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IMPACTO DA TRANSIÇÃO DEMOGRÁFICA NO FUNDO DE PARTICIPAÇÃO DOS MUNICÍPIOS NO BRASIL: EVIDÊNCIAS DE ANÁLISE ESPACIAL E MODELAGEM EMPÍRICA (2000-2030)

IMPACT OF THE DEMOGRAPHIC TRANSITION ON THE MUNICIPAL PARTICIPATION FUND IN BRAZIL: EVIDENCE FROM SPATIAL ANALYSIS AND EMPIRICAL MODELING (2000-2030)

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Abstract

How does Brazil's current demographic transition affect the financial sustainability of local governments that depend on the Municipalities' Participation Fund (FPM)? This study diagnoses the mismatch between the FPM allocation methodology and Brazil's population dynamics, quantifying the impact of population growth on municipal revenues. The study hypothesizes that the current design of the Fund operates as a procyclical fiscal mechanism, concentrating resources in areas experiencing population growth while financially penalizing municipalities facing demographic stagnation. The methodology combines a spatiotemporal analysis of census data from 2000, 2010, and 2022, as well as projections for 2030, covering the entire national territory, with inferential empirical modeling. In this second stage, logistic and linear regression models are applied to a sample of 1,883 municipalities that changed their FPM coefficient bracket. The spatial results reveal increasing concentration of resources in major metropolitan areas and regional hubs. The empirical evidence confirms high fiscal sensitivity: population growth significantly increases the probability of moving to a higher coefficient bracket and, by itself, explains 37.8% of the variation in the FPM coefficient. The study concludes that the distribution criteria should be reformulated by incorporating multidimensional indicators to promote greater fiscal equity in response to demographic decline across large areas of the country.

Keywords: Municipal Participation Fund; Demographic Transition; Fiscal Federalism; Spatial Analysis; Empirical Analysis.

Resumo

Como a atual transição demográfica brasileira impacta a sustentabilidade financeira dos governos locais dependentes do Fundo de Participação dos Municípios (FPM)? Este estudo diagnostica a dissonância entre a metodologia de cálculo do FPM e a dinâmica populacional brasileira, quantificando o impacto do crescimento demográfico sobre as receitas municipais. Parte-se da hipótese de que o atual desenho do Fundo opera como mecanismo fiscal pró-cíclico, concentrando recursos em áreas de expansão e penalizando financeiramente municípios com estagnação demográfica. A metodologia combina análise espaço-temporal dos dados censitários de 2000, 2010 e 2022 e projeções para 2030, abrangendo todo o território nacional, com

modelagem empírica inferencial. Nesta etapa, aplicam-se modelos de regressão logística e linear a uma amostra de 1.883 municípios que alteraram sua faixa de coeficiente. Os resultados evidenciam crescente polarização dos recursos nas grandes metrópoles e polos regionais. As evidências confirmam elevada sensibilidade fiscal: o crescimento populacional aumenta significativamente a probabilidade de ascensão de faixa e explica, isoladamente, 37,8% da variação do coeficiente do FPM. Conclui-se pela necessidade de reformulação dos critérios distributivos, incorporando indicadores multidimensionais que promovam maior equidade federativa diante do esvaziamento demográfico de extensas regiões do país.

Palavras-chave: Fundo de Participação dos Municípios; Transição Demográfica; Federalismo Fiscal; Análise Espacial; Análise Empírica.

1 Introduction

Brazilian federalism comprises a complex arrangement of relationships among different levels of government, characterized by the decentralization of responsibilities to subnational entities, particularly municipalities. However, this autonomy contrasts sharply with the substantial concentration of revenue collection at the federal level (Queiroz, 2024). Within this imbalance, intergovernmental transfers have become the financial cornerstone of local public administration. Among these transfers, the Municipal Participation Fund (Fundo de Participação dos Municípios—FPM) stands out as the primary mechanism through which the federal government transfers resources to municipalities. For most Brazilian municipalities, particularly those with smaller populations, it represents their most important source of revenue (Bremaeker, 2023).

Rather than merely transferring resources, the FPM was designed as an unconditional and redistributive transfer intended to promote fiscal equalization and reduce regional disparities. Its capacity to foster municipal socioeconomic development has been widely recognized (Queiroz, 2024). Despite its undeniable importance, the FPM distribution methodology has an inherent vulnerability: it is based primarily on municipal population size. For non-capital municipalities in particular, population size often remains the sole determinant of the amount received (Queiroz, 2024).

This dependence on a population-based criterion, historically grounded in the expectation of unlimited demographic growth (Rodrigues, 2023; Queiroz, 2024), is increasingly at odds with Brazil's demographic transition. The country has experienced a marked slowdown in population growth, recording the lowest annual growth rate in its history in 2022, at 0.52%.

More importantly, projections indicate that Brazil's total population may begin to decline in the near future (Queiroz, 2024), a scenario reinforced by evidence that the country's demographic dividend has already come to an end (Correa, 2023). As a direct consequence of this new demographic pattern, a substantial number of municipalities have experienced population decline (Rodrigues, 2023). This trend is expected to intensify, with more than half of the country's municipalities projected to lose population by 2030 (Queiroz, 2024).

