 1994; Suarez-Villa and Cuadrado-Roura 1993).

Notwithstanding these results, our belief is that by means of the traditional ß and s convergence approach it is not possible to obtain evidence of interesting issues related to the dynamics of the whole regional income distribution. For instance, whether convergence has existed, what regions have been the main contributors to such a process?, are there *convergence clubs*?, have the economies changed their position in the ranking of income or does a strong persistence dominate the process?... To answer these questions we need more information than the one supplied by the dynamic behaviour of an average economy (implicit in the traditional approach). This paper uses different tools (dispersion, inequality and polarization indexes, density functions, expanded rank-size functions and models of explicit distribution dynamics) to get more information about the regional income distribution dynamics. In this sense, our convergence analysis has much more in common with the ones in Quah (1993a, 1993b, 1996c, 1996d, 1996e), Bianchi (1995) and Desdoigts (1994) for the case of international economies.

Furthermore, the process of economic activity and growth is clearly related with a concrete geographical space in the regional case. The territorial location of productive factors, their mobility across adjacent regions, the interregional trade flows and, in general, the regional interrelationships motivates a spatially oriented convergence analysis that completes the general one. The application of global and local spatial association tests permits the detection of patterns of location of the economic activity in the territory of the EU. Moreover, shifts in these patterns throughout the analysed period may also be detected.

On the other hand, growth models predicts (if some) convergence in the output-labor force ratio that is supposed to translate into output per capita. In fact, much of the empirical work has tested the hypothesis in the latter variable due to the availability of data. However, the existence of important differences in the spatial distribution of the employment-population rate advice of a differenciated study for both magnitudes. In fact, regional diferences in the activity rate and, mainly, in the unemployment rate are rather high and showed an increasing trend during the eighties in the EU (CEC 1994). An *a priori* assumption is that the integration process (factor mobility, trade integration, tecnological diffusion, etc) and measures adopted to improve the economic performance of lagged regions (infrastructure investments, human capital dotation, etc) may favour the increase in productivity levels of poor regions but not automatically their per capita income levels. This means a convergence process in labour productivity but not in terms of per capita, the desequilibrium in labour market being the one which reflects the regional structural inequalities in the short-medium term.

Therefore our analysis focuses on disparities and convergence on both GDP per worker (as a measure of labor productivity) and per capita in the European Union. In the former case our sample includes 129 regions (at NUSTII level: Belgium (9), Germany (31), Greece (2)[1], Spain (17), France (21), Italy (20), Netherlands (10) and Portugal (5); at NUTSI level: UK (11) plus Denmark, Ireland and Luxembourg) for 1981 and from 1983 to 1992. In the case of GDP per capita we consider 143 regions (at NUTSII level: Belgium (9), Denmark (3),

[1] Lack of employed population for most Greek regions made not possible consider them in the analysis in term of GDP per worker.

Germany (31), Greece (13), Spain (18), France (21), Italy (20), Netherlands (10) and Portugal (5); at NUTSI level: UK (11) plus Ireland and Luxembourg) for the whole 1980-1992 period. Data source is the EUROSTAT REGIO database, even though additional information on employed population for some regions has been used due to a lack of it from that particular source. We have preferred to work with a short-period dataset but considering most of the periferal regions due to the belief that convergence must be viewed as poor regions catching up with rich ones. Discarding those regions will lead to an incomplete picture of the phenomena. GDP per worker is measured in ECU in order to take into account differences in the capacity to produce goods while GDP per capita is in PPS to consider the regional ability to purchase goods and so to achieve different levels of well-being.

2. Integration process and regional inequality dynamics in the EU

The stagnation in the regional convergence process observed since the late seventies or early eighties in the EU means that most of the poor regional economies have not been able to grow faster than the rich ones in the last years. However the facts seem to be more complex due to significant differences in the behaviour within the group of Northern regions and, mainly, within the one of the Southern regions. Neven and Gouyette (1994) observe a different pattern for the two groups. The Northern regions experienced a strong convergence process among them only in the second half of the decade meanwhile that process was observed in the first half among the poor Southern regions, whereas in the second half they at best stagnated.

This means that regional responses were different to the socioeconomic changes that ocurred in the last decade. Firstly, the industrial crisis strongly affects some of the early industrialised regions of the North. This regions had to face a deep crisis in their productive structure and not all of them were able to shift to more productive activities at the same speed. And the crisis had also hard consequencies on the weaker economies of the poor regions. In this case the possibilities of recovery were limited by their less diversified structure, lower capacities of innovation and higher macroeconomic desequilibria. Nevertheless, some of the regions that experienced a faster growth in the *boom* of the second half of the eighties were peripheral regions. Leonardi (1995) points out the above average growth of the Spanish, Portuguese and Irish regional economies. In contrast, the other peripheral country, Greece, experienced an important negative differential in the growth process of its regions (although problems in data and territorial definition for Greek regions and its volume of black economy might be distorting the results in the works that consider those regions). Furthermore, the rapid growth in the first two countries should not hide important internal differencies. For instance, Artís et al. (1996) observe significant variations in the growth of the Spanish regions in the eighties, mainly in its second half, detecting outstanding dynamical areas such as the Mediterranean regions, the Islands, Madrid or the Ebro Valley, but also others with a moderate growth. For the Italian case, Mauro and Podrecca (1994) argue against the *optimistic* view of the North-South dualism of Barro and Sala-i Martin (1991). The dispersion in GDP per capita for the Italian regions slightly increased in the last decade and their results neither support the hypothesis of unconditional ß convergence (the sign of the convergence parameter in their equation is non negative actually) nor the diminish in the gap between South and North-Central Italian regions[2].

This duality in the behaviour observed in the last years may lead to think in

[2] See Leonardi (1995, chapter 5) for a description of the Italian Mezzogiorno socio-economic performance related to the rest of Italian and EU regional economies.

a polarization process within the peripheral regions. In such a process the *winner* regions of each peripheral country would be catching up with the richer EU regions but leaving behind a group of *less fortunate* regions. This process might be related to a concentrical expansion of the economic activity, where the inner periphery is receiving the possitive effects of the integration faster and stronger than the outer periphery. In this sense it is relevant how in Spain the proximity to the rest of Europe is a significant factor when analyzing the relative regional growth in the last decades. This assumption arise the possibility of future developments for the outer peripheral regions of Spain, Portugal, Italy and even Greece.

Nevertheless, we must keep in mind that a second factor of a deep economic change took place in the eighties that could have strongly affected the regional distribution of the economic activity. As a cause or as a result of the industrial crisis, new production techniques as well as products have emerged. On one hand the vertical desintegration of industrial activities might have favoured the diffusion of activities from the core to the periphery, where they would have also profitted from lower salaries and political incentives. Although on the other, as far as the high technology industries and producer services located mainly in the core, the aggregate productivity of these regions would have been growing faster than the one of the periphery. This could be related with the initial phases of a new product cycle and the agglomeration forces that characterized such phases (Sternberg 1996). In addition, this process ran parallel to a deepening in the EU integration process. It is well known that the neoclassical models predicts an improvement of peripheral regions given that factors spatial shifts and trade are supposed to cause an equalization in the relative production levels. Suarez-Villa and Cuadrado-Roura (1993) and Molle and Boeckhout (1995) provide a synthesis of economic theories that hold regional convergence or divergence.

Violation of the restrictive neoclassical assumptions (perfect competition, absence of scale economies,...), difficulties in the transfer of technology among regions, differentiation in the type of industries in the core (high-value new products) and in the periphery (mature productions) and some other factors from the new growth theory (markets access, human capital and infrastructure dotation, efficiency of politic and economic institutions,...) counteract the optimistic predictions of the neoclassical models. Furthermore, there is some empirical facts that lead to doubt about these optimistic predictions. For instance the foreign direct investment in the EU countries seems not to be deterred by the higher labour costs of the Northern member states, being a combination of factors that shapes location decisions: proximity to markets, quality and availability of labour and infrastructures, quality of life and promotional policies of the host regions (Begg 1995).

On the other hand, the new theories of industrial location, trade and integration have proposed a U-shape relationship between the degree of integration and relocation of economic activity to the periphery (Krugman and Venables 1990; Krugman 1991). In this context an increase in the degree of integration from low initial levels cause a worsened in the periphery until the moment in which a threshold is achieved, where following integration would have positive consequencies to the activity in the periphery and then would contribute to convergence. Assuming that integration means a decrease in the trade costs (transport, information, regulatory,...) then some of the differences in the growth among peripheral regions might be due to their degree of real integration. Hallet (1996) shows the connection between the lower growth of Greece during the eighties and its lower level of integration due to its higher trade costs compared with other peripheral areas, that are related to the schedule of dismanthing trade barriers, the infrastructure dotation, accesibility and long-distance to the rest of the EU territory and some cultural issues as idiom or quality of communication services. In this sense, the level of real integration of Spanish and Portuguese regions (at least some of them) would have been beyond the critical point in the U-shape curve. Nevertheless, Brülhart and Torstensson (1996) have derived a somewhat worried result. The concentration of the increasing returns activities in the core decrease initially with integration although beyond a position in the curve, dispersion of these activities is reversed. Such a process is related with the gain in attractiveness of the periphery to the rest of the world due to its access to a large market and with its simultaneous loss of competitiveness related to the core, since the lower trade costs rise its locational advantage due to its larger home market and agglomeration economies. From their empirical results *one might infer that further reduction of trade costs in Europe can lead to considerable centripetal shifts in European industry. Under this scenario, we would expect increased concentration of scale-intensive production at the core of the EU, whereas the periphery would specialise in manufacturing activities not characterised by scale economies and non-manufacturing activities*. In our opinion, whether the conditions under their model is built are representative of the reality in the EU, this picture may be translated to a stagnation and even increase in the expected gap between the relative levels of production in the different categories of regions.

