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Absorptive Capacity of Positive Externalities in the Added Value of Rio de Janeiro State

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ABSTRACT

The present work has the objective of understanding the influence of spatial externalities on the creation of value in the state of Rio de Janeiro. An exploratory analysis of spatial data and a multiple regression complemented by a spatial autocorrelation model are used as methodological support; both are fed with official data from the Ministry of Labor, the Ministry of Finance (RJ), IBGE, FIRJAN and the DataViva platform. The results indicate the capacity of absorption of spatial concentration externalities and economic diversity externalities, and a negative influence of education externality on the composition of added value of the municipalities of Rio de Janeiro. This contradiction, where richer regions present a low predominance of education while poorer regions present a higher predominance of education in the Rio de Janeiro state, is an important research finding inverse to the debate in the literature that considers education as a relevant foundation of both wealth creation and consequent insertion of the regional environment in the context of digital transformation.

KEYWORDS: Positive Externalities, Absorptive Capacity, Rio de Janeiro, Spatial Autocorrelation.

1. INTRODUCTION

Brazil is, historically, one of the countries with the largest economies in the world. Only the state of Rio de Janeiro, one of the twenty-seven

Brazilian states, contributes to more than 10% of the country's gross domestic product, thus occupying the second largest economy among the Brazilian states. To achieve this result, the state has a strong service sector and a representative industrial park.

Industry in the state of Rio de Janeiro, which is the second largest sector responsible for state GDP, is heavily linked to metallurgy and oil production, activities that are highly extractive and are not heavily associated with a manufacturing industry (Silva, 2012). Still regarding about the extractive industry, the state is also strong in limestone, dolomite and salt production. Oil activity in turn is one of the great foundations of the state economy, having a very strong impact on several indicators.

It is natural that for a state with strong industrial character to have the occurrence of productive agglomerations, even those with a high degree of specialization. This is due to the creation and exploitation of synergies between companies when they share a defined geographical area. These cooperative relationships occur through diverse connections, whether horizontal or vertical, creating a series of peculiarities that make these companies more productive and competitive. These agglomeration of companies, sometimes with similar characteristics and unique relationships within the same location, generate benefits called positive externalities.

Considering particularly the state of Rio de Janeiro, it is important to note the existence of an unequal spatial distribution of productive agglomerations throughout its territory and regions[1] (CEPERJ). The Northern Region of the state of Rio de Janeiro is known for hosting companies that are heavily involved in the petroleum sector, and large projects such as the Açu Port Complex. The Metropolitan Region of the state, although linked to petroleum, also has an extensive diversified industrial sector and is home to many national and international-level companies. The Mountainous Region and North Region of Rio de Janeiro, in turn, are known for their clothing and textile industries. The Region of the Middle Paraíba, strategic for being a link of connection with other states, is home to the second largest agglomeration of industries of the federation of Rio de Janeiro. And the Northwest Region, although having a minor representativeness, has industries of the agricultural sector.

It is extremely important, therefore, to determine how the distribution of these agglomerations occurs in the state of Rio de Janeiro, and the

capacity to absorb positive externalities within this context. The present article is divided in six sections counting the introduction, being the next five respectively: bibliographical revision, with information of diverse studies on the subject; methods, where the analysis model will be described; results, where the relevant information will be extracted from the analysis model; discussion, with a comparison and reflection of the important information; and lastly the final considerations.

2. BIBLIOGRAPHIC REVIEW

Research on the capacity to absorb positive externalities in specific territories is an object of investigation already seen by relevant studies and authors. The existence of the need to understand the theme combined with the unique interests of each location regarding its capacity for absorption essentially fosters studies in the area (Caragliu and Nijkamp 2016).

Still in the context of studies about this subject, Vale and Castro (2010) propose the existence of three large integrated blocks of reflection. The first, the "typology of regional analysis and neoclassical inspiration" is linked to aspects attached to the perceptions of neoclassical economics, related to the presuppositions of strict rationality and successors of the "regional economy". The second is the "typology of regional analyzes of industrial organization". This is a direct heir of Marshall, with emphasis on literature on industrial districts (emphasis on the role of agglomerations in the generation of externalities and regional assets) and clusters (emphasis on competition and cooperation territorial dynamics). Finally, the third, the "typology of regional analyzes of institutional inspiration", with two lines of reflection: transaction costs theory, represented by Williamson; evolutionary institutional economy, represented by Schumpter.

