Brazilian Interregional Trade (1985-1996): An Exploratory Spatial Data Analysis[1]

ABSTRACT

The aim of this paper is to explore the spatial distribution of the interregional trade among the 27 Brazilian states for the years 1985-1996. To implement this methodology we use, as a dataset, the exports and imports flows of the Brazilian interregional input-output matrix. Based on a set of tools of spatial analysis its possible to detect the presence of global and local spatial autocorrelation in the distribution of trade and its components. The results of LISA statistics enable us to observe the presence of spatial heterogeneity in the interregional trade during the period of analysis. This paper concludes that, the detection of spatial clusters of high and low interregional trade throughout the period is an indication of the persistence of spatial disparities among the Brazilian states.

Key words: Exploratory spatial analysis, spatial autocorrelation, spatial heterogeneity and Brazilian economy

JEL classification: O18, O54, R11, R12.

1. Introduction

To better characterize the structure of Brazilian interstate trade, this section briefly characterizes the Brazilian interstate trade. According to Haddad and Perobelli (2002), the analysis of the interstate exports coefficient and the international exports coefficient, for the Brazilian states, in 1997, shows that, for every Brazilian state, the interstate exports are greater than the international exports. It is important to highlight that these differences vary in intensity among the states. The authors also showed that, for the majority of the small Brazilian states, the interstate flows are more important, in relative terms, than the international ones.

Based on the total trade between the Brazilian states, we constructed the Lorenz curve to verify if the trade is concentrated and if the pattern of concentration changes through the period. If there were a perfect distribution of trade between the Brazilian states the curves would have an inclination of 45 degree. The curves are distant from the 45 line so we can affirm that the distribution is unequal. The analysis of Figure 1 shows that the Brazilian interstate trade does not present changes in the period 1985-1996, meaning that the structure of trade presents a certain degree of stability. For both years there is a high degree of concentration. We can observe, for the year 1996, that seven states are responsible for 75% of the total Brazilian interstate trade.

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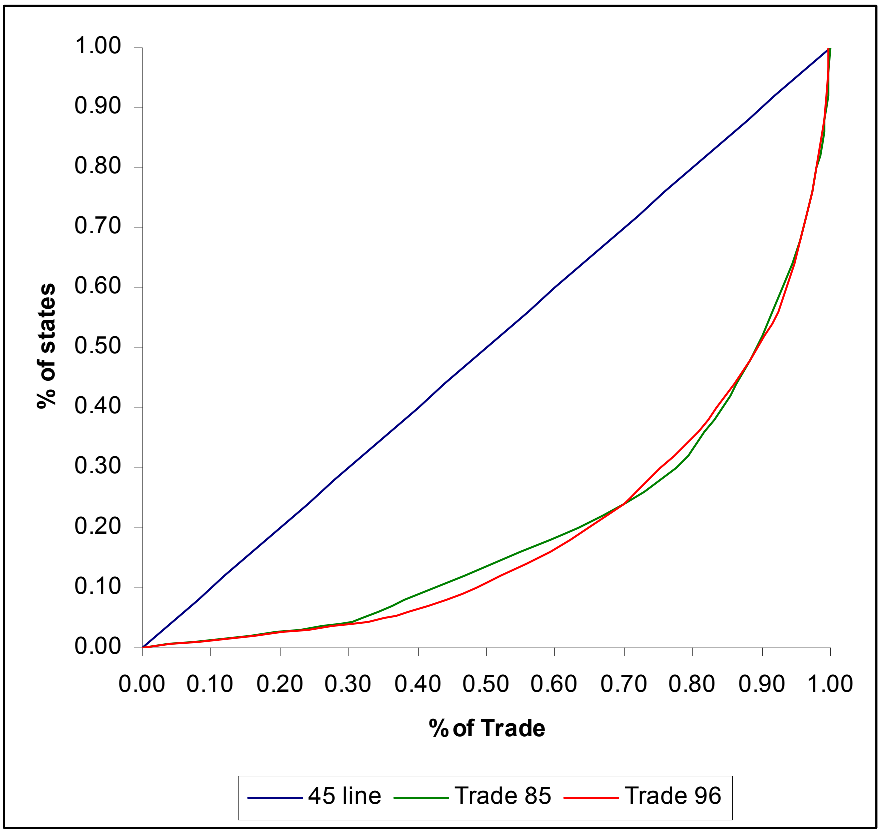
Figure 1 – Lorenz curve for the Brazilian Trade (1985 and 1996)



Source: Elaborated by the authors

Table 1. Distribution of Total Trade between the Brazilian states (1985 and 1996)
(%)

	N	*NE*	*SE*	*S*	*CO*	*Exports*
			1985			
N	0.25	0.19	1.44	0.16	0.04	2.08
NE	0.31	2.61	3.02	0.40	0.12	6.45
SE	1.83	5.33	9.56	6.69	3.52	26.93
S	0.30	0.92	6.52	3.54	0.69	11.96
CO	0.05	0.14	1.31	0.65	0.42	2.57
Imports	2.73	9.18	21.86	11.44	4.79	100.00
			1996			
N	0.02	0.26	1.66	0.19	0.10	2.23
NE	0.22	2.05	1.46	0.28	0.11	4.12
SE	1.98	4.53	14.54	5.45	4.65	31.16
S	0.38	0.94	4.78	2.61	1.09	9.80
CO	0.21	0.13	1.19	0.46	0.68	2.68
Imports	2.82	7.91	23.64	8.99	6.63	100.00

Source: Based on the Brazilian interstate matrix

Table 1 presents the distribution of Brazilian trade between the macro regions[2]. We can observe that: a) Southeast region increases its share in total trade in the period of around 6%, b) the intra-regional trade in

[2] The complete list of Brazilian macro regions and Brazilian states are presented in the Appendix.

the Southeast also increases and c) the flows between the other four region and Southeast region are bigger than the intra-regional trade for those regions in both years. Those results enable us to conclude that there is a degree of concentration in the Brazilian inter-regional trade.

The role played by the inter-regional interactions, as demonstrated in Perobelli and Haddad (2003), helps to comprehend how the state economies are affected by instabilities or modifications in international market as well as in regional market. This aspect is very important because for the smallest economies the performance of the most developed economies plays a very crucial role[3]. Also, for some Brazilian states the possibility of growth is not related to the international market, but with the domestic market.

The results presented above leads to more detailed discussion about the spatial disparities among the Brazilian states in terms of trade. To do this we will implement an Exploratory Spatial Data Analysis (ESDA). In other words, the ESDA framework will enables us to verify the spatial interaction among the Brazilian states by identifying the existence of spatial auto-correlation, spatial heterogeneity and clusters of trade (*e.g.* high intensity of imports and exports). We will try to incorporate the locational problem in the discussion about trade to analyze the economic performance of the regions.

The locational problem enables us to deal with two different spatial effects, they are: spatial dependence and spatial heterogeneity. First the spatial dependence is directly connected to the first geography law. The first geography law (Tobler, 1979), that affirms that, "*everything is related to everything else, but near things are more related than distant things*". Based on that law it is possible to affirm that the observations will be spatially agglomerated, which means that there will be clusters. In other words, the geographic data will not be independently located. It is important to highlight that under the geographic perspective the spatial dependence is a rule[4]. Second the idea of spatial heterogeneity is linked with the idea of instability of the economic behavior across the space in this study. In other words, it is linked to the spatial or regional differentiation, which means that there is some particular characteristics in each region. The definition of spatial regimes using dummy variables, functional forms and model coefficients can be highlighted through the spatial heterogeneity (or non stationarity) idea.

This work is organized as follows. In the second section, there is a brief review of the methodology. The third section presents the empirical results for the Brazilian economy, in the fourth section the robustness of the results is investigated and in the fifth section some conclusions are made.

2. Methodology

The ESDA framework is based on the spatial aspects of the database, which means that it deals directly with the idea of spatial dependence (*e.g* spatial association) and spatial heterogeneity. The objective of this method is describe the spatial distribution, the patterns of spatial association (spatial clusters), verify the existence of different spatial regimes or other forms of spatial instability (non stationarity) and identify atypical observations (*e.g. outliers*). It is possible to extract measures of spatial auto-correlation and local auto-correlation from these methods (Anselin, 1998).