Population decline is not merely a statistical phenomenon; it directly affects FPM transfers (Rodrigues, 2023; Queiroz, 2024), raising serious concerns about the fiscal sustainability of municipal governments (Rodrigues, 2023; Queiroz, 2024). Temporary legislative measures, such as phased transition periods introduced to mitigate these losses, are often considered insufficient because they do not provide structural changes to the Fund's distribution criteria. This lack of reform perpetuates existing distortions and may even encourage the creation of new municipalities in pursuit of higher transfer coefficients, further fragmenting territorial governance (Queiroz, 2024).

Given the complexity of the relationship between demographic dynamics and municipal financing, the existing literature, although addressing distortions in the FPM, still lacks in-depth investigations directly linking structural population changes to the criteria used for distributing these resources. Understanding this relationship is essential for reconsidering the allocation of public resources in a country undergoing population aging and increasing urbanization.

Against this backdrop, the present study proposes a quantitative methodology comprising two complementary components to address this research gap. The first, descriptive and spatiotemporal in nature, maps changes in FPM distribution between 2000 and 2030. The second uses inferential econometric analysis to quantify the fiscal sensitivity of transfers to demographic changes. This combined approach makes it possible to isolate and measure the demographic effect, providing quantitative evidence to inform the debate and the urgently needed reforms to the methodology used to calculate and distribute FPM resources. Ultimately, the study seeks to contribute to a more equitable resource management system that is consistent with the country's emerging demographic reality.

2 Demographic dynamics and fiscal sustainability

The relationship between the state and society is mediated by institutional arrangements that should reflect the population structure. However, a temporal disconnect has emerged: demographic dynamics evolve rapidly in response to cultural, public health, and urban transformations (Camarano; Kanso; Fernandes, 2014), while the legal and fiscal framework remains rigid and continues to reflect conditions that no longer prevail. The financing crisis affecting local governments is therefore not merely an accounting problem. It reveals the mismatch between a changing society and a static federal system, creating challenges for territorial governance and public policy (Faria; Spode, 2024). Understanding this phenomenon requires an examination of the population changes described by demographic transition theory (Grupo de Foz, 2021), followed by an analysis of how the rigidity of the fiscal revenue-sharing system has become a source of institutional inadequacy in the face of Brazil's changing demographic profile.

2.1 Demographic dynamics and fiscal sustainability

The relationship between the state and society is mediated by institutional arrangements that should reflect the population structure. However, a temporal disconnect has emerged: demographic dynamics evolve rapidly in response to cultural, public health, and urban transformations (Camarano; Kanso; Fernandes, 2014), while the legal and fiscal framework remains rigid and continues to reflect conditions that no longer prevail. The financing crisis affecting local governments is therefore not merely an accounting problem. It reveals the mismatch between a changing society and a static federal system, creating challenges for territorial governance and public policy (Faria; Spode, 2024). Understanding this phenomenon requires an examination of the population changes described by demographic transition theory (Grupo de Foz, 2021), followed by an analysis of how the rigidity of the fiscal revenue-sharing system has become a source of institutional inadequacy in the face of Brazil's changing demographic profile.

2.2 Demographic Transition Theory and the Brazilian Context

Understanding changes in the size and age structure of Brazil's population requires an analysis grounded in demographic transition theory. This model describes the historical shift

from a traditional equilibrium characterized by high mortality and birth rates to a modern regime in which both rates stabilize at low levels (Grupo de Foz, 2021). The conventional model comprises four distinct stages. During the first stage, population growth is slow or nonexistent because fluctuations in mortality offset high birth rates.

The second stage is characterized by a sharp decline in mortality while birth rates remain high, leading to accelerated population growth. During the third stage, birth rates begin to fall, slowing population growth. Finally, the fourth stage establishes a new equilibrium characterized by low birth and mortality rates (Grupo de Foz, 2021).

In Brazil, this process occurred unusually rapidly and was largely driven by external forces. Unlike European countries, where the transition unfolded over an extended period and was accompanied by gradual improvements in living conditions, Brazil's transition was propelled by factors such as rapid urbanization and the introduction of medical and public health technologies (Camarano; Kanso; Fernandes, 2014). Mortality began to decline steadily in the 1940s, resulting in population growth rates that peaked at approximately 3.0% per year during the 1950s and 1960s (Camarano; Kanso; Fernandes, 2014).

The third stage of the transition, characterized by declining fertility, began in Brazil in the mid-1960s. The total fertility rate, which stood at 6.2 children per woman among those born in the late nineteenth century, declined sharply among more recent cohorts, falling below the replacement level (Camarano; Kanso; Fernandes, 2014). Current research also considers the existence of a fifth stage, or second demographic transition, in which fertility remains below replacement level and the population tends to decline over the long term. This phenomenon has already been observed in countries such as Portugal and Japan and is projected to occur in Brazil over the coming decades (Grupo de Foz, 2021).

These dynamics have profoundly altered the country's age structure. Brazil has shifted from a predominantly young population to a process of rapid population aging. In 1872, older adults accounted for only 4.9% of the population; by 2010, this group already represented a substantial share, and projections indicate that Brazil may become a super-aged society in the future (Camarano; Kanso; Fernandes, 2014).

This process, however, is not unfolding uniformly across Brazil. The country is experiencing several demographic transitions simultaneously, marked by substantial regional inequalities. While the South and Southeast have reached advanced stages of population aging, with indicators comparable to those of developed countries, the North and Northeast still have younger population structures, although these regions are also undergoing demographic change (Faria; Spode, 2024). The population aging index reflects these disparities: it is significantly higher in the states of Rio Grande do Sul and Rio de Janeiro and lower in northern states such as Roraima and Amapá (Faria; Spode, 2024).

