# EFFECTS OF INCOME INEQUALITY ON THE ECONOMIC GROWTH OF BRAZILIAN STATES: AN ANALYSIS USING THE COINTEGRATED PANEL MODEL


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# EFFECTS OF INCOME INEQUALITY ON THE ECONOMIC GROWTH OF BRAZILIAN STATES: AN ANALYSIS USING THE COINTEGRATED PANEL MODEL


## Abstract

This aim of this article is to investigate the effects of income inequality on the economic growth of Brazilian states in the period from 1994 to 2011. The transmission mechanism of the effects of income inequality on economic growth is derived from the model proposed by Halter et al. (2014). The empirical formulation adopted to achieve this goal is divided into two stages. The first stage is limited to short-term analysis, and panel data models with fixed effects, random effects, and instrumental variables are used. In the second stage, the discussion turns to the use of the error correction model for a cointegrated panel. The results suggest a significant negative correlation between income inequality and the economic growth of Brazilian states in both short-term and long-term analyses.



**Keywords:** Income inequality. Economic growth. Brazilian states.



## Resumo

Este artigo tem o propósito de investigar os efeitos da desigualdade de renda sobre o crescimento econômico dos estados brasileiros, no período de 1994 a 2011. O mecanismo de transmissão dos efeitos da desigualdade de renda no crescimento econômico é derivado do modelo proposto por Halter et al. (2014). A formulação empírica adotada para alcançar esse objetivo irá se subdividir em duas etapas. A primeira irá se limitar a análise de curto prazo e serão utilizados os modelos de dados em painel com efeitos fixos, aleatórios e variáveis instrumentais. Na sequência, a discussão é direcionada para o uso do modelo de correção de erros para um painel cointegrado. Os resultados encontrados sugerem uma relação negativa e estatisticamente significativa entre a desigualdade de renda e o crescimento econômico dos estados brasileiros, tanto na análise de curto prazo, quanto na análise de longo prazo.



**Palavras-Chave:** Desigualdade de renda. Crescimento Econômico. Estados Brasileiros.

## 1 Introduction

Income inequality is a recurring theme in the Brazilian economy, principally with regard to studies of economic growth. This discussion gained ground in the economics literature of the 1990s with a series of studies investigating the role of income inequality in the process of economic growth. The following question always arises in this type of analysis: How does income inequality affect economic growth?

Two different approaches to this topic have been taken. The first, represented by Bertola (1991), Perotti (1992), Persson and Tabellini (1994), and Alesina and Perotti (1996), suggests the existence of mechanisms by which greater inequality harms economic growth; these include an endogenous fiscal policy, social and political instability, imperfect credit markets, and endogenous fertility rates.

Another branch of the economics literature emphasizes the beneficial effect of greater initial inequality in spurring economic growth through three channels: Kaldor's hypothesis, indivisible investment costs, and trade-offs between efficiency and equity. Stigliz (1969), Lazear and Rosen (1979), Li and Zou (1998), and Forbes (2000) are among the authors who emphasize this type of correlation.

Starting from this discussion, the present study investigates the effects of income inequality on the economic growth of different Brazilian states from 1994 to 2011. This study's main contribution is empirical because it presents stylized facts that aid in understanding the effects of income concentration on economic performance in different regions of Brazil.

Regional disparities in Brazil have always been a cause for concern and a subject of national debate, especially after the creation of the Superintendency for the Development of the Northeast (Superintendência do Desenvolvimento do Nordeste - SUDENE) in 1950. The notion of regional disparities is even more obvious when regional economic indicators are presented, such as those emphasized by Rands (2011). The numbers show that although the Northeast is home to 28% of the Brazilian population, it has a *per capita* gross domestic product (GDP) that is only 46.8% of the national *per capita* GDP, and only 35.3% of the *per capita* GDP found in the Southeast, which is the highest in the nation.[1] Other regions, such as the North and Center-West (excluding the federal district of Brasília) are also relatively poor, though their *per capita* GDPs are still higher than the Northeast.

