Departamento de Economía
Facultad de Ciencias Económicas
Universidad Nacional de La Plata

Universidad Nacional de La Plata

Quintas Jornadas de Economía Monetaria e Internacional

La Plata, 11 y 12 de mayo de 2000

Space and Regional Convergence in Brazil

Mariano Bosch Mossi (Universidad Politécnica de Cartagena),
Patricio Aroca (Universidad Católica del Norte, Chile) y
J. Ismael Fernández (Universidad de Valencia)

Space and Regional Convergence in Brazil

*Mariano Bosch Mossi**

*Patricio Aroca***

*J. Ismael Fernández****

*	Universidad Politécnica de Cartagena
**	Universidad Católica del Norte (Chile)
***	Universitat de València, Instituto de Economía Internacional

What if economies interact with each other in subtle ways that one cannot have predicted, regardless of how much understanding one has obtained about how a single economy behaves in isolation

(Quah 1997b)

A brief introduction

Economies (regions, countries) do not behave in isolation. Instead they are, most of the time, part of a bigger economic entity formed by others economies. Countries, and regions within countries are economically linked. Trying to find an explanation of what is happening in a determined economy goes necessarily through clarifying what is undergoing in the economic units influencing it. Economies benefit from the good performance of their trading partners and suffer from their crisis. The investment in infrastructures and communication networks has a spillover effect beyond the geographical boundaries. Human capital investment of an economy may be influenced by a tradition of research and human capital accumulation in the surrounding units, and be deprived if an environment of poverty, crime and instability prevails. This paper attempts to comprehend the influence of the economic space in the process underlying regional economic growth and convergence.

A massive amount of time and effort has been devoted to investigate economic growth, nationally and regionally. It is not the objective of this paper to comprise years of growth research in a few lines[1]. However, little consensus has been achieved and competing theories are not able to give a unique explanation of the real world evolving growth paths. Neoclassical theory of growth (Solow 1956, Swan 1956, Barro and Sala i Martin 1995) is based on the assumption of diminishing returns to capital and the existence of a steady state equilibrium to which all economies approach. If economies share similar characteristics (production functions, depreciation rates, technological

[1] For excellent summaries of the different theories and empirical tools see Barro and Sala i Martin (1995) and Durlauf and Quah (1997a).

progress, political institutions and other factors) they will tend to a common steady state and a convergence process will take place. Economies closer to the steady state will grow slower than those further away (unconditional convergence). If economies differ, then, they will tend, not to a common, but to its own steady state determined by their characteristics (conditional convergence).

Endogenous growth theorists (Romer 1986 and Lucas 1988) have, on the contrary, ruled out the diminishing returns assumption invoking the presence of spillover effects on the process of factor accumulation. “Spillover effects maintain non-diminishing social returns on investment with the result that human and knowledge capital can fuel ceaseless economic growth.” Fingleton (1999). Thus, there are no forces taking the economies towards a hypothetical steady state. Convergence is no longer a natural conclusion.

Empirically, an important body of the economic literature has focused on contrasting the existence or non-existence of convergence to test whether neoclassical or endogenous growth theories fit the data. Measures like the standard deviation are used to check whether the dispersion of GDP per capita of the analysed sample diminishes or increases over time (sigma -convergence). Cross sectional regression of the growth rate of income or product per capita on the initial level of the variable has been, normally, applied to study whether poor economies have grown faster than the relative richer ones (beta -convergence). Additional variables on the right hand side of the cross-section regression to control for the different steady states (See Levine and Renelt 1992 and Sala i Martin 1997) and panel data analysis have been empirical extensions to this framework of study. Sala i Martin (1996) reaches the conclusion that with the appropriate conditioning variables a rate of convergence of 2% per year is obtained for a number of samples. An alternative approach has been developed by Bernard and

Durlauf (1995,1996), Durlauf (1989) and Quah (1992), based on the study of the long-term forecasts of per capita output through unit root and cointegration procedures to test convergence hypothesis. In this case convergence is defined as the equality of long-term forecasts taken at a given fixed date. Thus, given the information at date t, economies i and j show convergence if the limit of the expectation of the difference between their long-term forecasts tends to zero. Evidence against convergence, in this sense, is found by Quah (1992) for the US per capita output.

One of the main attacks to neoclassical test of beta and sigma -convergence has been undertaken by Quah (1993a, 1993b, 1996, 1997a, 1997b), who has highly criticised the use of the moments of the distribution and the representative economy, implied by Barro style regressions, for being uninformative of important features occurring in the studied economy. Distribution dynamics, mobility, persistence, polarisation and stratification are issues taken up by Quah's literature, which from his point of view are missed by the cross sectional approaches[2]. Twin peaks shape of the world economies distribution, where separate clusters of rich and poor economies emerge as a stylised fact and disappearing of the middle class economies are the main tendencies during the last decades for the world economies. Evidence of similar behaviour has been found to be present in the European Union (EU) and regions of the EU cohesion countries, Spain, Portugal and Greece.

The focus of Quah on the entire distribution of the values studied provides an econometrics benchmark to, partially, satisfy the incipient interest in intradistribution dynamics. Despite the virtually mountains of papers written, Quah (1997a) argues that the new empirical growth literature remains in its infancy.

[2] For deep treatment of these issues see Quah (1996, 1997a, 1997b).

The theory

Most of the growth empirical literature considers the studied economies in isolation, independently of their location and their links with other economic units. Despite the fact that theoretical mechanisms that are said to drive regional convergence as technological diffusion, factor mobility and transfers of payments have explicit geographical components, the role of spatial effects in the regional studies has been widely ignored (Rey and Montouri 1997). Therefore, as it has been argued, isolation is not the natural environment where an economic unit develops and grows.