In any case, it seems that the process of integration and the sectoral and locational shifts might be causing a somewhat complex process of regional growth where not only the stress is on the dualism between the core and the periphery but also on a certain diversified behaviour within the core and, mainly, within the periphery. In this sense, the process of *regional inversion* (Suarez-Villa and Cuadrado-Roura 1993) or the *mosaic-type* regional growth model (Illeris 1993) may explain why some poor regions have been able to significantly improve their situation while others have hardly achieved to equal the average EU growth rates. The success of the former might be in their capacity to take advantage of their lower labor costs but also in the improveness in their dotation of infrastructures, communication networks and human capital resources and the institutional support (local, national and supranational). Then the simultaneous presence of these factors in a higher or lower degree seems to be a requeriment for the long-term *take off* of these economies. In this sense it is well known the neccessary, although not sufficient, condition of the infrastructure dotation for the economic growth (Button et al. 1995) and also the relevance of an adequate institutional environment (Leonardi 1995; Knack 1996). Therefore, both exogeneous and endogeneous factors should run jointly to promote real integration, attraction of activity and thus differential growth in the periphery.

The following sections try to shed light on how the regional distribution of labour productivity and per capita product in the EU have evolved over the last years and also on the relative behaviour of the poor peripheral regions. Furthermore, the spatial association tests will permit to detect significant spatial concentrations of economic activity and their shifts thoughout the considered period. Then, the results may contribute to test empirically some of the hipothesis about the dynamics of the regional inequality when changes in the economic activity and an economic integration process are ocurring in the EU.

3. Description of regional inequality and its evolution

Traditional analysis of regional disparities have focused their attention in the evolution of some indexes that measure the dispersion or inequality within the distribution of regional incomes. When considering the standard deviation of the (log) relative GDP per capita (usual measure of s convergence) in our sample, the results are well known. Figure 1 shows its stagnation throughout the period. Other inequality indexes show almost the same, as we can see in the case of the Atkinson index when we do not show specific aversion to poverty situations (A0.5). When we do, however, results are rather different. The Atkinson index with some poverty aversion (A20) shows an increase in the inequality mainly due to the behaviour since 1986. In other words, in spite of a global stagnation, poorest regions would have worsened their relative situation. In GDP per worker things are not the same (Figure 2). In this case all indexes, including the A20, show an important and general decrease in the inequalities. In 1992 their level is around a 25% less than in 1981. However the process is not linear during the period. Until mid-eighties the decrease is not significant, while in the second part of the decade starts a really impressive reduction.

These results show important differences in the convergence process in both variables, and agree with our hypothesis that the mechanism of integration causes convergence in productivity levels but not in per capita levels (at least in a short and medium term). Another important feature is that an adjustment mechanism seems to exist in less favoured regions, due to the fact that they tend to improve their productivity levels, and catch up with the medium ones, but at a cost of less employment and so without improving their per capita levels.

Another important issue is the possible occurrence of a polarization or stratification process. This means an increase in the homogeneity within groups of economies but an increase also in the distance between groups. Clearly this is a concept related to *local convergence* or *convergence clubs* (see for instance Baumol 1986; Ben-David 1994). The polarization index proposed in Esteban and Ray (1994) summarizes this process and for our variables it is also plotted in Figures 1 and 2. In both cases a slight increase in polarization is observed although at the end of the period we note similar initial levels. The characteristics of this index do not allow us to evaluate the absolute level of polarization, thus other tools should be used to detect convergence clubs in both variables. In any case the index shows no evidence of a deepening in that process. A useful technique for analysing the existence of convergence clubs is the estimation of the density function for the regional distribution of GDP per capita and per worker and the analysis of its multimodality. Quah (1996c) and Bianchi (1995) show the bimodality of the international income distribution whereas Quah (1996b) obtains no insights of it for a subsample of regions in the EU in GDP per capita. Figures 3 and 4 plot the estimated density functions for our variables. The densities were obtained using a gaussian kernel with bandwidth (h_{opt}) selected by means of (Silverman 1986: formulae 3.28):

$$h_{opt}= 1.06\ s\ n^{-1/5} \quad (1)$$

where s is the standard deviation and n the sample size. The distribution of the (log) GDP per capita relative to the average EU shows a very similar shape for all years. It is highly concentrated closed to the average value, even though an important mass of probability is observed at the right (poor regions). Taking into account that this way of selecting h_{opt} may oversmooth somewhat if the real distribution is multimodal, we also estimated the density with a bandwidth given by the expression 3.31 in Silverman (1986):

$$h_{opt}= 0.9\ A\ n^{-1/5} \quad (2)$$

where A=min(s, interquartile range/1.34). In this case the bimodality is more evident, reflecting an important group of regions with levels of GDP per capita below the average and with a trend, in some sense, to converge at a lower level than the rest of the economies. This result contradicts the ones in Quah (1996b), but it is important to note that our sample considers relatively poor regions of Portugal and Greece, not considered in that work. Moreover, it is worth saying that the distance between both modes in our case is far below the one detected between the two *peaks* in the distribution of the world economies.

On the other hand, there are also not any significant changes in the external shape of the distribution in GDP per worker along the period. And, in this case, unimodality seems the likely assumption. Only a long left tail sheds light on the existence of a small subset of economies with a level of productivity far below the average (mainly Portuguese and Greek regions), even thougth their dispersion prevents them from being considered as a club.

To that point we have derived the possible existence of bimodality in the regional distribution of GDP per capita in the EU, while unimodality of GDP per worker, in a static way and inside the considered sample. The dynamic consideration of these features and an out- of-sample extrapolation (as proposed in cited Quah's works) will be exposed next.

Which regions have been the main actors of inequality and its evolution? The application of the expanded rank-size function to the convergence analysis.

Any index which summarizes the level of dispersion or inequality in a single figure can not explain all the characteristics of the analysed distribution. Moreover, index time evolution is not able to show important information about the evolving distribution. In this way, Quah (1996a) and Leung and Quah (1996) show how any value of the parameter in the traditional convergence regression can be consistent with both cross-section distribution expanding or collapsing into a point. That means the dynamics of a "representative economy" give no guide of those of the whole distribution. On the contrary, the rank-size function allows us to have a vision of the inequalities through the whole cross-section. Moreover, the comparison in different time points sheds light on its evolution

(Fan 1992; Fan and Casetti 1994). The rank-size function is defined as double-logarithmic

$$\ln y = a + b \ln r \quad (3)$$

where y is the variable in descending order and r is the rank assigned to each one of the regions in that order. The presence of a high slope, b in the equation, shows a large gap between two regions in consecutive ranks, then a high level of inequality. From the results in Table 1 two conclusions may be derived. Firstly, a different behaviour during the eighties: there is a continous decrease of inequality in productivity meanwhile inequality remains almost constant in GDP per capita. Secondly, global inequality in the first half of the eighties was higher in productivity than in GDP per capita, but since 1987 the order is reversed. Despite this result confirms the convergence process in productivity, the estimation of global inequality from the rank-size function is higher in the case of productivity during a long period in the sample. However, the previous indexes showed the contrary. In our opinion this is an example of the sensitivity and inconsistency of the *systemic* measures of inequality. In fact, the rank-size function for both variables shows different levels of inequality for different kind of regions. In concrete it shows how larger inequality in productivity was the result of important differences in regions with very low levels, while the other regions showed closer levels. These facts raise the question about the likelihood that the linearity hypothesis were held, that is whether it is possible to accept the homogeneity in the slope regardless of the rank. Figures 5 and 6 show that in spite of the existence of a linear behaviour at medium ranks in the function, the slope increases quickly with rank when arriving to the highest ranks, mainly in productivity. Moreover, in some years the slope seems to be bigger in the lowest ranks (highest incomes) than the one in medium ranks. Therefore, it seems necessary to consider this non homogeneous behaviour of the slope[3]. An easy and direct way is by means of Casetti's (1972) expansion method. That method shows how starting from an initial model as (3), it is possible to endogenize the slope as a function of other variables, picking up the jump in the slope depending on the ranks. A direct way of doing this is by taking the slope as a function of *r*. In our case, and considering a cubic function of *r* for the slope expansion, we obtain:

$$\ln y = a + b_0 \ln r + b_1\, r \ln r + b_2\, r^2 \ln r + b_3\, r^3 \ln r \qquad (4)$$

Moreover, each parameter b_i has been expanded as a function of a time trend, *t*, to take into account the temporal evolution of inequality. A cubic temporal expansion was selected for GDP per capita while a quadratic was enough for productivity. For instance, in the former the final estimated expression, pooling the time series and cross-section data, was:

$$\ln GDP\ pc = a + [\sum_{i=0}^{3} b_{i0}\, t^i + \sum_{i=0}^{3} b_{i1}\, t^i\, r + \sum_{i=0}^{3} b_{i2}\, t^i\, r^2 + \sum_{i=0}^{3} b_{i3}\, t^i\, r^3\,]\ln r \qquad (5)$$

In this way, it has been possible to conclude about the contribution of particular ranks (types of regions) to global inequality as well as to its evolution. Results are summarized in Figures 7 to 10, where selected ranks or periods are fixed to observe the evolution of inequality along time or ranks. Regarding to GDP per capita, it can be observed the evolution described by means of the inequality indexes for every rank. Despite this, it is also clear the larger increase in inequality of the richest regions in the first half of the eighties and their larger decrease in the second half. Therefore, these results would confirm the ones

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3 It should be note that the shape of the function may shed light on the presence of convergence clubs. For example, a S-shape function would be due to low inequality among rich regions and among poor regions though large inequality between each group. Obviously, a linear function should be interpreted as no evidence of groups of regions homogeneous enough to become a club.

raised by the Atkinson index with high poverty aversion. In the productivity case, all types of regions contribute to continous convergence, though low ranks seems to decrease more their inequality again. On the other hand, differences in inequality among regions with medium-high levels and the lowest levels are extremes in this latter case.

Mobility within the regional GDP distribution.