A more specific cluster definition, made by Albuquerque and Brito (2002), is linked to the high need of a concentration of both sectoral and geographical companies, which generates externalities and consequently greater efficiency. A cluster has as its main characteristics the territorial proximity of economic agents, political, social, and interorganizational networks formed between them (Hoffman *et. al*., 2006 and Latres and Cassolato 2009).

Porter (1990) defines a cluster as a group of companies concentrated in the same geographical space delimited and in an interrelated way, with

the presence of related institutions, which may be a district, city, state or country. He also points out that different agglomerations have disparities in their degrees of sophistication, but that most of them include suppliers, companies and related financial institutions.

Similarly, the same region may have different agglomerations. In this case, each company in the cluster can participate, as it wishes, in different forms of interaction. The resurgence of this approach, which centrally places a specific locality or region as the focus of innovative and competitive advantages since 1970, is exemplified by regional economies and industrial districts such as Silicon Valley in California, Third Italy, Baden-Wurttemberg, *et al*. whose success was driven by the dynamism of local assets (Melo *et al*., 2012).

Regardless of the nomenclature used to designate different types of industrial agglomerations, Pugas et al. (2015) argue that in all of them there is a certain use of the synergies that are generated by the interactions between the companies of a cluster, which makes this environment more prone to the survival and growth of these companies. These synergies, also called positive externalities, can be productive or technological, and induce a higher level of competitiveness and efficiency. These externalities may also be classified into four types: Marshallians (productive dimension), schumpterians (innovative), Transactionals (information and knowledge exchange) and Jacobians (urban dimension).

Jorge and Dantas (2009) in his study about the phenomenon of the absorption of externalities highlight the importance of a qualified labor in the process of positive overflow of productivity from the foreign companies to nationals. This process can occur when a firm has an expressive number of skilled workers, since this makes higher the chances of absorbing external technological knowledge, and thus self-benefiting from productivity overflows.

Other studies also show the importance of the training of the workforce for this absorption of externalities occurs. In the field of innovation, Foster-McGregor *et al.* (2017) investigated the key role of knowledge diffusion through R&D investments and concluded that absorption capacity is commonly greater when both the industry in the country is more backward allied and the human capital is more educated. Mancusi (2008) argues that the positive externalities generated through international knowledge flows will depend on the country's ability to absorb this external knowledge, as it is possibly easier for those who invest in research and development.

The spatial concentration of these firms is extremely important in determining the capacity to absorb externalities. When companies, whether national or multinational, share the same geographic space, they allow the occurrence of positive externalities since this transfer occurs through channels of demonstration and imitation, labor volatility and interconnections between companies (Jordaan 2005). It is important to mention that productivity spillovers between firms, especially in agglomerations, can take place vertically (relationship between buyer and supplier firms and their advantages generated) or horizontally (relationship between competing firms, which stimulates innovative capacity and stimulates development) (Gonçalves 2005).

Crespo and Fountoura (2007) conducted a survey in which they analyzed a vast literature investigating the existence of foreign direct investment externalities on national companies that could be translated into productivity gains. They evaluated that the most common procedure used to make this evaluation consists of a regression where productivity is assumed as a dependent variable of the relevance of the foreign presence. They concluded that despite the expectation of positive effects from externalities on domestic firms, more recent studies using newer econometric techniques have challenged this consensus, and some of them have also shown the evidence of a negative influence on domestic firms.

3. METHODS

The methodology formulated with the purpose of analyzing the absorption capacity of positive externalities in the creation of value in the municipalities of Rio de Janeiro was based on a spatial analysis composed of two parts: an exploratory analysis and an econometric model. This model of analysis is similar to the one proposed by Rezende *et al*. (2016) and has the modification of some variables to improve and adapt the model to the state of Rio de Janeiro.

The first, the exploratory spatial data analysis (ESDA), identifies patterns of spatial associations using the global statistical indicator of spatial autocorrelation Moran's I. Since this indicator is generated globally, that is, a single value as a measure of spatial association for each observation, it may obscure certain local patterns. For this reason, this indicator is decomposed with the purpose of grouping similar values around a single observation, that is, spatial clusters that are statistically significant.

The clusters identified by ESDA present autocorrelation that can be positive or negative. When it is positive, there is a statistically significant similarity in the value of the attribute studied between certain localities, and it may be that ratio between "high/high" values (a cluster of high values of a certain variable) or "low/low" values (a cluster of low values of a certain variable). When it is negative, there is a statistically significant difference in the value of the attribute studied between nearby localities, and it may be that ratio between "high/low" values (a cluster of high values surrounded by one of low values) or "low/high "(a cluster of low values surrounded by one of high values).