A number of theoretical proposals support this idea: Krugman (1991), Puga (1998), Benabou (1993), Durlauf (1996) and Quah (1999). Krugman (1991) and Puga (1998) support the idea that manufacturing activities tend to locate in regions with larger demand which, at the same time, is determined by the spatial distribution of manufacturing. Under determined circumstances this may become a self-feeding process where the firms and workers migration to larger markets may lead to the emergence of a core-periphery pattern. In this situation most manufacturing industries may end up concentrated in a few regions, with the remaining regions playing a peripheral role as agricultural suppliers.

Benabou (1993) models the links between residential choice, education and productivity in a city composed of several communities. Local complementarities in human capital investment induce to occupational segregation. The model explains why there is a trend towards spatial segregation within a city in response to local externalities. The externality is based on the way education is formalised. Education is a local public good or club good. In each community the more agents invest in achieving high skills the easier is to do so. Local complementarities in education may operate through various channels. High-skilled workers, who earn higher salaries, are able to finance better schools for their youth. Adults serve as a role model to the youngsters who can see the benefits of becoming high-skilled workers. Therefore, high-skilled workers will move to areas where high-skill population is a majority. This process will lead to segregation, as low-skilled workers in a low-skilled area will find obstacles to invest in developing high-skills. Spatial location within a city influences, then, the ability of agents to invest in human capital, due to community spillovers. We can think of a country as a collection of cities within regions. Interregional migration in search of a better environment where human capital accumulation is easier can determine a context where regional clusters arise.

Durlauf (1996), on very similar grounds, describes the evolution of the distribution of income and the possible emergence of poverty in an economy in which education is locally financed and in which the empirical income distribution in a community affects the eventual occupational status of their offspring. Again, community spillovers in education is at the heart of the model.

Quah (1999) develops a model where economies produce jointly in coalitions and the factor accumulation of an economy is influenced by its relative position and relation to other economies. Stratification of economies into coalitions occurs.

From Theory to Empirics

Recently, several works have been developed to put forward the idea that the use of spatially located data, such as the GDP per capita of regions or nations, may generate a problem in estimating traditional econometric models to test convergence. Lopez-Bazo, Vaya, Mora and Surinach (LVMS, 1999) point out the evidence of spatial patterns in the traditional studies of European regional convergence. This patterns may be the result of the territorial location of productive factors, their mobility across adjacent regions, interregional trade flows and any interregional relationship. The strong links between regions within a country or regions of different countries may indicate that the economic fate of a specific region might not only depend on itself but also on the development of the regions connected to that region. Más, Maudos, Pérez (1995) show how Spanish regional output is explained, to some extent, by the public capital accumulation of the surrounding regions once taken into account private capital and labour contributions into the estimation of a regional production function. LVMS (1999) notice a high degree of spatial correlation of GDP per capita and per worker in the European Union using indicators of global and local spatial association (explained below). Similar results are reached by Rey and Montouri (1997) for the USA during the period 1930-1995. Fingleton (1999) proves that significant spatial dependence and heterogeneity is present in a sample of European regions. Evidence for convergence is weakened by taking into consideration these two elements. He argues that the vast majority of the studies which have, successfully, found evidence for convergence have failed to model for this and, therefore, the results may be misleading.

Quah (1996, 1997b) introduces explicitly the influence of space into the study of dynamics. Quah (1996) compares the influence of national-states and spatial-spillover factors on economic well-being across regions in Europe. The main results indicate that spatial effects matter more than macro effects. Quah (1997b) expands his conditional scheme and brings into the analysis not only who is next to who (spatial conditioning) but who trades with whom (trade conditioning). Quah argues that rich countries tend to trade with rich countries and so do poor countries.

Intriguing questions related to these issues remain unanswered. Evidence about the clustering of regions into high/low product areas seems clear, for a broad number of samples . However, although some theoretical explanations are available to address why regions cluster in space, causality remains as the main weakness of their empirical counterpart. Are clusters static or they appear and disappear over time? If they are static, do new regions add to the existing clusters? What are the implications of space and wealth clustering of the regions on their patterns of growth relative to other regions?. Do poor regions located in poor clusters find it more difficult to prosper than regions with access to a wealthier neighbourhood? What are the chances of leaving poverty trap situations?

The tools used to try to bring some light to these questions are, mainly, borrowed from two sources. Spatial concentration indexes and other utilities from spatial statistics tradition are implemented to quantify clustering. Quah's literature on intra-distribution dynamics is called , firstly to characterised the persistence or mobility within the sample and secondly, to establish whether the particular geographical location of a region explains its transitions towards higher or lower states of GDP per capita.

Data and sample

Brazil is the case of study. The regional GDP series from 1939 to 1998 are available from the Brazilian Central Bank. Years 1940 to 1946 are missing. Brazil is divided into 27 economic independent units. However, some adjustments have been necessary. Some Amazonian regions (Acre, Amazonas, Roraima and Rodonia), have been merged to form a unique region called Amazonia. Matto Grosso and Matto Grosso do Sul constitute a single region now. Amaná has joined Pará and Tocantins joined Goiás. Finally the Federal District was neglected in the study as it is an artificial structure. The basis for this adjustments may be found in previous studies of Brazilian regional economic growth (Azzoni).

Spatial statistics perspective

The spatial statistics literature has made available a number of methods and indicators to capture geographical interlinks (See Anselin 1988, 1995 and Griffitth 1996). Two main approaches can be taken to detect spatial dependence. The first approach stems from the need to derive a measure of overall spatial dependence of a determined variable within a set of spatially located units, like in our case the GDP per capita of a country . This is based on global statistics such as Moran I an Geary c[3].