Whether there is intra-distribution mobility or not is an outstanding fact when we are dealing with levels of inequality and its dynamics (ie convergence). The conclusions, and political decisions, should be different depending on whether or not individuals exchange their positions. In the former case a *mobility* situation exists, and decisions to change structural economic conditions would not be required (only those that soften cyclical responses would be). Otherwise *persistence* characterizes the distribution and those decisions might be justified.

By means of the rank-size function we have shet light on the contribution to global inequality of each region, statically as well as dynamically. Nevertheless, when sorting the regions in each one of the years the movements in the ranking of each economy have not been taken into account. That is, we may obtain the same value for the slope (*b*) in the rank-size function for different years and the conclusions would be different in the case that regions do not exchange their position (rank) or in the case that they do. For instance, with only two economies, A and B, let suppose that in period t: x_{At}=100 and x_{Bt}=200, and in t+1: x_{At+1}=200 and x_{Bt+1}=100. In both time periods the inequality parameter in the rank-size function would be the same (as would any dispersion or inequality measure), but perfect mobility would also exist. Circumstances would be rather different if none exchange were observed (persistence). Therefore, the sort procedure in the rank-size function inequality analysis *hides* movements within the distribution. The analysis of the rank-size function for each period, but keeping fixed the ranking at the initial year is a way of improving the analysis considering mobility. Figures 11 and 12 show those functions for selected years in GDP per capita and per worker. In addition to the evolution of inequality levels exposed above, movements (peaks) in productivity are more outstanding than in GDP per capita. In the former, they seem to be more important since 1985, strengthening the convergence process in this magnitude. In order to have an index of the amount of movements in the distribution for the whole time period, we compute a mobility measure from the difference between the rank-size function in last year with the ranking of that year and the same function but keeping the ranking of the initial year:

$$m_i = \frac{| y_0^T - y_T^T |}{m^T} \qquad M = \sum_i m_i \frac{p_i}{p_n} \tag{6}$$

where y_0^T is the distribution in period T keeping the ranking in period 0, y_T^T is the distribution in period T with the ranking of this period, μ^T is the value of the variable in the whole economic system (set of EU regions considered) and p_i / p_n is the relative population in region *i*. Figures 13 and 14 plot both functions. The value of this index for GDP per capita is 0.05627, clearly lower than the one for labor productivity, 0.1189. Moreover some of the richer regions show the most significant movements while in the other side of the distribution, poorer regions show almost perfect persistence. Movements in productivity, besides being bigger, contributed to convergence basically due to the behaviour of some high-productivity regions that decreased their relative levels towards the average and some low-productivity ones (but not the lowest) that increased their position in the ranking. It is worth insisting in the high persistence of the small subset of regions with the lowest levels of productivity. In addition to their contribution to global inequality, they were not able to permute positions with other regions. This means that if we consider them as a *low productivity club* no region was able to surpass its gravity attraction[4].

This graphical mobility analysis may be improved and formalized by means of an econometric model capable of considering the intra-distribution dynamics (Quah 1993a, 1996a, 1996c, 1996d). A *model of explicit distribution dynamics* (medd) has been used in the current convergence literature. In brief, following for instance Quah (1996a), let F_t be the distribution across the economies for the analysed variable in time t and $?_t$ a probability measure associated with each F_t. The probability measure $?_t$ is defined as

$$\forall\, y \in \_ : \quad l_t((-\infty , y]) = F_t(y) \qquad (7)$$

The simplest probability model describing distribution dynamics, considering discrete time, is a first order dependence specification

$$l_t = T^*(\; l_{t-1} , u_t \;) \qquad (8)$$

where u_t is a secuence of disturbances and T^* is an operator that maps probability measures in *t-1* and disturbances in *t* to probability measures in *t*. In such a model, the operator T^* collects the richness of the distribution dynamics, thus an estimation of it allow us to quantify such dynamics. Moreover, setting null values to disturbances and iterating in (8) we obtain how distribution will evolve in future

$$l_{t+k} = (T^* T^* \cdots T^*) \; l_t = T^{*k} \; l_t \qquad (9)$$

and therefore the characteristics of the variable distribution in the following periods. Taking expression (9) to the limit as $k \to \infty$ provides the long-run distribution of the analysed cross-section (given the case that an unique steady

4 In fact this circumstance belongs to the definition of *convergence club*.

state solution does really exist). From this long-run solution derived from the in-sample dynamics someone can infer the characteristics of the out-of-sample (forecasting) convergence/divergence process. Convergence in our variable involves a long-run distribution collapsing into a degenerate point mass while dispersion in $?_{t+k}$ ($k \rightarrow \infty$) should be viewed as divergence. Interesting conclusions might be drawn from particular non-convergence solutions. For instance, a multimodal limit distribution should be interpreted as a tendency to stratification in different *convergence clubs* (see Quah's cited works).

An easy way of working with this model is to make $?_t$ discrete, thus becoming a temporal sequence of vectors summarizing the probability of belonging to each one of the defined states. Then T^* just becomes a transition probability matrix, traditional in the Markov chains type of analysis[5]. Following this approach, Quah (1996b) derives an unimodal ergodic solution about the mean in GDP per capita, using a reduced sample of 78 regions that does not include, for instance, Greek or Portuguese regions, from 1980 to 1989. Different conclusions are drawn in Larch (1994) for the longer period 1970-1990 and the EU-9. His results show that a high degree of persistence characterizes the upper (richer) and lower (poorer) intervals and mobility in the eighties even decreased compared with the seventies. Neven and Gouyette (1994) reach similar results for the same period and a richer NUTSII sample.

Our previous results showed large differences in the convergence process in terms of GDP per capita and productivity, including the possibility of twin-peakness in the distribution for the former. Therefore, we continue with a parallel

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5 Discretization involves loss of information in some degree and inapropiate intervals might lead to a process with no Markov property. Nevertheless, one suppose this will not hide the relevant features for our analysis, as point out in Quah (1996d)

analysis for both magnitudes, considering five states[6] as the result of the discretization process. In GDP per capita the grid points that define the states were 75%, 90%, 100% and 115% (in percentatge of the average EU value). We took into account that initially the states included similar number of individuals and that they had similar width (in bounded ones). Table 2 summarizes the results. It is really outstanding the high persistence in the lower state (poorest regions). The probability that a region inside that group left it is insignificant. That fact involves a *poverty trap* and corroborate our previous results. Persistence is also evident in the other states, being also important for the richest regions. In fact the movements average the 10% and the second eigenvalue of the transition matrix (a measure of mobility) is fairly closed to unity (0.9796), indicating very small mobility. The ergodic distribution reflects the *poverty trap* showing a high probability mass in the lower state while some convergence to the average is observe on the part of the rest, mainly due to the loss of probability in the highest state in the long-run solution. This result should confirm the idea of a slow convergence mainly due to the behaviour of regions with GDP per capita levels not far behind the average and above the average, but lack of convergence to that levels of the group of the poorest regions.

When productivity was considered, grid points were stablished at 75%, 90%, 105% and 120%, maintaining the same criteria as in the per capita case. The results show lower persistence than in that case, although the lowest-productivity state shows the lowest mobility. The second eigenvalue equals 0.9222, as a result of the lower values in each one of the entries in the matrix main diagonal. An interesting feature deduced from the transition matrix is that once a lowest-

[6] Due to the fact that results might be sensitive to the discretization process (ie number of states) we also performed the analysis with a higher and lower number of states. Although the figures obviously changed, main results were quiet robust.

productivity region had left that level, the probability of going on to higher levels is larger than the probability of returning to the lower one. This was also the case in GDP per capita but then, the probability of leaving the less favoured state was so small that the effect vanished. As a result, the ergodic solution for productivity forecasts a concentration of probability around the mean values. In such a process, dynamics of both low and high productivity regions are outstanding. In short, dynamics of the whole distribution displays lower mobility in GDP per capita than in GDP per worker, and a trend to evolve to bimodality in the former, even though a *global* convergence process is expected to continue in the latter.

Due to the inestability in the relative regional growth process in the EU, detected in previous sections and considered in other works, we repeated the previous analysis for subperiods 1980(1)-1985 and 1985-1992. In GDP per capita a similar behaviour is observed for low income regions in both subperiods while in the upper tail of the distribution the convergence behaviour showed by the above average regions in the early eighties vanished in the second subperiod. This result agrees with the ones obtained in previous sections, confirming that the rich regions were the main *actors* of the convergence process during the eighties. In productivity, again things are rather different. Between 1981 and 1985, low-productivity regions showed high relative persistence due to higher mobility of around and above average regions. However, the fact that once a region left the lowest state never returned to it causes that this state disappeared in the long-run solution. In the following years, the role of the around and above average regions slightly decreased while regions below the average level increased their movements. Nevertheless this fact did not imply a strenghtening in the convergence process observed previously due to the wrong direction of some of those movements.

4. Spatial inequality distribution in the EU

In the previous section we have detected outstanding results about the regional dynamics and the convergence process in the EU in the last years. However that general analysis has not explicity considered the space in which the economic relationships take place. We have not empirically detected herein whether the regions showing high or low values of GDP per capita or productivity are randomly distributed in the EU space or on the contrary they are clearly located in a concrete territory. We have not tested neither the spatial patterns of the regional growth process throughout the period either. That analysis might help us to check the likelihood of some of the hypothesis about the recent regional growth (regional inversion, mosaic-like pattern of growth) or the persistence of a traditional core-periphery scheme. In this sense, it is relevant to test if the changes in the production processes and in the kind of products have had consequencies on the location of the most dynamical areas. The detection of clusters of high and low values of the analysed variables in the same areas at the beginning and at the end of the period will be seen as an evidence of persistence in the spatial inequality. On the contrary the disappearence of significant agglomerations would be a signal of a territorial difussion of the activity and wealth. Finally, another possibility is the desappearence of some clusters and the appearance of others, in which case shifts in the location of high and low dynamical areas will be detected.