The second part of the spatial analysis is based on an econometric model that captures the capacity of absorption of the externalities generated by the variables of economic diversity, education and market structure on the creation of value in the municipalities of Rio de Janeiro. Initially a multiple regression is performed, and a statistical technique used to analyze the relationship between a dependent variable (criterion) and independent (predictor) variables. The proposed regression model is given by:

$$Ln(VA) = \alpha + \beta 1\ IFDM\text{-}edu + \beta 2\ DivOcup + \beta 3\ NumEmp \quad (1)$$

Where:

- **Ln(VA):** Added Value, measures the additional value created when purchases goods and services are transformed by a productive process in each one of the municipalities of Rio de Janeiro. To reduce the heterogeneity of the data and to smooth its numerical scale with others, the natural logarithm was applied.
- **IFDM-edu:** FIRJAN index of municipal development (education), is a social indicator that captures the quality of education provided until elementary school. It is an indicator of human capital.
- **DivOcup:** Effective Diversity of Occupations, is an indicator of the economic diversity of a locality as it accounts the number of unique occupations (4 CBO digits) that are present being corrected by the participation that each unit represents. This index captures both the diversity of the labor market and the complexity of the economy, thus the economic diversity.
- **NumEmp:** Number of operating companies, measures the market structure of a locality through the number of companies operating in

it. It indicates the concentration of companies and the competitive advantages generated.

The data above was collected, respectively, on the website of the Ministry of Finance-RJ 17. (Ministério da Fazenda, 2018), FIRJAN website (FIRJAN, 2018), DataViva platform (Plataforma DataViva, 2018) and IBGE website 11. IBGE (2018); all data analyzed refer to the year 2013, due to the unavailability of all data for a most recent period. The latest version of the IFDM refers to the year 2013. The software used for the application of statistical tools is GeoDA, a free and open source with focus on the introduction of spatial data analysis, exploring and modeling certain spatial patterns (Anselin *et al*., 2006).

4. RESULTS

Based on ESDA, the local spatial autocorrelation patterns are identified through the local indicators of spatial association (LISA) for the variables: Added Value, IFDM-edu, Effective Diversity of Occupations, and the Number of Operating Companies. The Moran's I value is also given for each of them.

Illustration 1 below shows the local spatial autocorrection patterns of Added Value variable.

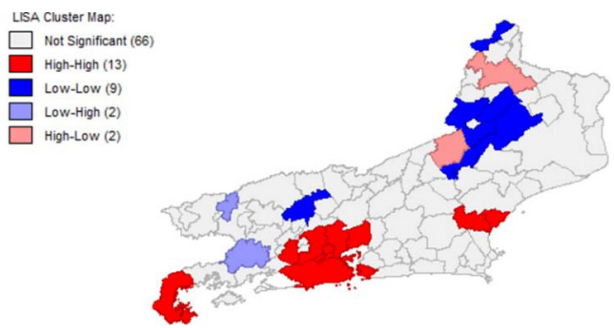

Illustration 1 - Added Value Clusters

For the Added Value variable, Moran's I is 0.319. As can be seen in figure 1, there is a cluster of high values in the Metropolitan Region formed by

the municipalities of Belford Roxo, Duque de Caxias, Magé, Mesquita, Niteroi, Niterói, Nova Iguaçu, Rio de Janeiro, São João de Meriti and Seropédica. Another cluster of high values of the Added Value variable is seen in the north of the Coastal Region composed of the municipalities of Casimiro de Abreu and Rio das Ostras. In contrast, there is also a cluster of low values between the Northwest Fluminense and Serrana Regions formed by the municipalities Cambuci, Cordeiro, Itaocara, Macuco, Miracema, Santo Antônio de Pádua, São José de Ubá and São Sebastião do Alto; there is a "low/high" relation on the part of this grouping with the municipalities of Cantagalo and Itaperuna.

Illustration 2 below shows the local spatial autocorrection patterns of the occupancy Diversity variable.