Evidently, this discussion is not new for the Brazilian economy, and a number of studies have attempted to explore and test explanatory hypotheses for the differences in regional growth rates within Brazil, including Lledó (1996), Bagolin et al. (2004), Jacinto and Tejada (2004), Salvato et al. (2008), Kakwani et al. (2010), and Galeano (2014).

Most of these studies attempt to test Kuznets' hypothesis that there is an inverted U-shaped correlation between inequality and growth; examples are Lledó (1996), Bagolin et al. (2004), Jacinto and Tejada (2004), and Salvato et al. (2008). The first of these studies was not able to find evidence to confirm this hypothesis for Brazilian states in the 1970s or 1980s. By contrast, the other studies were able to validate the hypothesis by analyzing municipalities in the state of Rio Grande do Sul, the Northeast region, and the state of Minas Gerais after the 1980s.

Taking a different perspective, Kakwani et al. (2010) analyze the relationship between the growth of poverty in Brazil based on the performance of different sources of income, such as the labor market – hypothesizing that an improvement in employment rates contributes to economic growth – and social programs enacted during the 1990s, finding that these social policies were successful in reducing poverty.

[1] Data are from the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística -IBGE) for 2008.

Along the same line of investigation, Galeano (2014) examines the improvement in Brazil's macroeconomic environment since the mid-1990s and the theory of endogenous growth, using the Theil index and convergence analysis to demonstrate some economic deconcentration from 1985 to 2008. However, her study suggests few improvements in terms of regional economic inequality, indicating a process of convergence that is very slow and that does not take the desired form of strong, widespread growth but rather weak growth in the regions of Brazil.

The present study differs from the others in that it adapts the discussion proposed by Halter et al. (2014) to the analysis of Brazilian states. Halter et al. (2014) derive the transmission channel between income inequality and economic growth, showing a non-monotonic adjustment trajectory[2] of production that leads to a linear theoretical model of income inequality and economic growth that is similar to those used in this type of approach.

The findings of this study suggest that inequalities in income and educational level are the principal determinants of different growth rates among Brazilian states. More specifically, it is found that additional years of schooling positively influence growth. By contrast, income inequality negatively affects this indicator.

The remainder of this article is divided into five sections. The next section shows the recent behavior of income inequality in Brazil. It is followed by the proposed theoretical discussion of Halter et al. (2014) for expressing the relationship between economic growth and income inequality. Section 4 of the article presents the panel data method with cointegration, in addition to the database used and its limitations. Section 5 shows and discusses the principal results of the empirical strategy. Finally, the article concludes with final considerations.

## 2 Recent behavior of income inequality in Brazil

Brazil is composed of regions that are diverse in size and shape as well as in their development and economic growth. These peculiarities lead back to the most important questions about economic growth, namely: Why does one region grow more than others? Is there income convergence among regions? What are the determinants of regional disparities? This section presents stylized facts from the literature on economic growth that can answer some of the questions posed above.

Table 1 shows growth and development statistics for the regions of Brazil in 2010. The first column contains *per capita* GDP data for 2010, showing that the Southeast held the largest share of the national GDP, making it the wealthiest region of Brazil in 2010, with a *per capita* GDP of BRL$25.99.

The Center-West region showed the second highest *per capita* GDP, with a value of BRL$24.95, followed by the South, with BRL$22.72. By contrast, the North and Northeast regions fell far behind, with *per capita* GDPs of BRL$12.70 and BRL$9.56, respectively.

The second column of Table 1 shows the GDP per worker in 2010. The difference between the first two columns is the denominator: the first divides the GDP by the total population, and the second divides it by the number of workers. The employment rate, shown in the third column on Table 1, is the ratio of the work force to the total population in each region.

[2] Non-monotonic adjustment allows for certain minimum levels of investment to be required for access to productive activity. Thus, different opportunities for production are available at different points along the income distribution.