Before presenting the measures of autocorrelation two important concepts are presented to develop the ESDA. First, spatial auto-correlation, which means that similar locations (*e.g.* observations that present a certain degree of spatial proximity) will coincide with the similarity value (correlation). Thus, there is positive spatial autocorrelation when high or low values of a specific variable form a cluster in the space

[3] The detailed discussion about the *"feedbacks"* between the Brazilian states was presented in the first chapter of Perobelli's doctoral thesis. In this paper we will only implement a detailed analysis of the aggregate flows of interstate trade.

[4] It is important to highlight that this rule is a contradiction in relation to the classical assumption of statistics that is the interdependence of the observations.

and there will be negative spatial autocorrelation when the neighborhood of certain geographic areas presents diverse values. Second spatial heterogeneity means that the economic behavior is not stable in the space and thus, it is possible to have diverse spatial patterns of economic development. The results can present spatial regimes such as, a cluster of developed regions – core or a cluster of less developed regions – periphery (Ertur and Le Gallo, 2003).

2.1 Global Spatial Autocorrelation

The global spatial autocorrelation can be calculated by the Moran's I statistic. This statistic gives the formal indication of the degree of linear associations between the vector of observed values at time t (z_t) and the weighted average of the neighborhood values, or the spatial lags (Wz_t). I values greater (or smaller) than the expected value $E(I) = -1/(n-1)$ means that there is positive autocorrelation (or negative). Following Cliff and Ord (1981), in formal terms, the Moran's I statistic can be expressed as follows:

$$I_t = \left(\frac{n}{S_o}\right)\left(\frac{z_t^{'}Wz_t}{z_t^{'}z_t}\right) \quad t = 1,\ldots n \tag{1}$$

where z_t is the vector of n observations for year t in deviation from the mean. W is the spatial weight matrix: the elements w_{ii} on the diagonal are set to zero whereas the elements w_{ij} indicate the way the region i is spatially connected to the region j. So is a scaling factor equal to the sum of all the elements of W.

When the spatial weight matrix is normalized in the row, in other words when the elements of each row sum 1, the expression in (1) will be:

$$I_t = \left(\frac{z_t^{'}Wz_t}{z_t^{'}z_t}\right) \quad t = 1,\ldots n \tag{2}$$

It is important to highlight that the Moran's I statistic is a global measure thus it is impossible to observe the structure of spatial correlation at regional level.

2.2 Local Spatial Autocorrelation

To observe if there is a local spatial cluster of high or low values and which are the regions that contribute the most to the spatial autocorrelation, we have to implement the measures of local spatial autocorrelation as Moran Scatterplot, G statistics and the Local Indicators of Spatial Association (LISA).

2.2.1 Moran Scatterplot

According to Anselin (1996), the Moran Scatterplot is a way to interpret the Moran's I statistic, in other words it is a representation of the regression coefficient and it enable us to visualize the linear correlation between z and Wz using a scatterplot of two variables. In the specific case of Moran's I statistic we have the scatterplot of *Wz* against *z*. Thus, the Moran's I coefficient will be the slope of the regression curve (*e.g.* scatterplot) and this slope indicates the degree of adjustment.

The Moran Scatterplot is divided into four quadrants. These quadrants correspond to the four patterns of local spatial association between the regions and its neighbors.
The first quadrant (located at the upper right corner) named high-high (HH) shows the regions that present high values for the variable in analysis (i.e. values above the mean) surrounded by regions that also present values above the mean for the variable in analysis.
The second quadrant (located at the upper left corner) classified as low-high (LH) displays the regions with low values but surrounded by neighbors that presents high values.
The third quadrant (located at the bottom left corner) is called low-low (LL) and presents the regions with low values to the variable in analysis surrounded by neighbors that also presents low values.
The fourth quadrant (located at the bottom right corner) called high-low (HL) displays regions with high values for the variable in analysis surrounded by regions with low values.
The regions those are located at quadrants HH and LL present positive spatial autocorrelation, meaning that these regions forms clusters of similar values. On the other hand, the quadrants HL and LH present negative spatial autocorrelation meaning that these regions form clusters of dissimilar values.

2.2.2 Local Indicators of Spatial Association (LISA)

According to Anselin (1995) a Local Indicator of Spatial Association (LISA) will be any statistic that satisfy two criterions: a) a LISA indicator has to give, for each observation, an indication of significant spatial clusters of similar values around the observation (*e.g.* region) and b) the sum of LISAs for every regions is proportional to the indicator of global spatial autocorrelation.

According to Le Gallo and Ertur (2003) the LISA statistic can be specified as follows:

$$I_{i,t} = \frac{\left(x_{i,t} - \mu_t\right)}{m_o} \sum_j w_{ij}\left(x_{j,t} - \mu_t\right) \quad com\ m_o = \frac{\left(x_{i,t} - \mu_t\right)^2}{n} \tag{3}$$

where $x_{i,t}$ is the observation in the region *i* for the year *t*, μ_t is the mean of observations across the regions in the year *t* and where the summation over *j* is such that only the neighbors values of *j* are included.

The statistic can be interpreted as follows: positive values of $I_{i,t}$ means that there is a spatial cluster of similar values (high and low); negative values means that there is spatial clusters of dissimilar values between the regions and its neighbors.

According to Anselin (1995), we can use the LISA statistic in order to measure the null hypothesis of no local spatial association. It is important to highlight that the general results on the distribution of a generic LISA may be hard to obtain, as it is the derivation of distributions for global statistics. In order to deal with this problem we have to work with the asymptotic results that are available. Thus, the alternative is the use of conditional randomization or permutation approach to yield empirical so-called pseudo significance levels. So, the significance levels of the marginal distributions will be approximated by Bonferroni inequalities or by the approach suggested in Sidák (1967) *apud in* Anselin (1995). *"This means that when the overall significance associated with the multiple comparisons (correlated tests) is set to* α*, and there are m comparisons, then the individual significance* α_i *should be set to either*

α / m *(Bonferroni) or* $1-(1-\alpha)^{1/m}$ *(Sidák)"* (Anselin, 1995 pp. 96). In this paper we will use the Bonferroni's approach.

2.2.3 Determination of the spatial weight matrix

The weight matrix is the way to express the spatial arrangement (*e.g* contiguity) of the data and is also the starting point for any statistical test or model. There is a wide range of weight matrices in the literature. It is possible to implement an ESDA based on a simple binary contiguity matrix or on a more complex structure. The spatial weight matrix *W* used in this work is based on the *k*-nearest neighbors calculated from the great circle distance between region centroids. The choice of the weight matrix is very important in an ESDA analysis because all subsequent steps (or results) will be based on this selection[5].
The form of the spatial weight matrix is the following:

$$\begin{cases} w_{ij}(k) = 0 \;\; if \;\; i = j \\ w_{ij}(k) = 1 \; if \, d_{ij} \leq D_i(k) \;\; and \;\; w^*_{ij}(k) = w_{ij}(k) / \sum_j w_{ij}(k) \;\; for \;\; k = 3,4,5 \\ w_{ij}(k) = 0 \; if \, d_{ij} > D_i(k) \end{cases} \tag{4}$$

where d_{ij} is the great circle distance between centroids of region *i* and *j*. $D_i(k)$ is the critical cut-off distance for each region *I*, above which interactions are assumed negligible.

According to Le Gallo and Ertur (2003) the choice of a fixed number of nearest neighbors instead of the use of a simple contiguity matrix is better because it is possible to avoid certain methodological problems that may appear when the number of neighbors is allowed to vary.

3. Empirical Results[6]

The database of Brazilian interregional trade is for the years 1985 and 1996. The flows are related to the interregional input-output table for the Brazilian economy to the period specified before. It is important to emphasize that, for 1985, only 26 states are considered and for 1996 all Brazilian states are considered.

3.1 Global spatial autocorrelation

Table 2 shows the results for the Moran's I statistic and the standard deviation for the interregional trade and its components (exports and imports) for the years 1985 and 1996. All coefficients are positive and statistically significant (p-value 0.001), based on an approach of 10000 random permutations (Anselin, 1995). The interregional trade and its components are characterized by a significant coefficient for global spatial autocorrelation, thus it is possible to affirm that the distribution forms clusters in both periods. In other words, the regions with high (low) values for trade are located near to the other regions that also present high (low) values for trade. This pattern occurs more frequently than if the localizations were taken randomly. The standardized value of Moran's I coefficients presents a certain degree of difference between the periods, meaning that the importance location in trade increased. For the year 1985, the

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[5] In this study we also use *K=3 and 4* in order to check the robustness of the results (see section 4).
[6] The presentation of the results follows the structure presented in Haddad (2002). In order to implement the ESDA we use SpaceStat1.90 (Anselin, 1999), Arcview3.2 and Geoda09b.

spatial autocorrelation is significant, but it is less intense[7]. This can be explained, in a first moment, by the intensification of trade during the period. This may suggest that there is an increasing in trade among the specific Brazilian regions. Even with this difference in the intensity between the coefficients of spatial autocorrelation the hypotheses of spatial randomness is rejected for all the variables in both periods.