A crucial consideration for municipal governance is the relationship between urban hierarchy and demographic dynamics. Population aging is more pronounced in local urban centers and small municipalities, not only because of declining fertility but primarily because young people migrate to major urban centers in search of opportunities (Faria; Spode, 2024). This demographic decline in small municipalities produces a form of population aging driven by the loss of working-age residents rather than necessarily by improvements in local living conditions, thereby threatening the fiscal sustainability of these municipalities (Faria; Spode, 2024).

The assumption of continuous population growth is inconsistent with the current demographic reality described by theory and demonstrated by census data. Brazil is moving toward a period of population stabilization followed by decline, with an increasingly older age structure and substantial heterogeneity across regions and types of municipalities (Camarano; Kanso; Fernandes, 2014; Faria; Spode, 2024). Given this accelerated and uneven transition, it

is essential to examine how Brazil's federal arrangement, designed in the mid-twentieth century, responds—or fails to respond—to these emerging demographic dynamics.

2.3 Fiscal Federalism and the FPM Mismatch

While Brazil's demographic landscape was undergoing the profound transformations described above, the municipal financing structure was being consolidated on assumptions shaped by a country whose population was still expanding. The analysis of intergovernmental transfers is grounded in the classical theory of public finance, according to which Musgrave (1989) identifies three essential functions of the state: allocation, distribution, and stabilization.

Within a federal system, Oates (1999) argues that the allocation function is performed more efficiently by local governments because of their ability to tailor services to the specific preferences and circumstances of their communities. In contrast, the distribution and stabilization functions require central coordination because of constraints such as factor mobility and the economic openness of subnational jurisdictions.

This asymmetry creates a need for intergovernmental transfers to address two types of fiscal imbalance: vertical imbalance, arising from the concentration of revenue at the central government level and the assignment of responsibilities to subnational governments; and horizontal imbalance, resulting from disparities in fiscal capacity and expenditure needs among jurisdictions at the same level of government (Shah, 2007).

From a normative perspective, transfers should promote fiscal equalization by enabling jurisdictions with different tax bases and social demands to provide comparable public services while exerting similar levels of fiscal effort (Shah, 2007). However, when resource allocation disregards local fiscal capacity or specific expenditure needs, the transfer mechanism may fail to fulfill its equalization function and may even widen regional disparities (Silva, 2005).

In Brazil, the Municipal Participation Fund (Fundo de Participação dos Municípios (FPM) was established as the primary instrument for implementing this redistributive principle and reducing such inequalities. Formally created by Constitutional Amendment No. 18/1965, the Fund introduced a new national tax system and was initially composed of 10% of the revenue collected from the Individual and Corporate Income Tax (Imposto de Renda—IR) and the Tax on Manufactured Products (Imposto sobre Produtos Industrializados (IPI) (Bremaeker, 2023; Queiroz, 2024).

The regulation of the FPM by the Brazilian National Tax Code (Código Tributário Nacional (CTN) in 1966 marked a fundamental change by replacing equal distribution with individual participation coefficients based on population brackets. This system was founded on the premise that smaller municipalities should receive proportionally more resources (Bremaeker, 2023; Queiroz, 2024).

The legislative development of the FPM reflects the consolidation of municipalities as autonomous members of the Brazilian federation, a status formally established by the 1988 Federal Constitution. Over the past several decades, various constitutional amendments, including Amendments No. 55/2007, No. 84/2014, and No. 112/2021, have increased the share of federal tax revenue allocated to the Fund, gradually raising it to 25.5% (Bremaeker, 2023). The current distribution system follows fixed criteria: 10% is allocated to state capitals, 3.6% to a reserve for highly populated municipalities, and the largest share, 86.4%, to all other municipalities, whose participation coefficients are determined almost exclusively by population size (Queiroz, 2024).

However, the FPM calculation methodology was established on the assumption of continuous and unlimited population growth (Rodrigues, 2023; Queiroz, 2024). The Fund's institutional design directly links municipal revenue to population counts, making municipal

finances highly sensitive to statistical fluctuations. This fiscal structure now conflicts with the structural demographic changes discussed in the previous section. The current model assumes indefinite population growth, despite the stabilization and even decline already observed in many municipalities (Rodrigues, 2023).

The 2022 Population Census confirmed the mismatch between fiscal rules and demographic conditions. It revealed the lowest population growth rate in Brazil's history, at 0.52%, and showed that 2,397 municipalities—equivalent to 43% of the national total—had lost residents since 2010 (Rodrigues, 2023; CNM, 2023). Most of these losses were concentrated within the lower FPM population brackets, directly affecting the revenues of municipalities that have historically depended on these transfers to maintain their administrative operations (Rodrigues, 2023; CNM, 2023; Queiroz, 2024).

In response to the abrupt effect of the new census data on the FPM distribution coefficients, Complementary Law No. 198/2023 established a ten-year transition period during which transfers to the affected municipalities would be gradually reduced (Rodrigues, 2023; CNM, 2023; Queiroz, 2024). Although this measure helps prevent immediate budgetary collapse, it remains a temporary solution and does not address the structural distortions of a financing model that disregards the emerging conditions of a country undergoing rapid demographic transition and population aging (Queiroz, 2024).