Global Moran I

$$I = \frac{n}{S} \sum_i \sum_j w_{ij} z_i z_j / \sum_i z_i^2 \qquad (1)$$

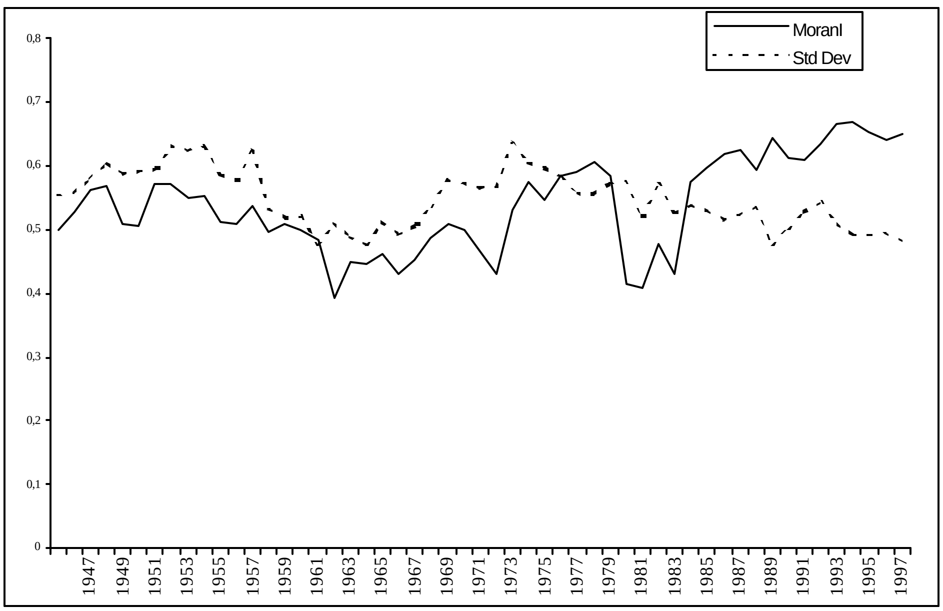
where n is the number of regions, w_{ij} are the elements of a binary contiguity matrix W(nxn), taking the value 1 if regions i and j share a common border and 0 if they do not, S is the sum of all the elements of W and the z_i and z_j vectors are the normalised log of GDP per capita of each region. The Moran I is distributed between 1 and -1. Values around 1 represent strong and positive (clustering of similar values) spatial dependence whereas values around -1 show negative spatial correlation (clustering of different values).

Figure 1 reports the evolution of Moran I versus the standard deviation of the GDP per capita of Brazilian regions. Several facts are worth mentioning. First of all, there is a strong evidence of a positive spatial dependence in the Brazilian regions. This means that the richer regions tend to be together as well as the poor regions. This situation appears to be quite stable with a light upward trend, especially at the end of the eighties.

[3] Only the Moran family statistics are reported in this paper as the Geary statistics have shown very similar results.

Secondly, a strong correlation between the spatial dependence index and the standard deviation of GDP per capita may be highlighted. Rey (1998) argues that this co-movement may reflect a dynamic characteristic of the regional clustering and two possible dynamics may explain this. On the one hand, an increase in the spatial dependence could be due to the regions in each cluster becoming more similar. On the other hand, an increase in the spatial dependence could also be due to newly formed clusters emerging during a period of increase income dispersion.

Figure 1: Global Moran statistic vs Standard Deviation of GDPpc of Brazilian Regions 1939-1998



The second approach consists of detecting local patterns of spatial association to explore further the spatial aspects of the data. In this context, it is important to know not only if the overall regional GDP of a country is concentrated , but also to identify in which specific regions that concentration is stronger and whether these regions concentrate high or low values of the variable analysed. Anselin (1995) points out that the degree of spatial association, as a result of the use of global statistics (like the global Moran and Geary statistics defined above), ignores the potential instability of local units of the overall sample. Only recently, new techniques have been suggested to treat this kind of instabilities. This techniques (see Getis and Ord 1992, Openshaw, Brundson and Chalton 1991, Openshaw, Cross and Charlton 1990 and Anselin 1993, 1995) try to recover the rich amount of information provided by these instabilities. We focus on the derivation of local indicators of spatial association (LISA) developed by Anselin (1995) and the interpretation of the Moran Scatterplot (Anselin 1993).

Following Anselin (1995) two properties of the LISA, which will condition its interpretation, may be described : a) the LISA for each observation gives an indication of the extent of significant spatial clustering of similar values around that observation, which means that the local indicator L_i should be such that it is possible to infer the statistical significance of the pattern of spatial association at location i; b) the sum of LISA's for all observations is proportional to a global indicator of spatial association. This two properties are expressed in equation (2):

$$\begin{aligned} &\Pr(L_i > \boldsymbol{d}_i) \leq \boldsymbol{a}_i \\ &\sum_i L_i = \boldsymbol{l}\Lambda \end{aligned} \qquad (2)$$

Where δ_i is a critical value and α_i is the significance level λ is the scale factor and Λ the global indicator of spatial association.

Local Moran and its correspondence to the global statistic are defined as follows:

Local Moran I

$$\begin{aligned} &I_u = \frac{n}{S} z_i \sum_i w_{ij} z_j \Big/ \sum_i z_i^{\,2} \\ &\boldsymbol{l} = S \end{aligned} \qquad (3)$$

A first interpretation of LISA as an indicator of local spatial clustering may be obtained using LISA as the basis for a test on the null hypothesis of no local spatial association. These local clusters may be identified as the observations for which LISA is significant, based on equation (2). However, LISA distributions are usually unknown. Anselin

(1995) suggests a method to generate an empirical distribution for LISA. This solution consists of the using conditional randomisation of the vector z_j. It is conditional in the sense that z_i remains fixed. The reasoning behind the randomisation procedure lies in the need to asses the statistical significance of the fact that a region is linked with its real neighbours . The generation of the distribution of region's i LISA is inferred by permutation of the neighbours that surround region i (obviously the region i is not used in the permutation). This empirical distribution provides the basis for a statement about the extremeness of the observed LISA. Those values of the empirical distribution that level $\alpha/2$ of probability on both sides of the derived distribution will set the border line to asses the significance of local statistics.