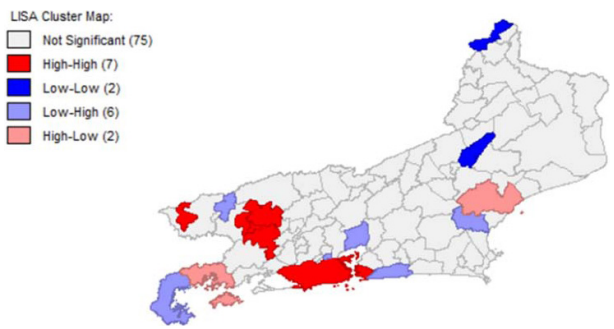

Illustration 2 – Effective Diversity of Occupations Clusters

For the variable Effective Diversity of Occupations, Moran's I index was only 0.011. As shown in Illustration 2, there is a small cluster of high values in the Metropolitan Region formed by the municipalities of Niterói and Rio de Janeiro. There is also another cluster of high values in the Region of the Middle of Paraíba formed by the municipalities of Barra do Piraí, Pinheiral, Piraí and Volta Redonda. Other clusters reveal a "high/low" relationship, such as Angra dos Reis (high) and Paraty (low), and Macaé (high) and Casimiro de Abreu (low).

Illustration 3 below shows the local spatial autocorrection patterns of the IFDM-edu variable.

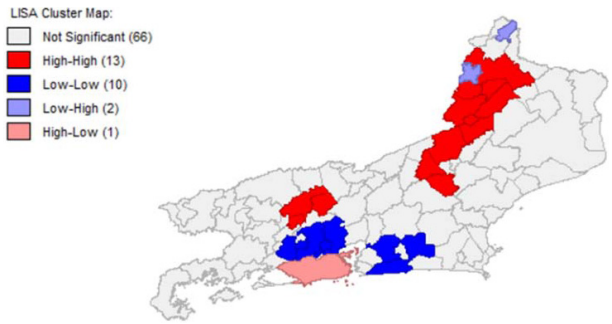

Illustration 3 – IFDM-edu Clusters

For the IFDM-edu variable, Moran's is 0.323. Illustration 3 illustrates the existence of a cluster of high values in the Northwest and Serrana Regions formed by the municipalities of Aperibé, Bom Jardim, Cambuci, Cantagalo, Dois Barras, Itaperuna, Laje do Muriaé, Miracema, Santo Antônio de Pádua and São José of Ubá. Another cluster of high values is located in the Center-South Fluminense Region formed by the municipalities of Engenheiro Paulo de Frontin, Paty do Alferes and Vassouras. In the Metropolitan Region there is a "low/high" cluster formed by the municipalities of Belford Roxo, Duque de Caxias, Mesquita, Nova Iguaçu, Queimados, São João de Meriti, Seropédica and Rio de Janeiro (high). In this same region there is another cluster of low values formed by the municipalities of Itaboraí, Maricá and Rio Bonito.

Illustration 4 below shows the local spatial autocorrection patterns of the Number of Companies variable.

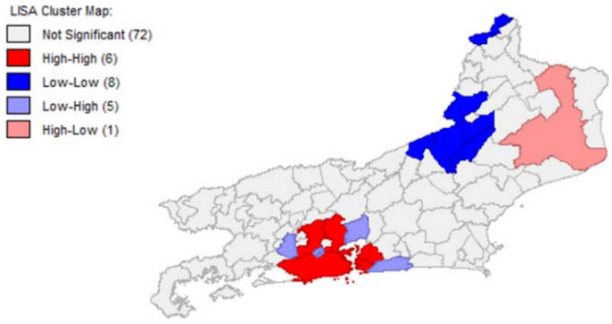

Illustration 4 – Number of Operating Companies Clusters

For the variable Number of Operating Companies, Moran's I is 0.047. Figure 4 shows a cluster of high values in the Metropolitan Region formed by the municipalities of Niterói, Nova Iguaçu, Rio de Janeiro, São Gonçalo and São João de Meriti. Some municipalities showed a "low/high" relationship with this group, being Magé, Maricá, Mesquita, Nilópolis and Seropédica. A cluster of low values can be seen between the Regions Northwest Fluminense and Serrana composed by the municipalities of Cantagalo, Carmo, Cordeiro, Itaocara, Macuco, Santo Antônio de Pádua and São Sebastião do Alto. The municipality of Campos dos Goytacazes shows a relationship of "high/low" with others around.

The second part of the spatial analysis consisted in the application in a spatial regression model that uses as base the equation (1) with the purpose of explaining the spatial effects of externality variables on the construction of Added Value in the municipalities of Rio de Janeiro.

$$\text{Ln (VA)} = \alpha + \beta 1\ \text{IFDMedu} + \beta 2\ \text{DivOcup} + \beta 3\ \text{NumEmp} \qquad (1)$$

The multiple regression showed an adjusted r-squared of 0.64. The number of multicollinearity condition was lower than 30 (29,61), indicating the non-presence of multicollinearity. The Jarque Bera test of non-collinearity was not significant (significance of 0.1), accepting the null hypothesis of a normal distribution. All the tests of heteroskedasticity accepted the null hypothesis that the variance is constant, not showing significance for the rejection of the null hypothesis, being them Breusch-Pagan test (significance of 0.23), Koender-Bassett test (significance of 0.25) and White Test (significance of 0.32). Moran's I index was significant (significance of 0.01) to reject the null hypothesis of non-spatial dependence.

Thus, the only test to choose the best spatial regression model that proved to be significant was the Spatial Lag Model, having a Robust LM (lag) with a significance of 0.00337. For the Spatial Lag Model, the values of the constant and the independent variables are shown in Illustration 5 bellow. All the variables were significant in the composition of the model.

Variable	Coefficient	Probability
Constant	12.4674	0.00000
DivOcu	0.060148	0.00000
IFDM-edu	-4.135	0.01673
NumEmp	1.59457e-005	0.00239
W_lnVA	0.352396	0.00002

Illustration 5 – Coefficients and Probabilities of Variables from Spatial Lag Model

For this final model, the r-squared is 0.71, a value higher than the adjusted r-squared of 0.64 from the common multiple regression, which indicates the improvement of the model.

5. DISCUSSION

The results obtained by the explanatory models show certain local and global patterns for each of the presented variables. Firstly, the local and later global standards were discussed through the spatial regression model.

The high Added Value cluster in the Metropolitan Region, shown in Illustration 1, demonstrates not only the concentration of Added Value in the capital Rio de Janeiro, which alone holds almost 40% of the total value, but also in the cluster, reaching a value of almost 59% of all Added Value of the state. This shows a very strong Added Value concentration in only 9 of all 92 counties, in the capital and some adjacent cities. In contrast, the cluster of low values between the Noroeste Fluminense and Serrana Regions is not responsible for making up 0.3% of the state Added Value. This shows a completely unequal creation of Added Value in the state of Rio de Janeiro, super concentrated in the capital and surrounding cities, and with small values in the northwest of the state.

Illustration 2 shows only two groups of high values for the Effective Diversity of Occupations index: one in the Metropolitan Region and another in the Middle Paraíba Region. Although the Added Value is concentrated in several cities of the Metropolitan Region, only the cities of Rio de Janeiro and Niterói have a significantly higher index of effective diversity of occupations in this area, with an average value of 94.25, a

value much higher than the average state of 57.90. This shows that these two cities benefit from better economic dynamics than their neighboring cities. There is another cluster of high values in the Middle of Paraíba Region, with a mean value of 76.21. Macaé is isolated as a value far superior to those who are around (113,84), because there is a complex economy in the petroleum sector.

There is a large cluster of high values for the index of IFDM-edu, as seen in Illustration 3, in the Northwest and Serrana Regions, with a value of 0.836, considered high, while the general mean of the state is 0.775, considered moderate. Another cluster of high values is in the Central South Region with a value of 0.801. The cluster of values of the Metropolitan Region of the river is considered moderate, with 0.666, well below the state average. Also in the Metropolitan Region, the other cluster has a value of 0.748, considered moderate, and although not as low as the value of the other cluster in the same region, is also below the state average. These two clusters in the Metropolitan Region indicate the weakness of the region in education.

As for the variable Number of Operating Companies, there are two groupings of values as illustrated in Illustration 4: One of high values in the Metropolitan Region that alone holds 61% of state companies; and another between the Serrana and Northwest Regions, composed of 7 cities, with only 1% of the state companies. One way to materialize as the distribution of companies in the state occurs irregularly, only the city of Campos dos Goytacazes holds 2.45% of the number of state companies, a value two and a half times higher than the group previously presented.

According to the clusters generated through the LISA analysis, it can be noticed that the clusters of high values of the Added Value variable are related to clusters of high values of the variables Effective Diversity of Occupations and Number of Companies Operating. Surprisingly, the opposite occurs with the IFDM-edu variable: The relationship between Added Value Creation and Education is inversely proportional. High value clusters of the Added Value variable tend to have low values of the variable IFDM-edu; and high value clusters of the IFDM-edu variable tend to have low values of the variable Added Value.