Table 2. Moran's I statistics for Trade and its components (1985 –1996)

Year	*Variable*	*Moran's I*	*Standard Deviation*	*Z value*
1985	Trade	0.1298	0.0634	2.6555
	Exports	0.1822	0.0716	3.0838
	Imports	0.0744	0.0543	2.0763
1996	Trade	0.5165	0.1009	5.5016
	Exports	0.4991	0.1012	5.3104
	Imports	0.5124	0.1009	5.4419

Note: The expected value for Moran's I statistic is constant for each year: E(I) = -0.0385

All statistics are significant at p=0.001

Considering the weight matrix, the Moran's I statistic using three, four and five nearest neighbors lead to the same results for the sign and significance of global spatial autocorrelation. The results are robust with regard to the choice of the spatial weight matrix[8].

3.2 Local Spatial Autocorrelation

3.2.1 Moran Scatterplot

The Figures 1 to 3 display the Moran Scatterplots results for the interregional trade and its components for the year 1996[9], with $k=5$ nearest neighbors. The results of positive spatial correlation (Moran's I) can be corroborated by the fact that most of the regions are located in quadrant HH and LL. For the interregional trade as a whole, we can observe that around 82% of the Brazilian states are characterized by the presence of similar values (37.04% in the quadrant HH and 44.44% in the quadrant LL). In respect to the atypical regions, i.e. regions that present deviation from the global pattern of positive autocorrelation, it is possible to verify, for 1996, that five regions have association with different values (1 in the quadrant LH and 4 in the quadrant HL).

All the results lead to the existence of spatial heterogeneity in the form of three different spatial regimes. The first correspond to the quadrant HH. It is formed by the Brazilian states located at the regions

[7] It is important to verify where integration is concentrated across the Brazilian territory. This question can be analyzed with more details when we introduce the results for the local spatial correlation, in other words when we verify the existence of local clusters of trade or spatial regimes.

[8] Complete results are available from the authors upon request.

[9] In this section the focus will be the year 1996.

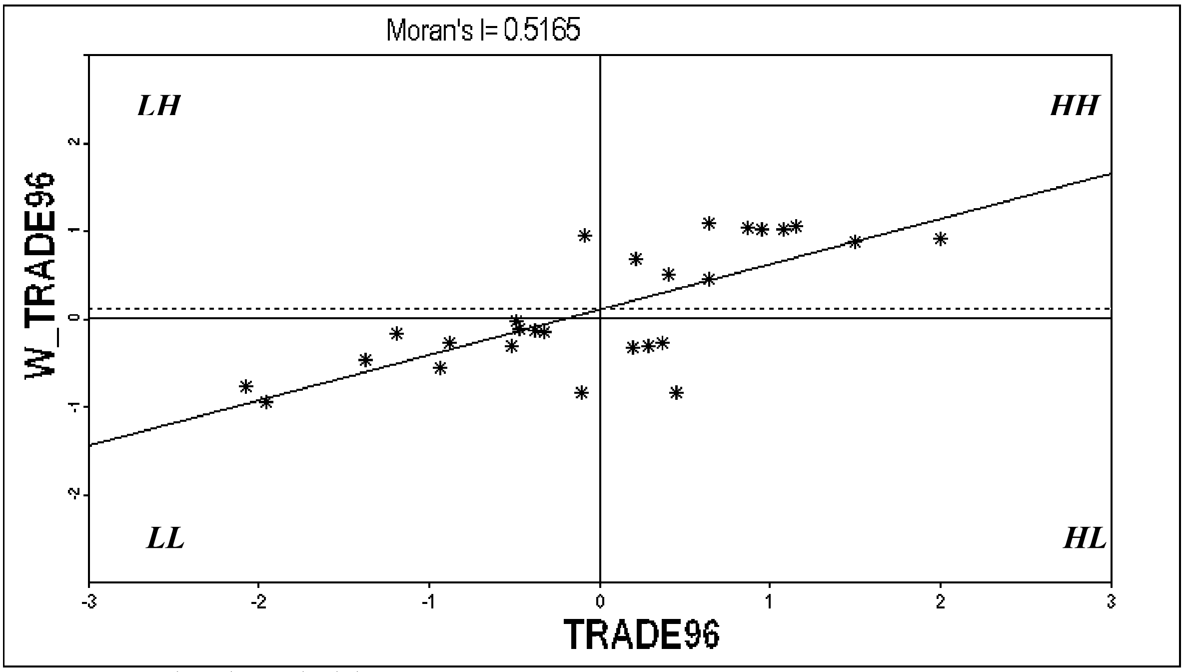
Southeast and South (the most developed portion of the country), Bahia state (one of the main pole of development of the region Northeast), Goias state (the new agricultural frontier in Brazil) and Distrito Federal[10]. The second regime corresponds to the quadrant LL and includes the states located at North region (except the Amazonas state) and Alagoas, Sergipe, Maranhao, Rio Grande do Norte, Piaui and Paraiba states located at the Northeast of Brazil. This regime is formed by states that present a small tradition in the trade. The third regime is formed by the states of Ceara, Pernambuco (Northeast region), Amazonas (North region) and Mato Grosso (Center-west region) and are located at the quadrant HL. These are states that present a higher spatial instability.

For the exports its also possible to pointed out three spatial regimes. They are: a) the first formed by the quadrant HH, which is composed by the states located at the Southeast, South and Goias and Bahia state, b) the second is formed by the observations located at the quadrant LL and is formed by the states of the region North (except Amazonas state) and the states of the region Northeast (except Ceara and Pernambuco) and c) the third regime is located at the quadrant HL and is formed by Amazonas, Pernambuco, Ceara and Mato Grosso states. The results for the imports enable us to observe three regimes (see Figure 3).

The results described before, for 1996, can be visualized in the Figures 4 to 6, in the Moran Scatterplot maps, which provide clear pictures of the spatial dependence. The maps help us to visualize the regimes described above. For the trade as a whole we can observe that the cluster formed by the high-high values is located in the portion center-south of the country. According to Diniz (1995), this part of the country presents the best transport network, a good number of medium size cities and also the most complete network of universities and research centers. This region can be classified as the part of the country that presents the best condition to develop in the short run. In this region is located the metropolitan areas of Rio de Janeiro, Sao Paulo, Belo Horizonte, Campinas, Curitiba and Porto Alegre. As Diniz (2002) pointed out they are the principal alternatives of the Brazilian industrial and productive expansion. The LL regime is located mainly at the North part of the country and it presents some spatial discontinuities in the Northeast.

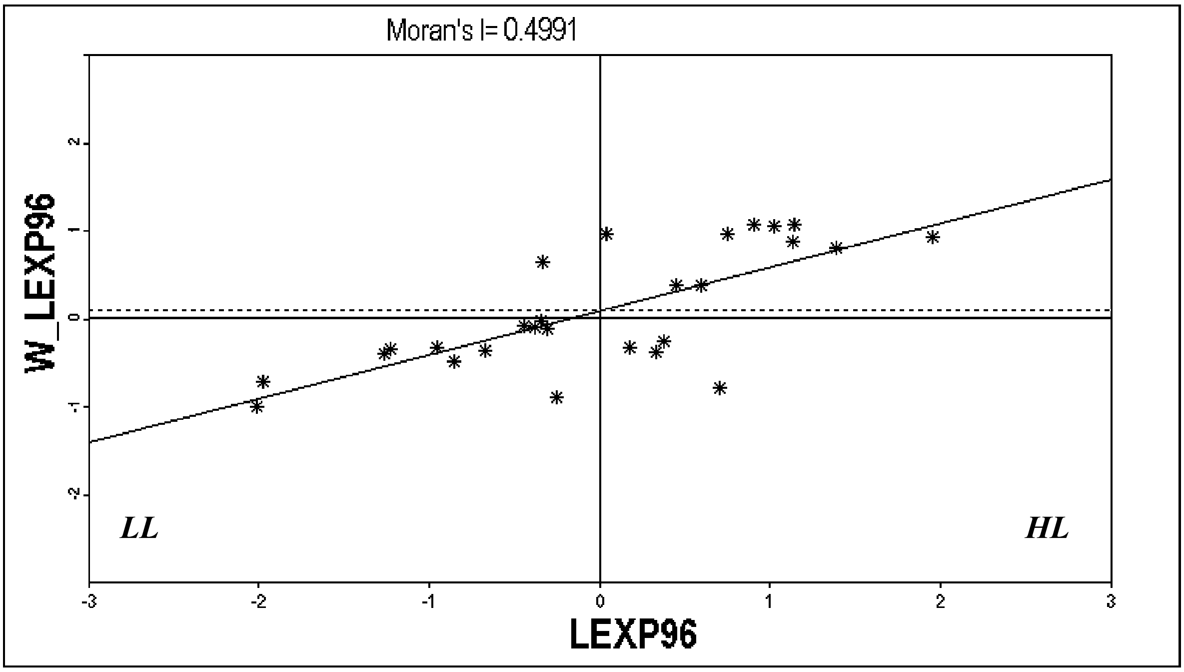
[10] The volume of imports can explain the result and also the characteristics of Brasilia that has the Federal Public Administration as the principal activity, presents the greatest income per-capita and is a region in which the consumption activities is more important than the production activities (Diniz, 2002).

