



An application of the Regional Development Trap index to a developing country

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Abstract: The study of economic geography aims to understand the growth trajectories of regions, explaining why some grow faster than others and why disparities in prosperity and well-being persist. The literature on regional performance highlights persistent variations, both in levels and in the trajectories and frequencies of these changes. Studies suggest the existence of development clubs, where regions display significant disparities across various indicators, often linked to long-term economic stagnation processes. In the Brazilian context, the country's transition from low to middle-income was interrupted by the crisis of the 1970s, exacerbating regional disparities, particularly in the North and Northeast regions. Economic recovery in the subsequent decades proved insufficient to overcome the middle-income trap due to persistent structural issues. This paper proposes a Regional Development Trap index tailored to the Brazilian context, aiming to fill a gap in the literature on regional traps. The study defines the concept of a regional development trap and applies a synthetic indicator to assess regional dynamism based on economic, productivity, and employment trends. This approach allows the identification of regions, dividing them into three groups: high, medium, and low risk of being trapped in a regional development trap between 2005 and 2020. The contribution offers a detailed analysis of regional disparities and provides valuable insights for targeted public policy formulation

Keywords: regional development trap; regional disparities; economic geography; regional dynamism; growth accelerations

Código JEL: O18, R11, O15

Área Temática: 4.Redes e sistemas urbanos, regionais e nacionais

Uma Aplicação do Índice de Armadilha de Desenvolvimento a um País em Desenvolvimento

Resumo: O estudo da geografia econômica visa compreender as trajetórias de crescimento das regiões, explicando por que algumas crescem mais rapidamente que outras e por que persistem disparidades nos níveis de prosperidade e bem-estar. A literatura sobre desempenho regional destaca variações persistentes tanto nos níveis quanto nas trajetórias e frequências dessas mudanças. Estudos indicam a existência de clubes de desenvolvimento, nos quais as regiões apresentam grandes disparidades em diversos indicadores, frequentemente associadas a processos de estagnação econômica de longo prazo. No contexto brasileiro, a transição do país de baixa para média renda foi interrompida pela crise da década de 1970, exacerbando as disparidades regionais, especialmente nas regiões Norte e Nordeste. A recuperação econômica nas décadas subsequentes não foi suficiente para superar a armadilha da renda média, devido a problemas estruturais persistentes. Este artigo propõe um índice de armadilha de desenvolvimento regional adaptado ao contexto brasileiro, com o objetivo de preencher uma lacuna na literatura sobre armadilhas regionais. O estudo define o conceito de armadilha de desenvolvimento regional e aplica um indicador sintético para avaliar o dinamismo regional com base em tendências econômicas, de produtividade e de emprego. Essa abordagem permite identificar as regiões, dividindo-as em três grupos: alto, médio e baixo risco de estar em uma armadilha de desenvolvimento regional entre 2005 e 2020. A contribuição oferece uma análise detalhada das disparidades regionais e proporciona insights valiosos para a formulação de políticas públicas direcionadas

Palavras-chave: armadilha de desenvolvimento regional; disparidades regionais; geografia econômica; dinamismo regional;

1. Introduction

A central theme of economic geography is understanding the varying growth trajectories of regions. Scholars have long sought to explain why some regions grow faster than others, why some struggle to achieve higher growth rates, and why significant disparities persist in their levels of economic prosperity and well-being (Crescenzi *et al.*, 2023; Diemer *et al.*, 2022; Dunford; Smith, 2000). A growing body of literature on regional performance indicators highlights persistent variation not only in the levels of performance but also in the trajectory and frequency of changes in such indicators.

Previous studies, primarily applied to European regions, suggest the existence of “development clubs”, wherein regions exhibit deep disparities in income, employment, industrial composition, education, productivity, innovation, urbanization, and demography. These disparities are often attributed to long-term economic stagnation processes that have detrimental effects on regional dynamics. For example, in Europe, many middle-income regions have experienced prolonged periods of low growth, weak productivity gains, and low job creation or even job losses. Some of these cases involve previously wealthy regions that have been pushed into the middle-income category (Diemer *et al.*, 2022).