3 Methodology

This study adopts a quantitative methodological approach comprising two complementary analytical components to investigate the relationship between demographic dynamics in Brazilian municipalities and FPM transfers. The analysis covers a 30-year period, focusing on 2000, 2010, and 2022, as well as projections for 2030.

3.1 Data Sources and Processing

Population data were obtained from the Population Censuses conducted by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística (IBGE) for 2000, 2010, and 2022, covering all 5,570 Brazilian municipalities. The 2030 analysis used estimates developed by the Population Estimates and Projections Laboratory (Laboratório de Estimativas e Projeções Populacionais (LEPP) at the Federal University of Rio Grande do Norte (Universidade Federal do Rio Grande do Norte (UFRN), which account for recent trends in municipal population growth and decline.

FPM data were compiled using the applicable distribution coefficients and the criteria established by the Brazilian Federal Court of Accounts (Tribunal de Contas da União (TCU, 2024), which uses population brackets as the primary parameter for allocating transfers to municipalities.

The datasets were structured and merged using the municipalities' IBGE identification codes, ensuring temporal comparability across the different sources. While the spatial analysis included all Brazilian municipalities, the subsequent econometric analysis focused on a specific sample comprising the 1,883 municipalities that changed FPM population brackets between 2000 and 2022. For models requiring the population growth rate for the most recent intercensal period, from 2010 to 2022, the final valid sample consisted of 1,454 observations.

3.1 Descriptive and Spatiotemporal Analysis

The first stage of the analysis was descriptive and exploratory and focused on the statistical processing and examination of municipal demographic and fiscal data. Population growth and decline rates were calculated for each municipality over the periods analyzed, along

with the expected changes in their FPM participation coefficients. This stage made it possible to identify shifts in demographic dynamics and determine how they corresponded to changes in municipalities' access to intergovernmental transfers, thereby contributing to an understanding of the potential effects of demographic transition on municipal revenue and local fiscal management.

The spatiotemporal analysis integrated demographic and fiscal data with the digital cartographic boundaries of Brazilian municipalities provided by the IBGE. This analysis was conducted using QGIS, an open-source geographic information system. Integrating these data made it possible to map the selected indicators and examine their geographic distribution, thereby identifying patterns of population concentration, growth, and decline associated with changes in FPM coefficients.

The analytical stage centered on the development of choropleth thematic maps to visualize the spatial distribution of FPM coefficients, expected changes in FPM transfers, and their relationship with observed demographic changes. The cartographic representations highlighted geographic differences in population dynamics and the distribution of intergovernmental transfers. They also contributed to identifying potential patterns of resource concentration in areas experiencing population growth and relative losses in participation among municipalities with stagnant or declining populations.

The Jenks Natural Breaks classification method was used to classify the data and define the value ranges displayed on the maps. This method identifies breakpoints within a data distribution by minimizing within-class variance while maximizing between-class variance (Jenks, 1967). It is particularly suitable for representing variables with heterogeneous spatial distributions because it defines class intervals according to the underlying structure of the data, thereby avoiding the use of equal intervals that could obscure relevant differences among municipalities.

Five classes were defined for each map to ensure adequate visual differentiation among the levels of the indicators analyzed and to highlight the spatial structure of the demographic and fiscal phenomena. Standardizing the number of classes also facilitated visual comparisons across maps, making it possible to examine how the geographic distribution of the population relates to the structure of FPM transfers throughout the period analyzed.

3.2 Inferential Empirical Modeling

In addition to the descriptive and spatial analyses, this study employs inferential econometric modeling to rigorously quantify the strength of the relationship between population growth and changes in FPM brackets.

This second stage focuses on a specific subset of the data comprising the 1,883 municipalities that changed FPM brackets between 2000 and 2022. The econometric analysis used the population growth rate from 2010 to 2022 as the main explanatory variable.

Two complementary models were estimated. First, a logistic regression model (Logit) was used to estimate the probability that a municipality moved to a higher FPM bracket, given its population growth rate. The dependent variable represents an "increase in bracket" and is a binary (*dummy*) variable that takes the value of 1 if the municipality moved to a higher bracket and 0 if it moved to a lower bracket. The general form of the Logit model is:

where Λ denotes the cumulative logistic distribution function (Wooldridge, 2010). Empirically, the model tests whether β_1 is positive and statistically significant, thereby addressing the following question: "Does a higher population growth rate increase the probability that a municipality will gain rather than lose FPM revenue?" Marginal effects were calculated to express the estimated impact in percentage points.

Second, an ordinary least squares (OLS) regression model was estimated using ΔFPM as the dependent variable. This continuous variable was constructed as the difference between the FPM coefficient observed in 2022 and that observed in 2000 ($FPM_{2022} - FPM_{2000}$). Unlike the binary variable used in the previous model, ΔFPM captures the magnitude of the fiscal change. For example, a value of $+0.2$ indicates that the municipality moved up one level on the transfer scale, whereas a value of $+0.6$ represents a substantial increase of three brackets. Conversely, negative values, such as -0.2, represent an actual loss of resources. The general form of the OLS model is:

In Equation (2), the coefficient β_1 measures fiscal sensitivity by estimating the average number of FPM coefficient points that a municipality gains or loses for each additional unit of its population growth rate. The model's coefficient of determination (R^2) was used to assess the overall explanatory power of demographic dynamics in accounting for the magnitude of the fiscal changes experienced by municipalities (Wooldridge, 2010).