Figure 1. Moran Scatterplot for Brazilian inter-regional trade - 1996



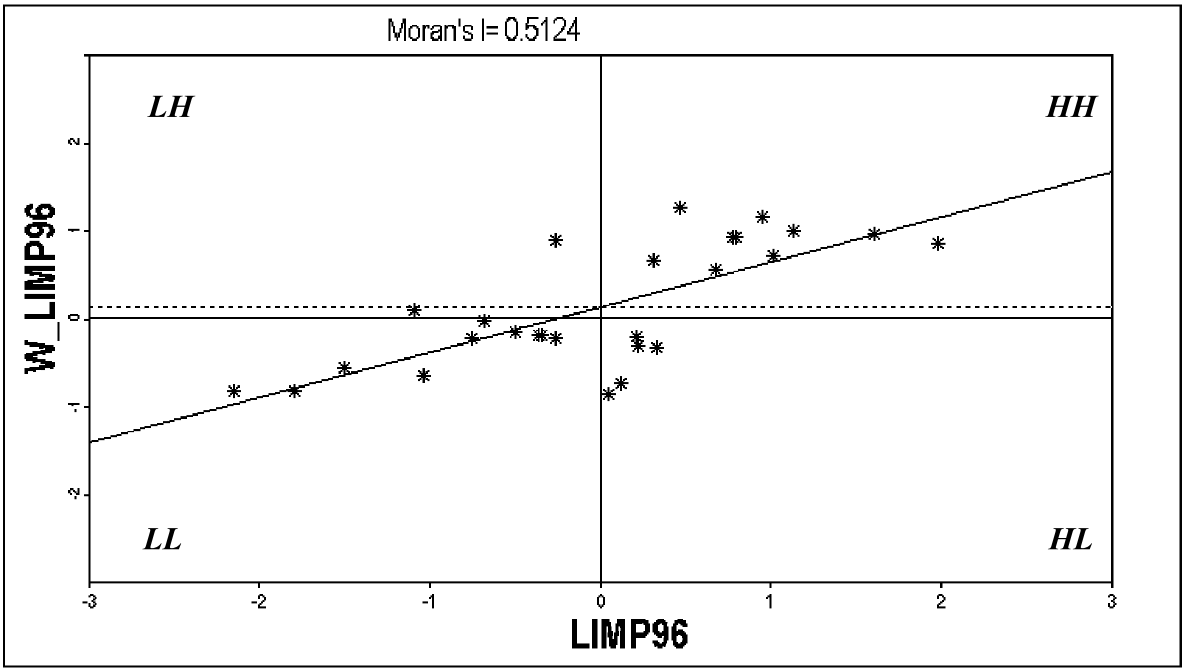
Source: Based on the methodology

Figure 2. Moran Scatterplot for Interregional Exports - 1996



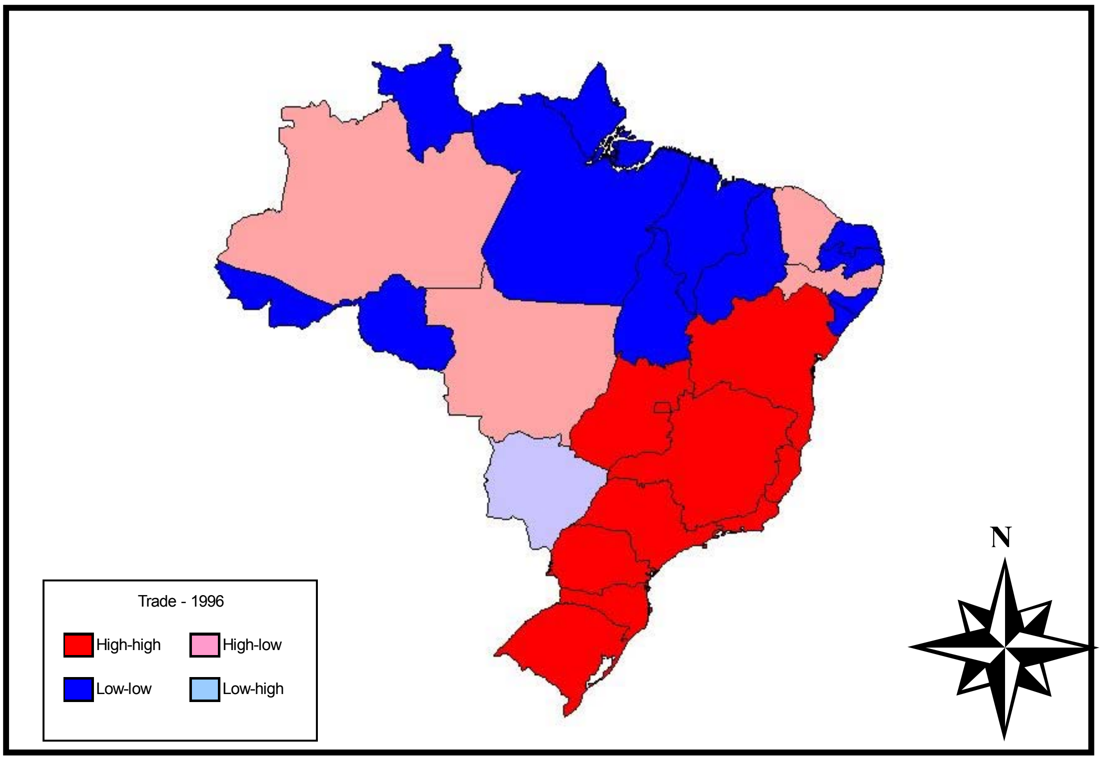
Source: Based on the methodology

Figure 3. Moran Scatterplot for Interregional Imports – 1996



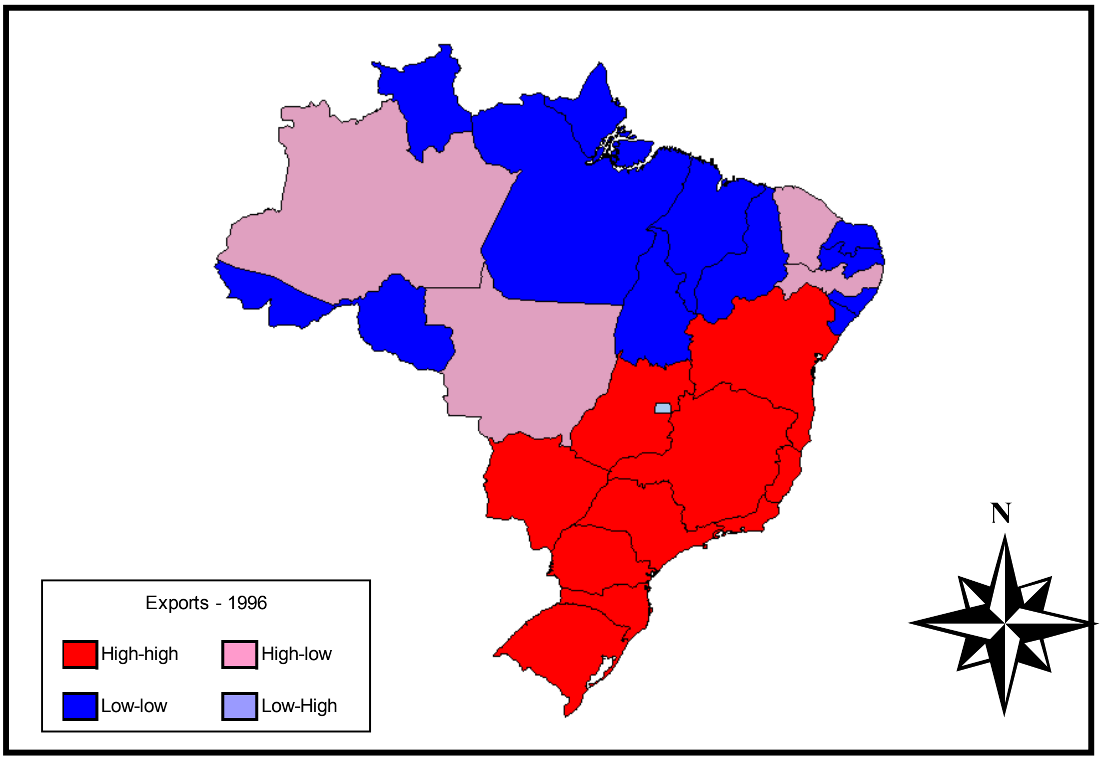
Source: Based on the methodology

Figure 4. Moran Scatterplot map for Brazil for Interregional Trade – 1996



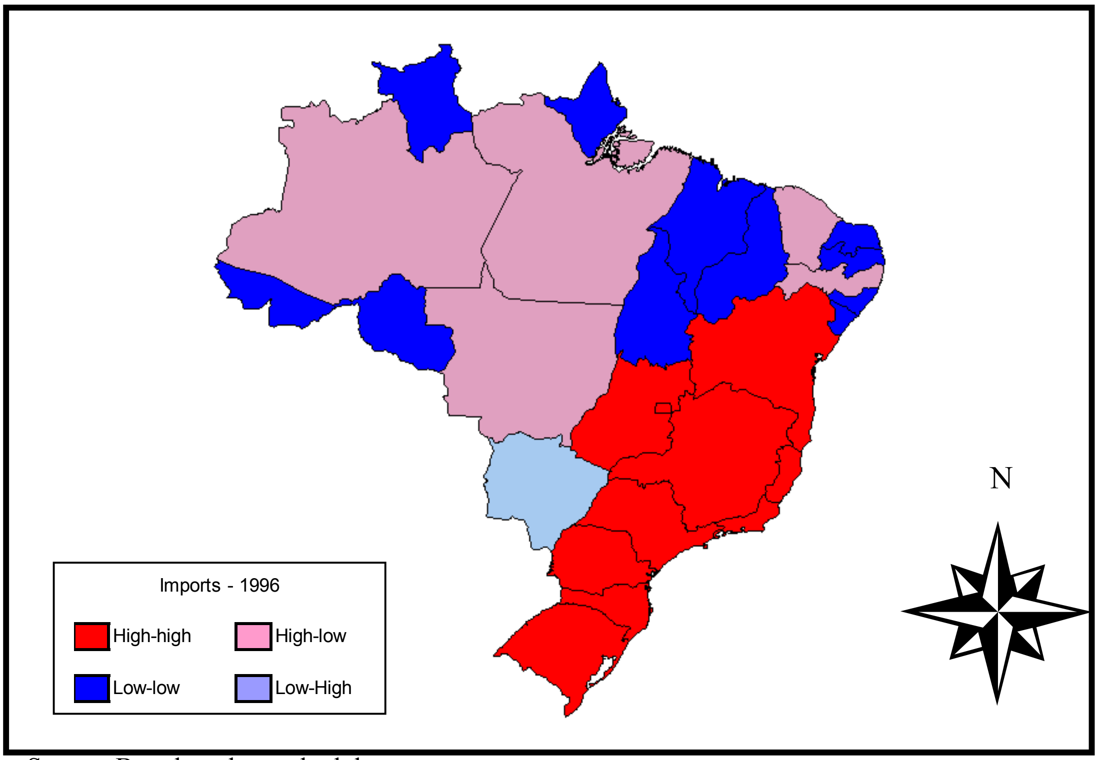
Source: Based on the methodology

Figure 5. Moran Scatterplot map for Brazil for Interregional Exports – 1996



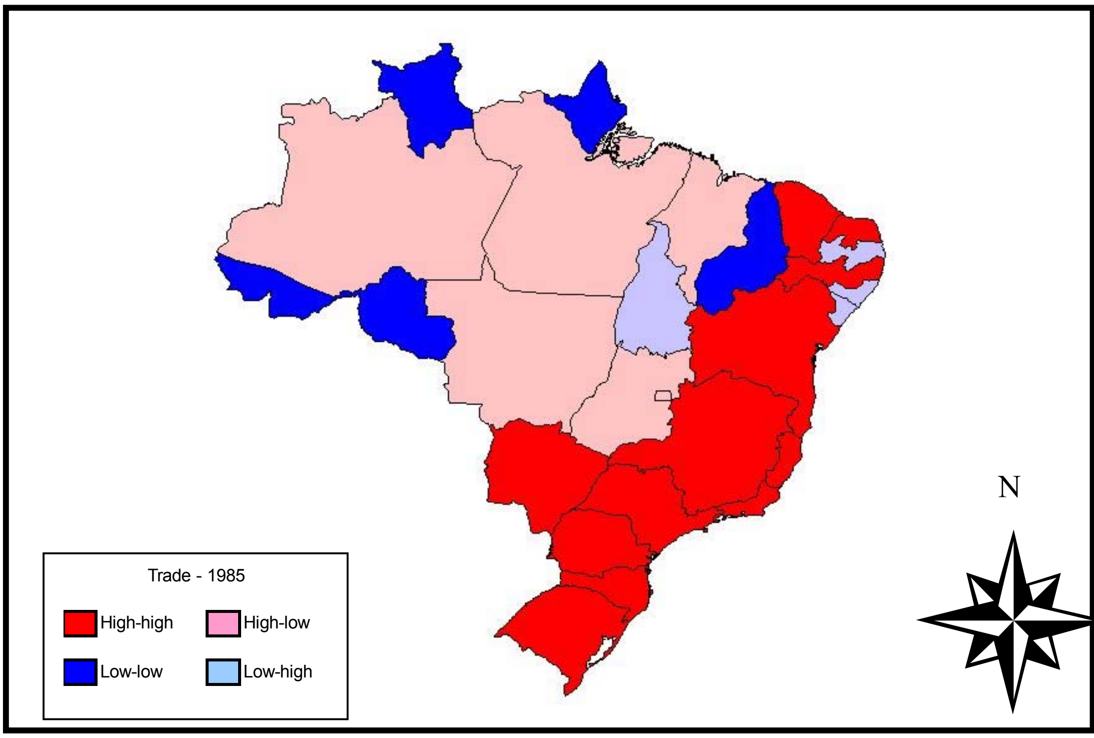
Source: Based on the methodology

Figure 6. Moran Scatterplot map for Brazil for Interregional Imports – 1996



Source: Based on the methodology

Figure 7. Moran Scatterplot map for Brazil for Interregional Trade – 1985



Source: Based on the methodology

Figure 7 displays the Moran Scatterplot Map for the interregional trade for the year 1985. It is possible to observe that during the period of analysis there is a decrease in the number of states located in the regime HH, which means that this regime became more concentrated in the portion center-south of the country. The increasing of the low-low regime (values below the mean for the interregional trade) in the North and Northeast of Brazil can corroborated the result. We can affirm that the improvement in the complexity of the productive sectors and the relevant role-played by the economies of scale, as a determinant of trade, will lead to a concentration trend of trade in some places (Helpman and Krugman (1985), Krugman (1991) and Markusen and Venables (2000)). In the Brazilian case, this phenomenon is occurring in the Southeast-South region, responsible for more than 70% of the Brazilian GDP. Knowing that trade is a function of income and output, even with a relative de-concentration of the industrial production at Rio de Janeiro and Sao Paulo city we can verify that there is a tendency of spatial re-concentration in the macro-region Southeast-south of the country (Diniz (1993) and Diniz and Crocco (1996)). This tendency is based on the development of second level metropolitan areas and medium size cities. They represent a high possibility of economic and industrial growth leading to an improvement in local income and total output and, as a consequence, an improvement in trade (interactions).

