EXTERNAL TRADE AND SPATIAL DEVELOPMENT IN BRAZIL:
AN EXPLORATORY ANALYSIS

Rogério Silva de Mattos
(FEA/UFJF)
Fernando Salgueiro Perobelli
(FEA/UFJF e NEREU/USP)

Resumo
O artigo objetiva melhorar a compreensão sobre as interações entre comércio exterior e
desenvolvimento espacial no Brasil. O estudo abrange 27 estados brasileiros, dois blocos de parcerios
comerciais representados pelo Mercosul e pela União Européia e também 3 anos no período 1989–
2003. A metodologia consiste da aplicação de análise exploratória de dados espaciais (ESDA) e é
baseada na utilização da estatística I de Moran para estudar a evolução temporal dos padrões de
autocorrelação espacial. A partir dessa abordagem, é possível verificar a existência de clusters de
estados com altos e baixos níveis de comércio exterior, assim como mudanças nesses clusters ao longo
do período entre o final dos anos 80 e o início do século 21. A análise nos permitiu examinar
consequências potenciais para os padrões de comércio exterior e de desenvolvimento econômico dos
estados produzidas por eventos econômicos relevantes do período. Ao final do artigo, perspectivas e
conclusões de política são apresentadas.

Abstract
The paper aims to enhance the understanding regarding the interactions between foreign trade and
spatial development in Brazil. The study abridges 27 Brazilian states, two blocks of trade partners
represented by Mercosur and European Union, and 3 years in the period 1989-2003. The methodology
consists of the application of exploratory spatial data analysis (ESDA) and is based on the use of
Moran’s I statistic to study the temporal evolution of spatial autocorrelation patterns. Based on this
approach, it is possible to verify the existence of clusters of high and low foreign trade states, as well as
the changes in these clusters along the period between the end of the 1980s and the beginning of the
21st century. The analysis enabled us to examine the potential consequences for the spatial pattern of
states’ foreign trade and economic development produced by relevant economical events of the period.
At the end of the paper, perspectives and policy conclusions regarding the Brazilian spatial
development are made.

Key-words: Brazilian states external trade, spatial development; exploratory spatial data analysis

1. Introduction
   During the 1990’s, the Brazilian economy underwent significant changes in its
external trade. As the most important facts of that period, we may point out the
settlement of Mercosur, the increase in the degree of openness of the Brazilian
economy, the negotiations to create a free trade area in the Americas (FTAA), and the
approximation to the European Union. All of these has contributed a lot to shift the
Brazilian economy engagement in free trade relations with other nations. On the other hand, the impacts of economic globalization upon the Brazilian economy displayed a diversified set of dynamics. As we can track from the behavior of regional economic indicators, absorption of those impacts throughout the Brazilian space took many forms and this can be explained by the regional heterogeneity of labor markets, productivity levels, technological innovations, and transportation costs. In a sense, the globalization process played the role of sharpening the differences of economic development among Brazilian regions.

According to Baer et al (2002), the allocation of resources by market forces in a freer trade environment will probably favor the Southeast and South regions because of the higher per-capita income in those regions and their strategic importance to the Brazilian trade structure. This view places focus on the increasing importances of Mercosur as a trade partner and of country’s intake in the globalization process. Also, Haddad (1997) developed simulations based on an inter-regional CGE model calibrated to the year 1985 and pointed out that, ceteris paribus, the Northeast region would be in disadvantage under a more open economy environment. Haddad’s results also indicate that with an indiscriminate cut off in tariff levels employment and production in the Northeast would be negatively affected, while the rest of the country would receive positive impacts.

This paper wants to contribute to the debate regarding the relevance of the spatial dimension for the Brazilian external trade. The basic theory of foreign trade states that a country’s exports depend on income of the rest of the world and on the effective exchange rate between domestic and foreign prices. For a country taken as a whole, this theory has been undoubtedly sound, but when the regions within the country are considered, their participation in foreign trade shall be influenced also by each region’s spatial features, in particular its location. For a (spatially) large country like Brazil, it means, for example, that being near (far) to the physical channels of access to foreign markets (ports, airports, etc.) or to the more developed regions of the country represents a significant comparative advantage (disadvantage) to a specific region. At the same time, this bears long run economic implications for a region and for the whole country. This perspective is important in the case of Brazil for it raises the question of what is better: to expand participation in the international markets by concentrating foreign trade in more developed regions or by distributing it among
regions. In analyzing these strategic options, the need for attenuating regional disparities of economic development has to be considered also.