This two-part methodological approach, combining spatial analysis in QGIS with econometric modeling, makes it possible not only to identify and map the municipalities most vulnerable to losses in FPM revenue but also to quantify the statistical strength of this relationship. Combining these analyses provides a more comprehensive understanding of the financial challenges and opportunities facing municipal governments amid Brazil's demographic transformations and offers robust evidence to inform discussions on reforming the Fund's distribution criteria.

4 Results and discussion

This study examined the mismatch between the FPM distribution methodology and Brazil's demographic transition by combining spatiotemporal analysis with econometric modeling to map fiscal vulnerability and measure the sensitivity of transfers to population changes.

4.1 Spatiotemporal Analysis of FPM Dynamics (2000–2030)

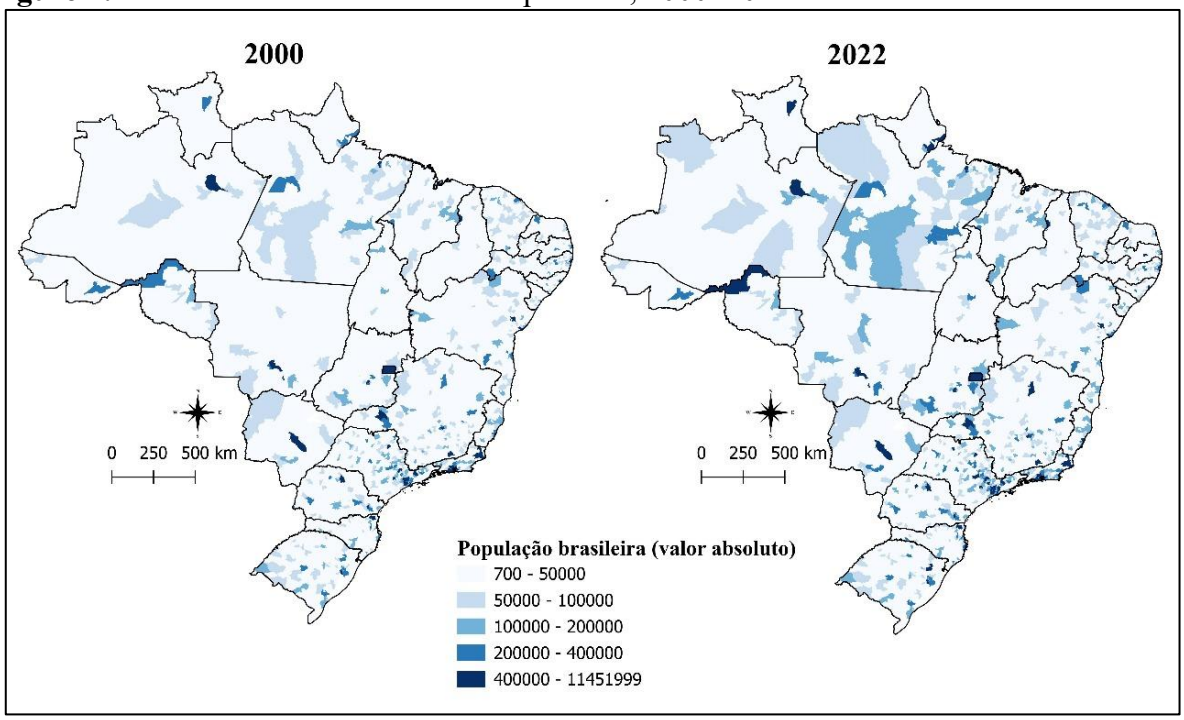
The results obtained from the quantitative and spatiotemporal methodological approach are presented and discussed below, with emphasis on Figures 1, 2, and 3. A comparison of the spatial distribution of Brazil's population in absolute terms in 2000 and 2022 reveals substantial spatial and temporal changes in the country's demographic structure. These patterns have direct implications for municipal governance and influence the allocation of FPM resources.

Figure 1 illustrates these population dynamics by showing the population size of each municipality in both periods. In 2000, the population was already heavily concentrated in the South and Southeast, as well as in state capitals and major urban centers in the Northeast, particularly along the coast, and in the Central-West. The most populous areas—represented by darker shades of blue and corresponding to municipalities with more than 200,000 inhabitants—formed well-established urban clusters. In contrast, vast areas, particularly in the Legal Amazon and parts of the semiarid Northeast, had relatively small populations, represented by lighter shades of blue and consisting predominantly of municipalities with fewer than 50,000 inhabitants.

By 2022, population concentration had intensified along established urban corridors. The expansion of highly populated areas surrounding major metropolitan centers in the South and Southeast indicates the continuation of urban concentration and conurbation, along with the growth of medium-sized cities in the interior of these regions. In the Northeast, although state capitals retained their prominence, several regional hubs in the interior also moved into

higher population brackets. In the Central-West, substantial growth occurred around Brasília and Goiânia, as well as in areas associated with the expansion of agribusiness in Mato Grosso and Mato Grosso do Sul. In the North, despite the persistence of vast sparsely populated areas, noticeable population growth occurred around Manaus and Belém and in several municipalities in Pará and Rondônia, frequently along corridors of economic development.