The second interpretation of LISA is the detection of local instability and outliers. Given that the local statistics keep a proportional relation to the global statistic, it is possible to find out which observation shows more relevant contribution to the global statistic. In our case, this represents the identification of regions whose GDP clustering is above its expectation under a space randomly distributed GDP per capita.

Even another tool is the Moran scatterplot which is the graphical complement of LISA to visualise local instability. It plots the values of Wz_j on z_i, where W is the row-standardised[4] first order contiguity matrix and z_i are the standardised values of the analysed variable. In the present context, we would plot the standardised log of per capita GDP of a region against its spatial lag (also standardised), which it is not other thing than the weighted average of the log of GDP per capita of its neighbours. The Moran scatterplot divides the space in four areas, which correspond, to the four types of possible local spatial association between a region and its neighbours. Quadrant I: high GDP per capita regions with high GDP per capita neighbours. Quadrant II: low GDP

[4] In the row standardised matrix the columns sum up to 1.

per capita regions surrounded by high GDP per capita neighbours. Quadrant III: low GDP per capita regions surrounded by low GDP per capita neighbours. Finally, quadrant IV: regions with high GDP per capita with low GDP per capita neighbours (Rey and Montouri 1997). The regions located in quadrants I and III represent the association of similar values (positive spatial correlation) whereas the quadrants II and IV show association of opposite values (negative spatial correlation). Proliferation of regions in quadrants I and III is expected in a scenario where rich and poor regions cluster separately, generating differentiated areas of high and low output. If regions were located randomly around the axis cross, occupying indifferently the four quadrants, no pattern of spatial dependence would arise. Nevertheless, still instabilities could be found for individual observations.

Figures 2 and 3 plot the Moran scatterplot for the first and the last year of the Brazilian sample (1939, 1998). The first phenomenon worth mentioning is the confirmation of the dominance of positive spatial association. In terms of the Moran scatterplot, this means that regions are mainly located in quadrants I and III, and this situation is exacerbated to the extreme in Figure 3 where all the regions are in quadrants I and III. The process of polarisation has followed a curious pattern. Take for instance the vertical axis formed by regions Minas Gerais, Espirito Santo, Pernambuco and Goiás (12,13,20,8) in Figure 2. This hypothetical line has rotated clockwise to leave regions 12 and 13 in the quadrant I and deepen region 8 into quadrant III. In other words, only regions that had rich environments were able to abandon an under average situation (in terms of GDP per capita) and reach an above average position. This is the case for regions 12 and 13. Apart from regions 12 and 13, only the region 2 has changed quadrant moving from I to III, this transmits the idea that the situation appears to be permanent over time. We will develop the topic of persistency and mobility latter on.