In the case of Brazil, the second half of the twentieth century saw the country transition from a low-income to a middle-income nation in the global context. However, this growth was interrupted by the crisis of the late 1970s, during which Brazil, alongside other emerging economies, faced severe macroeconomic imbalances that persisted for the following two decades (Canuto, Dinh, and Ayn here 2024). This national trajectory, both during the growth phase and the subsequent crisis, did not unfold uniformly across space. Instead, it exacerbated regional disparities, with the North and Northeast lagging behind the rest of the country, especially in relation to São Paulo and the Southeast as a whole.

Carrying the burden of its historical challenges, Brazil's economy regained growth capacity from the 2000s onward. Economic expansion, coupled with conditional cash transfer policies, contributed to reducing poverty and inequality, both among individuals and across regions (Fernandes and Pereira 2024). However, these advancements proved insufficient to elevate the country to high-income status or substantially reduce regional inequalities. This stagnation can largely be attributed to the persistence of structural issues within the Brazilian economy, which have kept it trapped in what is widely known as the “Middle-Income Trap”.

The concept of middle-income traps in developing countries refers to economies that have successfully transitioned from low- to middle-income status but subsequently experienced prolonged stagnation in growth. These traps have been linked to the inability to drive continuous productivity increases and to shift workers into more knowledge- and technology-intensive (i.e., more complex) sectors (Bianchi *et al.*, 2024; Hidalgo, 2021).

For regions within developing countries, this problem is more complex. As a populous, continental middle-income country with marked regional inequalities, Brazil presents a particularly challenging case. Some regions have demonstrated a strong capacity for income growth, job creation, productivity improvement, and even innovation. However, other regions have faced stagnation, with low-income growth and significant job losses, particularly in manufacturing. National-level studies suggest that such regions may be trapped in long-term economic stagnation, potentially experiencing both low- and middle-income traps (Im; Rosenblatt, 2013; Radosevic; Yoruk, 2018).

Despite these insights, the application of country-level analyses and indicators to subnational areas requires substantial conceptual and methodological adjustments. Even studies focused on European regions demand modifications to address the specific characteristics of developing countries. For instance, European regions tend to be caught at considerably higher levels of gross domestic product (GDP) per capita than their counterparts in developing countries (Diemer *et al.*, 2022).

In this context, the aim of this paper is to introduce a Regional Development Trap Index for a developing country like Brazil, addressing a significant gap in the literature through a more nuanced regional analysis. First, we define the concept of the regional development trap, highlighting how some regions have reached middle-income status but remain stagnant, while others continue to be trapped in low-income conditions. Building on this and following Diemer *et al.* (2022), we apply a synthetic indicator to assess regional dynamism in terms of economic, productivity, and employment performance relative to recent trends. This approach allows us to pinpoint regions in Brazil at significant risk of entrapment between 2005 and 2020 and to examine the key factors that differentiate them.

Therefore, this paper contributes to the literature on regional economic dynamics by developing an index tailored to identifying regional development traps in a developing country context. While previous studies have largely focused on European regions, our approach adapts and refines these frameworks to account for the structural and institutional specificities of Brazil. By constructing a synthetic indicator that captures regional economic, productivity, and employment trends, we provide a systematic method for assessing the risk of entrapment in both low- and middle-income situations. This allows for a more granular understanding of the persistence of regional disparities and the factors driving stagnation, offering insights that are critical for designing targeted policy interventions.

The paper proceeds as follows. The next section reviews the related literature on regional development traps and the dynamics of economic growth. Section 3 describes the data, and the measures used to construct the Regional Development Trap Index. In Section 4, we present and discuss our findings, highlighting the regional variations and the factors contributing to the trap. The final section offers a conclusion.

2. Methodology

The aim of this study is to identify Brazilian regions that are either already in a development trap or at significant short-term risk of falling into one. This requires distinguishing between a level indicator and a flow (growth) indicator, as well as analytically separating the structural characteristics of regions from their economic performance. Although these two dimensions are historically interconnected, only persistent differences in growth rates can lead to a lasting divergence in the trajectories of different regions.

With this distinction in mind, it is essential to establish objective parameters for classifying a region as being “caught in a trap”. Im and Rosenblatt (2013) highlight that this classification can be defined in either absolute or relative terms, each yielding distinct conclusions at the national level.