Table 1. Growth and development statistics for 2010 (in 2010 BRL$)

| Region | GDP *Per capita* (2010 BRL$) | GDP per worker (2010 BRL$) | Employed/ Total pop. (in %) | Avg. Growth, 1985-2010 (in %) | Time to double GDP |
|---|---|---|---|---|---|
| Center-West | 24.95 | 47.00 | 0.53 | 4.15 | 17 |
| North | 12.70 | 35.75 | 0.36 | 5.18 | 14 |
| Northeast | 9.56 | 20.90 | 0.46 | 3.97 | 18 |
| South | 22.72 | 41.73 | 0.54 | 3.27 | 21 |
| Southeast | 25.99 | 48.96 | 0.53 | 2.43 | 29 |

**Source:** Authors.

A comparison of the *per capita* GDPs for the North and Northeast regions in 2010, for example, reveals that although they were similar in that year, the GDP/worker ratios were much different. This result is explained by the fact that workers comprise a much larger percentage of the total population in the Northeast than in the North. Finally, the last two columns in Table 1 show economic growth in Brazil's macro-regions. The fourth column reports the mean annual rate of GDP growth between 1985 and 2010, drawn from the variation in the natural logarithm of the GDP. It can be noted that the mean annual GDP growth rate of the Southeast was only 2.43% between 1985 and 2010 whereas the Center-West, Northeast, North, and South grew at a faster rate than the Southeast, with the North registering the fastest rate of growth, a remarkable 5.18%.

With regard to the time it would take each region to double its GDP, shown by column 5 in Table 1, the Southeast's GDP would double in 29 years, whereas the North's GDP would double in approximately 14 years. In other words, if these growth rates were to persist for two generations, a citizen of the North region would be approximately 20 times richer than his or her grandparents. It is important to note, however, that growth rates can lead to significant differences in individual wealth.

It is important to emphasize that all of the data presented in Table 1 can be used as measures for comparing the development levels of states or regions; however, this article uses the *per capita* GDP as a measure of well-being. This argument is the same as that made by Jones (2000), namely, that the *per capita* GDP represents the sum of the available product, per person, that can be consumed, invested, or otherwise employed and is the most general measure of well-being. By contrast, the GDP per worker is more closely related to labor productivity.

Figure 1 shows the relationship between GDP growth rates in 1985-2010 and the initial *per capita* GDP in 1985 as well as the relationship between GDP growth rates for the same period and GDP per worker in 1985. This figure was created to determine whether income appears to be converging among Brazilian states.

The hypothesis of convergence is intended to verify whether the difference in *per capita* income among the states diminished over time. Figure 1 suggests that the hypothesis of convergence among Brazilian states is rejected, both for *per capita* GDP and for per worker GDP. In short, the existing gap between *per capita* GDPs in poor and rich regions of Brazil is not narrowing.[3]

[3] The hypothesis of the convergence of income among Brazilian states is discussed again and more formally in section 5.