On the basis of the above considerations, we analyze in this paper the importance that Brazilian states’ locations bear for the country to take part in the globalization process through foreign trade. In other words, we want to answer the question: Is location relevant to external trade? As part of our research efforts to answer this question, we present here an exploratory spatial data analysis (ESDA) of the Brazilian exports to and imports from Mercosur and European Union. This particular focus of our study is able to provide clues regarding the way in which distinct trade agreements with these two blocks of nations might impact the Brazilian foreign trade as a whole and the state of regional disparities of economic development within the country. We shall remark that it is still a preliminary, exploratory study but which can indicate suitable directions for further research.

This paper is organized as follows. The second section makes a brief review of the methodology. The third section presents the empirical results for the Brazilian economy, and the fourth section outline some conclusions.

2. Methodology

The ESDA framework was developed to explore the spatial aspects of a database. It deals directly with the ideas of spatial dependence (e.g. spatial association) and spatial heterogeneity. The goals of ESDA are to describe the spatial distribution, identify 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).

Two concepts are especially relevant for one to develop an ESDA. The first is spatial auto-correlation, which refers to the degree in which nearby locations (e.g. geographic areas presenting a certain degree of spatial proximity) coincides in terms of their attribute values (correlation). There is positive spatial autocorrelation when similar (high or low values) for a specific variable or attribute set up clusters of regions in space, and there will be negative spatial autocorrelation when the neighbors of certain geographic areas presents dissimilar values. The second concept is spatial heterogeneity, which means that an attribute behavior is not stable in space allowing the existence of diverse spatial patterns of attribute’s values. The results may indicate
different spatial regimes such as, for instance, a cluster of developed regions – core - or a cluster of less developed regions – periphery (Ertur and Le Gallo, 2003).

With regard to spatial autocorrelation, the ESDA techniques allow us to extract measures of global and local spatial autocorrelation (Anselin, 1998). We talk about each of these in the next two subsections.

2.1 Global spatial autocorrelation

Global spatial autocorrelation can be measured with the Moran’s $I$ statistic. This statistic indicates the degree of linear association between a vector of observed values for a spatial attribute ($z_i$) and the weighted average of the neighbors’ values, or the spatial lags, ($Wz_i$) at a particular period of time $t$. $I$ values greater (smaller) than the expected value $E(I)=-1/(n-1)$ means that there is positive (negative) autocorrelation. Following Cliff and Ord (1981), the Moran’s $I$ statistic can be formally expressed as:

$$I_t = \left( \frac{n}{S_0} \right) \left( \frac{z_i Wz_i}{z'_i z'_i} \right) t = 1,...,n$$

where the $z_i$ elements are measured in deviations from the mean. $W$ is the spatial weight matrix, defined in such a way that the elements $w_{ii}$ on the diagonal are set to zero whereas the elements $w_{ij}$ ($i \neq j$) indicate the way that region $i$ is spatially connected to the region $j$. $S_0$ is a scaling factor equal to the sum of all the elements of $W$. When the spatial weight matrix is normalized in the row (the elements of each row sum up to 1), the expression in (1) can be simplified to:

$$I_t = \left( \frac{z_i Wz_i}{z'_i z'_i} \right) t = 1,...,n$$

2.2 Local spatial autocorrelation

The Moran’s $I$ statistic is a global measure and thus does not allow us to observe the structure of spatial correlation at regional levels. In order to observe the existence or not of local spatial clusters made up by regions with similar or dissimilar values for the attribute of interest (regions which contribute the most to form a pattern of spatial
autocorrelation), we have to compute indicators or measures of local spatial autocorrelation, such as the Moran Scatterplot, the G statistics and the local indicators of spatial association (LISA). In the still preliminary analysis we present in this paper, we had to limit ourselves to the use of only one of these indicators, the Moran Scatterplot\(^1\), about which we talk in the next subsection.

2.2.1 Moran scatterplot

According to Anselin (1996), the Moran Scatterplot is a way to interpret the Moran’s \( I \) statistic. It is a graphical device that enables us to visualize the global spatial autocorrelation represented by Moran’s \( I \) because it is equivalent to the slope of the linear regression between \( Wz \) and \( z \) in a scatterplot of these two variables.