A relative approach assumes that the “target” or wealthier region is itself evolving. In other words, for a poorer region to catch up to the per capita output level of a wealthier region, it must consistently grow at a higher rate than the latter. Even if, over a decade, the poorer region reaches the per capita income level that the wealthier region had at the start, it would still not have escaped its lower-income status if it grew at the same or a slower rate than the wealthier region. Conversely, an absolute threshold or “fixed target” disregards growth rate differentials, which could lead to increasing regional disparities. In this case, a poorer region might surpass the income threshold that classifies it as poor but remain significantly behind wealthier regions.

In this study, we adopt an intermediate classification method based on a hierarchical clustering algorithm applied to per capita income levels. This approach ensures consistent and robust boundaries for intertemporal comparisons.

Regardless of the parameters used to classify regions into income categories (e.g., low-income, middle-income, high-income), what ultimately defines a development trap is the dynamic capacity of the regional economy. Thus, the core objective of this study is to construct an indicator that assesses the “risk” of a region being—or becoming—trapped in a development trap, based on the growth patterns of selected economic variables. This indicator was subsequently transformed into a categorical variable using the same hierarchical clustering algorithm. The following subsections provide a detailed description of these procedures.

2.1. Data

The dataset used in this study was constructed using data from three sources: the Annual Report of Social Information (RAIS), the Brazilian Institute of Geography and Statistics (IBGE), and the Institute of Applied Economic Research (IPEA).

First, we used data from RAIS, compiled by the Ministry of Labor and Employment (MTE), to derive variables related to formal employment, including the number of jobs and employment per capita. These variables are essential for understanding labor market dynamics and regional variations in formal employment over time. Second, we used data from IBGE, which provided socioeconomic indicators such as gross domestic product (GDP) per capita at constant 2010 prices, as well as demographic data. These indicators are crucial for assessing economic performance and income levels across different regions, enabling a comparative analysis of regional development trajectories. Lastly, we incorporated data from IPEA to complement our analysis, focusing on regional economic complexity, infrastructure, and other macroeconomic indicators. These additional data helped contextualize growth patterns and structural changes within Brazil’s regions.

The dataset covers the period from 1999 to 2020. The calculation of growth rates with a five-year lag led to the loss of the first five observations, while one additional observation was lost due to the

calculation of acceleration indicators. As a result, the Development Trap Index (DTI) was measured for the period between 2005 and 2020.

The regional analysis is conducted at the level of Brazilian mesoregions, which are intermediate spatial units defined by IBGE. These mesoregions, similar to NUTS-2 regions in the European Union, provide an appropriate level of analysis for examining regional development dynamics in Brazil. By adopting mesoregions as the unit of analysis, this study captures significant variations in economic performance and employment patterns across the country, allowing for the identification of regional disparities and the potential for regions to fall into—or remain in—development traps.

2.2. Regional Development Trap Index

Following Diemer et al. (2022) and Çinar (2023), and adapting their approach to the regional context of the Brazilian economy, we employ an index that captures economic, productivity, and employment performance. This index is constructed based on a combination of growth rates, accelerations, and deviations of three key variables: 1) gross domestic product (GDP) per capita at constant 2010 prices, which serves as the standard economic indicator in the literature; 2) Labor productivity, measured as the total gross value added at constant 2010 prices per formal employment relationship; and 3) The formal employment rate, defined as the proportion of formal employment relationships relative to the total population, serving as an indicator of employability.

The procedure for measuring the index consists of four stages. First, the compound average growth rate of each variable (y) is calculated using a five-year time lag, as shown in Equation 1. Consequently, each observation of the growth rate captures the short-term dynamics of the variables over the preceding five years.

$$g_{it,t-5} = \frac{1}{5} \times \ln \left(\frac{y_{it}}{y_{it,t-5}} \right) \quad \text{Equation 1}$$

Secondly, to capture structural changes in the dynamics of the variables, we calculate the acceleration, which is measured as the difference between the observed growth rate and the growth rate from the previous period (as shown in Equation 2). This calculation incorporates a time window spanning the last 10 years, allowing for the identification of shifts in the growth trajectory over a longer period.