There are two factors that give some lights to understand the problem of diminishing of HH and increasing in LL: They are: 1) the re-location of some industries and 2) the income-distribution.
1) *The re-location:* according to Diniz (2000) even with the re-location of some industries (textile and food) toward the Northeast region (based on fiscal incentives), the industrial base of the Brazilian economy (metallurgy, mechanical, electric equipment, electronic equipment and chemical) still concentrated in the Southeast-South. Thus, the interactions among these sectors may contribute to the increasing of trade within the region.
2) *The income-distribution:* also from the trade literature, we can use the relationship between trade and income to help us to better understand the movement of concentration of HH states. According to Lavinas *et al,* (1997) the difference between the highest income per capita (Southeast) and the lowest one (Northeast), for 1990, is 0.35. The spatial distribution of GDP per capita, for 1994, shows that: a) the states located at South-Southeast plus Distrito Federal and Amazonas are responsible for the highest level of GDP per capita (>R$3.000,00 per year); b) the Northeast (Bahia, Pernambuco, Alagoas, Sergipe and

Rio Grande do Norte) and the North and Center-West (except Amazonas and Distrito Federal) presents a per-capita GDP between R$1.500,00 and R$3.000,00 and c) Tocantins and the others states of Northeast (Piaui, Maranhão, Ceara and Paraiba) presents the smallest level o GDP per capita (< R$1500,00 per year).

3.2.2 LISA (Local Indicator of Spatial Association)

The local patterns of spatial association (LISA) for the Brazilian interregional trade and its components are presented in the Moran significance maps at Figures 8 to 11, using the 5% Bonferroni pseudo-significance level[11]. Examining the maps, there are some persistent local clusters that deserve attention.

First of all, it is possible to affirm that the local pattern of spatial association reflects the global trend toward positive spatial autocorrelation since 84.6% of the significant LISA for the interregional trade as a whole, using the 5% pseudo-significance level, fall either into quadrant HH or quadrant LL of the scatterplot. We can also highlight that there is an imbalance in the distribution between the associations of the HH and LL types since 63.6% of the regions fall into the quadrant HH. Thus, it is possible to conclude that there are mainly significant regions with high trade surrounded by other regions with high trade. Those regions are located at the Center-South of Brazil (from Minas Gerais to Rio Grande do Sul state). The persistence of this pattern can be explained trough the spillovers of Sao Paulo on the surrounding states. Sao Paulo state has an important role as a pole of attraction. The metropolitan area of Sao Paulo (in the end of 80`s) presented diseconomies of scale, an increase in the development of the surrounded area occurred. As a consequence, we can affirm that the trade within this area increased (Figure 8).

The second point is that the deviations from the global trend are really limited. They represent only 15.4% of the significant LISA. For the interregional trade we observe the existence of one HL region, also know “diamonds in the rough” represented by the Amazonas state, as classified by Rey and Montouri (1999) and Le Galo and Ertur (2003). According to Diniz (2003), the growth at Manaus, the state capital, and the most important center of the region, is based on fiscal incentives and its industrial base, formed by electronic goods. These features do not enable a high interaction within the macro region. On the other hand, we can also detect one LH region formed by Mato Grosso do Sul state “the doughnuts” (Figure 8).

In Figure 9 it is possible to observe the LISA results for interregional exports for the year 1996. The main characteristics are: a) the local patterns of spatial association reflect the global trend toward positive spatial autocorrelation since 91,6% of the significant LISA fall either into quadrant HH or quadrant LL of the scatterplot, b) there is also an inequality in the distribution between the associations of HH and LL types since the majority of the regions fall into the quadrant HH, c) the regions formed by states with high exports surrounded by states with high values for exports are concentrated in the center-south of the country and d) the states that present exports below the average are located at the north of Brazil. Thus, for the exports, its possible to classify the pattern presented as a core (center-south) periphery (north) scheme.

The results for interregional imports can be observed at Figure 10. The structure of distribution of HH states in the center-south and LL states in the north of the country also occurs for interregional imports. A very interesting result is observed for Distrito Federal. It is classified as HH and the result can be explained by the productive structure of Distrito Federal, which has the service sector as the principal activity and presents a small industrial and agricultural (*e.g.* present a low share in the local GDP) as we highlighted before.

Comparing Figures 8 and 11 enables us to verify if regional trade clusters persist over time. Two important aspects are highlighted. The cluster of HH states became smaller and for the year 1996 is

[11] For more details see Anselin (1995).

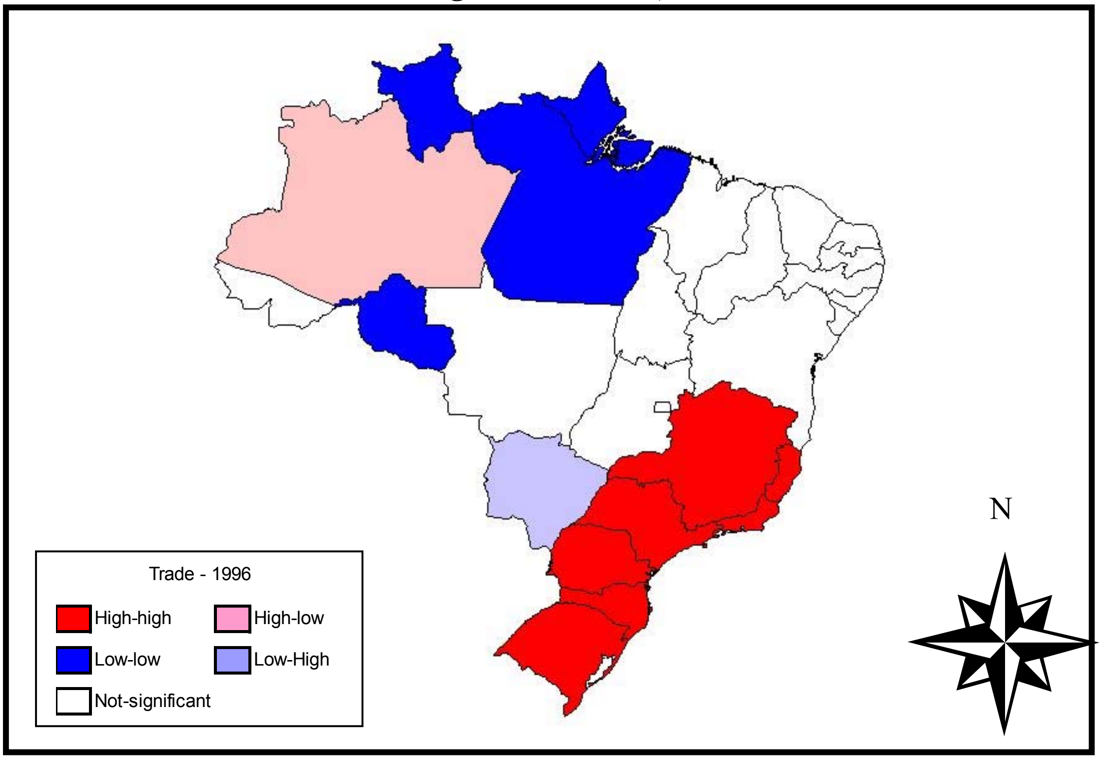
formed exclusively by the states located in the Southeast and South region. The cluster formed by LL states increased in the direction of the North region. Thus, this may suggest that the difference between the North and South in Brazil increased.

The characteristics of Brazilian regional development can help us to understand the movement of trade during the period of analysis. According to Diniz (1993), in 1970 began the process of spatial de-concentration of the Brazilian economic development. In 1970, Sao Paulo state was responsible for 58,1% of the Brazilian industrial production, and its metropolitan area was responsible for 44% of the Brazilian industrial production, and its share on the industrial employment was 34%. In 1985, the metropolitan area of Sao Paulo was responsible for 29,4% of the total industrial production and its share in the total employment was 29,4%. Diniz (1993) pointed that there was a spatial limit in the process of de-concentration. In other words, the process did not spread across the country. In the beginning there was an improvement of the development in the municipalities neighborhood of Sao Paulo metropolitan area. In the later years it is possible to observe a path of de-concentration towards the area formed by Belo Horizonte – Uberlândia – Londrina/Maringá – Porto Alegre – Florianópolis – São José dos Campos – Belo Horizonte.

Andrade and Serra (1999) analyzed the process of de-concentration during the period 1990-1995 and concluded that, during this period, the pattern of concentration within the area pointed by Diniz (1993) continues. Thus those points can help us to better understand the pattern of trade during 1985-1996.