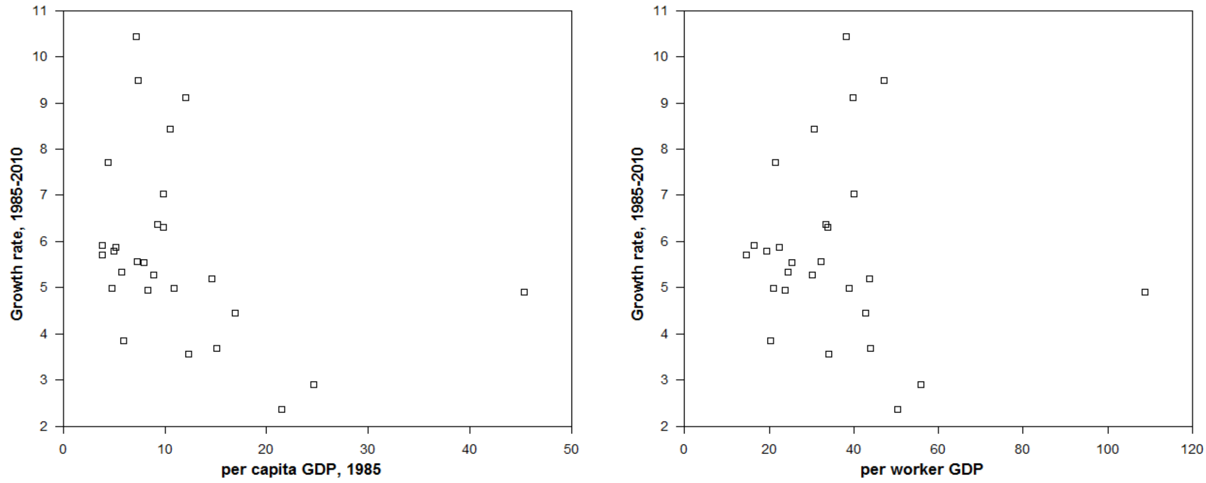


Figure 1. Relationship between growth rate and *per capita* GDP as well as per worker GDP
**Source:** Authors.

This result is corroborated by Figure 2, which shows the behavior of *per capita* GDP for the regions of Brazil between 1985 and 2011. It can be observed that the richest and poorest regions at the beginning of this period maintained their relative positions over the period, with the Southeast and Northeast appearing as the richest and poorest regions, respectively, in 1985 and in 2011. Once again, this finding contradicts the hypothesis of convergence in growth rates over this period.

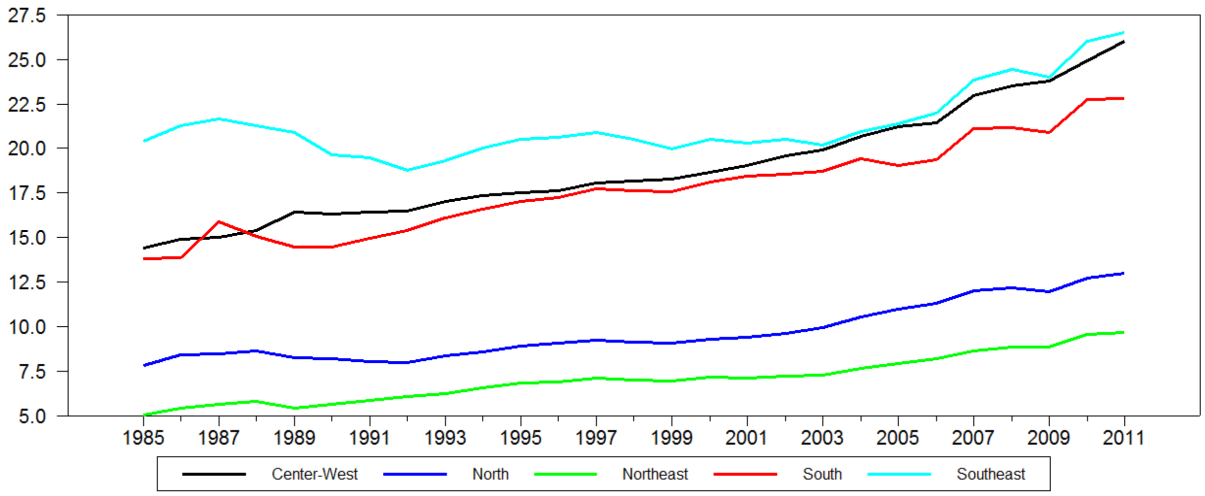


Figure 2. Behavior of *per* capita GDP in the Center-West, North, Northeast, South, and Southeast regions between 1985 and 2011
**Source**: Authors.

Figure 3 shows the recent evolution of the gap or ratio between the richest 10% and the poorest 40% in different regions of Brazil from 1985 to 2010. The graph of this indicator shows that the distance between the richest and the poorest widened in all regions from 1985 to 1994, after which the trend was reversed and there has been a sharp and sustained narrowing of the gap.

During this period, the greatest reduction in the gap between the richest and the poorest was in the South, where the ratio of income between the richest 10% and the poorest 40% of the region's population declined from 18.64 in 1995 to 9.99 in 2014; this decline represents a

46.39% reduction in the gap. By contrast, the Southeast saw the smallest reduction in the rich-poor gap, at 32.88%.