$$a_{it} = g_{it,t-5} - g_{it-5,t-10} \quad \text{Equation 2}$$

The third step is to quantify the deviation in growth observed in the regions both state to which it belongs (equation 3) and of Brazil as a whole (equation 4)¹.

$$d_{it}(e) = g_{it} - g_{et-1} \quad \text{Equation 3}$$

$$d_{it}(c) = g_{it} - g_{ct-1} \quad \text{Equation 4}$$

For the last step, following Diemer et al (2022), two distinct approaches are used to measure developmental pitfalls. The first (equation 5) is based on an average of dummies, defined by the accelerations and deviations of the variables, assuming the value 1 when they present a positive value, or 0 otherwise. The second is based on a standardized average of the observations (equation 6)².

¹ This is the main difference between the original proposal, in which the deviations are calculated in relation to the countries and in relation to the European Union as a whole. We considered the country as the aggregate dimension and the states of the federation as the intermediate, while our regional cut is the Brazilian mesoregions, which are similar to the EU NUTS2.

² Note that both methods were adapted to obtain results for the Federal District of Brasília, which does not belong to any state

$$DTI_1 = \left\{ \begin{array}{l} 1 - (\sum Da_{it} + \sum Dd_{it}(e) + \sum Dd_{it}(c))9^{-1} \\ Brasília: 1 - (\sum Da_{it} + \sum Dd_{it}(c))6^{-1} \end{array} \right\} \quad \text{Equation 5}$$

$$DTI_2 = \left\{ \begin{array}{l} \frac{[-1[(\sum a_{it} + \sum d_{it}(e) + \sum d_{it}(c))9^{-1}] - \mu^{uns.I dt_2}]}{\sigma^{uns.I dt_2}} \\ Brasília: \frac{-1[(\sum a_{it} + \sum d_{it}(c))6^{-1}] - \mu^{uns.I dt_2}}{\sigma^{uns.I dt_2}} \end{array} \right\} \quad \text{Equation 5}$$

In the standardized version, it is the mean and standard deviation before the standardization process referring to the first annual result of the indicator (2005). As highlighted by Diemer et al. (2022), the second measure is more sensitive to outliers and is often harder to interpret, unlike the first approach, which relies on dummy variables. However, the first method does not take into account the size of the variations in the variables, potentially leading to an underestimation or overestimation of the risk of falling into or remaining in a development trap in the region (see Figure 2).

2.3. Building Groups

To identify development traps in Brazilian regions, it is essential to construct groups that allow for comparison over time. To achieve this, we employed a hierarchical clustering algorithm as the foundation for categorizing the Regional Development Trap Index (DTI) and per capita gross domestic product (GDP), which serves as a proxy for income levels.

Hierarchical clustering is a set of techniques aimed at organizing data into a hierarchy of groups, without the need to pre-define the number of clusters. This method can be performed in two main ways: bottom-up, where each data point begins as an individual cluster and clusters are successively merged, and top-down, where all data points start as one cluster and are progressively divided. The objective is to group observations in such a way that elements within each group are more similar to each other than to elements in other groups (Hair *et al.*, 2019).

Among the various available algorithms, we used Ward's agglomerative method. This method minimizes the sum of squared distances (WSS) within clusters at each merging step, ensuring that the variance within the resulting groups is as small as possible. At each step, Ward's method merges the two clusters whose combination results in the smallest increase in total variance. This characteristic often leads to clusters of relatively similar size, making it particularly effective when aiming for compact and homogeneous groups (Hair *et al.*, 2019).

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To define the optimal number of clusters, we applied the elbow method, which identifies the point where the reduction in WSS slows down, forming an "elbow" on the graph. The location of this elbow marks the optimal number of clusters, striking a balance between model complexity (with a higher number of clusters) and cluster cohesion (reflected by a lower WSS). The procedure involved standardizing the data and applying Ward's clustering algorithm by year for each variable (DTI1, DTI2, and GDP per capita). The results of the cluster hierarchy and thresholds for each variable are presented

in Figure A1 and Table A1 in Annex A.