Figure 2: Moran Scatterplot for Brazilian regions 1939

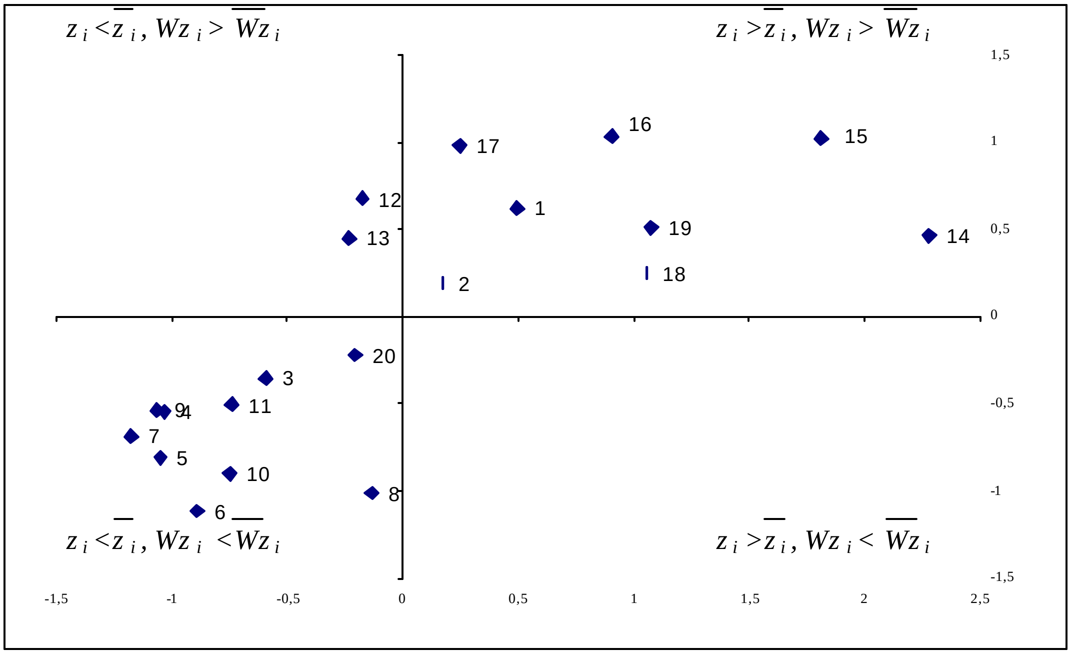


Figure 3: Moran Scatterplot for Brazilian regions 1998

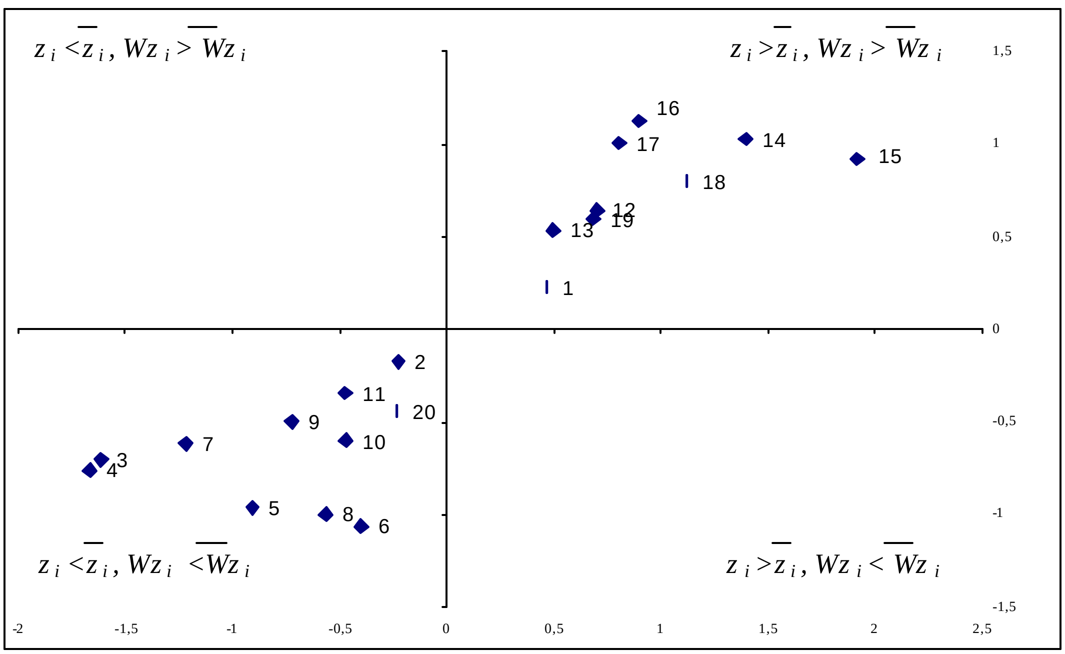
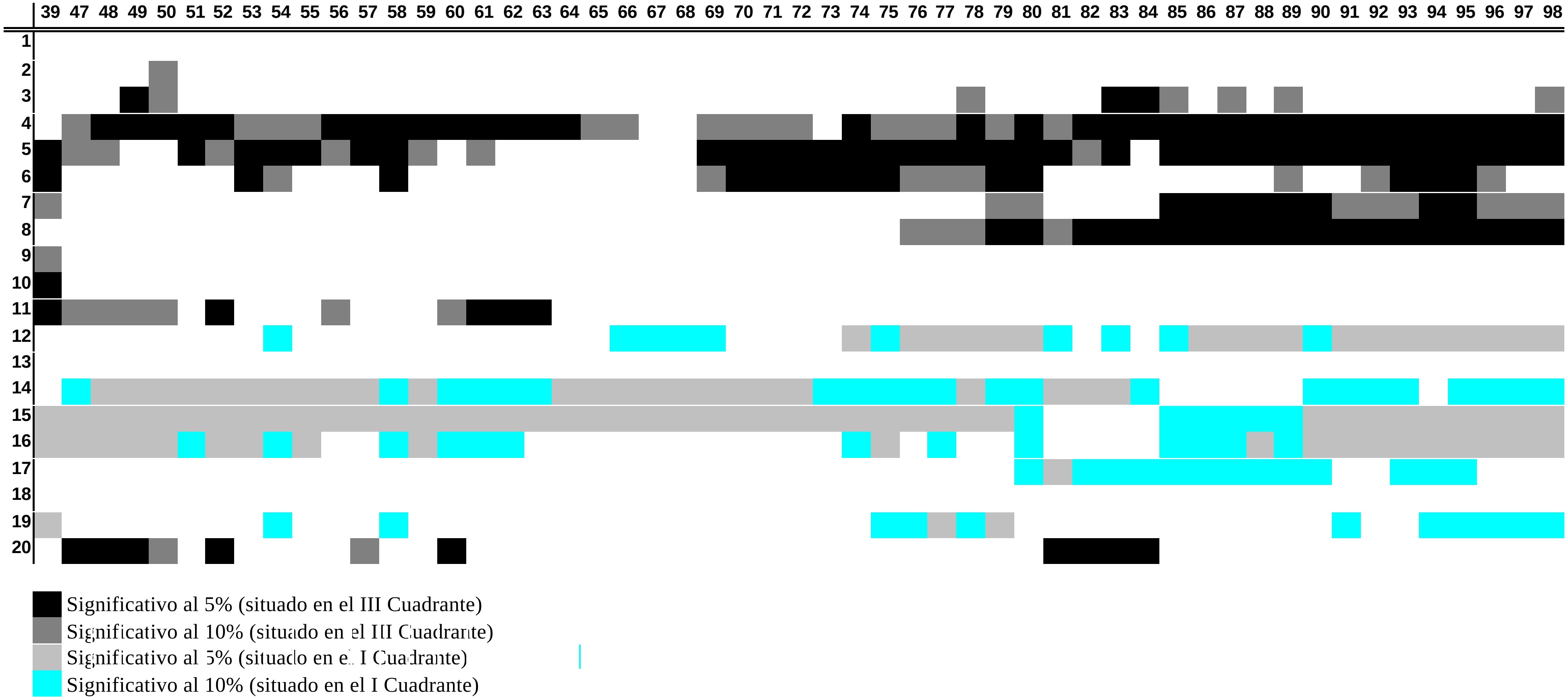


Figure 4 reports the results of the conditional randomisation approach. It plots the regions local Moran statistics, the situation of the region in the Moran Scatterplot and its significance over time. Two relevant aspects are pointed out in Figure 4. First of all, the significant observations are concentrated in quadrants I and III, both types of positive association. This is the natural reflection of the previously found pattern of global positive association. Secondly, the two important clusters are revealed to be significant for most of the years, what exhibits their persistence throughout the period. In the north east, Piaui, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Bahia and Goiás (4,5,6,7,8,11,20) seem to constitute the low product cluster, whereas in the south east Rio de Janeiro, Sao Paulo, Paraná, Minas Gerais (14,15,16,12) are the high product cluster. At the same time, the previously mentioned story about regions 8 and 12 can be verified. Region 8 originally stays unclustered up to 1976 in which clusters in the low product area and remains clustered until the end of the period. A similar behaviour is developed by region 12 in the high product area. Therefore, some evidence of spatial influence is found.