On the other hand, different spatial patterns of the economic activity are related with different assumptions about the geographical transmission of shocks. The symetric or assymetric regional responses to general shocks or the transmission of region-specific shocks to neighbours regions may produce a spatially determined process of regional growth with clear repercussions on the location of activity by means of, for instance, the links between the productive structure of the regions and their trade. This fact is supposed to acquire more relevance due to the loss of capacity of the policies at a national basis to counteract these shocks and their spatial transmission from the implementation of the European Monetary Union. Therefore, the existence of a global process of (positive and significant) spatial correlation would be a signal of large territorial integration and somewhat symetric economic evolution. Local spatial association (clusters of high/low levels of production or fast/low growth), instead, would reflect disparities in structural conditions and differences in responses to shocks.

Spatial distribution of production and tests of global spatial dependence

Relationships among regions belonging to the same national economy and the increasing links between the ones of different member states (transnational transport networks, trade, technology diffusion,...) provoke that the evolution of each one were strongly related to the evolution of, at least, the neighbour regions. In this context of externalities and regional spillovers it is unlikely to assume the independence and randomless of the observations in the distribution of the regional production. Thus, the hypothesis of spatial independence applied to GDP per capita and labor productivity among the EU regions seems an unrealistic assumption.

We test overall spatial correlation by means of the Moran's I and the Geary's C statistics. The expression of the Moran's I is:

$$I = \frac{n}{S} \frac{\sum_i \sum_j w_{ij} \, z_i \, z_j}{\sum_i z_i^2} \qquad (10)$$

where n is the number of observations, w_{ij} is the element of the weights matrix corresponding to the regions i and j, S is the sum of all weight (all the elements in the weights matrix) and z_i represent the normalized value of the variable in region

i. After standarization[7] of the statistic, a significant and positive coefficient indicates a tendency for clustering of similar values while when the coefficient is significantly negative the tendency is for opposite values to cluster. The expresion of the Geary's C is quite similar though in this case the variance of the attribute, instead of the covariance, is used. Again after standarization, a significant negative value for this statistic means more association of similar values than the ramdomly expected and the reverse for the opposite. In our analysis we have defined the weight matrix as a standarised first-order contiguity matrix. That is the element w_{ij} in the matrix is 1 if regions i and j are neighbours and 0 otherwise.

The results for both the levels of GDP per capita and per worker and their growth rates are shown in Table 3[8]. Large significant and positive (negative) values of the Moran's I (Geary's C) reveal the presence of spatial association of similar values among neighbour european regions in GDP per capita and in productivity. However, in the latter the value of the statistic displays a certain decrease between the initial and the final year. If this behaviour persists in the next periods a tendency to a spatially random distribution of productivity might be expected in the future. By no means the same process may be infered to the GDP per capita distribution. Related to the global association in the growth rates, in both cases the null of absence of spatial correlation is rejected. The outstanding fact at this point is that the value for the statistics is much larger for the distribution of productivity.

Spatial clusters and tests of local spatial association

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7 Given the non-normality for the distributions of GDP per capita and productivity, we have applied a randomization assumption to obtain the standarized values.

8 Results in this section has been obtained by SpaceStat (Anselin 1995a).

An important shortcoming of the overall spatial association statistics is that they are not sensitive to situations where the clusters are concentrated in specific areas of the analysed territory only. From the point of view of the regional inequalities analysis, they are also unconclusive due that their value in the case of complete spatial inequality and complete equality is really close. Considering this we compute two test of local association: the G_i (Getis and Ord 1992) and the local-Moran's I_i (Anselin 1995b). Both statistics indicate to a what extent each region is sorrounded by regions with high or low values of the analysed magnitude. The first one can be applied to positive variables and is defined as:

$$G_i = \frac{\sum_j w_{ij}(d)\, x_j}{\sum_j x_j} \qquad i \neq j \tag{11}$$

where $w_{ij}(d)$ are the elements of the contiguity matrix for a given distance d. Once standarized, a positive significant result indicates a spatial cluster of high values, whereas a negative one indicates a clustering of low values. The local-Moran statistic (a LISA measure of spatial association[9], Anselin 1995b) can be defined as:

$$I_i = \frac{z_i}{\sum_i z_i^2 / n} \sum_{j \in J_i} w_{ij}\, z_j \tag{12}$$

where z_i is the observation for region i in deviations from the mean and J_i is the set of neighbouring regions to region i. In this case a significant positive (negative) result indicates the existence of a cluster of similar (dissimilar) values sorrounding region i. Moreover, this LISA statistic permits the detection of outliers, defined as regions with a contribution to the global indicator significantly higher than the mean.

9 A local indicator of spatial association (LISA) satisfies: a) the value for each observation permits the detection of spatial clusters of similar values, b) the sum of the values for each observation is proportional to the global indicator of spatial association.

By means of these local spatial association tests we can detect *hot spots* or macro-regions showing values of GDP per capita or productivity far behind the average, as well as clusters of regions with significant low values. Comparing the evolution of those clusters throughout the period we can trace the patterns of location of the activity and wealth, and relate the results to the convergence analysis. In GDP per capita (Table 4), the presence of associations in regions of some countries is appreciated, specially in Germany, Italy, Spain, Portugal and Greece. In concrete, we detect a significant concentration of high values in Southern Germany (Stuttgard and Karlsruhe, spreading to Oberbayern, Mittelfranken and Darmstadt in the early nineties) and Northern Italy (Piamonte, Lombardia and Emilia-Rogmana). Geographical proximity of both clusters would be reflecting the positive effect of economic externalities to density and aglomeration economies and the best adaptation of these regions to the economic changes compared with the old-industrial core economies of Northern Germany, the South of Belgium and UK. On the other hand, clusters of low values in GDP per capita are located in the poorest regions of the EU: North-West (Galicia, Asturias, Castilla-León) and South of Spain (Castilla-La Mancha, Andalucía, Extremadura and Murcia), and all the Portuguese and Greek regions. Finally, a cluster of low values also appears in the South of Italy (Basilicata and Calabria). A similar pattern is detected in productivity (Table 5). Clusters of low values are concentrated in the North-West and South of Spain and in Portugal, appearing also a numerous cluster of low values in UK at the early nineties[10]. On the contrary, we have not detected a great number of significant clusters of high values in this case. It is interesting to point out the disappearance of an association of high values in the Netherlands (Groningen, Friesland and Drenthe)

[10] It is worth saying that the two Greek regions for which productivity data were available were excluded from this analysis due that we had not data for their neighbourging regions.

in the second half of eighties. Evolution of gas prices is the well-known reason of this feature. In the nineties Liguria, in the North of Italy is the sole region that showing high productivity values was also sorrounded by regions with significant high values.

When the local spatial association in growth rates were analysed (Table 6), two facts were outstanding. First the existence of a larger number of significant clusters in productivity than in GDP per capita, and second, clusters of high growth rates in productivity in those regions that concentrated low values through the eighties (Galicia, Castilla-León, Castilla-La Mancha, Andalucía, Extremadura, Portugal and Italy except the regions of North West, North East, Lombardia and Emilia-Romagna). We have also detected clusters of low growth rates in productivity in regions that started with high levels (basically The Netherlands and UK). Finally, Weser-Ems, Luxembourg and Lisboa display a significant negative I_i value reflecting a local core-periphery scheme in the growth rates of GDP per capita. In addition, Alentejo shows a negative value of this indicator but in this case it concentrates a low growth rate of GDP per capita surrounded by regions that display high rates.

Two conclusions could be drawn from the above results. Firstly, no evidence of important movements in the composition of the detected *hot spots* along the period would lead to think in regions having difficulties to leave their clusters of high/low values. That is to say, high persistence in the spatial characterization seems to exist despite the drift of the core to the South due to the consolidation of the Northern Italian regions and the loss of relative positions of the Northern early-industrialised regions. Nevertheless, the detection of clusters of high productivity growth rates in regions that showed the lowest levels at the beginning agrees with our previous results about the continuous convergence process in that magnitude. Taking into account that these regions have experienced the largest unemployment rates, the contribution of the increase of production to the productivity growth should not be consider as the sole factor for such a process. Secondly, the detection of two significant concentrations, one of high values in the North and another of low values in the South. This fact is obvious in GDP per capita though less clear in productivity. It would arise the idea of a spatial differentiation in the distribution of these variables among the European regions. In that sense, a QAP test (Anselin 1995a) and the estimation of a Spatial Anova (Griffith 1992) enhance the existence of structural inestability within the EU and a somewhat Core-Hinterland scheme all along the period. This spatial instability is also important in two South countries, Spain and Italy. It is important to say that these results should advise that an erroneous specification in the traditional ß-convergence equation for the whole sample could exist. Even though the conditional approach might mitigate the problem, our intuition is that it can hardly consider the whole set of factors and regional links neccesary to get a correct specification.

5. Final remarks and Conclusions

The changes in the economic activity since the late seventies have had important consequencies on the industrial composition, the activity location and the pattern of trade among other factors. Then, these have also affected the behaviour of the regional economies and their relative performance, even in the short-time period of hardly a decade and a half. As a consequence, the process of regional economic convergence might have also experienced changes related to its previous evolution. And, of course, this happened in a moment when the integration process advised on the importance of regional cohesion within the EU.