As a result, we identified three groups for the Development Trap Index and four groups for GDP per capita. This choice reflects a significant reduction in WSS while maintaining an analytically consistent number of categories across variables. The clusters reveal regional development patterns captured by the DTI1 and DTI2 indicators and income disparities through GDP per capita.

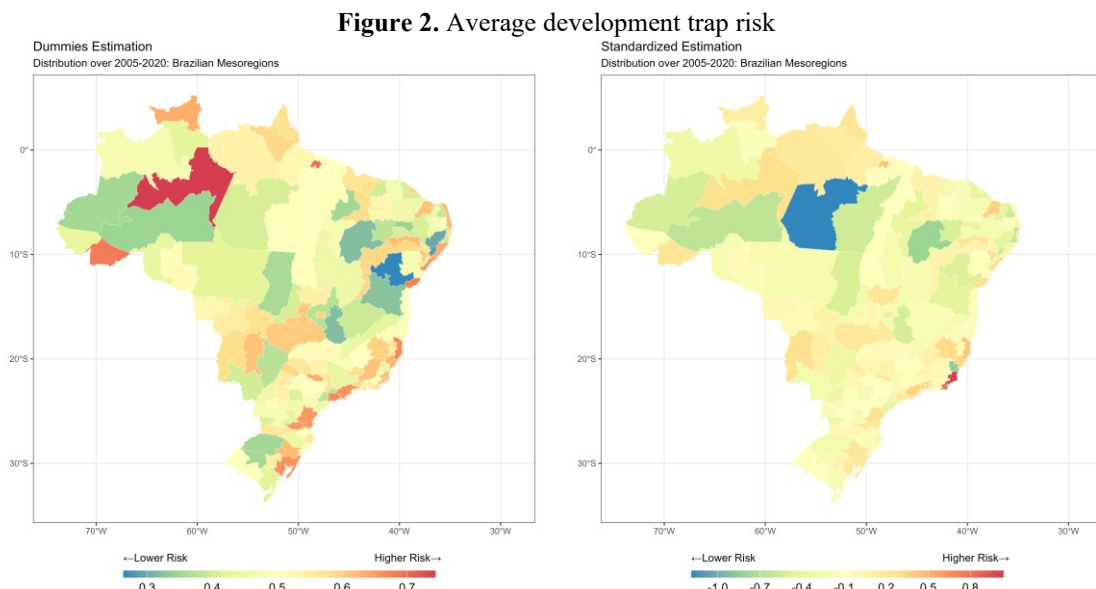
This categorization forms the basis for subsequent analyses, enabling temporal and spatial comparisons of regional development and income. Grouping the observations reveals persistent patterns, structural changes, and regions at risk of falling into development traps.

3. Discussions and Results

Figure 2 presents the average distribution of the indicators (DTI_1 and DTI_2) over the entire period, where higher values correspond to an increased likelihood of a region falling into or remaining trapped in middle- or low-income strata.

Notably, the indicator based on the dummy variable (DTI_1) exhibits fewer extreme results, as it is constrained between 0 and 1, whereas its standardized counterpart (DTI_2) displays continuous values approximately centered around zero. While DTI_1 facilitates clearer comparisons between regions, it may obscure the intensity of regional dynamics and critical inflection points. This suggests that both measurement approaches provide complementary insights.

The average risk level varies across the country, revealing spatial patterns with clusters of high- and low-risk areas. Regions with higher average risk tend to be concentrated in densely populated areas, including state capitals and major economic hubs, as well as specific interior regions across all macro-regions. Conversely, regions with the lowest risk levels are predominantly located in the country's interior, particularly in areas characterized by agricultural and mineral production.



Source: Prepared by the authors based on the results of the research

In other contexts, these findings have been interpreted as evidence of absolute and conditional convergence, wherein poorer regions tend to grow at faster rates than wealthier ones (Almeida; Moreira, 2019). However, a closer examination of regional trajectories beyond these average trends reveals a more nuanced reality. The results capture a spectrum of development paths, ranging from regions that benefited most from Brazil's economic growth regime in the 21st century to those marginalized and constrained by structural challenges (Fernandes; Pereira, 2024).