We can, therefore, suggest that the tendency towards stability (with a light upward trend) of the global indicator for spatial association is due, mainly, to the strengthening of these two regional clusters. These clusters have been able to attract to their influence peripheral regions that were, at the beginning of the sample, unclustered.

Figure 4:Local Moran Statistic significance for Brazilian regions 1939-1998



Dynamics

Unconditional dynamics

The implementation of the spatial statistics tools has allowed us the identification of global and local patterns of spatial association in a regional growth economy model. Observing the composition of the clusters for different static points of time one could get an idea of the evolution of the cluster composition and their strength over time. However, it would enrich the analysis to know whether regional clustering has influenced output dynamics. Quah (1993a) develops the analytical framework to deal with transitional dynamics.

Following Quah's framework (1993a) , let F_t denote the distribution of GDP per capita across regions at time t. We can define the law of motion

$$F_{t+1} = M^* F_t \tag{4}$$

where M maps one distribution into another, and consequently contains information of the flow from F_t , to F_{t+1}. The element M quantifies the mobility or persistency from one period to another. Equation (17) is similar to a standard first-order autoregression, except its values are distributions, and it does not contain explicit disturbance or innovation, which for simplicity is set to zero. An additional useful consideration of the model is that once characterised the transition M and assuming it is time invariant, a predictor for future cross section distribution may be obtained from:

$$F_{t+s} = (M^*M^*M^*\ldots M)^* F_t = M^s F_t \tag{5}$$

Taking s to the limit, one can define the probably long term distribution of the GDP per capita. In this respect, a convergence process would generate a F_{t+s} distribution tending towards a point of mass whereas a trend towards dispersion or a bimodal distribution would represent divergence. An easy and common way to approach the model is to discretise the distribution F_t into a set of possible values of GDP per capita relative to the country's mean. In this case F_{t+1} can be represented by probability vectors. An arbitrary number of n possible states may be defined. The derivation of matrix M is now straight forward as we can compute which regions transit from one interval to another. The division in n states of nature returns us a Markov chain nxn matrix where element (j,k) entry is the probability for the region in state j to transit to state k. The main diagonal of this matrix denotes persistence, as it picks up the probability for a region of remaining in its original state after the transition period.

The so-called Ergodic vector representing the F_{t+s} distribution when s tend to infinity could be retrieved by doing M^s (i.e.s=1000), which converges to a rank-one transition probability matrix. Then, all its rows must be equal, and moreover equal to that probability vector satisfying:

$$F_{\infty} = M' F_{\infty} \tag{6}$$

There are two important issues here. Firstly, there is no rule of thumb to set the intervals. Quah (1997b) suggests that the selection of these intervals is made in a way that the n states hold similar number pairs of observation-years in each row and this would return the so called uniformly defined matrix. We have followed this approach and five states have been defined relative to the average GDP of the sample. Regions with GDP less than 54% of the average, regions between 54% and 70%, regions between 70% and 92%, regions between 92% and 135% and regions with 135% or higher. One must keep in mind that this procedure is, again, entirely arbitrary and no reasoning assures its goodness. The second issue at stake is the transition period chosen to jump from one state to another. Logically the shorter this period is, the smaller the chance for a region to transit from one interval to another, and therefore higher persistency the matrix will return.

Table 1 shows the transitional dynamics for the Brazilian regions. A ten year transition period has been taken to generate the matrix . Some results may be highlighted. First of all, persistence seem to be highest in the extremes (states one and five). This means that regions with GDP per capita distanced from the mean find it difficult to abandon this situation, foremost in state five where 88% is the probability to remain in the club of the rich regions. Secondly, a greater mobility is found in the middle of the distribution. Most of the transitions are concentrated in the states two, three, and four, which are those around the average. Around 35% of the regions in state two manage to ascend to the third state in a ten year time period whereas 14% are dropped into the first state. Dynamics in state three are similar. Despite there is still a high degree of persistency (almost 52% of the regions do not transit in a ten years time period) the other half of the sample move towards higher or lower states (30% descent to lower levels and 18% ascend). In state four persistence is around 69% and it does not seem to be a special pattern of attraction upwards or downwards in the distribution.

Moreover, the Ergodic vector describes the future distribution of the regions in a far away future. An optimistic message is returned by this vector. Although, some stratification is taking place, there is a bias towards the upper end of the distribution, which is good news for under-average regions.

Conditional dynamics.

The introduction of space dependence as a factor determining output dynamics has been attempted by Quah (1996) through a conditioning scheme of the transition probability matrix. A series of output relative to the neighbours output is constructed for every economy. This is the conditioning series. Now, the matrix is constructed with the pre- and post- conditioned values. If the conditional series had no explanatory power at all, one should expect that poor regions were poor relative to its surroundings and the rich were richer than their nearby regions. Then, and identity matrix would emerge. However, if poor regions shared border with similar poor regions their relative output would not depart from the average of the cluster. Mass of probabilities concentrated around the mean state represent this situation. This similar scheme may be applied to other conditioning variables

Table 1: Unconditional Dynamics: Ten years transition period.