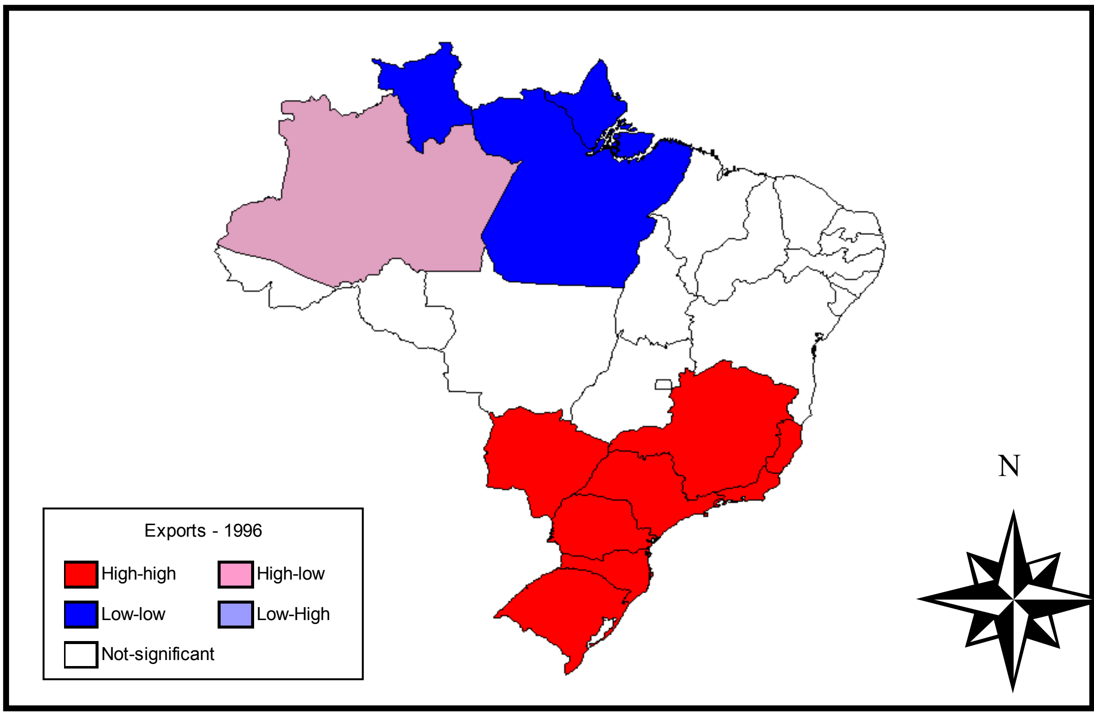
The idea presented above can be corroborated by the results presented by Andrade and Serra (1998) and Diniz ad Crocco (1996). The authors shows that in Brazil the number of industrial areas with more than 10.000 industrial employments increase from 33 in 1970 to 90 in 1991. From these 57 new industrial areas, 44 were located in the Southeast-South of Brazil.

Figure 8. Moran significance map for Brazilian interregional trade – 1996 (5% of pseudo-significance level)



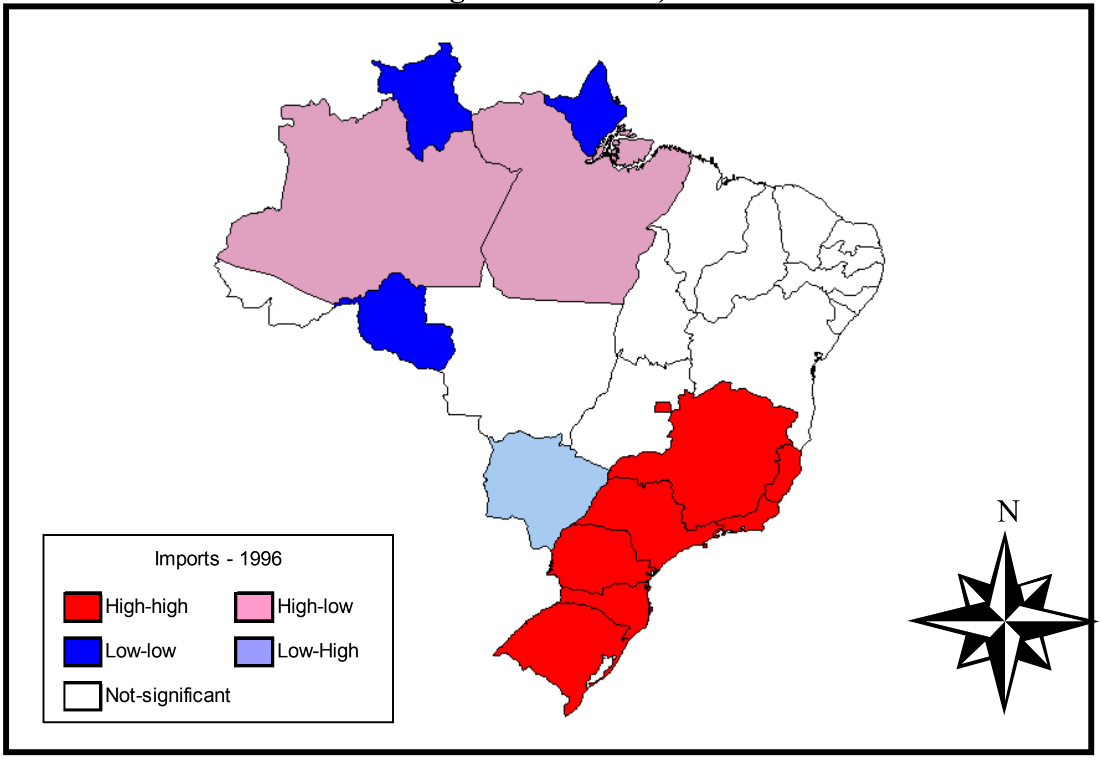
Source: Based on the methodology

Figure 9. Moran significance map for Brazil for Interregional Exports – 1996 (5% of pseudo-significance level)



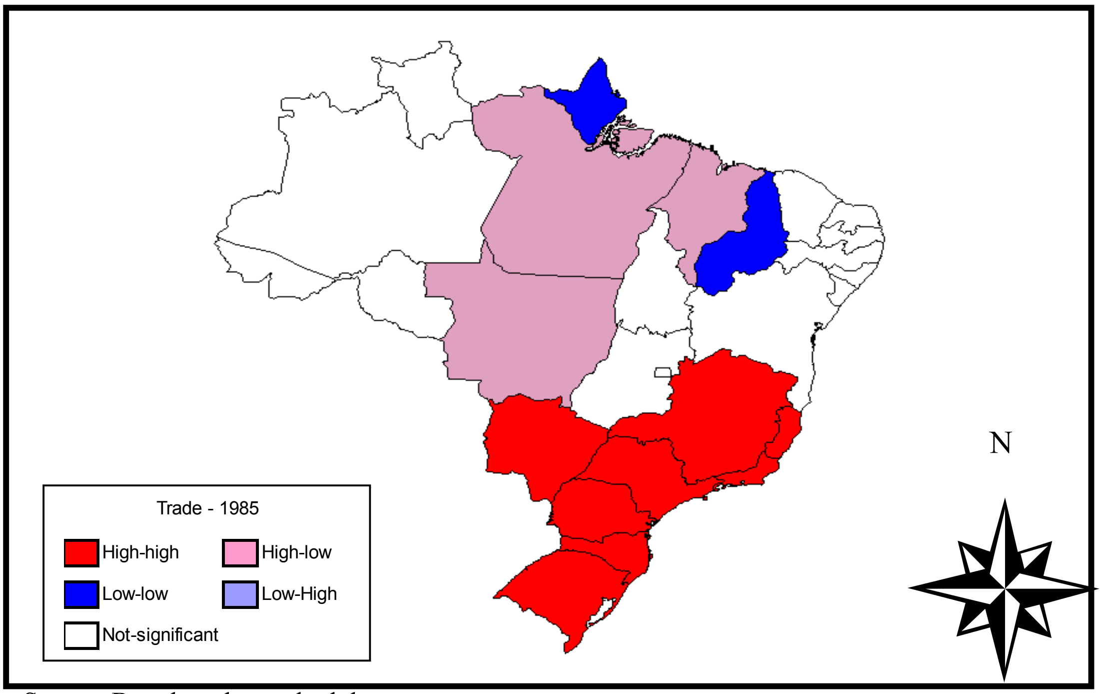
Source: Based on the methodology

Figure 10. Moran significance map for Brazil for Interregional Imports – 1996 (5% of pseudo-significance level)



Source: Based on the methodology

Figure 11. Moran significance map for Brazil for Interregional Trade – 1985 (5% of pseudo-significance level)



Source: Based on the methodology

4. Robustness analysis using transition probability matrices

The results will be considered robust if they don't change when we modify the number of neighbors. According to Le Gallo and Ertur (2003 p 15) " *the results are robust if a region that is in a particular* *state with the k neighbor matrix (i.e not significant, HH, LL, HL, LH statistics), remains in this state for the other weight matrices."* In order to reach this objective the authors suggest using the transition matrices framework because it measures the transitions between two different distributions for a given point in time[12].