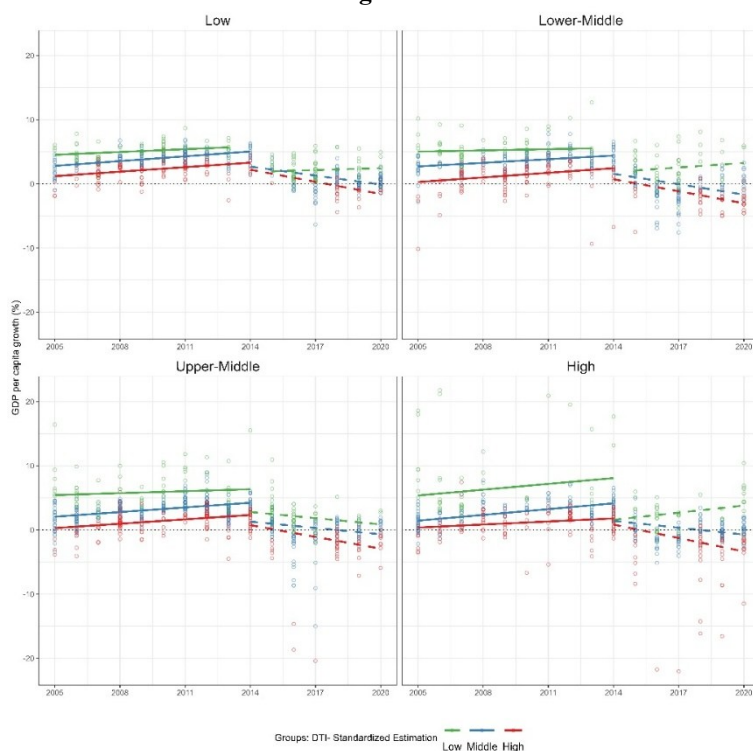
The period under analysis is not a homogeneous unit without disruptions. Between 2004 and 2014, Brazil experienced the expansionary phase of a significant growth cycle, followed by a deep recession in 2015–2016 and subsequent stagnation until 2019. The COVID-19 pandemic in 2020 introduced yet another major economic shock. For a middle-income country marked by profound regional inequalities, the cumulative effects of a decade of crises and stagnation pose complex challenges with potential long-term repercussions.

Figure 3 illustrates the economic growth performance of regions, categorized by GDP per capita groups and risk groups of falling into an economic development trap. The disparities in growth dynamics across regions and risk groups are evident.

The figure highlights several key patterns. First, regions in higher-income groups (higher GDP per capita) exhibited more volatile growth rates and greater dispersion, in contrast to the more stable trajectories of low-income regions (lower GDP per capita) during both expansionary and recessionary periods. Second, low-risk regions recorded higher growth rates; however, an accelerating growth trend was observed across all risk and income groups until 2014. After this point, the trend reversed, with many regions experiencing deep recessions. While low-risk regions were also affected, they were the only ones that managed to recover some growth momentum—except for middle-upper-income regions—contrasting with the sharp decline observed in high-risk areas. Third, and finally, the divergence in growth levels among risk groups was more pronounced in high-income regions.

A particularly notable observation is the emergence of regions within the high-income group that demonstrate strong economic growth alongside minimal risk of falling into development traps. The concentration of such regions in the Centro-Oeste suggests that their economic performance is closely linked to Brazil's successful integration into global markets as a leading exporter of agricultural and mineral commodities. This pattern also helps explain the recovery observed in low-risk regions after 2014, which stands in contrast to the trajectories of other regions during the same period.

Figure 3.



Source: Prepared by the authors based on the results of the research

Between 2005 and 2014, many high-income regions—as well as others that ascended to this