Number	**Upper Endpoint:**				
	0.54	**0.70**	**0.92**	**1.35**	**¥**
(167)	0.75	0.18	0.05	0.02	
(170)	0.14	0.47	0.35	0.05	
(170)	0.04	0.26	0.52	0.16	0.02
(166)	0.02	0.02	0.11	0.69	0.15
(167)				0.12	0.88
Ergodic	**0.12**	**0.13**	**0.17**	**0.25**	**0.33**

Nevertheless, the information contained in this matrix is very similar to what the spatial statistics perspective may reveal. But this sort of analysis does not allow us to answer questions like why regions within the same state (similar GDP per capita) move in opposite directions? What did it make some regions to climb positions towards higher output status whereas others were dragged to the bottom step of the ladder? In order to investigate these questions we have redefined the transition matrix to capture the influence of the geographical environment in dynamics. We are interested in studying the states separately and see how the belonging in a determined cluster lag conditions its growth path. We take the region-years pairs of an specific n state (n=1,2...5) and sort them out in different intervals as before, but this time in reference to its spatial lag relative to the mean. We can construct, then, n lxk Markov chain matrices where entry (l,k) of the matrix n is the probability of a region, initially located in state n, with a spatial lag l to transit to state of income k. Consequently, we will have n matrices (as many as GDP states defined), each matrix with l rows (as many as spatial lag intervals defined) and k columns (as many as GDP states to transit). The n column of matrix n will represent persistence. The appearance of non-zero entries in a contra-clockwise turn from the vertical axis formed by the n column denotes the power of attraction of the poles (the richest and the poorest sets of regions). Actually, what we are doing is defining nxl states instead of only n. Regions are now classified not only because they have got a level of GDP per capita but also accounting for their relative influence of the regional neighbours. The destination states of transition are kept to be k. This sort of conditioning captures the capacity that geographically located economic units have to drag their neighbours towards well-being or poverty.

Evidence in states one and five shows persistence as the key feature, but at the same time some degree of mobility is present in regions around the average. Our intuition was that some regions found it easier to increase their GDP to higher states of GDP per capita if they were spatially located in a high product environment and vice-versa. In the terms of the present model we should expect that regions surrounded by regions with high GDP per capita were more likely to transit to higher states than regions clustered in low product scenarios.

Tables 2 and 6 show movements in the extremes states of the sample (state one and five). As before, strong persistence is the main feature and the spatial lag of the regions do not seem to establish differentiated transitional behaviour. This is coherent with previous findings.

A very different picture is drawn when we look at tables 3, 4 and 5. These tables focus on states two, three and four. Transitions in these states are highly determined by the spatial lag of the regions. Let’s see, for instance, the dynamics in table 3 where state two is represented. Column two, in this case implies persistency. Only 27 % of the regions that initially started in state two and additionally, had a spatial lag above 0.75 of the mean (the higher of this group) remain in that state, 56% succeeded in transiting to state three and 9% to state four after a ten year period. As we move up in the rows and the regional spatial lag decreases we detect smaller chances to improve one region's initial situation.

Table 4 reports the results for state three. There is an optimistic view for those regions with high spatial lags as they stand a great chance of going ahead to states four, 49%, and even to state five, 11%. Moreover, they are less likely to move downwards to state two, only 8%, than regions with similar GDP but lower spatial lag. Lower relatives spatial lags return higher probabilities of descending rank.

Finally, the message of state four matrix is broadly the same. Regions with wealthier surroundings tend to behave better, in the sense, that they stand more chances to move upwards than downwards in the transition matrix.

Table 2: Conditional Dynamics: State 1 [0-0.54]. Ten years transition period.

Number		**Upper Endpoint:**				
Spatial Lag		**0.54**	**0.70**	**0.92**	**1.35**	**¥**
(45)	**0.54**	0.51	0.36	0.11	0.02	
(45)	**0.61**	0.89	0.11			
(37)	**0.65**	0.86	0.11	0.03		
(40)	**¥**	0.75	0.12	0.05	0.08	

Table 3: Conditional Dynamics: State 2 [0.54-0.70]. Ten years transition period.

Number		**Upper Endpoint:**				
Spatial Lag		**0.54**	**0.70**	**0.92**	**1.35**	**¥**
(41)	**0.63**	0.12	0.51	0.34	0.03	
(40)	**0.69**	0.17	0.65	0.15	0.03	
(45)	**0.75**	0.16	0.47	0.33	0.04	
(44)	**¥**	0.09	0.27	0.55	0.09	

Table 4: Conditional Dynamics: State 3 [0.70-0.92]. Ten years transition period.

Number		**Upper Endpoint:**				
Spatial Lag		**0.54**	**0.70**	**0.92**	**1.35**	**¥**
(44)	**0.62**		0.34	0.64	0.02	
(47)	**0.77**	0.13	0.34	0.45	0.08	
(42)	**0.94**		0.26	0.64	0.10	
(37)	**¥**		0.08	0.32	0.49	0.11

Table 5: Conditional Dynamics: State 4 [0.92-1.35]. Ten years transition period.

Number		Upper Endpoint:				
Spatial Lag		**0.54**	**0.70**	**0.92**	**1.35**	**¥**
(39)	**1.30**	0.03	0.08	0.25	0.59	0.05
(42)	**1.45**	0.07	0.02	0.07	0.72	0.12
(45)	**1.57**			0.11	0.73	0.16
(40)	**¥**			0.02	0.73	0.25

Table 6: Conditional Dynamics: State 5 [1.35-∞]. Ten years transition period.

Number		Upper Endpoint:				
Spatial Lag		**0.54**	**0.70**	**0.92**	**1.35**	**¥**
(44)	**1.4**				0.16	0.84
(47)	**1.55**				0.07	0.93
(42)	**1.65**				0.03	0.97
(37)	**¥**				0.11	0.79

Conclusions

Strong evidence of spatial clustering in Brazil has been found. Two clusters, a low-product one in the Northeast and a high-product one in the Southeast have been revealed. These clusters seem to have become stronger over time and regions initially unclustered have, slowly, joined the existing clusters.