Figure 1: Distribution of the Brazilian Population, 2000–2022



Source: Prepared by the authors based on the study findings.

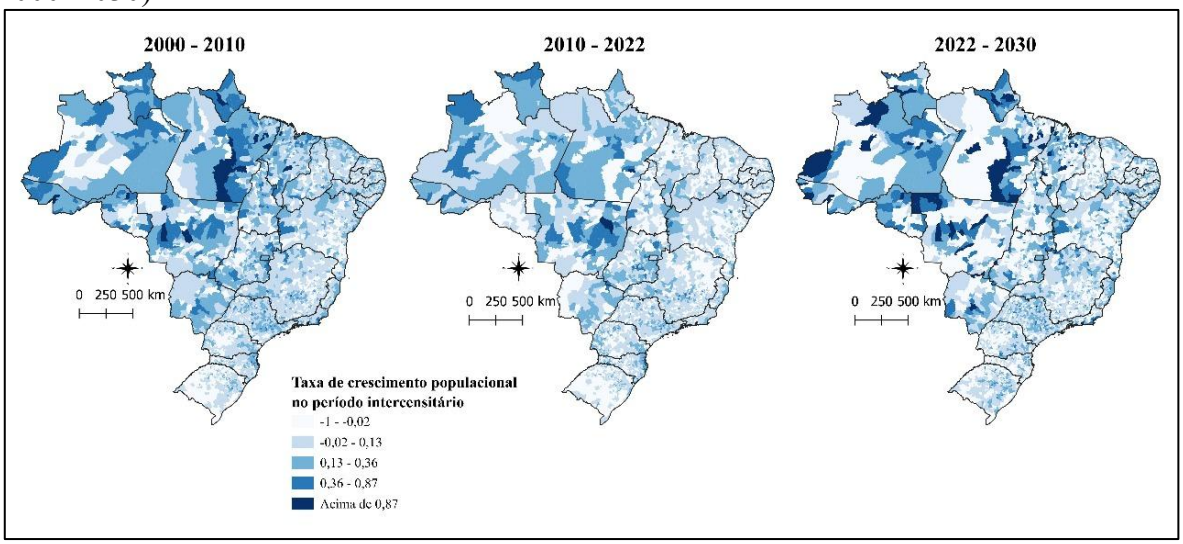
This spatial evolution of the population, characterized by growth and increasing concentration in urban centers alongside the persistence of vast sparsely populated areas, reflects Brazil's demographic transition and its effects on population distribution across the country. The concentration of growth in a limited number of urban centers, while most municipalities remain within the lowest population brackets or experience stagnation or decline, has critical implications for the FPM.

Figure 2 extends the population distribution analysis by illustrating municipal population growth rates across three distinct periods: 2000–2010, 2010–2022, and 2022–2030. The choropleth maps use shades of blue to represent variations in growth rates and are essential for understanding the demographic dynamics underlying changes in absolute population size and, consequently, in FPM coefficients.

During the 2000–2010 period, population growth was more geographically widespread, with several regions recording positive rates, represented by medium to dark shades of blue. The Central-West and North—particularly along corridors of agricultural expansion and infrastructure development as well as parts of the interior of the Northeast and Southeast, contained clusters of municipalities with substantial population growth. Nevertheless, even during this period, some areas already exhibited very low or negative growth rates, represented by lighter shades of blue or white, indicating population stagnation or decline in isolated locations or municipalities with specific socioeconomic conditions.

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Figure 2: Municipal Population Growth Rates in Brazil: Intercensal Periods and Projections (2000–2030)



Source: Prepared by the authors based on the study findings.

The transition to the 2010–2022 period reveals a substantial slowdown in population growth across much of Brazil. The dark-blue areas representing higher growth rates become less extensive and more localized. Growth declined markedly in several regions that had previously expanded, including the Northeast and parts of the Southeast and South. This map supports the findings of the 2022 Census, which recorded the lowest annual population growth rate in Brazilian history, at 0.52%, as well as substantial population losses across numerous municipalities. Areas that continued to experience stronger growth tended to consist of major metropolitan regions and their surrounding areas or specific municipalities with particular economic advantages that attracted new residents.