Our analysis has profitted from an alternative and richer approach to the traditional convergence analysis, recently developed in the literature with the aim of studying the dynamics of the whole regional distribution. In this sense some interesting facts have been looked out. The first one is that the analysis of both GDP per capita and per worker has permitted to detect important differences in their convergence process. The fast and continous convergence observed in productivity has not equivalence in living standards measured by GDP per capita. The process of economic integration in the EU would have enhanced an equalization of productivity among firms and, at an aggregate level among regions, as a result of the need to achieve a common standards of competitiveness. However, in a framework of liberarization and free trade, firms that were not able to achieve those standards were expulsed from the market. As a result, weak economies of poor regions would have suffered higher desequilibria in their labour markets. Whether regional availability of attracting and holding new activities did not equilibrate that fact, it can be view as a possible explanation of the observed convergence in productivity but not in living standards. It is also important to note that regional policy at an EU level (projects of infrastructure dotation, human capital investment, ...) might have a direct effect over productivity of labour but unless they really improved attractiveness of less developed regions to economic activity, its effects over GDP per inhabitant are less obvious, mainly in a short-medium term. On the other hand, we must keep in mind that large interregional migration flows are neither expected nor politically promoted. Moreover, changes in EU labour markets might favour skilled labour movements from poor to rich regions that in a long-term view could have undesirables consequences on convergence. In this sense, movements of firms to poor regions could offer an alternative to migration as a way to improve their relative situation (Begg 1995). In this sense, several studies reveals that in spite of

Objective 1 regions being net inflows of foreign direct investments, little evidence exists that these investments are deterred by higher labour costs in Northern regions. Furthermore, it is important to keep in mind that foreign direct investments tend to concentrate in the most favoured regions of poor countries or areas (as for instance in Catalonia or Madrid in the Spanish case).

A second outstanding result is that most of the contribution to the changes in the overall level of inequality was due to the behaviour of regions with high GDP per capita. The spatial analysis has detected a certain change in the geographical location of clusters of high production regions, with a shift toward the South of the traditional core. That corresponds with the substitution as leading regions of the ones specialized in mature activities by those that were able to host the new high-value activities. However the results do not support a significant process of general diffusion in the location of these activities, mainly towards the poor peripheral regions. The absence of convergence in GDP per capita due basically to the impossibility of the poor regions to experience significant upward movements in the ranking as well as the persistence in the spatial clusters of low values in the traditional periphery might be seen, in our opinion, as the evidence of the persistence in the locational disadvantages of these economies, even in a world where the activity is less dependent of specific geographical locations. In this sense our results show how despite the progressive dematerialization, the location and physical geography still matters in the EU (as stated in Quah, 1996b). Nevertheless this fact should not hide the ability of some peripheral regions to profit from this new scenario. Differences in the real level of economic integration, institutional and industrial environments, location and in general dotation of endogeneous as well as exogeneous factors, may explain why some peripheral regions were able to improve their position while others were not. In any case, the convergence process up to the early eighties might be associated with the diffusion to the periphery of the mature activities (automobiles, consumer durables, petrochemicals) whereas the born of high-value activities of a new product cycle (computers, electronics, telecommunications) would have provoked a renewal in the concentration forces to take profit from the agglomeration economies, R&D, human capital and physical infrastructure dotation and amenities of the core regions. The evolution in the phases of those products could lead again to a convergence process in the future as the one observed until the eighties. However some peculiarities of the new products (as the constantly shortening cycles for technology intensive products) might exclude the expected spatial diffusion, and then a convergence process, in the next future.

As a conclusion, we think that, unlike the continous equalization in the labor productivity levels, a certain polarization in two clubs in living standards remain within the regions of the EU. Both groups approximately match with the traditional core-periphery division and this heterogeneity is expected to persist in the next future in spite of some isolated *regional inversion* experiences.

Finally, it is important to note that regional productivity was not adjusted by partial time employment, thus differences in the ratio full-partial employment among regions would have effect on disparities in that magnitude. Results could also change if *black economy* was in any way considered as well as changes in the official definition of regions through the analysed period. Moreover, some possibilities demand a deeper study. For example, Garcia-Milà and Marimon (1995) conclude that convergence in productivity is only observed among Spanish regions in semi-public sectors, while non significant convergence is observe in productivity for private sectors. Thus direct effect of, for instance, regional policy might be contamining aggregate results. In any case, an obvious conclusion is that regional convergence is not a simple process and if someone tries to aproximate the phenomena by means of only a magnitude, a deformed and uncomplete picture can be obtained. The simultaneous analysis of different magnitudes seems to be the logical approach.

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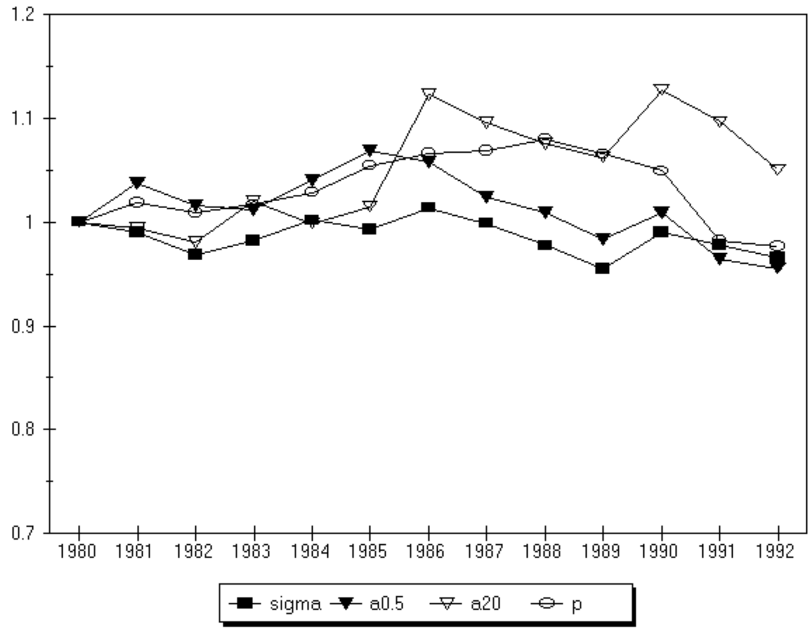

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Figure 1. S-convergence, Atkinson with low (0.5) and high (20) poverty aversion and polarization indexes for GDP per capita. (% of initial year)

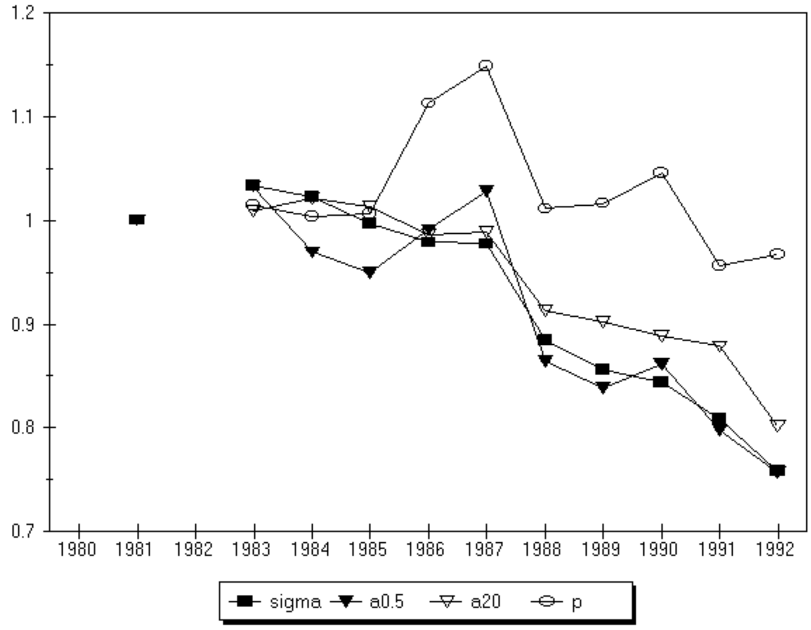

Figure 2. s-convergence, Atkinson with low (0.5) and high (20) poverty aversion and polarization indexes for GDP per worker. (% of initial year)

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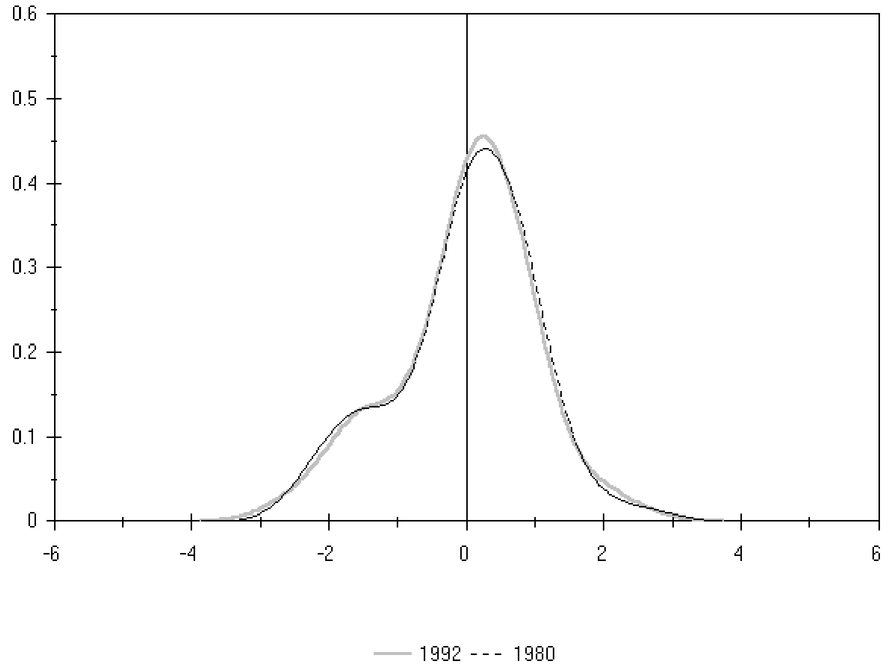
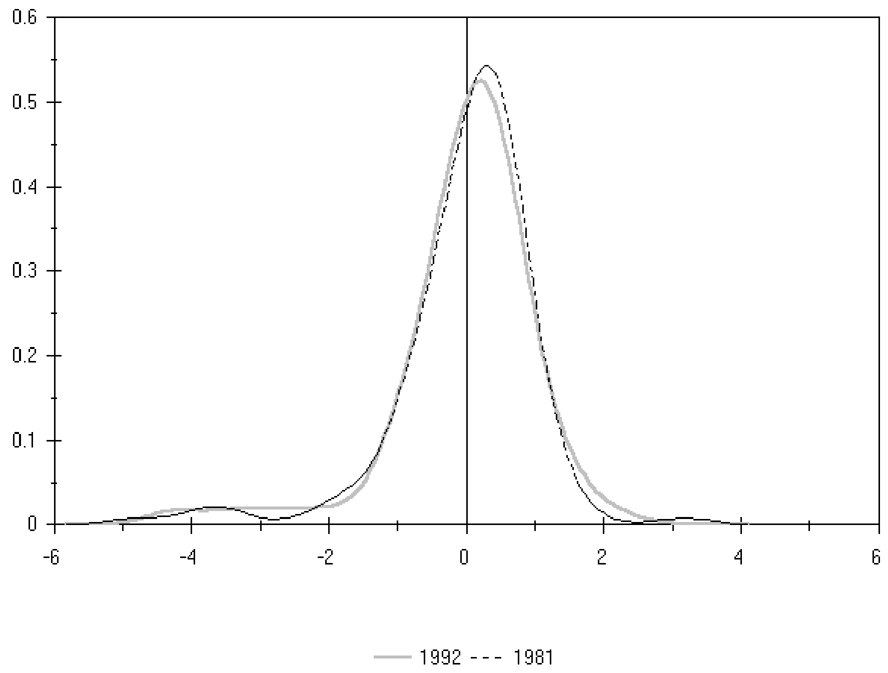