Table 3 shows two different transition probability matrices for studying the robustness for the LISA statistic for trade, for the year 1996, using 5% Bonferroni significance level[13]. The results show that a region associated with a significant LISA statistic remains in the same state whatever the number of neighbor chosen. Thus we can affirm that the results are robust no matter which weight matrix is chosen.

Table 3. Robustness analysis for LISA statistics (Interregional Trade – 1996)

	K=4	*NS*	*HH*	*LL*	*HL*	*LH*
	NS	100.00	0.00	0.00	0.00	0.00
	HH	14.29	85.71	0.00	0.00	0.00
K=5	*LL*	66.67	0.00	33.33	0.00	0.00
	HL	0.00	0.00	0.00	100.00	0.00
	LH	0.00	0.00	0.00	0.00	100.00

	K=3	NS	HH	LL	HL	LH
	NS	100.00	0.00	0.00	0.00	0.00
	HH	0.00	100.00	0.00	0.00	0.00
K=5	*LL*	33.33	0.00	66.67	0.00	0.00
	HL	0.00	0.00	0.00	100.00	0.00
	LH	0.00	0.00	0.00	0.00	100.00

Source: Based on the methodology

5. Conclusions

The motivation of this paper was to understand the structure of trade among the Brazilian states. The application of the Exploratory Spatial Data Analysis in the input-output flows enables us to affirm that there is positive spatial autocorrelation, which persists during the period 1985-1996, meaning that regions with relatively high (or low) trade are and remain localized close to other regions with relatively high (or low) trade. The analysis of the standardized value of Moran's I statistic enables us to affirm that the structure of Brazilian interstate trade became more intense during the period.

The LISA results confirm the significant presence and persistence over time of local spatial autocorrelation in the form of two distinct spatial clusters of high and low values of trade and its components.

Ceteris paribus, the results lead to an increase in the regional disparities among the Brazilian regions, because the cluster of high trade is located at the Southeast-South of Brazil and the cluster of low trade is increasing in the North part of the country.

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[12] For more application of this methodology see Le Gallo (2003), Rey (2001) and Dall'erba (2003).

[13] The robustness analysis for LISA statistics for Exports and Imports for the year 1996 and for the year 1985 is available upon request.

Some recent characteristics of the Brazilian economy are the increase of the number of industrialized cities in the South-Southeast, the distribution of the industrial sectors across the country (having high-tech industries located in the South-Southeast), the transport network and the research network and with the determinants of trade (e.g. economies of scale). Adding those to the results of this paper, we can affirm that the regional disparities in Brazil will persist along time.

References

Andrade, T. A and Serra, R. V (1999). Desconcentração industrial no Brasil: 1990/1995. Texto para Discussão Nemesis.

Anselin, L (1999). SpaceStat, a software package for the analysis of spatial data vesion 1.90. AnnArber, BioMedware.

Anselin, L (1998). Interactive techniques and exploratory spatial data analysis. Longley P.A, Goodchild M.F, Maguire D.J and Wind D. W (eds). **Geographical information systems: principles, techniques, management and applications.** Wiley:New York. p 253-265

Anselin, L (1996). The Moran scatterplot as an ESDA tool to assess local instability in spatial association. Fisher, M, Scholten, H.J and Unwin, D (eds). **Spatial analytical perspectives in GIS.** Taylor&Francis. London. p 111-125

Anselin, L (1995). Local indicators of spatial association – LISA. *Geographical Analysis.* v 27 (2), April. p 93-115.

Cliff, A. D and Ord, J.K (1981). Spatial processes: models and applications: Pion, London.

Diniz, C. C (2002). A nova configuração urbano-industrial no Brasil. In Kon, A (org). **Unidade e fragmentação: a questão regional no Brasil.** Ed. Perspectiva. São Paulo.

Diniz, C. C (2000). A nova geografia econômica do Brasil. In Reis Velloso (org). **Brasil 500 anos. Futuro, presente, passado.** Ed. José Olympio.

Diniz, C. C (1995) Estudo da competitividade da indústria brasileira: competitividade industrial e desenvolvimento regional no Brasil. IEI/Unicamp, IEI/UFRJ, Funcex. Mimeo.

Diniz, C. C (1993). Desenvolvimento poligonal no Brasil: nem desconcentração nem contínua polarização. *Revista Nova Economia*, vol 3, n.1 Belo Horizonte.

Diniz, C. C and Crocco, M.A (1996). Reestruturação econômica e impacto regional: o novo mapa da indústria brasileira. *Revista Nova Economia*, vol 6, n.1. Belo Horizonte.

Dall'erba, S (2003). Distribution of regional income and regional funds in Europe 1989-1999: An exploratory spatial data analysis. Discussion Paper REAL 03-T-1. UIUC.

Ertur, C and Le Gallo, J (2003). An exploratory spatial data analysis of European regional disparities, 1980-1995. in Bernard Fingleton (ed) **European regional growth: advances in spatial science.** Springer-Verlag p 55-98.

Getis, A and Ord, J. K (1992). The analysis of spatial association by use of distance statistics. *Geographical Analysis.* v 24 p 189-206.

Haddad, E.A and Perobelli, F.S (2002). Integração regional e padrão de comércio dos estados Brasileiros In Kon, A (org). **Unidade e fragmentação: a questão regional no Brasil.** Ed. Perspectiva. São Paulo.

Haddad, M A (2002) An exploratory spatial data analysis of human development in Brazil. (mimeo)

Helpman, E and Krugman, P.R (1985). **Market structure and foreign trade: increasing returns, imperfect competition, and the international economy.** Cambridge. MA. MIT Press.

Krugman, P.R (1991). **Geography and trade.** Cambridge. MA. MIT Press.

Lavinas, L, Garcia, E.H and Amaral, M. R (1997). Desigualdades regionais: indicadores socioeconômicos nos anos 90. Texto para Discussão n. 460. IPEA, Rio de Janeiro.

Le Gallo, J and Ertur, C (2003). Exploratory spatial data analysis of the distribution of regional per capita GDP in Europe, 1980-1995. *Papers in Regional Science* v 82(2) p175-201.

Le Gallo, J (2003). Space-time analysis of GDP disparities among European regions: A Markov chains approach. International Regional Science Review, forfhcoming.

Ord, J. K and Getis, A (1995). Local spatial autocorrelation statistics: distributional issues and an application. *Geographical Analysis.* v 27 p 286-305.

Perobelli, F.S and Haddad, E. A (2003). Interdependence among the Brazilian states: an Input-Output approach. Discussion Paper REAL/UIUC 03-T-18.

Rey, S (2001). Spatial empirics for economic growth and convergence. *Geographical Analysis.* v 33(3), July. p 195-214.

Rey, S and Montouri, B (1999). US regional income convergence: a spatial econometric perspective. *Regional Studies* 33 p. 143-156.

Tobler, W (1979). Cellular geography, in Gale, S and Olsson, G (Eds), **Philosophy in geography**, p 379-86. Dordrecht: Reidel

APPENDIX

Brazilian Macro regions and States

Macro region	*State*
North (N)	Acre (AC)
	Amazonas (AM)
	Amapá (AP)
	Para (PA)
	Rondônia (RO)
	Roraima (RR)
	Tocantins (TO)
Northeast (NE)	Alagoas (AL)
	Bahia (BA)
	Ceará (CE)
	Maranhão (MA)
	Paraíba (PB)
	Pernambuco (PE)
	Piauí (PI)
	Rio Grande do Norte (RN)
	Sergipe (SE)
Southeast (SE)	Espírito Santo (ES)
	Minas Gerais (MG)
	Rio de Janeiro (RJ)
	São Paulo (SP)
South (S)	Paraná (PR)
	Santa Catarina (SC)
	Rio Grande do Sul (RS)
Center-west (CW)	Distrito Federal (DF)
	Goiás (GO)
	Mato Grosso (MT)
	Mato Grosso do Sul (MS)