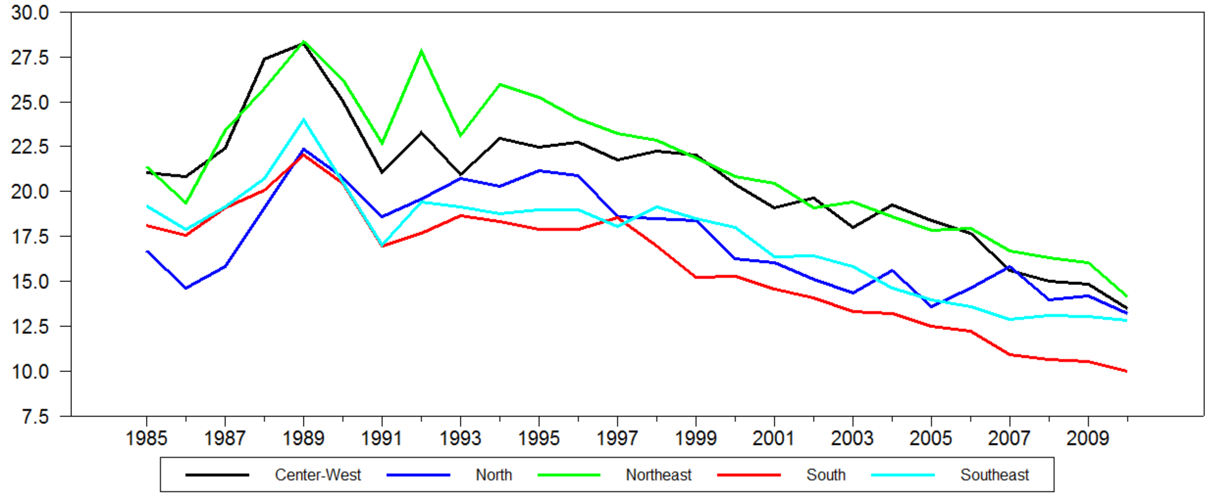


Figure 3. Ratio between the income of the richest 10% and the poorest 40% of the population
**Source:** Authors.

Table 2 also shows the behavior of income inequality on a national scale and a regional scale between 1990 and 2014, as measured by the Gini index. It is important to note that the Gini index measures the degree of income inequality among individuals, according to *per capita* household income. This index ranges from 0 to 1, with a coefficient close to 1 indicating a very unequal income distribution and a coefficient closer to 0 indicating less income concentration.

Table 2. Behavior of income inequality in the regions of Brazil from 1990 to 2014

| Year-Region | Center-west | North | Northeast | South | Southeast | Brazil |
|---|---|---|---|---|---|---|
| 1990-1995 | 0.598 | 0.576 | 0.613 | 0.562 | 0.566 | 0.566 |
| 1996-2000 | 0.599 | 0.578 | 0.613 | 0.559 | 0.563 | 0.600 |
| 2001-2005 | 0.584 | 0.549 | 0.587 | 0.529 | 0.555 | 0.582 |
| 2006-2010 | 0.566 | 0.522 | 0.563 | 0.499 | 0.522 | 0.552 |
| 2011-2014 | 0.527 | 0.518 | 0.535 | 0.465 | 0.503 | 0.527 |
| Δ%(2014/1990) | -16.39 | -13.47 | -17.62 | -21.00 | -13.19 | -6.94 |

**Source:** Authors.

The reduction in income inequality in Brazil shown in Figure 3 is corroborated by the analysis of the Gini index. The scenario is the same as that presented above, with a perceptible reduction in the inequality of income distribution in Brazil from 1990 to 2014 of 6.94%, which represents a reduction of 0.04 points on the Gini index. Nevertheless, with an index over 0.50 in 2014, Brazil still demonstrates a high concentration of income compared to other developing countries such as Argentina and Uruguay, where the Gini indices for 2013 were 0.423 and 0.419, respectively.

Following the trend of the Brazilian economy, all of the macro-regions also showed a reduction in income inequality, though these effects were greater in the Southern region of the country. The South reduced income inequality among its population by 21% between 1990 and 2014, making it the region with the lowest concentration of income in 2014.