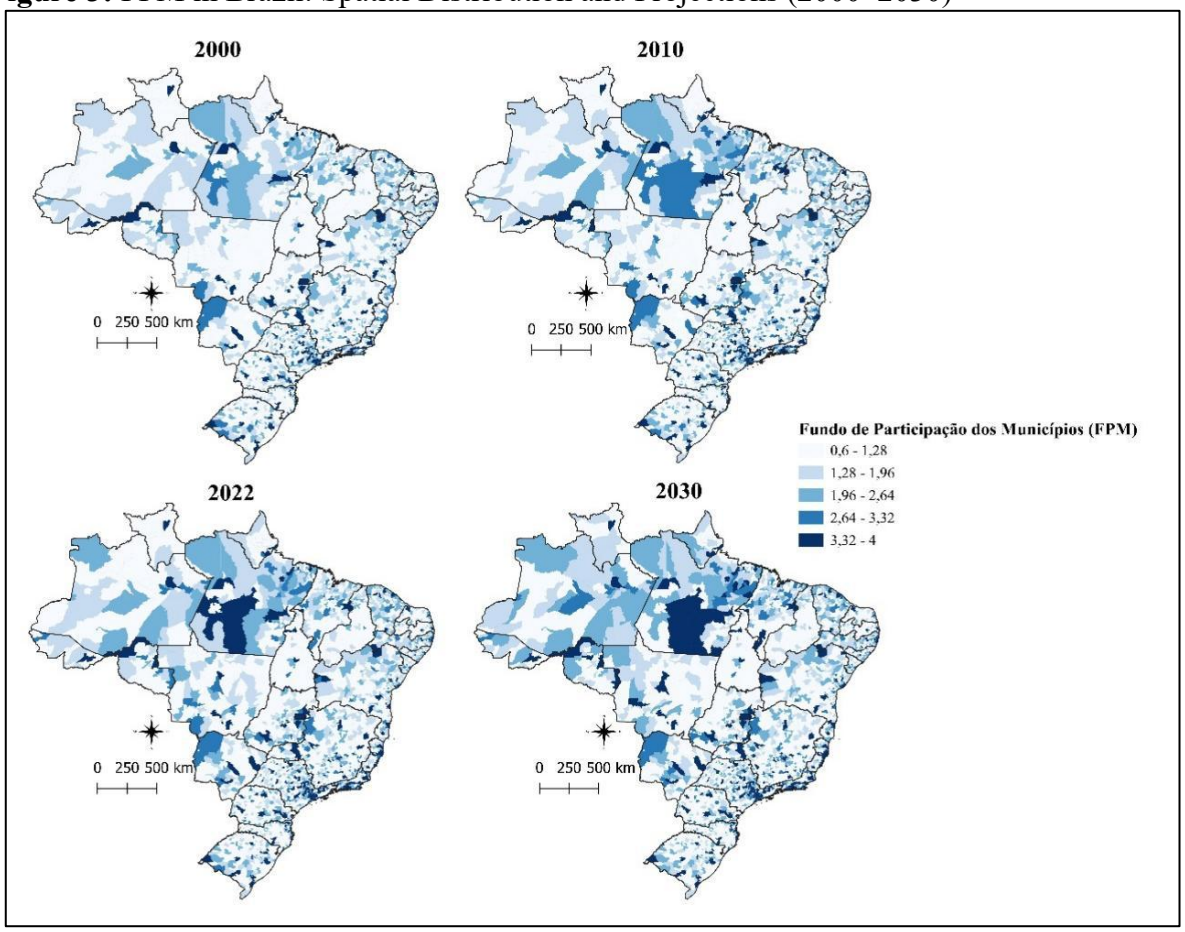
The map for the projected 2022–2030 period, based on LEPP/UFRN estimates, indicates an intensification of population slowdown and decline. Areas with negative or near-zero growth, represented by lighter shades and white, become even more prevalent and extensive, covering a substantial portion of Brazil. Positive-growth areas, represented by darker shades, are limited to a small number of locations, generally the largest urban centers and regions that retain some capacity to attract migrants.

Figure 3 presents the spatial distribution of municipal FPM coefficients in 2000, 2010, and 2022, together with projections for 2030. This series of maps uses different shades of blue to represent FPM coefficient brackets, ranging from 0.6–1.2 to 3.2–4.0, and provides insight into the financial consequences of the demographic dynamics examined above.

According to the maps in Figure 3, the distribution of FPM coefficients in 2000 already reflected the population criterion: smaller municipalities received lower coefficients, whereas larger urban centers had higher coefficients. Nevertheless, municipalities within the intermediate coefficient brackets predominated.

The transition to 2010 and, more markedly, to 2022 reveals an overall upward trend in FPM coefficients across several regions of the country. Darker-blue areas indicating higher coefficients become more prominent, particularly in the Southeast and South and in some urban centers in the Northeast and Central-West. This increase may be attributed both to population growth in certain locations, as shown in Figure 1, and to successive percentage increases and adjustments to population brackets over the decades. The 2022 map already captures the initial effects of the 2022 Census and the most recent redistribution trends.

Figure 3: FPM in Brazil: Spatial Distribution and Projections (2000–2030)



Source: Prepared by the authors based on the study findings.

The map projected for 2030 is particularly relevant because it combines demographic projections with their expected consequences for FPM transfers. The highest coefficients tend to become increasingly concentrated in a limited number of areas and municipalities. Visually, the 2030 map indicates greater polarization, with demographically consolidated regions expected to receive the largest transfers. In contrast, extensive areas of Brazil—particularly smaller inland municipalities in the Northeast, parts of the Southeast and South, and remote areas of the North, where population stagnation or decline is projected—remain within the lowest coefficient brackets.

4.2 Empirical Evidence of the Demographic Effect on FPM Bracket Changes

To inferentially validate the patterns identified in the spatial analysis, the econometric analysis focused on the subset of 1,883 municipalities that changed FPM brackets between 2000 and 2022. The analysis begins by presenting the descriptive statistics for the variables included in the models, as shown in Table 1.

Table 1: Descriptive Statistics for the Variables Analyzed

Variable	Obs.	Mean	Standard Deviation	Min.	Max.	Description
ΔFPM	1,833	0.247	0.275	−0.6	2.4	Net change in the FPM coefficient (2000–2022)
Moved to a Higher Bracket	1,833	0.862	0.344	0	1	Dummy variable (1 = moved up; 0 = moved down)
Population Growth Rate, 2010–2022	1,454	0.157	0.165	0.000	1.782	Population growth rate (2010–2022)

Source: Prepared by the authors based on the research findings.