Figure 3. Estimated density function, GDP p.c.

Figure 4. Estimated density function, GDP p.w.



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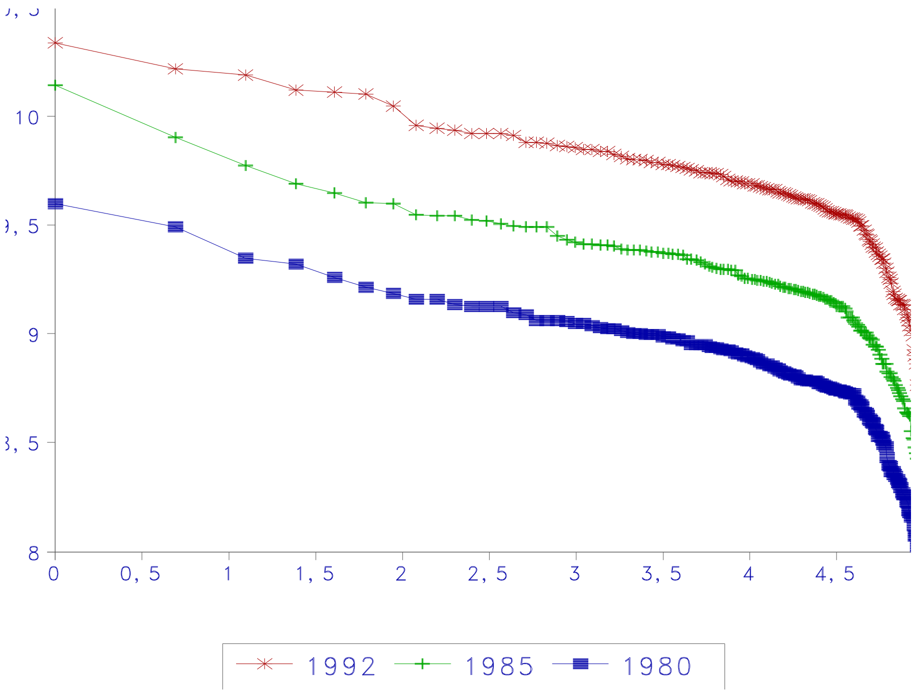
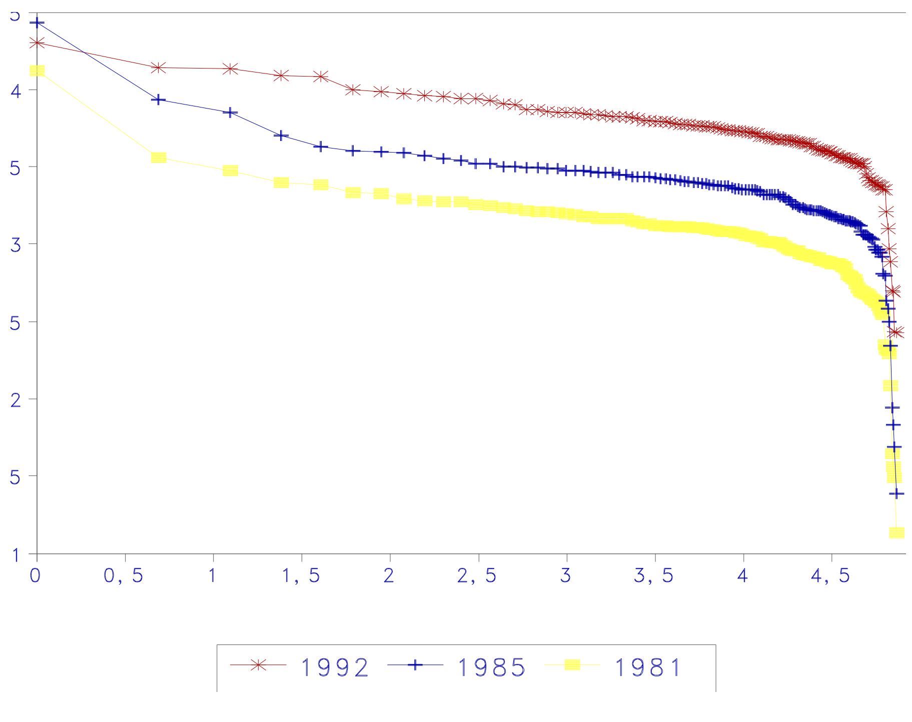


Figure 5. Rank-size function, (logs) GDP p.c.

Figure 6. Rank-size function, (logs) GDP p.w.



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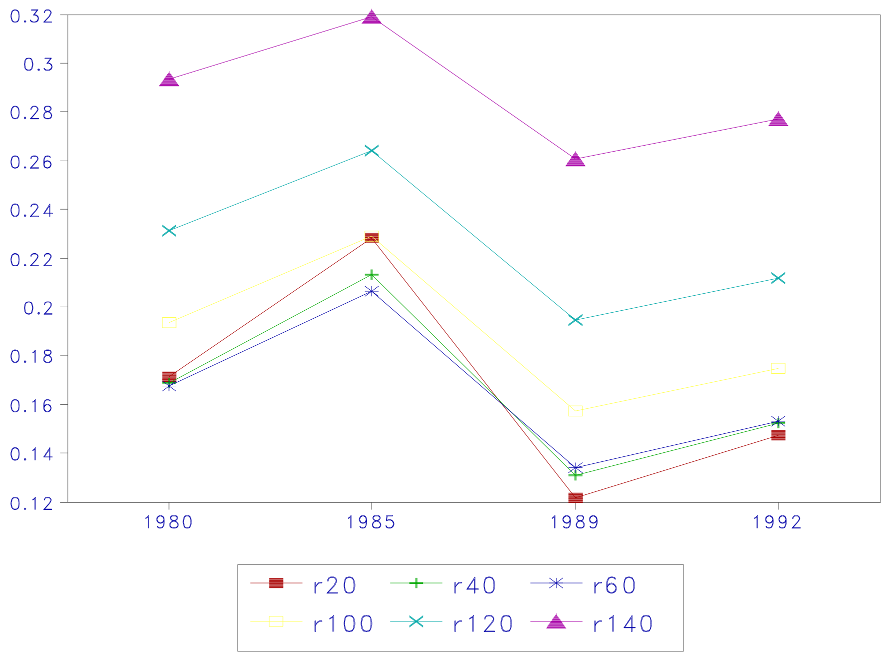

Figure 7. Inequality at selected ranks, GDP p.c.

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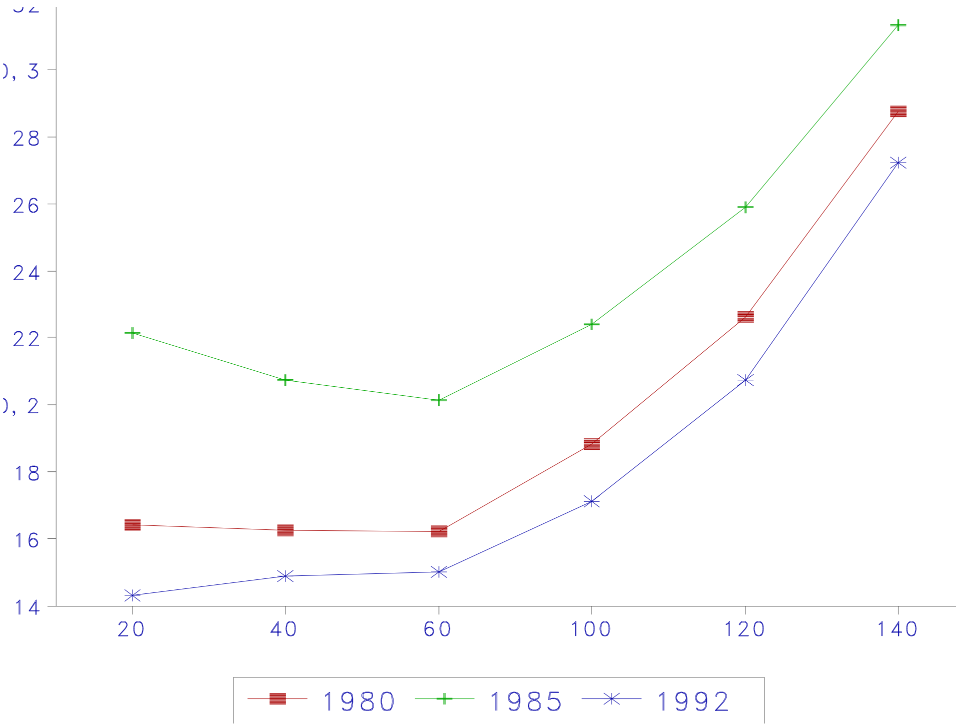
Figure 8. Inequality at selected years, GDP p.c



¡Error!Marcador no definido.