It is worth noting that all regions experienced a continuous downward trend in income inequality, although this trend was less pronounced in some regions than in others. Thus, after the South, the Northeast, Center-West, North, and Southeast experienced reductions in inequality of 17.62%, 16.39%, 13.47%, and 13.19%, respectively.

Nevertheless, an analysis of inequality at the end of this period, in 2014, shows that although the Southeast had the smallest decline in its income distribution gap, the Northeast, Center-West, and North are still the regions with the highest indices of income inequality in Brazil, with Gini indices of 0.535, 0.527, and 0.518, respectively.

## 3 Theoretical model

This section presents the discussion proposed by Halter et al. (2014) in which they seek to derive the transmission channel between income inequality and economic growth. The theoretical framework presented below permits a non-monotonic adjustment trajectory of production[4] and leads to a linear theoretical model of income inequality and economic growth that is similar to those used in this type of approach.

The model is based on an economy populated by families characterized by an infinite life horizon and aversion to risk, with this latter component represented by the discount factor β < 1. All individuals derive utility from consuming a single produced good. Thus, their preferences are represented by the following intertemporal utility function:

$$\mathcal{U}_t = \mathbb{E}_t \{\textstyle\sum_{s=0}^{\infty} \beta^s \, c_{t+s}\}, \tag{1}$$

where $c_t$ denotes consumption in the period t and $\mathbb{E}_t$ is the conditional expectation operator on the information available at t. Individuals differ in their allocation of productive assets (represented, for example, by capital stock).

This economy is composed of rich and poor individuals. Poor individuals are represented by the fraction $\sigma$ > ½ of the population (poor individuals are represented by P) because the majority of the population consists of wage earners and their allocation of assets takes the form $\omega^p\,(D_t) < 1$, in which 1 is the mean income in the economy.

The state variable[5] of $D_t \in \{L, H\}$ represents the degree of inequality of assets in the economy, where L signifies a low degree and H a high degree of inequality. From this segmentation arises a scenario in which the allocation of poor individuals with a low level of inequality is larger than the allocation of poor individuals with a high level of inequality, which can be described by $\omega^p(L) > \omega^p\,(H)$.

All individuals have access to a simple technology that uses the productive physical capital asset as an input factor. In formal terms, the technology is characterized by the following production function:

$$q\,(\omega, G_t) = \begin{cases} a^l\,\omega X(G_t): & \omega < \omega^c \\ a^h \omega X(G_t): & \omega \geq \omega^c \end{cases}, \quad a^l < a^h \tag{2}$$

where $q$ is the product; $X(G_t)$ represents the level of public good provided by the government; and $a^h$ and $a^l$ represent high and low levels of productivity, respectively.

The supply of the public good is represented by the state variable of $G_t \in \{0,1\}$. For low levels of inequality, if the government invests in the public good, then $G_t$ = 1; otherwise, $G_t = 0$. As a result, we have $X(1) - X(0) \equiv \Delta X > 0$.

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[4] The idea posits minimum levels of investment required to gain access to productive activities; thus, there are different production opportunities available along the income distribution.

[5] This is the smallest group of variables that determines the state of a dynamic system. If at least "n" variables $(X_1(t), X_2(t), \ldots, X_n(t))$ are necessary to completely describe the behavior of a dynamic system, then these "n" variables are a group of state variables. They describe the future response of a system, given the current state, the input stimuli, and the equations that describe the dynamic.

The aggregate production of the private sector is represented as follows:

$$\mathbb{Y}\,(D_t\,,G_t\,) = (\,a^h - \,\sigma\,(\,a^h - \,a^l\,)\,\omega^P\,(\,D_t\,)\,)\,X(G_t) \tag{3}$$

Note that the aggregate production is lower than its first best level, which is equal to $a^h\,X\,(\,G_t\,)$. This occurs because a positive fraction of the total stock of productive assets is used by companies with low average productivity.

To linearize the model, we impose $\omega^P\,(D_t) = \,1 - \,D_t$, with $D_t\, \in \,\{L, H\}$ being the difference between the mean allocation and a poor individual's allocation. