# Industrial Policy and Export Productivity: Analysis by Company Size and Microregions

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**Abstract:** This study aimed to investigate the possible spatial relationship between resources granted by the Brazilian Development Bank (BNDES) disaggregated by company size and export productivity in Brazil's micro-regions. The study period was between 2009 and 2020. Data showed that most BNDES resources earmarked for the manufacturing industry were concentrated in the South and Southeast, particularly in the microregions close to the main commercial centers. By contrast, a pattern of low intensity in financing and productivity was observed in the microregions located in the country's central area. The econometric results indicate the spatial spillover effects of BNDES financing on microenterprise export productivity across various microregions. Additionally, network analysis revealed that the microregions with the highest export volumes were not in the main cluster, indicating that they mainly exported simple or low-productivity products.

**Keywords**: BNDES, Size of companies, Microregions, Export productivity
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## 1 INTRODUCTION

This study aims to determine whether there is a positive relationship between the BNDES credit and the sophistication of the productive structure of Brazil's microregions. Simultaneously, it determines whether the intensity of this spillover varies depending on the size of the companies that receive funds.

Depending on the results, the study intends to infer the extent to which the granting of loans by the BNDES is trapped in a process of endogeneity, verifying what the study calls the "Tostines paradox trap." This "trap" refers to a process in which a public policy instrument ends up being captured by the companies with the best conditions to access it and, precisely because of this condition, will be the companies that least need the given public policy instrument. This creates a virtuous circle for companies with higher productivity which, by receiving more resources, further increases their conditions for receiving resources from other public sources. This is advantageous for companies that are already competitive; however, in the meantime, it becomes an obstacle for companies that, because of numerous structural problems, have low productivity.

The general objective of this study is to verify whether there is evidence of a spatial relationship between BNDES resources (by company size) and the export productivity of Brazil's microregions. The Hausmann et al. (2007) method was used to create the export productivity index. Spatial econometrics was used to analyze how the microregions are associated with each other in terms of productivity spillover and how this may be associated with the resources received from the BNDES.

This study considers the relevance of structuralist theory and emphasizes points of divergence from it, mainly the idea that structural change occurs with a shift from low- to high-productivity sectors. The greatest divergence, which is the cause of heterogeneity in terms of national productivity, lies in the different sizes of companies: large companies with high productivity and small companies with low productivity. In other words, the problem is not mainly sectoral as traditionally considered by structuralist authors.

This study is divided into five sections. Section 2 presents a literature review. Section 3 discusses the methodology, with the source and database, and Section 4 presents the results of the network analysis, exploratory analysis of spatial data, and econometric model. Section 5 presents the final considerations of the study.

## 2 LITERATURE REVIEW: PRODUCTIVITY AND INFORMALITY IN BRAZILIAN SMALL BUSINESSES AND THE RELATIONSHIP WITH INDUSTRIAL POLICIES

This section addresses the interrelationship between productivity and informality in small businesses in Brazil and highlights how informality reflects a country's economic and social conditions. Studies suggest that informality, far from merely being a transgression, is a survival and adaptation strategy for many businesses that directly affects productivity. The lack of effective public policies that encourage formalization and provide access to resources such as credit and training is identified as one of the main obstacles to the growth of these companies. This section also discusses the strategies implemented in Brazil between 2003 and 2016, which has limited results despite efforts. Policies focus on established sectors without promoting necessary economic diversification or innovation.

### 2.1 Productivity and informality in Brazilian small businesses

Productivity of small businesses in Brazil is a widely discussed topic in the literature, particularly in relation to the informality that permeates this sector. According to Nogueira and Zucoloto (2019), informality should not be seen as a mere transgression but as a historical response to the country's economic and social conditions. The authors argued that informality and semi-formality were common characteristics among companies of various sizes and sectors, reflecting a culture of adaptation and survival. This perspective is corroborated by studies that indicate that informality represents a significant portion of Brazilian economic activity, with generally low productivity levels.

The literature also points out that informality limits small businesses' access to essential resources such as credit and training, directly affecting their productivity. According to Nogueira and Zucoloto (2019), the lack of effective public policies supporting small businesses is one of the main obstacles to their growth. Soto (1987) discusses how bureaucracy and the lack of incentives for formalization contribute to the perpetuation of informality, making it difficult for companies to transition to a formal status.

Furthermore, the history of Brazilian society, marked by a culture of occupation and adaptation, sustains informality. The social and economic formation of Brazil, which has historically valued the way of "get by," influences how small businesses operate. This adaptation is often necessary for survival in challenging economic environments where creativity and innovation are essential.

Bresser-Pereira (2010) addressed the issue of informality by discussing the importance of public policies that promoted economic and social inclusion, highlighting that formalization could lead to an increase in the productivity and competitiveness of small businesses.

Maloney (2004) re-evaluated the traditional understanding of informality in the labor markets of developing countries. The author argues that informality is not merely a subsistence sector for those excluded from formal employment but can be a strategic choice based on rational considerations. He suggested that workers and entrepreneurs opted for informality to avoid the high costs of formalization and maintain operational flexibility. This study analyzes empirical data from Latin America, shows that informality is often associated with productivity levels comparable to those in the formal sector, and discusses policies that can encourage formalization without sacrificing the benefits that it provides.

Amitrano et al. (2023) revealed that the Brazilian Labour Reform (BLR), implemented in 2017, had largely failed to foster a meaningful recovery in employment levels following the 2015–2016 crisis. This led to a significant increase in informal employment, with more workers in precarious positions and without formal contracts, thus reversing the previous decline in informality. This shift resulted in a growing share of employment in low-productivity sectors. By contrast, formal employment in high-productivity areas has decreased, raising concerns about the overall productivity and economic growth. The BLR has been criticized for institutionalizing informality and making it more difficult for workers to access legal protection, ultimately exacerbating existing labor market issues and negatively affecting GDP and labor productivity growth.

Nogueira and Zucoloto (2019) proposed the implementation of public policies that encourage formalization and training to improve the situation of small businesses. This includes access to credit, professional training, and support for innovation, all of which are crucial for increasing the competitiveness and sustainability of small businesses. The study suggests that a more favorable business environment can facilitate the transition of companies from informality to formality, promoting an increase in productivity and contributing to a country's economic development.

In summary, the informality and low productivity of small businesses in Brazil are interconnected issues that demand critical analysis and implementation of effective solutions, requiring a deeper reflection on public policies aimed at this vital sector of the economy.

Some studies have also addressed the issues of small businesses in other countries. Kallmuenzer et al. (2024) discussed the adoption and performance outcomes of digitalization in small and medium-sized enterprises (SMEs). They highlight that while some SMEs can leverage digital technologies to optimize processes and improve efficiency, many face difficulties owing to uncertainty and cultural resistance. Qualitative research conducted through interviews revealed that factors such as the availability of appropriate technologies and the digital skills of the workforce facilitated digitalization. Conversely, a risk-averse culture and dependence on legacy systems are significant barriers. The study concludes that a strategic balance between these elements is crucial for effective digitalization in SMEs, providing valuable insights into the factors influencing their adoption and performance outcomes in the context of SMEs.

Castro-Silva and Lima (2023) explored the difficulty faced by knowledge-intensive small businesses in retaining highly skilled workers, emphasizing the importance of knowledge intensity in employment duration. Using a Portuguese dataset that associated employers and employees and a proportional hazards model, the authors demonstrated that skilled workers in small businesses faced a penalty in terms of employment duration, unlike those in large companies where there was a duration premium. Even small companies that pay above-market wages struggle to retain these workers, limiting their ability to innovate. This study suggests the need for policies that reduce barriers to knowledge and recognize human resources as essential assets for new companies.

Owalla et al. (2022) provided a systematic review of the literature on the productivity of SMEs. This study highlights the importance of SMEs for economic growth and job creation, particularly in developed economies. This review focuses on the internal and external factors affecting SME productivity. The main themes identified were organizational environment, organizational capabilities, investments, types of innovation, external knowledge base, and commercialization. The analysis reveals the fragmented nature of the current research and proposes a future research agenda that includes broader comparative analyses within SMEs and between SMEs and large companies, a holistic approach to understanding human capital in SMEs, the importance of contextual factors such as geographic location and socioeconomic conditions, and methodological improvements to better capture the dynamics of SME productivity. The policy implications suggest that policymakers should focus on sustainable support for SMEs, including training, facilitating collaborations, and targeted interventions that consider company-specific factors such as size, age, sector, and location.

### 2.2 Industrial policies and economic development in Brazil

During the Workers' Party governments (2003–2016), Brazil implemented three main industrial policies: the Industrial, Technological, and Foreign Trade Policy (*Política Industrial, Tecnológica e de Comércio Exterior*, PITCE) in 2004; the Productive Development Policy (*Política de Desenvolvimento Produtivo*, PDP) in 2008; and the Greater Brazil Plan (*Plano Brasil Maior*, PBM) in 2011. These policies aimed to stimulate the country's economic and industrial development but faced significant challenges, such as the 2008 financial crisis, which shifted the focus of the policies toward countercyclical measures at the expense of the continuity of previously established industrial strategies.

Despite these efforts, the results of these policies have been mixed. The allocation of resources through the BNDES to established sectors (Almeida et al., 2014), such as meat, mining, and oil, has reinforced static comparative advantages rather than promoting the diversification of Brazil's productive structure and increasing the country's economic complexity. The lack of diversification and continuation of protectionist practices had limited the positive impact that these policies could have had on the national economy.

Stumm et al. (2019) highlighted that the results of industrial policies during the Lula administration fell short of expectations because of an asymmetry between costs and benefits as well as failures in the clarity and prioritization of sectors. Arbix et al. (2017) reinforced this assessment by arguing that a lack of focus on innovation was a critical factor compromising the success of these policies. They suggest that future industrial strategies should place innovation as a central objective for achieving effective and sustainable economic diversification in Brazil.

Pineli and Narula (2023) argued that despite the initially similar import substitution industrialization strategies adopted by Brazil and Mexico between the 1950s and the 1970s, based on structuralist diagnoses such as those of Prebisch and Furtado, both countries faced limits in developing internationally competitive capabilities. The debt crisis of the 1980s marked the exhaustion of this model, leading to profound changes: Mexico implemented radical liberal reforms and became deeply integrated into global value chains through exports and foreign direct investment (FDI), particularly from the United States; however, Brazil pursued more gradual reforms and maintained a stronger focus on the domestic market. Despite these divergent trajectories, both countries converged toward a similar outcome: low sustained economic performance characterized by unstable growth and limited structural impact from foreign investment.

Gaspi and Silva (2024) have analyzed how the strength of social counter-movements (such as labor unions and civil organizations) influences the formulation of industrial policies in Brazil, particularly on the role of the BNDES as the main instrument of state financing. The authors show that in sectors with strong social mobilization, such as the automotive industry, the BNDES conditions its financing on requirements associated with local content, innovation, and job creation, thus characterizing a neo-corporatist regime. By contrast, in the animal protein sector, marked by the absence of social pressure, banks massively financed companies such as JBS and even acted as shareholders without imposing relevant conditionalities, configuring a disembedded neoliberal regime and practices of corporate welfare. In the pharmaceutical sector in which social mobilization was more diffused, BNDES support came with selective conditionalities, resulting in an embedded neoliberal regime.

Giesteira et al. (2024) conducted a comparative analysis of the economic and technological dynamism of Brazil's industrial sectors from 2007 to 2020, aiming to identify correlations between these outcome variables and the implementation of sectoral industrial policy, particularly through instruments such as financing from the BNDES and Finep[3], as well as public procurement. The findings suggested that most sectors did not significantly diverge from the general patterns observed in the manufacturing industry, that exceptional performance was not necessarily associated with the diversity of policy instruments, and that high-technology sectors appeared to have responded particularly well to the combined use of BNDES and Finep financing alongside public procurement.

For more information on the industrial policies in Brazil, see the articles by Prates et al. (2017), Machado (2019), Stein and Herrlein Jr. (2016), and Salama (2019).

Industrial policies, particularly BNDES financing, play a crucial role in promoting productivity and reducing informality among small businesses in Brazil. However, these small businesses often face significant difficulties in accessing subsidized credit because the criteria established for granting financing tend to favor larger and more structured companies. This situation can create endogeneity problems in public policies because by prioritizing large companies, financing initiatives may inadvertently perpetuate inequality in access to resources, thereby limiting growth opportunities for small businesses. Without the necessary financial support, these companies struggle to invest in technology, training, and innovation, which are fundamental to increasing their competitiveness. Formalization, in turn, not only improves the visibility and sustainability of businesses but also contributes to the creation of a more robust business environment in which small companies can thrive and fully

[3] Finep is a Brazilian public agency that promotes science, technology, and innovation in companies, universities, technological institutes, and other public or private institutions.

integrate into the formal economy, resulting in an overall increase in productivity and the creation of quality jobs. However, as evidenced by this review, it is essential to proceed with caution to ensure that the pursuit of greater formalization of small businesses does not entail costs that outweigh their benefits.

## 3 METHODOLOGY

In this study, we made empirical efforts to create export productivity indices. The detailed project required the application of various methodologies. Initially, we organized and processed the database, associating it with Brazil's productive structure through spatial and network analyses and descriptive techniques (such as spatial indicators, basic statistics and maps). We then developed the indices themselves, interpreting them in the light of theory. Finally, we investigated whether there is a spillover relationship between BNDES funding and the economic complexity of Brazil's micro-regions, considering the size of the benefited companies.

### 3.1 Source and database

In this study, we used data on GDP per capita, exports and BNDES financing for the manufacturing industry in Brazil's micro-regions. GDP per capita data was collected on the platform of the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística - IBGE). Information on exports was collected from the Comex Stat platform (2023), while data on BNDES financing was obtained directly from the institution's platform. We focused on automatic indirect operations from 2009 to 2020. In addition, the financing amounts were adjusted for inflation, based on the IPCA for 2020.

### 3.2 Productivity associated with the export basket (EXPY)

The index that measures the productivity associated with an economy's export basket was proposed by Hausmann, Hwang, and Rodrik (2007). Their proposal was to assess productive efficiency and the level of specialization in the variety of products that an economy export. The calculation of implicit product productivity (PRODY) is obtained by weighting the revealed comparative advantage with the level of per capita income of each micro-region. The following equation shows the index proposed by the authors. This approach has been adapted to suit the objectives of this research.

$$\text{PRODY}_K = \sum_J \frac{\left(\frac{xjk}{x_j}\right)}{\left(\frac{\sum_j x_{jk}}{\sum_j x_j}\right)} Y_j \ , \qquad (1)$$

$PRODY_K$ represents the implicit productivity of the product $k$, $x_{jk}$ refers to the export of product k in micro-region j, $X_j$ refers to the total exports of the *j-th* micro-region and $Y_j$ the per capita income of micro-region *j*. Thus, the numerator $(x_{jk/X_j})$ represents the share of a given commodity in the export basket of the respective micro-region, and the denominator $\frac{\sum_j x_{jk}}{\sum_j x_j}$ represents the share of that same commodity in the country's export basket. The ratio $\frac{\left(\frac{xjk}{x_j}\right)}{\left(\frac{\sum_j x_{jk}}{\sum_j x_j}\right)}$ represents the revealed comparative advantage (RCA) of a microregion. The sum $(\sum_J)$ the weighting of per capita income by the RCA index of a given product, for all microregions, corresponds to the implicit productivity of the product in the country.

About the specialization of the range of exported products (EXPY), this indicator is calculated by adding the share of each product in the export basket of each microregion, multiplied by the PRODY of that product in the country, as shown in the following equation:

$$EXPY_{jt} = \sum_K \frac{X_{jkt}}{X_{jt}} PRODY_K \ , \qquad (2)$$

This index (EXPY) represents the productivity associated with the export basket of a given micro-region *j* in period *t*. $X_{jkt}$ is the export of product *k* in micro-region *j* at time *t*, and $X_{jt}$ is the total export of the micro-region at the time *t*.

Some studies have used the Hausmann, Hwang and Rodrik (2007) index to assess export productivity (Jarreau and Poncet 2009; Minondo 2010; Kume, Piani, and Miranda 2012; Rubin and Waquil 2013; Silva and Batista 2015). However, to our knowledge, only the study by Da Silva and Hidalgo (2016) used the EXPY index specifically for Brazil. More information about these studies can be found in Table A.1 in the appendix.

### 3.3 Spatial analysis concepts

Spatial econometrics focuses on analyzing cases where there is interdependence between different locations, which implies that a region can be affected by nearby regions and even by those further away. For this, an exploratory data analysis is essential to verify the spatial dependence between variables. Dependency analysis is one of the first considerations when working with a spatial model. This refers to the interaction between individuals in different locations within a sample, checking whether there is a spatial relationship between the variables.

Spatial econometrics has emerged as a field of study within econometrics, gaining relevance in explaining certain economic phenomena and in other areas (Anselin, Florax, e Rey 2013). The main difference between traditional econometrics and spatial econometrics is the incorporation of spatial effects in the latter's regression analyses.

Thus, what characterizes and justifies the use of spatial analysis is the dependence between variables. In other words, nearby regions may have a greater impact on certain variables than distant regions.

Exploratory spatial data analysis (ESDA) evaluates hypotheses of spatial dependence and autocorrelation. Checking the autocorrelation hypothesis requires a matrix of spatial weights based on geographical proximity. This hypothesis can be tested using Moran's I, which measures the relationship between the covariance and variance of the data (Almeida, 2012), and a scatter diagram with the lag of the variable of interest on the vertical axis and the non-lag variable on the horizontal axis. The coefficient of the resulting line can be positive or negative, indicating the direction of the possible correlation.

Autocorrelation in spatial data can be classified as global or local. Although global autocorrelation may not be evident due to the large number of regions, local patterns may still exist, which characterizes local spatial autocorrelation. To identify the presence of this local autocorrelation, Moran's statistic can be used through local indicators of spatial association (LISA), which adjust and combine information from the Moran's I scatter plot with the local association significance map.

Moran's I coefficient is used to categorize data into four quadrants, which reflect the relationships between variables. These quadrants are called low-low (LL), high-high (HH), low-high (LH) and high-low (HL) (Almeida 2012). HH indicates that the region and its neighboring areas have values above average. The LL classification indicates that both the region in question and its neighboring regions have values below the average. Quadrant HL is assigned when the region under analysis has high values and its neighbors have low values. If a region is in the LH quadrant, this means that the region has low values while its neighbors have high values.

In this article, we will use both univariate and bivariate analysis — to examine the autocorrelation between two different variables. This approach is valuable for identifying whether the values of a variable in one region are related to the values of another variable in nearby areas. Although univariate and bivariate analysis share fundamental principles, bivariate analysis focuses on the relationship between two variables in both the scatter plot and the cluster analysis. For example, in the LL quadrant, one variable may have low values in one region, while the other variable also has low values in neighboring regions.

### 3.4 Spatial econometric model

Considering an ordinary least squares econometric model:

$$y = X\beta + \varepsilon,$$

where *y* is a vector with the dependent variable data, *X* is a matrix of n x k regressors, and *ε* represents the stochastic term, the model estimated in the present work can be represented as follows:

$$lnEXPY_i = \beta_0 + \beta_1 lnMicro_i + \beta_2 lnLow_i + \beta_3 lnMedium_i + \beta_4 lnLarge_i + \beta_5 lnAV\_serv_i + \beta_6 lnAV\_agri_i + \beta_7 lnAV\_ind_i + \varepsilon_i \quad (3)$$

Where i represents the microregions of Brazil, with i = 1...558; EXPY the productivity index associated with income level (Hausmann, Hwang, and Rodrik 2007). Micro, Small, Medium, and Large represent the sizes of companies for which BNDES provided financing; AV_serv, AV_agri and AV_ind represent the added value of the service, agricultural and industrial sectors, respectively and ε represents the stochastic term of the model.

Traditional econometrics is widely used to model relationships between economic variables, but does not explicitly consider spatial effects. When spatial autocorrelation is suspected (i.e., spatial dependence between observations), it is necessary to resort to spatial econometrics. The first step when working with spatial models is to create a spatial weight matrix, which reflects the geographic proximity between observation units.

The spatial econometric model differs from the OLS mainly due to the inclusion of the spatial weight matrix. Spatial autocorrelation can be checked in the error term or in the dependent variable. If present, we estimate the SEM (Spatial Error) or SAR (Spatial Autoregressive) models, respectively. If autocorrelation occurs simultaneously in the error term and the dependent variable, we consider the estimation of the SDM model (Spatial Dynamic Model).

The procedures required to regress a spatial cross-section model are presented by Florax, Folmer and Rey (2003). According to the authors, after estimating an OLS model, it is necessary to look at the values of the Lagrange multipliers for error (ML$\lambda$) and lag (ML$\rho$). If none are significant, keep the OLS model. If only ML$\lambda$ is significant, estimate the SEM model. If only ML$\rho$ is significant, estimate the SAR model. If both are significant, choose the model with the highest significance. The SARMA model is also an option when both (ML$\rho$ and ML$\lambda$) are statistically significant.

To ensure the reliability of a spatial econometric model, it is essential to carry out various tests to check for the presence of autocorrelation, multicollinearity and heteroscedasticity. Multicollinearity, which occurs when the explanatory variables have linear relationships with each other, is generally detected by the Variance Inflation Factor (VIF); a VIF greater than 10 indicates an $R^2$ greater than 0.90, suggesting possible collinearity between the variables. Spatial autocorrelation in the regression residuals is tested by Moran's I, with the null hypothesis (H0) that the errors follow a normal distribution. Heteroscedasticity is assessed by the Breusch-Pagan test, where the null hypothesis indicates homoscedasticity (homoscedastic errors). The Jarque-Bera test is used to verify the normality of the regression residuals. In cases of heteroscedasticity, the use of Generalized Moment Models (GMM) or instrumental variables is recommended. In GMM models, the Anselin-Kelejian test verifies the absence of spatial autocorrelation in the residuals, with H0 being the hypothesis of no autocorrelation.

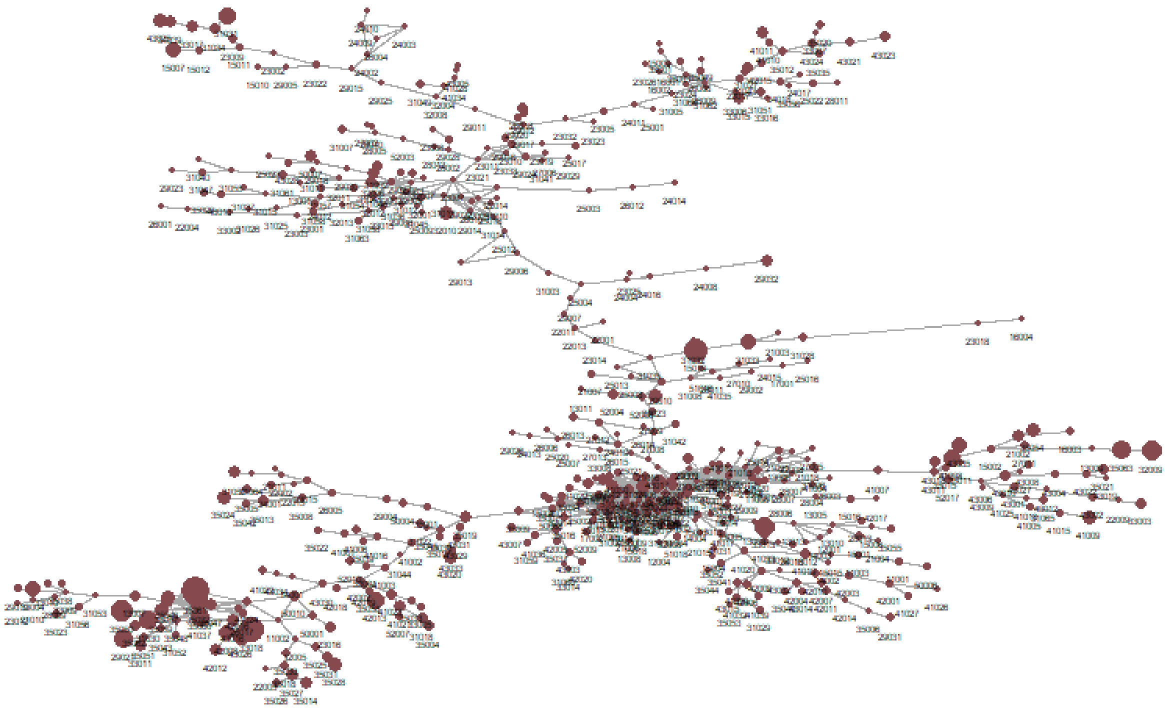
# 4 RESULTS

## 4.1 Exploratory analysis of spatial data

Figures 1 and 2 show the proximity networks for the Brazilian microregions and the products exported. A network is a structure composed of nodes and edges that represent entities and connections between them, respectively. In this study, the nodes are the microregions, and the edges represent the proximity relationships between the products exported by the microregions. The microregions were represented by five-digit codes, and the products were represented by codes in the SH4 position. The description of exported products follows the Commodity Description and Coding System known as the Harmonized System (HS). The processed data used four-digit codes (HS4) to describe the exported products. The nodes represent products, and their sizes are proportional to the total trade of the microregions for a given product.

The links connect products with a high probability of being exported to more than one microregion. The likelihood of a region producing a new product depends on how close it is to other products that are already produced in that region. A country's ability to diversify and move toward the production of more complex products depends on its location in the product space (Hausmann et al., 2013). Thus, the location of a microregion in the product space captures information regarding its productive potential and the ability to expand this potential, given the products already produced and exported.

Figure 1. Proximity-based network for Brazil's microregions (2009–2020)



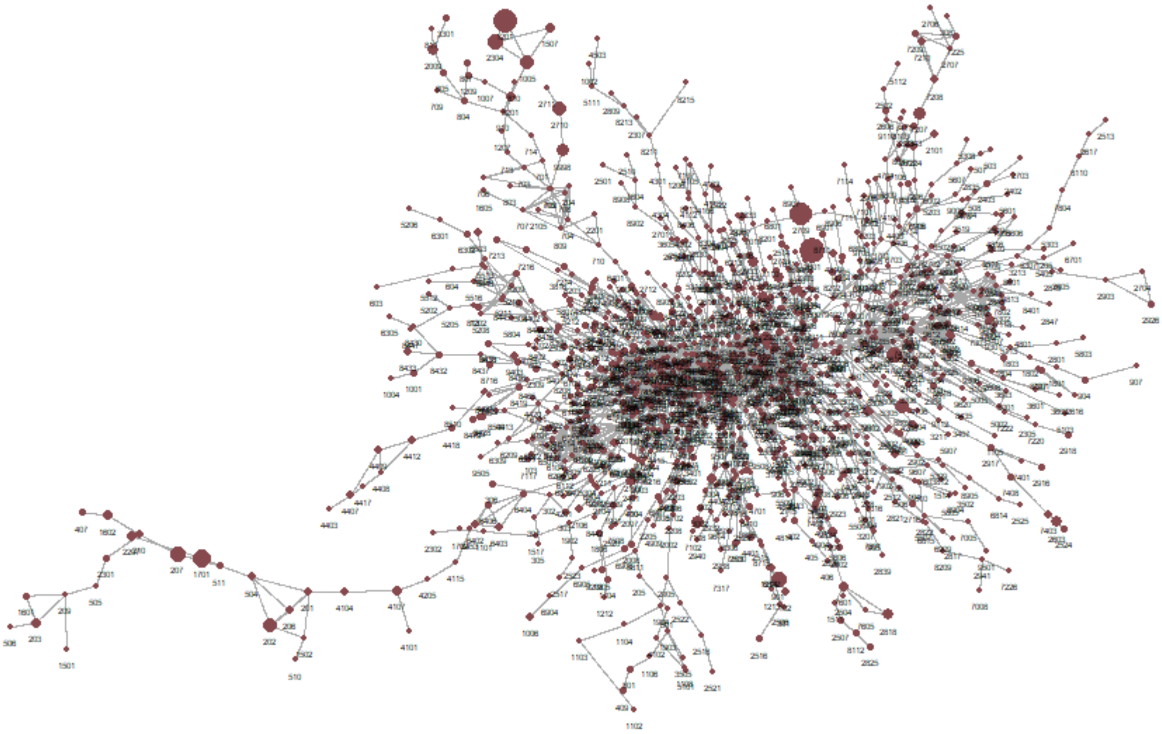
Own elaboration based on data from comex stat and R software
Note: The size of the bubble represents the microregion's share of a country's exports.

The figure showing the network as a whole is difficult to visualize in detail because of the number of microregions (558) displayed. However, it is possible to observe specific patterns such as microregions isolated in the network. This is the case for Maragão (16004, AP), which is connected only to Sertão de Crato (23018, CE). This indicates that the products exported by the Maragão microregion are close to those exported by the Sertão de Crato microregion and are distant from other microregions, particularly those that are more connected to other nodes in the network. The same applies to Porto Seguro (29032, BA), which is connected only to Borborema Potiguar (24014, RN).

These two cases were observed at the right end of the microregion network. In other words, these isolated microregions have little potential to expand into new markets because of the lack of iterativity with microregions that produce products that are more connected in networks and, in general, more sophisticated. Because the relationship of proximity occurs with only one or a few other microregions, it is expected to be more difficult for them to expand into other markets; therefore, the expectation of growth and sophistication in their production structure is lower.

Another relevant result was that the microregions with the highest volume of exports (largest nodes) were not part of the cluster in the network with the greatest number of links. The microregions with the highest volume of exports are on the extreme left of the network (Figure 1), whereas those with the greatest links are in the lower central part of the network. This indicates that the theoretical basis of the economic complexity approach, which is designed to analyze the trade relationship between countries, is fully valid in the context of Brazils microregions. The traditional approach of Hidalgo and Hausmann (2009) considers complexity to be the result of the diversification and exclusivity (not ubiquity) of the products a place exports and not just the quantity exported. Thus, microregions can have competitive advantages in specific sectors, resulting in high exports of simple or low-complexity products, which displaces these microregions outside the cluster with greater links.

Figure 2. Proximity-based network for products exported by Brazil's microregions (2009–2020)



Own elaboration based on data from comex stat and R software
Note: The size of the bubble represents the product's share in the country's exports.

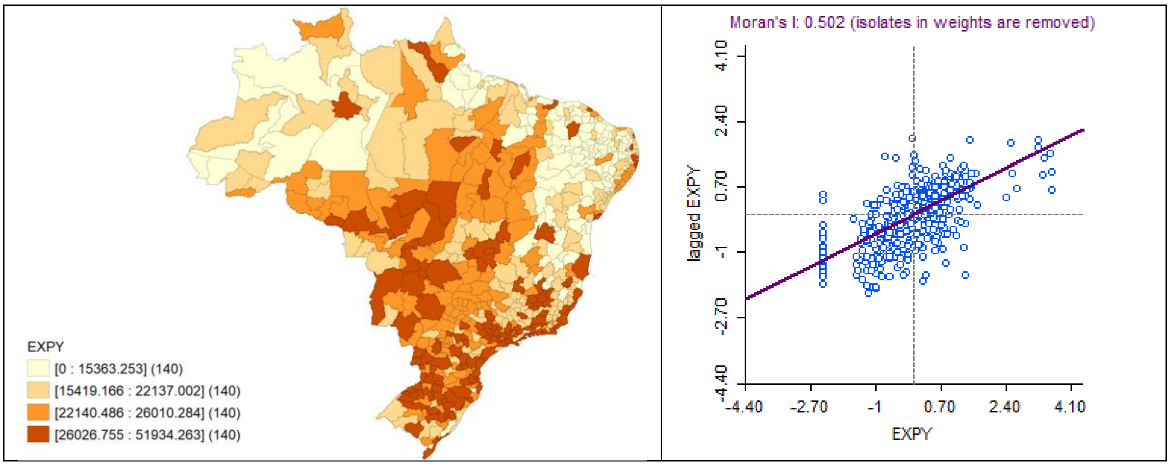
Figure 2 shows the product space of products exported by Brazil's microregions. The product space shows how products exported by Brazil's microregions are connected. Products with more connections are expected to become increasingly sophisticated. One example is a computer with links to several other industries that supply inputs.

In the case of the empirical exercise, we consider products 1501 (pork and poultry fat) and 4101 (bovine hides and skins), which are linked to only one other product and are far from the central part of the network. These products do not need to be associated with many other industries and are not linked to other categories. Thus, products in a network with numerous links tend to be more complex because they need to be associated with other industries to be produced.

Figure 3 shows the export productivity measures for Brazil's microregions. The figure contains a map that classifies the values by quartiles and a graph representing the Moran's index, which aims to check how the values are correlated in spatial terms. In other words, a linear line close to 45° indicates a spatial autocorrelation for export productivity: microregions with high export productivity tend to be neighbors of microregions with high export productivity, and microregions with low productivity tend to be neighbors of microregions with low productivity. High values were observed for most microregions in the South and Southeast regions and some microregions in the country's Midwest region.

Figure 3. Spatial analysis of productivity associated with the export basket (EXPY) between 2009 and 2020

| **Productivity associated with the export basket (EXPY)** |
|---|

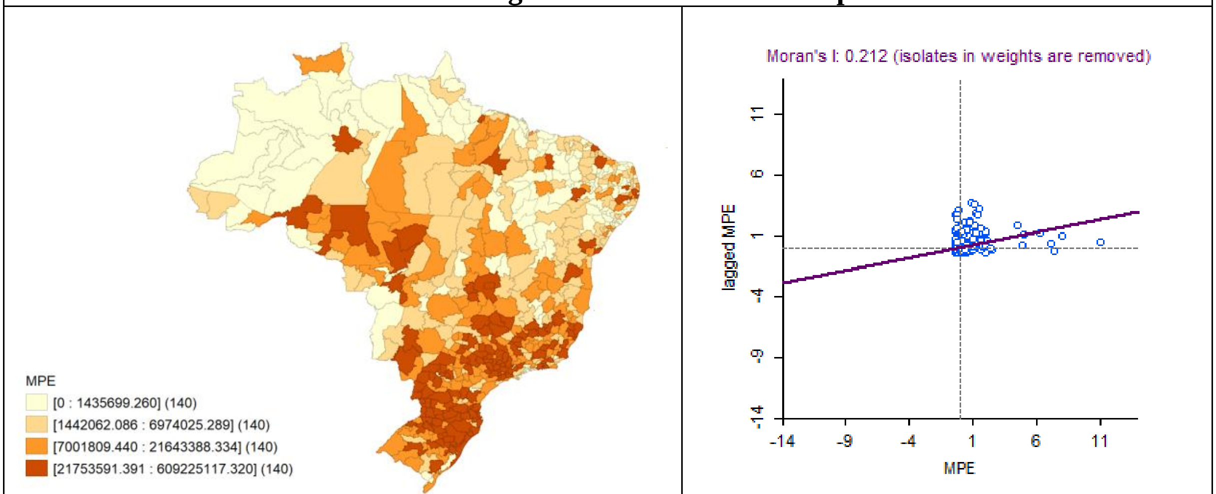



Source: Own elaboration based on survey results
Note 1: The map (left) is classified into quartiles, and the graph (right) represents dispersion using the Moran index.

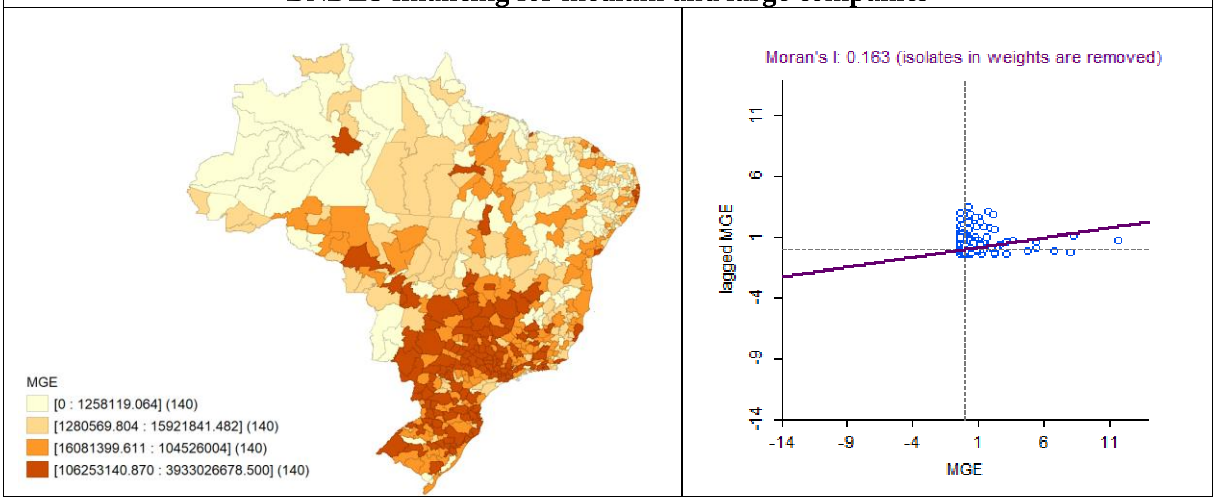
Figure 4 shows the spatial analysis of the BNDES financing for micro and small companies on the first map, and medium and large companies on the second map. The data show that the BNDES funding is more intense in the South, Southeast, and Midwest regions, particularly in the large commercial centers (metropolitan regions of São Paulo and Rio de Janeiro), coastal microregions (Blumenau, Itajaí, and Joinville) and microregions strong in agribusiness (Campo Grande, Dourados, and Tres Lagoas).

Figure 4. Spatial analysis of the BNDES financing based on company size (micro, small, medium, and large) between 2009 and 2020

**BNDES financing for micro and small companies**



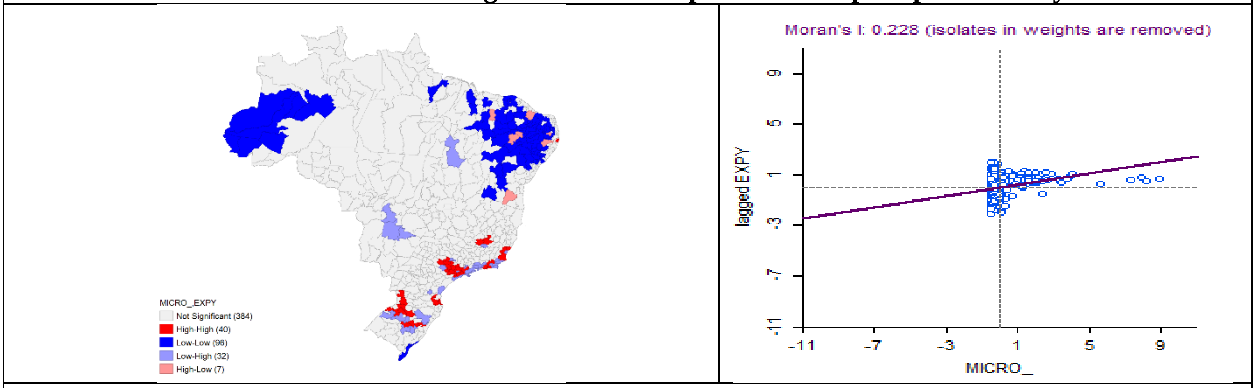

**BNDES financing for medium and large companies**



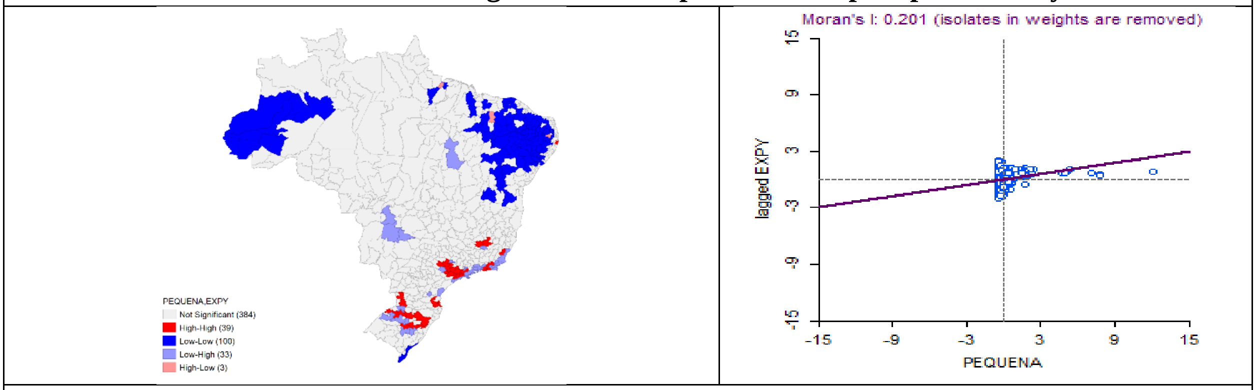

Source: Own elaboration based on survey results
Note 1: Values for the manufacturing industry only
Note 2: The map (left side) is classified into quartiles, and the graph (right side) represents dispersion using the Moran index.

Figure 5. Bilisa: BNDES financing based on company size (micro, small, medium, and large) and export productivity between 2009 and 2020

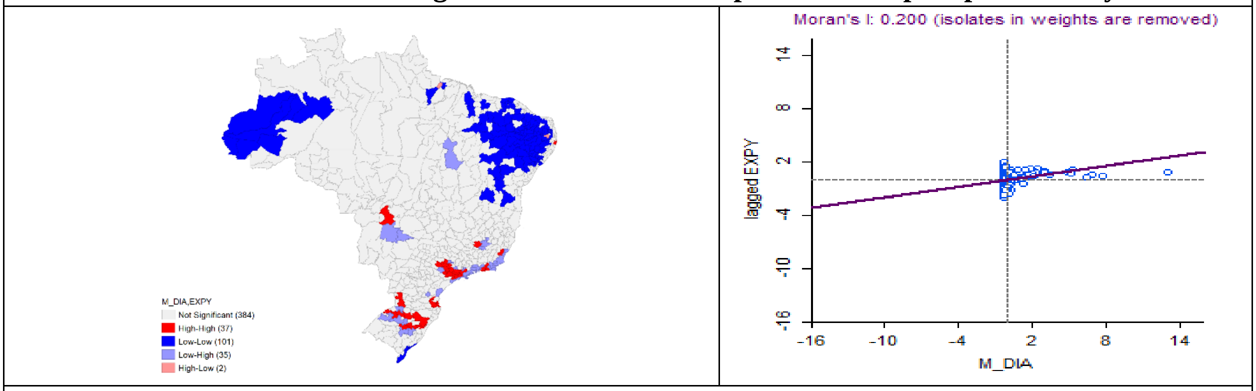
**Bilisa: BNDES financing for microenterprises and export productivity**



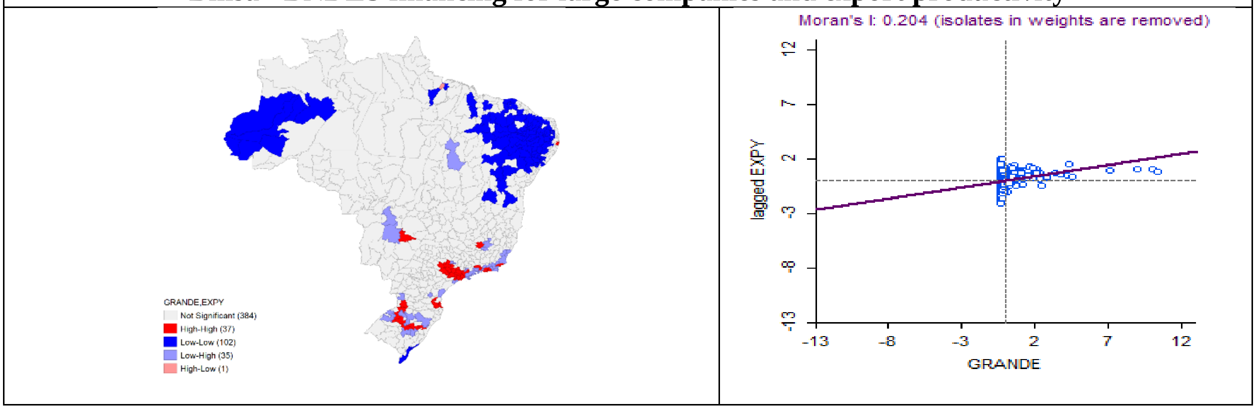

**Bilisa: BNDES financing for small companies and export productivity**




**Bilisa: BNDES financing for medium-sized companies and export productivity**




**Bilisa - BNDES financing for large companies and export productivity**




Source: Own elaboration based on survey results.
Note: Red, high-high; dark blue, low-low; light blue, low-high; beige, high-low.

Figure 5 shows low-low patterns (in dark blue) in many of the microregions in the North and Northeast. This indicates that they have low export productivity and are surrounded by microregions with low productivity.

This finding highlights the structural heterogeneity between the country's regions and raises discussions on measures to increase the productivity of these regions. Simultaneously, high-high patterns were observed in large commercial and manufacturing centers, such as the Vale do Itajaí region and Northern Santa Catarina, the Serra Gaúcha region, Greater São Paulo, and the metropolitan region of Rio de Janeiro.

### 4.2 Spatial econometric model

This subsection discusses the results of the spatial econometric model used in this study. The productivity index associated with the export basket is used as the dependent variable. We use ordinary least squares (OLS) and the generalized method of moments (GMM). The explanatory variables in the three models include categories of companies (micro, small, medium, and large) that received financing from the BNDES, as well as the values added in the service, agricultural, and industrial sectors (represented by VA_serv, VA_agri, and VA_ind, respectively).

Specification tests were conducted according to the approach described by Anselin et al. (2013). The specification tests aimed to determine the most appropriate model. The tests indicated that the spatial autoregressive (SAR) model was the most appropriate. Heteroscedasticity problems in the OLS estimation were observed; thus, the GMM was adopted. The estimation followed the approach proposed by Kelejian and Prucha (1999, 1998), which was particularly appropriate for cross-sectional spatial models such as SAR, SEM, and SARMA, given the endogeneity of the spatially lagged dependent variable and the potential for spatial autocorrelation and heteroscedasticity in the residuals. The instruments used were internally generated from the exogenous variables through their spatial lags, which was a standard practice in the spatial GMM studies. For comparison and robustness against spurious regressions, we present the results of the OLS, SAR, SEM, and SARMA.

Table 1. Estimation results: Dependent variable: productivity index associated with the export basket

| Coefficients | OLS (1) | OLS (2) | SAR (GMM) | SEM (GMM) | SARMA (GMM) |
|---|---|---|---|---|---|
| Constant | 4,103*** (1,02) | 3,359*** (0,97) | 0,951 (1,12) | 3,258*** (1,37) | 1,076 (1,15) |
| Micro | 0,178*** (0,03) | 0,177*** (0,03) | 0,187*** (0,03) | 0,214*** (0,07) | 0,166*** (0,06) |
| Low | -0,010 (0,03) | -0,011 (0,02) | -0,028 (0,02) | -0,014 (0,05) | -0,028 (0,05) |
| Medium | 0,049** (0,02) | 0,052** (0,02) | 0,050*** (0,01) | 0,056 (0,03)** | 0,044 (0,02) |
| Large | 0,064*** (0,010 | 0,065*** (0,01) | 0,031* (0,01) | 0,038 (0,02)* | 0,039** (0,02) |
| VA_agri | 0,137* (0,07) | 0,090 (0,07) | 0,045 (0,07) | 0,083 (0,08) | 0,048 (0,05) |
| VA_ind | 0,331** (0,13) | 0,048 (0,05) | 0,028 (0,05) | 0,049 (0,05) | 0,439 (0,04) |
| VA_serv | -0,356** (0,15) | | | | |
| λ | | | | 0,355*** (0,08) | |
| θ | | | | | -0,267 (0,19) |
| ρ | | | 0,420*** (0,11) | | 0,439 (0,12) |
| $R^2$ | 0,280 | 0,273 | 0,332 | | 0,332 |
| AIC | 2399,89 | 2403,46 | | | |
| SC | 2434,51 | 2433,76 | | | |
| Moran's I | 5,64*** | 5,82*** | | | |
| ML – Lag | 35,08*** | 37,05*** | | | |
| ML – Error | 29,82 | 31,83*** | | | |
| ML - Sarma | 35,55*** | 37,62*** | | | |
| MLR – Lag | 35,08** | 5,78** | | | |
| MLR – Error | 0,46 | 0,56 | | | |
| Breusch-Pagan test | 579,89*** | 595,65*** | | | |
| Jarque-Bera test | 1813,72*** | 1826,69*** | | | |
| Multicollinearity test | 101,28 | 41,58 | 1,192 | | |

Source: Own elaboration based on GeoDa Space software.
Notes: Standard errors are in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

For estimations using the productivity index associated with the export basket as the dependent variable, the results indicated statistically significant coefficients for micro, medium, and large companies. All have positive signs; however, the relationship is stronger for smaller companies. In other words, financing for small companies has a positive effect on the productivity of exports from microregions, and this effect is significantly greater than that for medium and large companies.

This result indicates that microregions that receive more funding from microenterprises tend to have a higher productivity associated with the export basket. In other words, they tend to change their production structure and move closer to that of microregions with higher per capita income. The lag also has a positive sign, indicating that microregions tend to benefit from the foreign trade productivity of neighboring microregions. Control variables such as the value added of the sectors were statistically significant only in the OLS model. The results indicate a positive relationship between the value added in the industrial and agricultural sectors and export productivity, with the coefficient of industry being significantly higher. By contrast, the value added in the service sector exhibited a negative association with export productivity.

In the analysis of the results, the distribution of the BNDES resources and export productivity across Brazilian microregions reveals significant patterns of regional heterogeneity. The microregions in the South and Southeast, where the majority of funding is concentrated, demonstrate higher levels of productivity, supporting the hypothesis that access to financial resources is a crucial factor for economic development. By contrast, the Northern and Northeastern regions, characterized by low productivity and a lack of investment, face structural challenges that limit their growth potential. This disparity suggests the need for targeted policies that not only increase the volume of funding but also promote capacity building and innovation among microenterprises in less-favored regions. Furthermore, the correlation analysis between company size and funding effectiveness indicates that micro and small enterprises, while representing the majority of the sector, still struggle to absorb the benefits of the BNDES resources. This raises questions about the adequacy of credit policies and the need for more robust support to foster competitiveness and the complexity of exported products.

## 5 FINAL CONSIDERATIONS

The results of this study indicate a strong relationship between the financing of microenterprises and productivity in foreign trade activities in Brazil's microregions. In addition to demonstrating this positive relationship, the findings indicate the existence of spatial spillover effects, in which microenterprise financing not only influences the productivity of foreign trade but also propagates to neighboring microregions, generating a cumulative and beneficial effect on the transformation of the local productive structure.

This study also allowed us to observe that the majority of the BNDES resources for the manufacturing industry are oriented toward the South and Southeast regions and, mainly, toward microregions that are home to large commercial centers. Regardless of their size, these regions concentrate on companies that are already at a higher level of productive development. It appears that what has been happening is that the most "mature" businesses are the ones gaining more access to credit. However, as the results of this study show, strategies to reduce structural heterogeneity should focus on investments in locations farther away from large commercial and industrial centers. Moreover, what is observed is the occurrence of yet another reproduction of the phenomenon of endogeneity of public policies, in which companies that are part of a dynamic and more sophisticated axis are those that receive more resources. They reach the criteria for receiving these resources in a later period, which becomes a barrier for companies outside this dynamic axis.

The study also found that the microregions with the highest volume of exports (larger nodes) did not belong to the cluster with the most connections. This finding indicates that these regions are competitive in specific sectors, exporting mainly simple or low-complexity products, which moves them away from the main cluster characterized by greater connections. Therefore, even if some microregions have high exports, they may focus on simple or low-complexity products, which place them outside the cluster of more interconnected areas. In other words, the variety and exclusivity of exported products (economic complexity) are not directly associated with the export potential of a microregion, highlighting the importance of the characteristics of the products being exported.

In general, the structural heterogeneity between Brazil's microregions is evident, and specific policies must be implemented to increase productivity in areas with lower performance. Low-performing microregions face several challenges that influence their productivity and economic development, such as deficient infrastructure (e.g., roads, ports, electricity, and telecommunications), technological limitations, low economic diversification, social inequality, and unemployment, and the focus of present work, that is, low intensity of the BNDES resources to promote local development. These factors must be considered when formulating strategies to drive the growth in these regions.

Despite the robustness of the results and relevance of the adopted spatial econometric methods, this study has some limitations. First, although high values of the export productivity index (EXPY) are positively correlated with regional development, this does not necessarily imply a causal relationship. It is possible that other structural factors such as institutional quality, infrastructure, human capital, and the business environment play decisive roles in enabling productive sophistication and attracting BNDES financing. Moreover, the EXPY index focuses on the sophistication of exported goods without explicitly accounting for the origin of the inputs or technologies involved in their production. Thus, microregions may appear to export complex products while relying heavily on imported components. Future studies could benefit from the integration of input-output matrices or supply chain indicators to overcome this limitation. Finally, although evidence suggested that policy measures should target lagging regions, our study did not evaluate the effectiveness of specific mechanisms. Further investigation is required to identify the types of industrial policies—credit allocation, technical assistance, infrastructure development, or training programs—that are most effective in stimulating productivity and structural transformation in less dynamic areas.

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**APPENDIX A**

Table A.1 - Summary of works that used the methodology of Hausmann, Hwang and Rodrik (2007)

| Territory and analysis mode | Period | Authors | Main results |
|---|---|---|---|
| China | 1997 to 2007 | Jarreau and Poncet (2009) | China had a very high EXPY index compared to its global level of development. |
| 113 countries (developed and underdeveloped) | 1999 to 2001 | Minondo (2010) | Economic growth can occur more rapidly and sustainably through specialization in higher quality products. |
| Compare Brazil with some emerging countries (China, South Korea, Mexico, Russia and India) | 1996 to 2007 | Kume, Piani and Miranda (2012) | The level of export specialization in Brazil increased in the period 1996-2000 and remained constant in subsequent years. |
| Southern Cone Countries (Argentina, Brazil, Chile, Paraguay and Uruguay) | 1992 to 2009 | Rubin and Waquil (2013) | The more specialized the export basket of agribusiness products in the countries of the Southern Cone, the greater the growth effects of income levels for these countries. |
| Southern Cone Countries | 2000 to 2011 | Silva and Batista (2015) | Brazil, Argentina, and Uruguay had a higher EXPY index than other Southern Cone countries, but the index for Southern Cone countries remained below the world average. |
| Brazil, through analysis by technology intensity levels | 2000 to 2013 | Baraúna and Hidalgo (2016) | The EXPY index of Brazilian exports deteriorated over the years, mainly in relation to high-tech products. |

Source: adapted from Teixeira et al. (2021)

Table A.2 – Foreign trade productivity of Brazil's microregions

| **Microregion** | **Foreign trade productivity (EXPY)** |
|---|---|
| Porto Velho | 23693.29 |
| Guajará-Mirim | 25005.12 |
| Ariquemes | 19714.5 |
| Ji-Paraná | 22005.13 |
| Alvorada D'Oeste | 22562.22 |
| Cacoal | 22706.26 |
| Vilhena | 23760.3 |
| Colorado do Oeste | 26026.75 |
| Cruzeiro do Sul | 15173.39 |
| Tarauacá | 0 |
| Sena Madureira | 19410.5 |
| Rio Branco | 20578.86 |
| Brasiléia | 22140.49 |
| Rio Negro | 11556.39 |
| Japurá | 0 |

| | |
|---|---|
| Alto Solimões | 18960.92 |
| Juruá | 0 |
| Tefé | 14959.24 |
| Coari | 19634.86 |
| Manaus | 29518.53 |
| Rio Preto da Eva | 19381.81 |
| Itacoatiara | 21029.98 |
| Parintins | 14667.27 |
| Boca do Acre | 16014.31 |
| Purus | 14364.48 |
| Madeira | 14658.7 |
| Boa Vista | 24303.67 |
| Nordeste de Roraima | 15731.78 |
| Caracaraí | 21722.31 |
| Sudeste de Roraima | 14885.16 |
| Óbidos | 18253.83 |
| Santarém | 22806.91 |
| Almeirim | 21796.5 |
| Portel | 14717.62 |
| Furos de Breves | 14446.77 |
| Arari | 9848.203 |
| Belém | 19272.94 |
| Castanhal | 13823.31 |
| Salgado | 14354.35 |
| Bragantina | 13803.99 |
| Cametá | 10211.94 |
| Tomé-Açu | 10767.77 |
| Guamá | 17967.95 |
| Itaituba | 18430.97 |
| Altamira | 19536.39 |
| Tucuruí | 18364.3 |
| Paragominas | 23502.63 |
| São Félix do Xingu | 23311.66 |
| Parauapebas | 31029.18 |
| Marabá | 18493.04 |
| Redenção | 22825.93 |
| Conceição do Araguaia | 23122.76 |
| Oiapoque | 16237.92 |
| Amapá | 15363.25 |
| Macapá | 23476.71 |
| Mazagão | 26070.61 |
| Bico do Papagaio | 25983.84 |
| Araguaína | 23195.31 |
| Miracema do Tocantins | 25600.43 |
| Rio Formoso | 22753.23 |
| Gurupi | 24729.39 |
| Porto Nacional | 26135.97 |
| Jalapão | 25859.96 |
| Dianópolis | 26010.28 |
| Litoral Ocidental Maranhense | 0 |
| Aglomeração Urbana de São Luís | 23307.94 |
| Rosário | 16185.05 |
| Lençóis Maranhenses | 11145.51 |
| Baixada Maranhense | 22056.53 |
| Itapecuru Mirim | 10315.01 |
| Gurupi | 16170.37 |
| Pindaré | 19320.99 |
| Imperatriz | 24180.13 |
| Médio Mearim | 15186 |
| Alto Mearim e Grajaú | 6662.914 |
| Presidente Dutra | 0 |
| Baixo Parnaíba Maranhense | 26190.93 |
| Chapadinha | 25854.12 |
| Codó | 11091.87 |

| | |
|---|---|
| Coelho Neto | 23552.85 |
| Caxias | 22637.45 |
| Chapadas do Alto Itapecuru | 25502.69 |
| Porto Franco | 26228.24 |
| Gerais de Balsas | 25776.02 |
| Chapadas das Mangabeiras | 25660.13 |
| Baixo Parnaíba Piauiense | 8804.966 |
| Litoral Piauiense | 10045.28 |
| Teresina | 17552.14 |
| Campo Maior | 8775.464 |
| Médio Parnaíba Piauiense | 0 |
| Valença do Piauí | 0 |
| Alto Parnaíba Piauiense | 26226.51 |
| Bertolínia | 23412.79 |
| Floriano | 21876.16 |
| Alto Médio Gurguéia | 25941.07 |
| São Raimundo Nonato | 11027.04 |
| Chapadas do Extremo Sul Piauiense | 25429.44 |
| Picos | 10305.32 |
| Pio IX | 9754.698 |
| Alto Médio Canindé | 12353.13 |
| Litoral de Camocim e Acaraú | 11979.39 |
| Ibiapaba | 16741.99 |
| Coreaú | 8005.368 |
| Meruoca | 0 |
| Sobral | 12962.37 |
| Ipu | 0 |
| Santa Quitéria | 12096.47 |
| Itapipoca | 15552.04 |
| Baixo Curu | 27552.6 |
| Uruburetama | 13736.45 |
| Médio Curu | 12550.94 |
| Canindé | 13161.93 |
| Baturité | 9172.243 |
| Chorozinho | 11402.95 |
| Cascavel | 20629.92 |
| Fortaleza | 22461.07 |
| Pacajus | 15544.11 |
| Sertão de Cratéus | 32265.08 |
| Sertão de Quixeramobim | 14919.4 |
| Sertão de Inhamuns | 0 |
| Sertão de Senador Pompeu | 11667.16 |
| Litoral de Aracati | 13647.31 |
| Baixo Jaguaribe | 12840.73 |
| Médio Jaguaribe | 20889.99 |
| Serra do Pereiro | 9661.726 |
| Iguatu | 11925.45 |
| Várzea Alegre | 11200.44 |
| Lavras da Mangabeira | 0 |
| Chapada do Araripe | 0 |
| Caririaçu | 0 |
| Barro | 0 |
| Cariri | 12102.77 |
| Brejo Santo | 11808.89 |
| Mossoró | 14412.5 |
| Chapada do Apodi | 13010.65 |
| Médio Oeste | 13085.85 |
| Vale do Açu | 16062.39 |
| Serra de São Miguel | 0 |
| Pau dos Ferros | 0 |
| Umarizal | 0 |
| Macau | 24107.38 |
| Angicos | 12542.09 |
| Serra de Santana | 10647.68 |

| | |
|---|---|
| Seridó Ocidental | 13619.1 |
| Seridó Oriental | 19088.59 |
| Baixa Verde | 13617.13 |
| Borborema Potiguar | 8858.093 |
| Agreste Potiguar | 10040.26 |
| Litoral Nordeste | 18921.22 |
| Macaíba | 19304.21 |
| Natal | 30408.57 |
| Litoral Sul | 20429.76 |
| Catolé do Rocha | 11265.03 |
| Cajazeiras | 10337.27 |
| Sousa | 9885.585 |
| Patos | 12147.31 |
| Piancó | 0 |
| Itaporanga | 0 |
| Serra do Teixeira | 7476.496 |
| Seridó Ocidental Paraibano | 10911.81 |
| Seridó Oriental Paraibano | 7910.141 |
| Cariri Ocidental | 0 |
| Cariri Oriental | 0 |
| Curimataú Ocidental | 7523.183 |
| Curimataú Oriental | 9854.205 |
| Esperança | 23412.79 |
| Brejo Paraibano | 0 |
| Guarabira | 27868.53 |
| Campina Grande | 13340.03 |
| Itabaiana | 8361.205 |
| Umbuzeiro | 0 |
| Litoral Norte | 15572.64 |
| Sapé | 14466.63 |
| João Pessoa | 20076.86 |
| Litoral Sul | 22013.39 |
| Araripina | 10965.08 |
| Salgueiro | 0 |
| Pajeú | 22647.2 |
| Sertão do Moxotó | 13192.61 |
| Petrolina | 15113.66 |
| Itaparica | 12179.91 |
| Vale do Ipanema | 8292.504 |
| Vale do Ipojuca | 15966.47 |
| Alto Capibaribe | 18070.94 |
| Médio Capibaribe | 10982.43 |
| Garanhuns | 21534.53 |
| Brejo Pernambucano | 10784.79 |
| Mata Setentrional Pernambucana | 28042.8 |
| Vitória de Santo Antão | 20616.59 |
| Mata Meridional Pernambucana | 23799.95 |
| Itamaracá | 23406.15 |
| Recife | 28892.42 |
| Suape | 41697.21 |
| Fernando de Noronha | 0 |
| Serrana do Sertão Alagoano | 0 |
| Alagoana do Sertão do São Francisco | 8798.603 |
| Santana do Ipanema | 0 |
| Batalha | 0 |
| Palmeira dos Índios | 14952.02 |
| Arapiraca | 25549.38 |
| Traipu | 0 |
| Serrana dos Quilombos | 23157.59 |
| Mata Alagoana | 23579.79 |
| Litoral Norte Alagoano | 14245.93 |
| Maceió | 23343.22 |
| São Miguel dos Campos | 23750.3 |
| Penedo | 23693.65 |

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|---|---|
| Sergipana do Sertão do São Francisco | 0 |
| Carira | 12753.62 |
| Nossa Senhora das Dores | 0 |
| Agreste de Itabaiana | 20163.98 |
| Tobias Barreto | 12903.15 |
| Agreste de Lagarto | 16435.07 |
| Propriá | 11197.45 |
| Cotinguiba | 0 |
| Japaratuba | 22640.7 |
| Baixo Cotinguiba | 21275.75 |
| Aracaju | 21760.66 |
| Boquim | 17228.46 |
| Estância | 17748.22 |
| Barreiras | 25777.03 |
| Cotegipe | 16110.74 |
| Santa Maria da Vitória | 24895.12 |
| Juazeiro | 13615.68 |
| Paulo Afonso | 17443.15 |
| Barra | 9174.984 |
| Bom Jesus da Lapa | 13291.42 |
| Senhor do Bonfim | 18228.32 |
| Irecê | 19113.14 |
| Jacobina | 16189.36 |
| Itaberaba | 13027.06 |
| Feira de Santana | 25807.96 |
| Jeremoabo | 7523.183 |
| Euclides da Cunha | 8478.573 |
| Ribeira do Pombal | 16731.77 |
| Serrinha | 13360.63 |
| Alagoinhas | 17656.87 |
| Entre Rios | 16974.63 |
| Catu | 23798.26 |
| Santo Antônio de Jesus | 21525 |
| Salvador | 34883.34 |
| Boquira | 9143.643 |
| Seabra | 17822.51 |
| Jequié | 12306.75 |
| Livramento do Brumado | 11840.37 |
| Guanambi | 32045.63 |
| Brumado | 10478.48 |
| Vitória da Conquista | 16793.69 |
| Itapetinga | 15763.29 |
| Valença | 14771.86 |
| Ilhéus-Itabuna | 12787.51 |
| Porto Seguro | 30257.6 |
| Unaí | 25603.04 |
| Paracatu | 17340.88 |
| Januária | 12306.32 |
| Janaúba | 19069.01 |
| Salinas | 15189.65 |
| Pirapora | 20521.01 |
| Montes Claros | 22892.19 |
| Grão Mogol | 14611.93 |
| Bocaiúva | 25006.18 |
| Diamantina | 11534.23 |
| Capelinha | 17427.07 |
| Araçuaí | 10911.71 |
| Pedra Azul | 11708.45 |
| Almenara | 12672.58 |
| Teófilo Otoni | 16117.16 |
| Nanuque | 23093.03 |
| Ituiutaba | 23545.76 |
| Uberlândia | 24725.34 |
| Patrocínio | 18588.18 |

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|---|---|
| Patos de Minas | 19293.86 |
| Frutal | 23697.29 |
| Uberaba | 24097.6 |
| Araxá | 24554.33 |
| Três Marias | 27072.01 |
| Curvelo | 16145.84 |
| Bom Despacho | 20722.87 |
| Sete Lagoas | 22474.78 |
| Conceição do Mato Dentro | 32265.08 |
| Pará de Minas | 17048.55 |
| Belo Horizonte | 29609.06 |
| Itabira | 31813.99 |
| Itaguara | 44053.25 |
| Ouro Preto | 31972.37 |
| Conselheiro Lafaiete | 29265.21 |
| Guanhães | 9886.243 |
| Peçanha | 9776.104 |
| Governador Valadares | 15419.17 |
| Mantena | 27488.13 |
| Ipatinga | 31174.46 |
| Caratinga | 17685.68 |
| Aimorés | 12045.28 |
| Piuí | 18563.01 |
| Divinópolis | 22137 |
| Formiga | 15526.84 |
| Campo Belo | 17658.09 |
| Oliveira | 18673.83 |
| Passos | 24017.03 |
| São Sebastião do Paraíso | 17863.53 |
| Alfenas | 18141.72 |
| Varginha | 18114.51 |
| Poços de Caldas | 19381.66 |
| Pouso Alegre | 31820.84 |
| Santa Rita do Sapucaí | 25895.9 |
| São Lourenço | 19095.98 |
| Andrelândia | 16991.84 |
| Itajubá | 30128.29 |
| Lavras | 26725.97 |
| São João Del Rei | 18596.99 |
| Barbacena | 22015.92 |
| Ponte Nova | 26435.81 |
| Manhuaçu | 17419.17 |
| Viçosa | 16896.81 |
| Muriaé | 17474.02 |
| Ubá | 26443 |
| Juiz de Fora | 27035.39 |
| Cataguases | 20414.58 |
| Barra de São Francisco | 26978.25 |
| Nova Venécia | 20282.08 |
| Colatina | 19268.9 |
| Montanha | 17580.93 |
| São Mateus | 13077.28 |
| Linhares | 28391.31 |
| Afonso Cláudio | 18640.88 |
| Santa Teresa | 17342.2 |
| Vitória | 33387.83 |
| Guarapari | 32236.74 |
| Alegre | 17492.46 |
| Cachoeiro de Itapemirim | 27908.92 |
| Itapemirim | 42606.72 |
| Itaperuna | 18903.36 |
| Santo Antônio de Pádua | 20962.44 |
| Campos dos Goytacazes | 49772.29 |
| Macaé | 51440.32 |

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|---|---|
| Três Rios | 30613.13 |
| Cantagalo-Cordeiro | 22409.53 |
| Nova Friburgo | 21870.93 |
| Santa Maria Madalena | 16300.89 |
| Bacia de São João | 48829.6 |
| Lagos | 48896.72 |
| Vale do Paraíba Fluminense | 33798.94 |
| Barra do Piraí | 28916.09 |
| Baía da Ilha Grande | 51770.81 |
| Vassouras | 21034.47 |
| Serrana | 25808.41 |
| Macacu-Caceribu | 20233.79 |
| Itaguaí | 33260.42 |
| Rio de Janeiro | 42983.29 |
| Jales | 22427.44 |
| Fernandópolis | 23485.45 |
| Votuporanga | 25132.13 |
| São José do Rio Preto | 23744.85 |
| Catanduva | 22463.55 |
| Auriflama | 22738.88 |
| Nhandeara | 23422.41 |
| Novo Horizonte | 21063.88 |
| Barretos | 22998.33 |
| São Joaquim da Barra | 24616.5 |
| Ituverava | 23006.07 |
| Franca | 18014.7 |
| Jaboticabal | 20973.19 |
| Ribeirão Preto | 26935.67 |
| Batatais | 24555.43 |
| Andradina | 25055.4 |
| Araçatuba | 25435.04 |
| Birigui | 23511.75 |
| Lins | 24681.92 |
| Bauru | 25284.95 |
| Jaú | 28471.25 |
| Avaré | 22045.15 |
| Botucatu | 29644.78 |
| Araraquara | 19265.7 |
| São Carlos | 33244.59 |
| Rio Claro | 31185.3 |
| Limeira | 27299.68 |
| Piracicaba | 34853.3 |
| Pirassununga | 25374.15 |
| São João da Boa Vista | 20700.66 |
| Mogi Mirim | 30335.47 |
| Campinas | 33702.59 |
| Amparo | 25419.87 |
| Dracena | 23392.31 |
| Adamantina | 25994.06 |
| Presidente Prudente | 23821.38 |
| Tupã | 24188.73 |
| Marília | 28243.66 |
| Assis | 22045.36 |
| Ourinhos | 22379.54 |
| Itapeva | 22859.62 |
| Itapetininga | 25205.01 |
| Tatuí | 28852.85 |
| Capão Bonito | 20866.69 |
| Piedade | 22430.63 |
| Sorocaba | 29771.99 |
| Jundiaí | 32145.46 |
| Bragança Paulista | 30091.27 |
| Campos do Jordão | 20125.69 |
| São José dos Campos | 27632.87 |

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|---|---|
| Guaratinguetá | 28301.8 |
| Bananal | 13971.4 |
| Paraibuna/Paraitinga | 20562.59 |
| Caraguatatuba | 50140.17 |
| Registro | 27458.03 |
| Itanhaém | 21194.24 |
| Osasco | 31246.55 |
| Franco da Rocha | 20309.73 |
| Guarulhos | 33234.46 |
| Itapecerica da Serra | 27072.33 |
| São Paulo | 29414.13 |
| Mogi das Cruzes | 31898.2 |
| Santos | 28851.86 |
| Paranavaí | 21131 |
| Umuarama | 24385.68 |
| Cianorte | 24175.21 |
| Goioerê | 24363.22 |
| Campo Mourão | 27337 |
| Astorga | 25145.66 |
| Porecatu | 26143.52 |
| Floraí | 26037.61 |
| Maringá | 25793.8 |
| Apucarana | 22914.68 |
| Londrina | 25300.19 |
| Faxinal | 24682.63 |
| Ivaiporã | 22345.92 |
| Assaí | 20950.36 |
| Cornélio Procópio | 26348.92 |
| Jacarezinho | 26659.66 |
| Ibaiti | 22165.73 |
| Wenceslau Braz | 27543.59 |
| Telêmaco Borba | 27212.49 |
| Jaguariaíva | 21097.87 |
| Ponta Grossa | 28180.07 |
| Toledo | 27598.48 |
| Cascavel | 27923.92 |
| Foz do Iguaçu | 27629.29 |
| Capanema | 26838.29 |
| Francisco Beltrão | 24426.45 |
| Pato Branco | 27585.58 |
| Pitanga | 24269.29 |
| Guarapuava | 26628.74 |
| Palmas | 22820.07 |
| Prudentópolis | 20892.55 |
| Irati | 24963.82 |
| União da Vitória | 21029.04 |
| São Mateus do Sul | 26482.42 |
| Cerro Azul | 19626.33 |
| Lapa | 27991.61 |
| Curitiba | 31442.88 |
| Paranaguá | 27083.91 |
| Rio Negro | 25662.59 |
| São Miguel do Oeste | 27082.59 |
| Chapecó | 27046.12 |
| Xanxerê | 27302.33 |
| Joaçaba | 24586.73 |
| Concórdia | 26196.21 |
| Canoinhas | 24388.47 |
| São Bento do Sul | 22339.16 |
| Joinville | 32682.49 |
| Curitibanos | 22237.57 |
| Campos de Lages | 26318.26 |
| Rio do Sul | 26622.07 |
| Blumenau | 27431.5 |

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|---|---|
| Itajaí | 27915.95 |
| Ituporanga | 25577.5 |
| Tijucas | 24304.97 |
| Florianópolis | 28731.78 |
| Tabuleiro | 14410.71 |
| Tubarão | 25719.78 |
| Criciúma | 27953.23 |
| Araranguá | 24695.43 |
| Santa Rosa | 28607.89 |
| Três Passos | 30115.78 |
| Frederico Westphalen | 25511.3 |
| Erechim | 27800.83 |
| Sananduva | 23930.29 |
| Cerro Largo | 26773.83 |
| Santo Ângelo | 27018.94 |
| Ijuí | 27635.57 |
| Carazinho | 29068.83 |
| Passo Fundo | 26588.82 |
| Cruz Alta | 25862.65 |
| Não-Me-Toque | 32424.96 |
| Soledade | 16892.22 |
| Guaporé | 28848.52 |
| Vacaria | 26634.17 |
| Caxias do Sul | 31448.25 |
| Santiago | 26628.29 |
| Santa Maria | 25347.91 |
| Restinga Seca | 23906.19 |
| Santa Cruz do Sul | 26189.5 |
| Lajeado-Estrela | 23433.21 |
| Cachoeira do Sul | 27945.83 |
| Montenegro | 27690.83 |
| Gramado-Canela | 17822.41 |
| São Jerônimo | 51934.26 |
| Porto Alegre | 27953.74 |
| Osório | 20821.59 |
| Camaquã | 23089.16 |
| Campanha Ocidental | 21975.79 |
| Campanha Central | 22095.98 |
| Campanha Meridional | 27453.42 |
| Serras de Sudeste | 19520.44 |
| Pelotas | 19779.08 |
| Jaguarão | 22627.73 |
| Litoral Lagunar | 27234.77 |
| Lagoa Mirim | 0 |
| Lagoa dos Patos | 0 |
| Baixo Pantanal | 27987.66 |
| Aquidauana | 23012.19 |
| Alto Taquari | 26896.19 |
| Campo Grande | 24675.41 |
| Cassilândia | 25464.87 |
| Paranaíba | 23109.37 |
| Três Lagoas | 30125.66 |
| Nova Andradina | 23079.03 |
| Bodoquena | 20450.13 |
| Dourados | 26511.15 |
| Iguatemi | 24562.35 |
| Aripuanã | 22158.47 |
| Alta Floresta | 19219.08 |
| Colíder | 25306.72 |
| Parecis | 26458.78 |
| Arinos | 25609.86 |
| Alto Teles Pires | 27665.68 |
| Sinop | 26988.77 |
| Paranatinga | 24027.21 |

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|---|---|
| Norte Araguaia | 26995.64 |
| Canarana | 26433.05 |
| Médio Araguaia | 24087.64 |
| Alto Guaporé | 18486.09 |
| Tangará da Serra | 25250.58 |
| Jauru | 21969.72 |
| Alto Paraguai | 25621.24 |
| Rosário Oeste | 18830.78 |
| Cuiabá | 25546.37 |
| Alto Pantanal | 16557.94 |
| Primavera do Leste | 27323.27 |
| Tesouro | 24369.39 |
| Rondonópolis | 27516.67 |
| Alto Araguaia | 28462.61 |
| São Miguel do Araguaia | 21169.76 |
| Rio Vermelho | 20931.53 |
| Aragarças | 16232.58 |
| Porangatu | 20381.99 |
| Chapada dos Veadeiros | 16355.44 |
| Ceres | 22726.5 |
| Anápolis | 28185.55 |
| Iporá | 16734.62 |
| Anicuns | 19905.75 |
| Goiânia | 22730.83 |
| Vão do Paranã | 27067.97 |
| Entorno de Brasília | 26812.57 |
| Sudoeste de Goiás | 26832.66 |
| Vale do Rio dos Bois | 23530.18 |
| Meia Ponte | 25329.19 |
| Pires do Rio | 26533.38 |
| Catalão | 25755.86 |
| Quirinópolis | 25484.97 |
| Brasília | 28692.11 |

Source: Prepared by the author based on data from Comex Stat and IBGE using R software.