However, the Moran Scatterplot also allows us to visualize local spatial instability, say, by observing the patterns in which the data points spread in the scatter plot. This is accomplished by the division of the Moran Scatterplot into four quadrants that correspond to the four patterns of local spatial association between a region and its neighbors. The first quadrant (upper right corner) is named high-high (HH) and shows regions (data points) with high values for the attribute of interest (i.e. values above the mean) which are surrounded by regions also with high values for that attribute. The second quadrant (upper left corner), named low-high (LH), displays regions with low values which are surrounded by regions with high values. The third quadrant (bottom left corner), named low-low (LL), displays regions with low values which are surrounded by regions also with low values. Finally, the fourth quadrant (bottom right corner), named high-low (HL), displays regions with high values which are surrounded by regions with low values.

The regions located at quadrants HH and LL present positive local spatial autocorrelation, because these regions form clusters of similar values. By their turn, the regions in quadrants HL and LH present negative spatial autocorrelation meaning that these regions form clusters of dissimilar values.

2.3 Spatial weight matrix

The proximity or spatial 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

\(^1\) However, this choice of ours should not prejudice the use of the other LISA in the particular application we have made.
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 greatest circle distance between region centroids. The choice of the weight matrix is very important in an ESDA because all subsequent steps (or results) will be based on this selection.

The spatial weight matrix based on the $k$-nearest neighbors is usually set up according to the following rule:

$$
\begin{cases}
  w_{ij}(k) = 0 & \text{if } i = j \\
  w_{ij}(k) = 1 & \text{if } d_{ij} \leq D_i(k) \text{ and } w_{ij}(k) = w_{ij}(k) / \sum_j w_{ij}(k) \text{ for } k = 3, 4, 5 \\
  w_{ij}(k) = 0 & \text{if } d_{ij} > D_i(k)
\end{cases}
$$

(3)

where $d_{ij}$ is the greatest circle distance between centroids of region $i$ and $j$. $D_i(k)$ is the critical cut-off distance for each region $I_i$, 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

The database of Brazilian states international trade used here is for the years 1989, 1998 and 2003. We used the dataset on flows by origin and destination from Aliceweb (MDIC, 2004). In order to diminish the impact of the states’ size upon the results, we implemented the exploratory analysis based on states’ per capita exports and imports. The population database was taken from IBGE.

3.1 Global spatial autocorrelation

Table 1 shows numerical results for the Moran’s I statistic, its standard deviation, and the associated p-values for regional per capita exports to and imports from Mercosur and European Union for 1989, 1998, and 2003. The Moran’s I figures
were computed for Brazilian states using a proximity matrix built up based on 4 nearest neighbors. These numbers for standard deviations and associated p-values were computed by a simulation approach based on 10,000 random permutations for each year’s sample values (Anselin, 1995). For Mercosur, all Moran’s I coefficients (exports and imports) are positive and statistically significant, as indicated by the small p-values. For the European Union, all coefficients are positive and significant in the majority of cases with a p-value below 0.10. Thus, in general both exports and imports realized with the two blocks of Mercosur and European Union are characterized by a significant coefficient of global spatial autocorrelation, allowing us to conclude that the spatial distributions of these variables form clusters of regions with similar values in the years of analyses. In other words, regions with high (low) values for exports or imports tend to be located nearby other regions that also present high (low) values for external trade.

3.2 Local spatial autocorrelation

3.2.1 Exports to Mercosur

Figure 1 displays the Moran Scatterplots for per capita exports to Mercosur in the years of 1989, 1998, and 2003. The positive spatial correlation indicated by Moran’s I (tab. 1) is reinforced in fig. 1 because most of the regions form clusters of positive local spatial autocorrelation in both quadrants HH and LL. For the year 1989 (fig 1.a)), we can observe that nearly 85.1% of the Brazilian states are characterized by the presence of similar values (33.3% in the quadrant HH and 51.8% in the quadrant LL). The same pattern shows up for the years 1998 (fig 1.b) and 2003 (fig 1.c). With regard to the atypical regions, i.e regions that present deviations from the observed global pattern of positive autocorrelation, it is possible to verify that, for 1989, four regions have association with different values (two in quadrant LH and two in the quadrant HL).