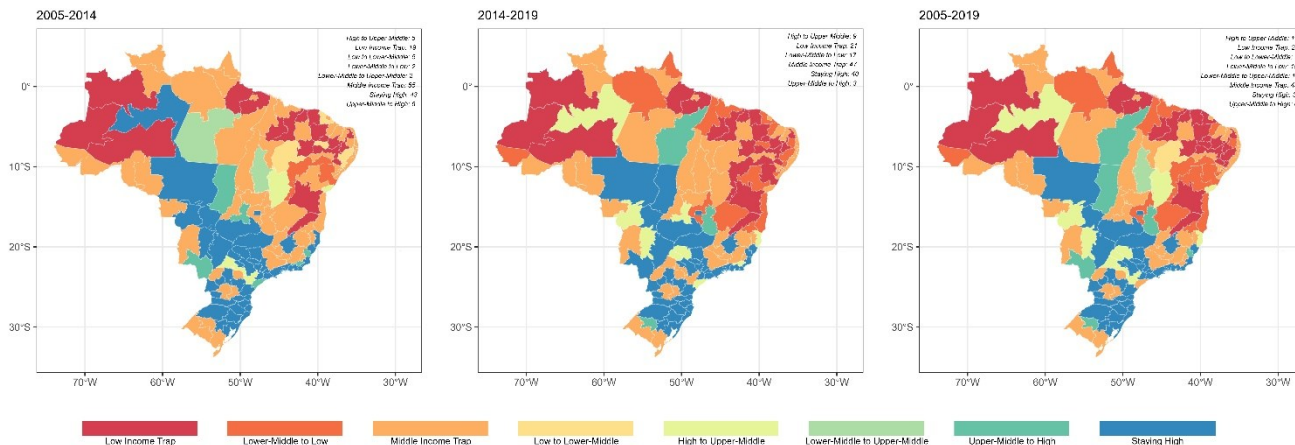
status or to upper-middle-income status—were concentrated in central Brazil, forming what could be described as “new rich regions” (Figure 4). This rise contrasts sharply with the near stagnation observed in some “old rich regions” during the same period, particularly in the Southeast, including parts of São Paulo and Rio de Janeiro. This complex landscape reflects the interplay of structural and macroeconomic trends alongside endogenous factors such as institutional arrangements and localized policies.

The stagnating “old rich regions” historically drove Brazil’s economic growth throughout the 20th century, primarily through industrialization and national market integration. However, these regions are now experiencing a persistent decline in industrial complexity and competitive capacity, leading to premature deindustrialization (Rodrik, 2016; Sugimoto; Diegues, 2022). As a result, some of the country’s most industrialized mesoregions face an increasing risk of falling into an economic development trap, heightening the likelihood of regressing to middle-income status.

These findings underscore that the crisis following 2014 cannot be dismissed as a short-term fluctuation. Rather, it is deeply rooted in the structural challenges of the Brazilian economy, which manifest regionally through varying types of development traps.

Despite the growth observed between 2005 and 2014, the results indicate that transitions between income groups were exceptions. Most regions maintained their previous status, with areas trapped in middle-income and low-income traps remaining largely unchanged (Figure 4). In the post-2014 period, while a few mesoregions exhibited upward trajectories, the vast majority—despite differences in income levels and regional challenges—remained caught in a middle-income trap. The economic crisis had a significant impact, leading to the regression of several high-income regions to middle-income status and pushing many middle-income regions into low-income conditions.

Figure 4.



Source: Prepared by the authors based on the results of the research. Note: The **low-income trap** refers to regions that remain classified within the low GDP per capita group in both years. The **middle-income trap** applies to regions that were classified as lower-middle or upper-middle in both years.

Interestingly, although no perfect linear relationship exists between development trap risk levels and income status, an increase in the proportion of mesoregions classified as high risk preceded the 2015–2016 crisis. This rise in high-risk classifications began in 2010 and peaked in the initial year of the crisis (2015). From the second year of the series onward, middle risk became the predominant classification among mesoregions.

This middle-risk profile indicates stability, but its implications vary depending on income status. For high-income mesoregions, stability may not pose an immediate threat unless it persists over time, as prolonged stagnation increases the likelihood of transitioning to high risk and, ultimately, regressing to middle-income status. Conversely, for middle- and low-income regions, a middle-risk classification often signals an inability to undergo the structural transformation necessary to escape poverty or progress to high-income levels.

4. Conclusions

The analysis of regional economic trajectories in Brazil from 2005 to 2019 highlights the persistent and multifaceted nature of regional inequality. While the period up to 2014 saw significant improvements in growth and income levels across several regions, the post-2014 economic crisis exposed structural vulnerabilities that have hindered sustained progress. The rise of "new rich" regions in the Center-West—driven by an export-oriented growth model—stands in stark contrast to the stagnation of "old rich" regions in the Southeast, where premature deindustrialization and structural challenges have increased the risk of economic development traps.