This reading of the clusters revealed by the LISA analysis is also stated in the econometric model: the constants' value of the spatial lag regression shown in Table 1 reveals that all the independent variables have positive

values except the IFDM-edu variable, with negative coefficient. The creation of Added Value in the municipalities of Rio de Janeiro can be explained, mostly, by the econometric model proposed. However it also reveals that if there is the capacity of absorption of the externalities of economic diversity and concentration of companies, the opposite can be said of the variable education, since even if its influence on the regression model is significant, it shows an inconsistency in the state of Rio de Janeiro where clusters of cities with lower levels of education tend to have a greater creation of Added Value.

6. FINAL CONSIDERATIONS

The model proposed to investigate the existence of the capacity to absorb positive externalities proved to be very effective both in terms of a detailed analysis of certain groups in the territory of Rio de Janeiro and in terms of a comprehensive analysis for the whole state.

According to the results obtained, it was proved the existence of capacity to absorb the externalities of economic diversity and market structure in the creation of Added Value in the municipalities of Rio de Janeiro, while the absorption of the externality of education was inversely proportional to the creation of Added Value. The method of evaluating the absorption capacity was also efficient in terms of its statistical validation and the results obtained.

It was also verified the existence of spatial dependence in the creation of Added Value with the use of spatial lag model, where the autocorrelation is attributed to the own variable response in the search for a model more appropriate to the studied territory. The application of the spatial lag model further improved the regression results, also revealing the unequal form in which the variables studied are distributed throughout the state, that is, Added Value clusters in the state of Rio de Janeiro have a strong pattern of heterogeneity. Regions which receive a large amount of investments have demonstrated ability to concentrate wealth, while regions of low investment the pattern of wealth generation is much lower, as its concentration.

It is important to mention the contrast between indicators of education and creation of Added Value, a comparison that resulted a different response than expected. Municipalities with a high education rate and, consequently, high human capital, should excel in the construction of added value. In contrast, municipalities with high levels of education had, for the most part, minimal contributions to the creation of value.

Paradoxically, the richer regions had a lower predominance of education. This contradiction is an important finding of the research that shows a profile of the peripheral region inverse to the debate in the literature on the subject, that is, education constitutes a relevant foundation of wealth generation and the consequent insertion of the regional environment in the context of digital transformation. This logic may not be generalized. Other elements act in the formation and distribution of wealth regionally.

Given the results obtained, it is verified the importance of this study to understand the creation of value in the state of Rio de Janeiro and the variables that contribute to its design. Indeed, further studies to improve the current model and to seek a deeper understanding between the variables education and added value and their inversely proportional values are recommended.

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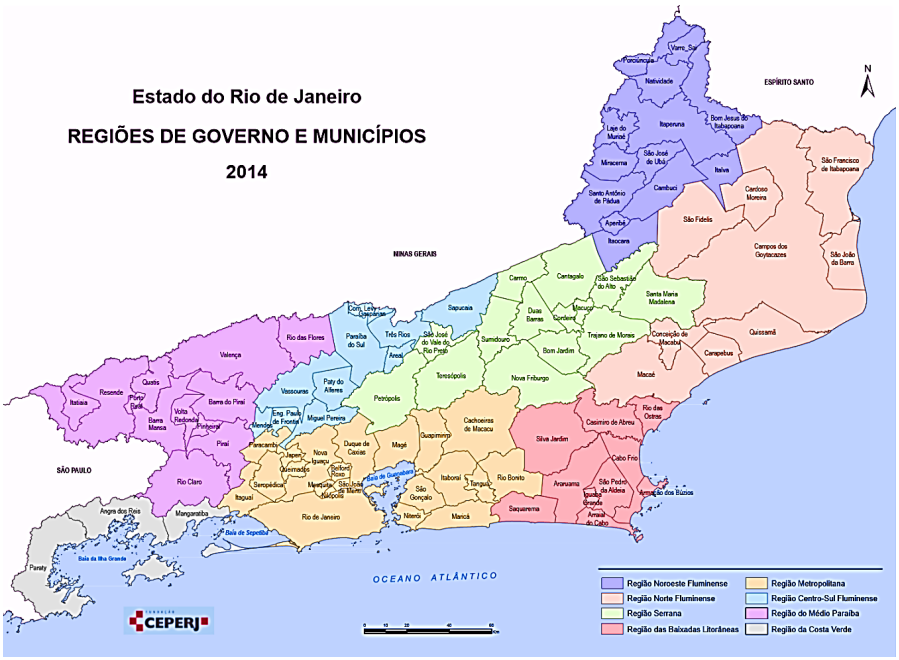
APPENDIX



Notas Finais

[1] The map showing different government Regions and municipalities of Rio de Janeiro state may be seen on Appendix.