We have also proved that the growth paths of the Brazilian regions have been, partially, determined by their environment. Those regions with wealthier neighbours had better chances to prosper.

It seems feasible that spatial connection may help regional interaction, however, the way in which capital accumulation influences interlinked regions may work differently. Interindustrial links, migration, trade flows, human capital exchange may be the channels that make space important. The researchers are most interested in transitional dynamics and how these links determine the region's path towards a better or worse state. The microeconomic nature and effects of coalition formation and spatial spillovers need to be further explored.

Bibliography

Anselin, L. (1988), "Spatial Econometrics: Methods and Models". Kluwer. Dordrecht.

Anselin, L. (1993), "The Moran Scatterplot as and ESDA tool to assess local instability in spatial association", GISDATA Specialist Meeting on GIS and Spatial Analysis, Amsterdam.

Anselin, L.(1995), "Local Indicators of spatial association-LISA", Geographical Analysis, 27. 93-115.

Azzoni, M (1995), "Convergence in the Brazilian Regions". PhD Thesis, Universidad Pontificia de Rio de Janeiro.

Barro, Robert J. and Sala i Martin, Xabier. (1995), Economic Growth , McGraw-Hill.

Benabou, Ronald. (1993), "Workings of a City: Location, Education, and Production", Quarterly Journal of Economics, 108(3):619-52, August.

Bernard, Andrew B. and Durlauf, Steven N. (1995), "Convergence in International Output", Journal of Applied Econometrics, 10(2), 97-108, April.

Bernard, Andrew B. and Durlauf, Steven N. (1996), "Interpreting Test of the Convergence Hypothesis", Journal of Econometris, 71(1-2), 161-174.

Desdoigts, Alain. (1994), "Changes in the World Income Distribution: A non Parametric Approach to Challenge the Neoclassical Convergence Argument". PhD thesis, European University Insitute, Florence, June.

Durlauf, Steven N. and Quah, Danny, T. (1998), "The New Empirics of Economic Growth", Centre for Economic Performance Discussion Paper 384. December.

Durlauf, Steven N. (1996), "A Theory of Persistent Income Inequality", Journal of Economic Growth, 1(1), 75-93, March.

Fingleton, Bernard. (1999), "Estimates of Time to Economic Convergence: An Analysis of Regions of the European Union", International Regional Science Review , 22(1),5-34. April.

Getis, A. and K. Ord (1992). "The Analysis of Spatial Association by Use of Distance Statistics" ,Geographical Analysis. 24, 189-206.

Griffith (1996) "Spatial Statistics"

Krugman, Paul. (1991), "Increasing Returns and Economic Geography". Journal of Polical Economy

Lamo, Ana R(1996). "Cross-Section Distribution Dynamics". PhD thesis, LSE, February.

Levine, Ross and Renelt, David. (1992), "A Sensitivity Analysis of Cross-Country Growth Regressions", American Economic Review, 82(4), 942-963, September.

Lopez-Bazo, Enrique, Vayà, Esther, Mora, Antonio J. and Suriñach, Jordi. (1999). "Regional economic dynamics and convergence in the European Union", Annals of Regional Science, 33, 343-370.

Lucas Jr. Robert E. (1988), "On the Mechanics of Economic Development", Journal of Monetary Economics, 22(3), 3-42, June.

Mas, M., Maudos, J., Perez, F.(1995), "Infrastructures and Productivity in the Spanish Regions".

Openshaw, S., Brundson C. and Charlton M. (1991), "A Spatial Analysis Toolkit for GIS", EGIS'91 Proceedings of the Second European Conference on Geographical Information Systems, 788-96. Utrecht. EGIS Foundation.

Openshaw, S., Cross A. and Charlton M. (1990), "Building a Prototype Geographical Correlates Exploration Machine", International Journal of Geographical Information Systems, 4, 297-311.

Puga, Diego (1998), “Rising and Fall of Regional Inequalieties”, European Economic Review 43(2), February 1999: 303-334

Quah, Danny T. (1992), "International Patterns of Growth: I. Persitence in Cross-Country Disparities", Working paper, LSE, London. October.

Quah, Danny T. (1993a), "Empirical cross-section dynamics in economic growth. European Economic Review 37; 427-443.

Quah, Danny T. (1993b), "Galton's fallacy and test of the convergence hypothesis" The Scandinavian Journal of Economics, 95(4), 427-443, December.

Quah, Danny T. (1996), "Regional convergence clusters across Europe", European Economic Review 40(3-5), 1951-1958, April.

Quah, Danny T. (1997b), "Regional Cohesion from local isolated actions I. Historical outcomes", Centre for Economic Performance Discussion Paper 378. December.

Quah, Danny T. (1997a),"Empirics for growth and distribution: Stratification, polarization and convergence clubs". Journal of Economic Growth, 2(1), 27-59, March.

Quah, Danny, T. (1999), "Ideas determining convergence clubs", Working Paper (Incomplete Version).

Rey, Sergio J. and Montouri Brett D. (1997), "US Regional Income Convergence: A Spatial Econometric Perspective". Regional Studies, 33(2), 143-156.

Romer, Paul M. (1986), "Increasing Returns and Long-run Growth", Journal of Political Economy, 94(5), 1002-1037, October.

Sala i Martin, Xabier. (1996), "Regional Cohesion: Evidence and Theories of Regional Growth and Convergence", European Economic Review, 40(6), 1325-1352, June.

Sala i Martin, Xabier. (1997), "I just Ran Two Million Regressions", American Economic Association Papers and Proceedings, 87(2):178-183, May.

Solow, Robert M. (1956), "A contribution to the Therory of Economic Growth", Quarterly Journal of Economics, 70(1), 65-94, February.

Swan, Trevor W. (1956), "Economic Growth and Capital Accumulation", Economic Record, 32, 334-361. November.