Os dados descritivos expostos na Tabela 1 revelam um cenário predominantemente de expansão fiscal na amostra: 86,2% dos municípios ascenderam de faixa no período analisado, enquanto 13,8% sofreram redução. A variação média positiva (*ΔFPM* de 0,247) indica que, em média, os municípios ganharam pouco mais de dois décimos de coeficiente. Contudo, o desvio padrão relevante e a amplitude dos dados (de perdas de -0,6 a ganhos expressivos de 2,4) sugerem uma heterogeneidade significativa, que busca ser explicada pela variável de crescimento populacional.

Para investigar os determinantes da direção dessa mudança, estimou-se o modelo de regressão logística. O objetivo foi verificar se a taxa de crescimento populacional aumenta a probabilidade de um município se enquadrar no grupo que obteve ganhos de faixa, em detrimento daqueles que perderam. Os resultados das estimativas e os efeitos marginais são apresentados na Tabela 2.

Table 2: Probability of Moving to a Higher FPM Bracket

Variable	Coefficient (\(\beta\))	Standard Error	Marginal Effect (\(dy/dx\))
Growth Rate (2010–2022)	5.976**	2.506	0.108
Constant	3.288***	0.292	—
Observations	1,454	—	—

Source: Prepared by the authors based on the research findings.
Note: *** Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

The results presented in Table 2 show that the population growth rate has a positive and statistically significant effect on the likelihood of moving to a higher FPM bracket. The marginal-effects analysis is particularly informative: for each additional percentage point in a municipality's population growth rate, its estimated probability of moving to a higher FPM bracket increases by approximately 10.8 percentage points. This result suggests that demographic dynamics operate as a strict selection mechanism. In other words, municipalities

with stagnant populations face a significantly greater probability of being downgraded or remaining in lower brackets, whereas population growth is the primary driver of upward bracket changes.

After establishing the effect of population growth on the probability of moving to a higher bracket, an ordinary least squares model was estimated to measure the magnitude of this effect. Table 3 presents the linear regression results, in which the dependent variable is the magnitude of the change in the FPM coefficient (*ΔFPM*).

Table 3: Determinants of the Magnitude of Changes in the FPM Coefficient

Variable	Coefficient (β)	Standard Error
Population Growth Rate (2010–2022)	0.883***	0.029
Constant	0.184***	0.006
R^2	0.3784	
Observations	1,454	

Source: Prepared by the authors based on the research findings.
Note: *** Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

The results presented in Table 3 corroborate and extend the previous findings. The estimated coefficient of 0.883 is highly significant and indicates that the transfer system is strongly sensitive to demographic changes. In practical terms, for each one-unit increase in the population growth rate, a municipality tends to gain nearly 0.9 points in its FPM coefficient.

Furthermore, the coefficient of determination (R^2) of 0.378 indicates substantial explanatory power. The recent population growth rate alone accounts for approximately 37.8% of the variation in the magnitude of FPM bracket changes observed in the sample.

Taken together, this empirical evidence supports the study's central hypothesis. Under its current design, the FPM operates as a procyclical mechanism in relation to demographic dynamics, directing increasing volumes of resources toward the areas of population concentration identified in the spatial analysis while imposing severe fiscal constraints on areas experiencing population decline. This process widens the financial gap between growing and declining municipalities.

5. Final considerations

This study examined the mismatch between the FPM distribution methodology and Brazil's demographic transition by combining spatiotemporal analysis with econometric modeling to map fiscal vulnerability and measure the sensitivity of transfers to population changes.

Regarding the spatial dimension, the results reveal increasing polarization. The cartographic analysis showed that population concentration in major urban centers and economic development corridors—particularly in the Southeast, South, and regional hubs in the Central-West—is expected to intensify through 2030, enabling these areas to maintain or increase their FPM coefficients. In contrast, extensive parts of the country, particularly in the semiarid Northeast and remote areas of the North and Southeast, face population decline or stagnation. For most small municipalities in these regions, projected negative growth signals an inevitable future reduction in their primary source of revenue, further exacerbating long-standing regional disparities.

The econometric analysis corroborated and quantified the severity of this dependence. The empirical evidence indicates that the current FPM framework operates as a procyclical fiscal mechanism: population growth is not merely one contributing factor but the primary determinant of resource allocation.

The Logit model confirmed that demographic stagnation increases the probability of a municipality losing its relative position, while the OLS model revealed a high degree of revenue sensitivity, with each additional unit of population growth associated with a substantial increase in the FPM coefficient ($R^2 \approx 37.8\%$). These findings demonstrate that the current system financially penalizes municipalities precisely when they are losing population and may require greater support to maintain the per capita provision of public services.

In light of this evidence, the exclusive reliance on population size as a distribution criterion is unsustainable for Brazil's federal arrangement over the coming decades. Temporary measures, such as the transition periods established by Complementary Law No. 198/2023, may mitigate immediate fiscal shocks but do not address the structural problem of linking municipal financing to indefinite population growth in a country whose demographic expansion is coming to an end.

The study therefore recommends an urgent reform of the FPM distribution criteria toward models that incorporate multidimensional indicators, including demographic decline, local purchasing power parity, and fiscal needs. Such changes would reduce the dependence of municipalities' financial viability on population counts while promoting greater equity and sustainability in local public administration.

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