All the results point out to the existence of spatial heterogeneity in the form of four different spatial regimes. For 1989, the first correspond to quadrant HH. It consists of the Brazilian states located at the Southeast and South regions (the most developed part of the country) and the Mato Grosso do Sul state. The second regime corresponds to quadrant LL and includes the states located at the North (except the Amapa state) and Northeast (except the Bahia state) region, and the Tocantins and
Mato Grosso states that are located in the Center-west region of Brazil. The third regime is formed by the state of Bahia and Amapa and is located at the quadrant HL. The fourth regime is formed by Goias and Distrito Federal and is located at the quadrant LH.

The results described before for 1989, 1998 and 2003 can also be visualized in the maps of Figure 2, which provides a clear picture of the spatial dependence. The maps help us to visualize the regimes described above. For 1989, we can observe that the cluster formed by high-high values is located in the center-south portion of the country. It is important to highlight the modifications that took place after the creation of Mercosur. Comparing Figure 2.a with Figure 2c, we verify that the high-high regime for exports is smaller and is more concentrated in 2003 than in 1989.

3.2.2 Imports from Mercosur

Figure 3 shows the results for imports from Mercosur. We can affirm that there are three spatial regimes in the year 1989 and four spatial regimes in years 1998 and 2003. For 1989, the first regime corresponds to the quadrant HH and is formed by Rio de Janeiro, Paraná and Rio Grande do Sul. The second regime is located in the quadrant LL and is formed by the states located at the North region, the Northeast region (except Paraíba and Rio Grande do Norte), the Center-west region (except Mato Grosso do Sul), plus the states of Minas Gerais and Espirito Santo. The third regime is located at quadrant LH and is formed by the states of Paraíba, Rio Grande do Norte, Mato Grosso, Sao Paulo and Santa Catarina.

Figure 4 displays the maps for states' imports from Mercosur in 1989, 1998 and 2003. It is possible to observe that during the period of analysis there is an increase in the number of states located in the regime HH, and we can also verify that the regime became more concentrated in the center-south portion of the country. On the other hand there is a decrease in the regime LL, but it is still concentrated in the North and Northeast regions. We might affirm that the creation of Mercosur, by inducing augmented imports from that region, is also inducing the concentration of imports in a small part of the country.

3.2.3 Exports to European Union

Figure 5 shows the results for exports to European Union in 1989, 1998 and 2003 with \( k=4 \) 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 year 1989, we can observe that around 70% of the Brazilian states are characterized by the presence of similar values (22.2% in the quadrant HH and 48.14% in the quadrant LL). The results present the similar pattern for the others years. With regard to the atypical regions it is possible to verify, for 1989, that eight regions have association with different values (4 in quadrant HL and 4 in quadrant LH).

The results reveal the existence of spatial heterogeneity in the form of four different spatial regimes. For 1989, the first correspond to the quadrant HH. This quadrant is formed by the states located at the South region, and at Sao Paulo, Minas Gerais and Mato Grosso state. The second regime corresponds to the quadrant LL and includes only states located at Northeast and North region of Brazil. The third regime is composed by the states of Amapa, Para, Mato Grosso do Sul, and Espirito Santo. The states of Rio de Janeiro, Goias, Distrito Federal and Roraima compose the fourth regime.

The results described before are better visualized in the Figures 6a, 6b and 6c that display maps which enables us to describe the regimes pointed out above the spatial dependence patterns. We can observe that the cluster formed by high-high values is located at the Center-south portion of the country. Another aspect to highlight is that this cluster does not change during the period of analysis. It is also important to underline that the cluster formed by low-low values underwent a small change. The majority of states pertaining to this cluster are located at Northeast region.

### 3.2.4 Imports from European Union

Figure 7 reveals the results for imports from European Union. We can affirm that there is three spatial regimes in the years under analyze. The first regime (quadrant HH) in 1989 is composed by only four states. On the other hand, the same regime has eight states in 1998 and 2003.