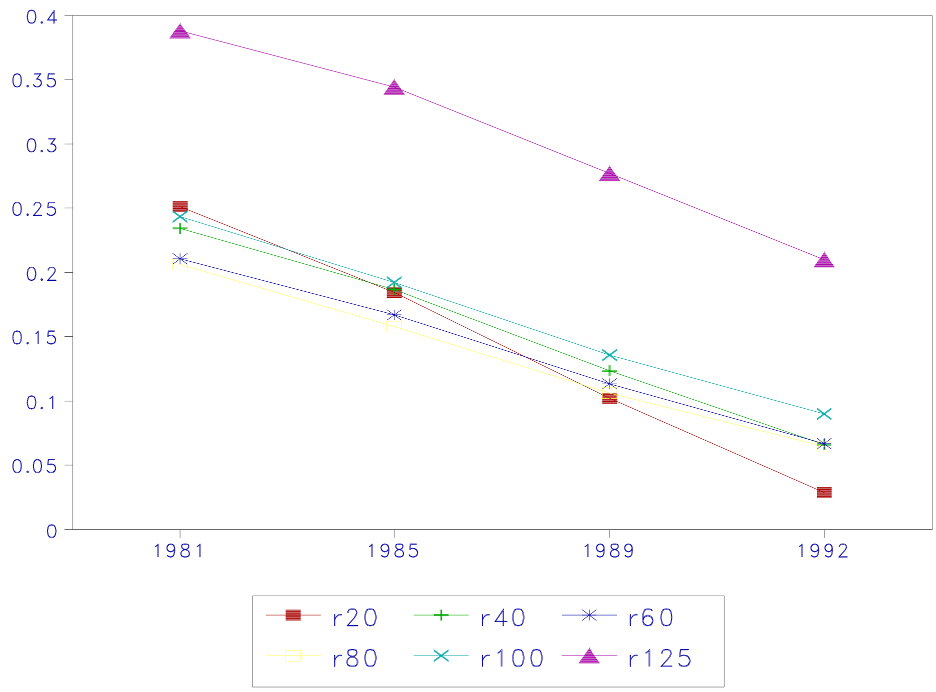
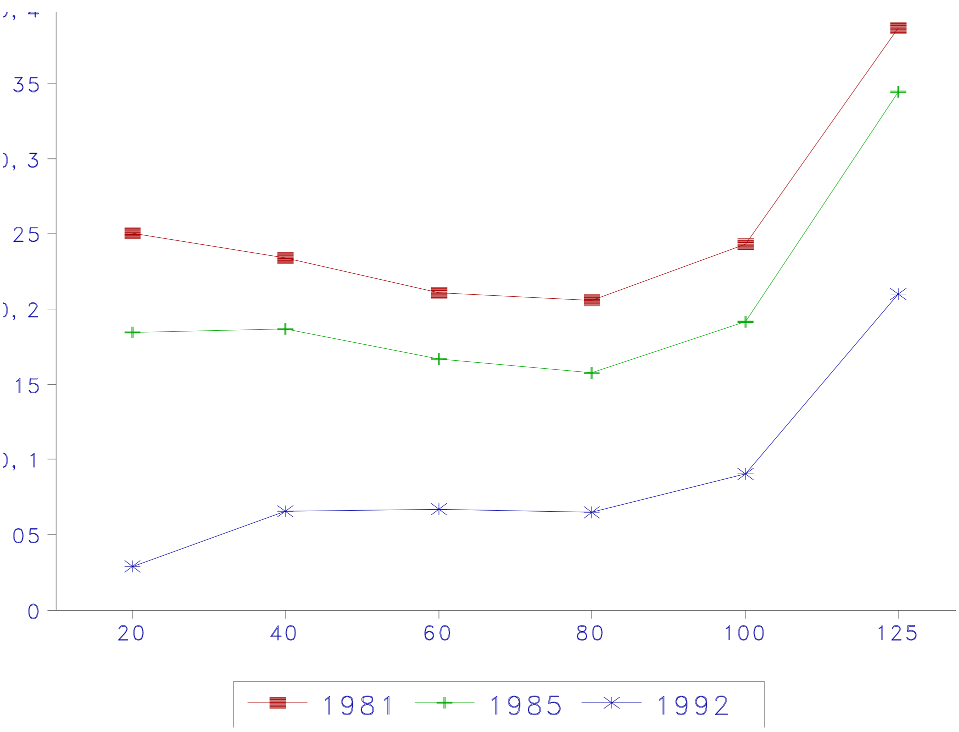


Figure 9. Inequality at selected ranks, GDP p.w.

Figure 10. Inequality at selected years, GDP p.w.



¡Error!Marcador no definido.

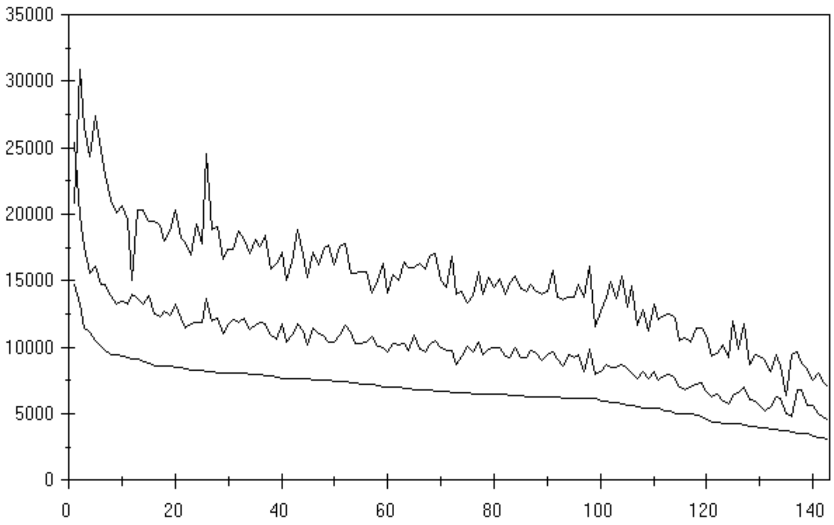
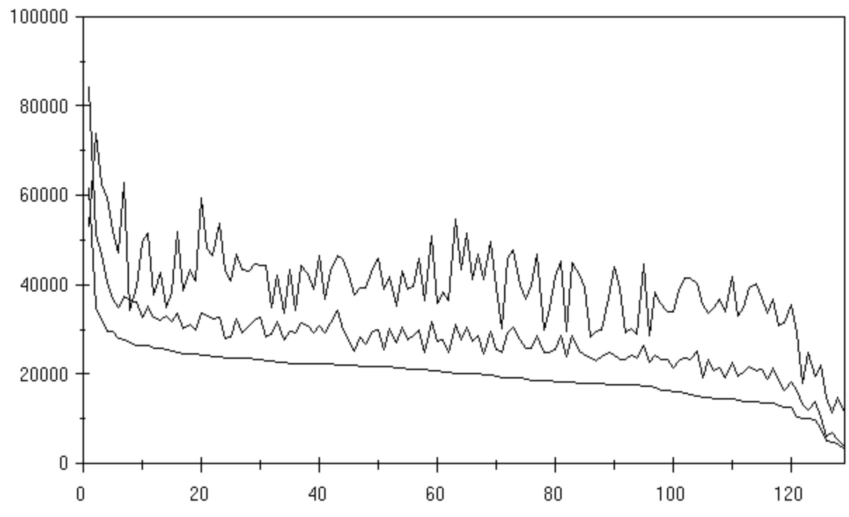


Figure 11. Rank-Size functions keeping the ranking at initial year, GDP p.c.

Advancing upwards 1980, 1985, 1992

Figure 12. Rank-Size functions keeping the ranking at initial year, GDP p.w.
Advancing upwards 1981, 1985, 1992



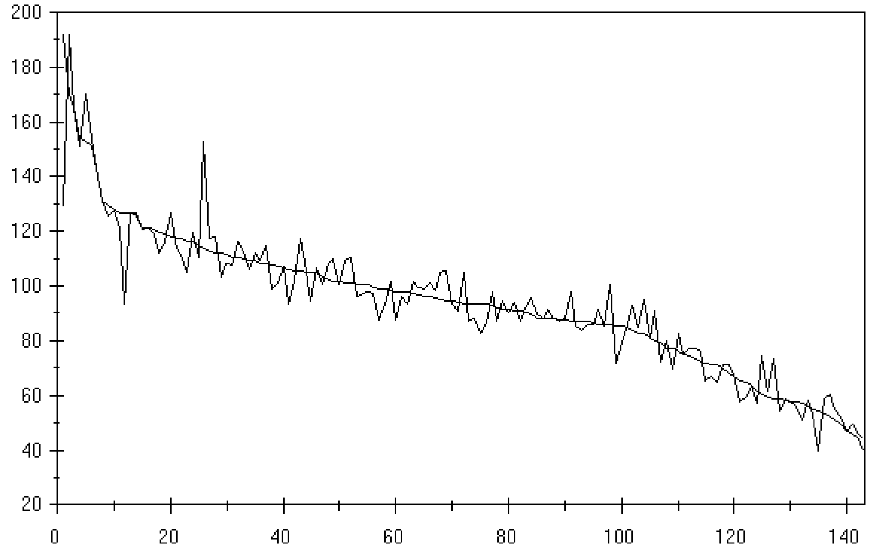


Figure 13. Mobility in GDP p.c distribution, 1980-92.

Figure 14. Mobility in GDP p.w distribution, 1981-92.

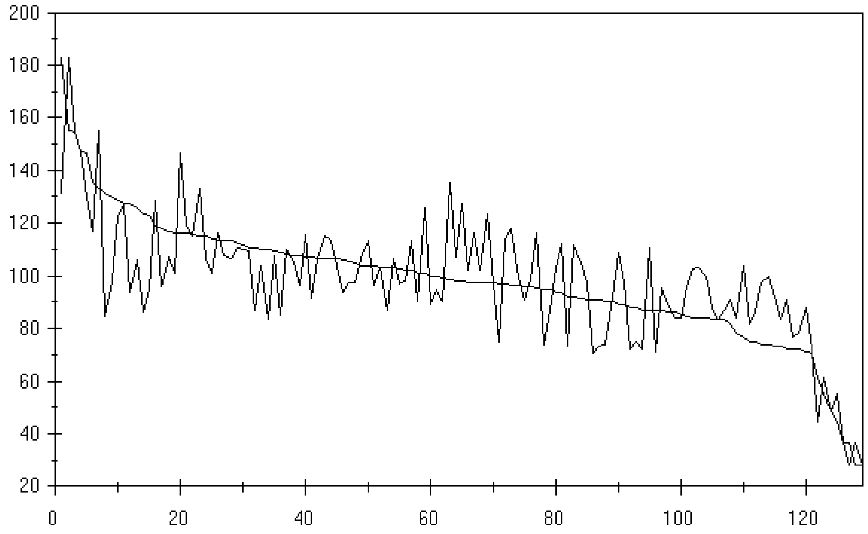


Table 1. Levels of inequality from the rank-size function

	GDP p.c	GDP p.w
1981	-0.2766	-0.2935
1985	-0.2791	-0.2822
1992	-0.2638	-0.2293

Table 2. Results of distribution dynamics (markov chains approach).

GDP Per Capita	**GDP Per Worker**
1980-1992 grid: (0, 75%, 90%, 100%, 115%, +∞) initial: (0.223 0.167 0.188 0.195 0.223) $\begin{pmatrix} 0.980 & 0.019 & 0 & 0 & 0 \\ 0.032 & 0.862 & 0.105 & 0 & 0 \\ 0 & 0.086 & 0.856 & 0.056 & 0 \\ 0 & 0 & 0.069 & 0.877 & 0.053 \\ 0 & 0.003 & 0 & 0.083 & 0.913 \end{pmatrix}$ ergodic: (0.305 0.187 0.222 0.176 0.108) 2on eigenvalue: 0.9796	*1981-1992* grid: (0, 75%, 90%, 105%, 120%, +∞) initial: (0.201 0.155 0.224 0.255 0.162) $\begin{pmatrix} 0.839 & 0.160 & 0 & 0 & 0 \\ 0.082 & 0.760 & 0.157 & 0 & 0 \\ 0 & 0.089 & 0.804 & 0.103 & 0.002 \\ 0 & 0.002 & 0.120 & 0.794 & 0.082 \\ 0 & 0 & 0.005 & 0.189 & 0.804 \end{pmatrix}$ ergodic: (0.097 0.188 0.321 0.273 0.119) 2on eigenvalue: 0.9222
1980-1985 $\begin{pmatrix} 0.981 & 0.018 & 0 & 0 & 0 \\ 0.036 & 0.845 & 0.118 & 0 & 0 \\ 0 & 0.087 & 0.851 & 0.060 & 0 \\ 0 & 0 & 0.111 & 0.828 & 0.059 \\ 0 & 0 & 0 & 0.112 & 0.887 \end{pmatrix}$ ergodic: (0.363 0.183 0.247 0.134 0.070) 2on eigenvalue: 0.9777	*1981-1985* $\begin{pmatrix} 0.863 & 0.136 & 0 & 0 & 0 \\ 0 & 0.828 & 0.171 & 0 & 0 \\ 0 & 0.117 & 0.723 & 0.148 & 0.010 \\ 0 & 0 & 0.193 & 0.724 & 0.081 \\ 0 & 0 & 0 & 0.254 & 0.745 \end{pmatrix}$ ergodic: (0 0.242 0.355 0.292 0.026) 2on eigenvalue: 0.8693
1985-1992 $\begin{pmatrix} 0.978 & 0.021 & 0 & 0 & 0 \\ 0.030 & 0.873 & 0.096 & 0 & 0 \\ 0 & 0.085 & 0.859 & 0.054 & 0 \\ 0 & 0 & 0.038 & 0.912 & 0.048 \\ 0 & 0.005 & 0 & 0.058 & 0.935 \end{pmatrix}$ ergodic: (0.247 0.172 0.181 0.227 0.171) 2on eigenvalue: 0.9816	*1985-1992* $\begin{pmatrix} 0.826 & 0.173 & 0 & 0 & 0 \\ 0.116 & 0.732 & 0.151 & 0 & 0 \\ 0 & 0.079 & 0.833 & 0.086 & 0 \\ 0 & 0.004 & 0.090 & 0.823 & 0.082 \\ 0 & 0 & 0.008 & 0.158 & 0.833 \end{pmatrix}$ ergodic: (0.113 0.169 0.309 0.272 0.134) 2on eigenvalue: 0.9344

Table 3. Global autocorrelation spatial statistics

	(log) GDP p.c.				(log) GDP p.w.			
	1981	1985	1992	81-92	1981	1985	1992	81-92
Moran's I	10.08	9.82	10.49	3.31	11.11	10.40	9.94	11.02
Geary's C	-9.41	-9.23	-9.47	-2.86	-8.11	-7.45	-7.36	-10.02

Note: all values are significant at 5%

Table 4. Significant clusters in (log) GDP p.c.

		1981	1985	1992
		Germany	*Germany*	*Germany*
$I_i>0$	$G_i>0$	Stuttgart	Stuttgart	Stuttgart
		Karlsruhe	Karlsruhe	Karlsruhe
		Darmstadt*	Darmstadt	Darmstadt
			Mittelfranken	Mittelfranken
				Oberbayer
				Tuebingen*
		Italy	*Italy*	*Italy*
		Piemonte		Piemonte*
		Lombardia	Lombardia	Lombardia
		Emilia-Romagna	Emilia-Romagna	Emilia-Romagna
				Veneto*
				Trentino-Alto Adige*
		France		*France*
		Ille de France		Ille de France*
		Spain	*Spain*	*Spain*
	$G_i<0$	Com. Valenciana	Com. Valenciana*	
		Andalucía	Andalucía	Andalucía
		Murcia	Murcia	Murcia
		Galicia	Galicia	Galicia
		Castilla-León	Castilla-León	Castilla-León
		Castilla-La Mancha	Castilla-La Mancha	Castilla-La Mancha
		Extremadura	Extremadura	Extremadura
			Asturias*	Asturias
		Portugal	*Portugal*	*Portugal*
		North	North	North
		Center	Center	Center
		Alentejo	Alentejo	Alentejo
		Algarve	Algarve	Algarve
		Lisboa*	Lisboa	
		Greece	*Greece*	*Greece*
		Anatoliki Makedonia	Anatoliki Makedonia*	Anatoliki Makedonia
		Kentriki Makedonia	Kentriki Makedonia	Kentriki Makedonia
		Dytiki Makedonia	Dytiki Makedonia	Dytiki Makedonia
		Dytiki Ellada	Dytiki Ellada	Dytiki Ellada
		Thessalia	Thessalia	Thessalia
		Ipeiros	Ipeiros	Ipeiros
		Peloponnisos	Peloponnisos	Peloponnisos
			Sterea Ellada	Sterea Ellada
			Attiki*	Attiki
		Italy	*Italy*	*Italy*
		Basilicata	Basilicata	Basilicata
		Calabria	Calabria	Calabria
$I_i<0$		-	-	-

Note: * means that the value of the statistics is only significant at 10%

Table 5. Significant clusters in (log) GDP p.w.

		1981	1985	1992
$I_i>0$	$G_i>0$	*Netherlands* Groningen Drenthe	*Netherlands* Groningen Drenthe	*Italy* Liguria
	$G_i<0$	*Spain* Galicia Castilla-León Andalucia Extremadura Castilla-La Mancha *Portugal* Norte Centro Alentejo Algarve Lisboa *Italy* Basilicata*	*Spain* Galicia Castilla-León Andalucia Extremadura Castilla-La Mancha Asturias* *Portugal* Norte Centro Alentejo Algarve Lisboa	*Spain* Galicia Castilla-León Andalucia Extremadura *Portugal* Norte Centro Alentejo Algarve Lisboa *U.K.* Yorkshire y Humberside East Midlands North West Wales North*
$I_i<0$		-	-	-

Note: * means that the value of the statistics is only significant at 10%

Table 6. Significant clusters in the growth rates of GDP p.c. and GDP p.w. in the period 1981-1992

		GDP p.c. growth rates	GDP p.w. growth rates
$I_i>0$	$G_i>0$	*Germany* Unterfranken Dramstadt* Oberbayern* *U.K* Northern Ireland *Ireland* *Spain* Castilla-La Mancha Com. Valenciana Murcia*	*Spain* Castilla-La Mancha Castilla-León Extremadura Andalucía Galicia *Portugal* Norte Centro Alentejo Algarve Lisboa *Italy* Toscana Umbria Marche Lazio Abruzzo Molise Puglia Basilicata Calabria Campania Emilia-Romagna* Sicilia*
	$G_i<0$	*France* Picardie *Netherlands* Groningen Drenthe *Greece* Thessalia* Dytiki Ellada*	*Netherlands* Groningen Drenthe Friesland Oost-Nederland Utrech Noord-Holland Noord-Brabant Zuid-Holland Limburg *U.K.* North Yorkshire y Humberside East Midlands South East West Midlands North West Wales South West*
$I_i<0$		*Germany* Weser-Ems *Luxembourg* *Portugal* Lisboa Alentejo	-

Note: * means that the value of the statistics is only significant at 10%