The interaction between income levels and risk profiles provides critical insights. Lower-income regions with lower risk levels show potential for overcoming poverty barriers, whereas middle-income regions—particularly those caught in a middle-income trap—face greater challenges due to higher risks and structural limitations. These findings underscore the need for targeted regional policies that address the specific constraints affecting different income groups.

Ultimately, the patterns observed during this period reflect broader structural challenges in the Brazilian economy, including the limitations of the primary export model, the uneven impacts of macroeconomic shifts, and the lack of structural transformation in many regions. Addressing these issues requires a comprehensive strategy that integrates regional development initiatives with national economic policies, fostering innovation, industrial diversification, and equitable growth across the country.

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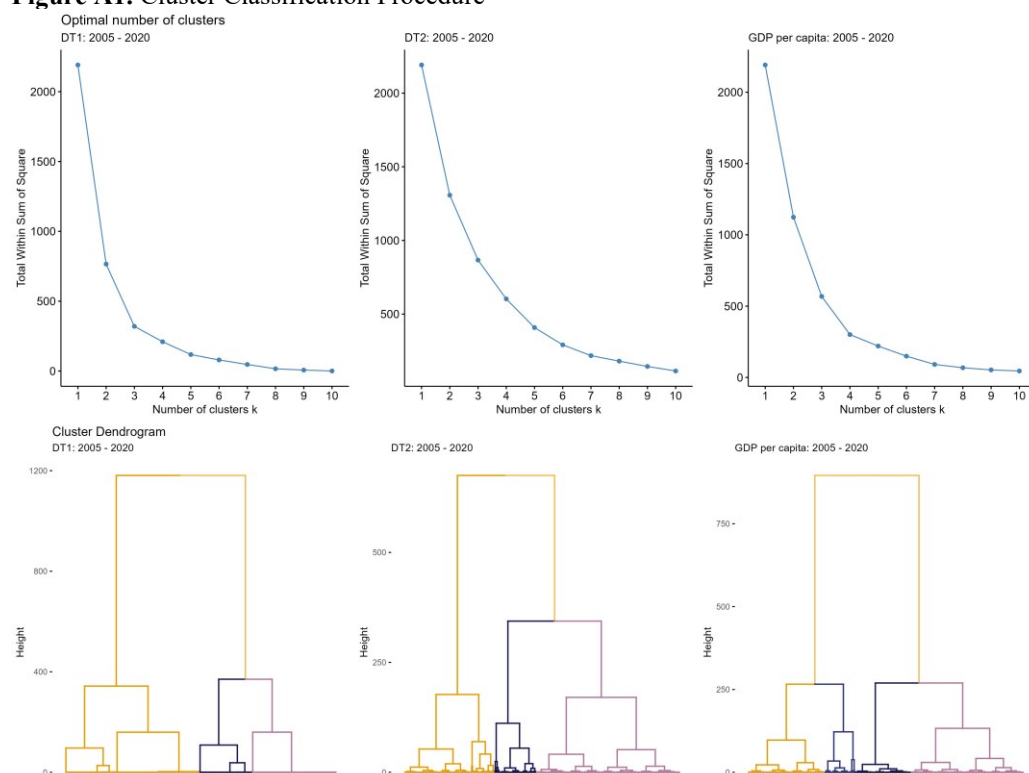
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Annexes

Figure A1. Cluster Classification Procedure



Source: Prepared by the authors based on the results of the research

Table A1. Mean of annual groups thresholds

Thresholds	Development Trap Index: Dummies Estimation	Development Trap Index: Standardized Estimation	Gross Domestic Product Per Capita*	
Low	[0.028, 0.319)	[-3.510, -0.895)	[4.00, 8.04)	
Middle	[0.431, 0.569)	[-0.660, 0.426)	lower	[8.52, 13.20)
			upper	[13.90, 20.40)
High	[0.674, 1.000]	[0.845, 3.190]	[21.40, 70.3]	

Source: Prepared by the authors based on the results of the research. *Thousands of Brazilian reais constant at 2010 prices.