The analysis of the maps in Figure 8a, 8b and 8c help us to visualize the regimes showed by the Moran Scatterplot. The regime HH increased during the period of analysis. It was formed by MinasGerais, Rio de Janeiro, Espirito Santo and Rio Grande do Sul in 1989. In 1998 and 2003, the regime increase and now is formed by the states locates at South, Southeast and Distrito Federal.
4. Final remarks

It shall be stressed that the analysis presented above was just a preliminary effort to study the target problem. We have limited ourselves to explore only the results for the Moran’s I statistic and the associated Moran Scatterplots and maps. Further research based on significance tests, other LISA based approaches, and spatial econometric models should be considered as a necessary step forward.

However, our study was able to provide some evidence of different patterns in the temporal evolution of Brazilian regional trade with Mercosur as compared with European Union. With regard to regional imports, for both Mercosur and European Union an increasing degree of spatial correlation took place between 1989 and 2003 resulting in augmented concentration in the south regions. With regard to regional exports, two dissonant movements has taken place: for Mercosur, the same pattern of increasing spatial autocorrelation with concentration in the south regions has occurred; however, for European Union, regional exports has showed up a diminishing degree of spatial autocorrelation and thus a reduction in the degree of concentration in the south regions.

Although the tools of analysis we have used did not allow us to asses the impacts of these movements on Brazilian trade as whole - an important side of the problem to be examined in the future - the latter finding regarding the different patterns of regional exports bears relevant implications for the regional disparities in Brazil. While regional imports, either from Mercosur or European Union, are getting each time more concentrated in the south regions, the behavior of regional exports have produced dissonant impacts on the regional disparities of economic development. In other words, exports to Mercosur have worked up to keep regional economic development concentrated in the south, while exports to European Union have worked up to redistribute such development towards other regions of the country.
References


Table 1. Moran’s I statistics for Brazilian states’ per capita trade with Mercosur and European Union (1989, 1998 and 2003)

<table>
<thead>
<tr>
<th>Trade Variable</th>
<th>Moran's I</th>
<th>Std. Dev.</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mercosur</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Per Capita Exports</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. 1989</td>
<td>0.3286</td>
<td>0.1143</td>
<td>0.0050</td>
</tr>
<tr>
<td>. 1998</td>
<td>0.5173</td>
<td>0.1053</td>
<td>0.0010</td>
</tr>
<tr>
<td>. 2003</td>
<td>0.4822</td>
<td>0.1164</td>
<td>0.0010</td>
</tr>
<tr>
<td><em>Per Capita Imports</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. 1989</td>
<td>0.1446</td>
<td>0.0645</td>
<td>0.0110</td>
</tr>
<tr>
<td>. 1998</td>
<td>0.1941</td>
<td>0.0191</td>
<td>0.0160</td>
</tr>
<tr>
<td>. 2003</td>
<td>0.4781</td>
<td>0.1054</td>
<td>0.0020</td>
</tr>
<tr>
<td><strong>European Union</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Per Capita Exports</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. 1989</td>
<td>0.3269</td>
<td>0.1108</td>
<td>0.0070</td>
</tr>
<tr>
<td>. 1998</td>
<td>0.1544</td>
<td>0.1111</td>
<td>0.0041</td>
</tr>
<tr>
<td>. 2003</td>
<td>0.0924</td>
<td>0.1023</td>
<td>0.1130</td>
</tr>
<tr>
<td><em>Per Capita Imports</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. 1989</td>
<td>0.1368</td>
<td>0.1107</td>
<td>0.0760</td>
</tr>
<tr>
<td>. 1998</td>
<td>0.3081</td>
<td>0.1079</td>
<td>0.0090</td>
</tr>
<tr>
<td>. 2003</td>
<td>0.3620</td>
<td>0.1166</td>
<td>0.0060</td>
</tr>
</tbody>
</table>

Note: The expected value for Moran’s I statistic is constant for each year: E(I) = -0.0385
Figure 1. Moran Satterplot: Per Capita Exports – Mercosur

a) 1989

b) 1998

c) 2003
Figure 2. Per Capita Exports – Mercosur
Figure 3. Moran Satterplot: Per Capita Imports – Mercosur
Figure 4. Per Capita Imports – Mercosur
Figure 5. Moran Satterplot: Per Capita Exports – European Union
Figure 6. Per Capita Exports – European Union

a) 1989

b) 1998

c) 2003
Figure 7. Moran Satterplot: Per Capita Imports – European Union
Figure 8. Per Capita Imports – European Union

a) 1989

b) 1998

c) 2003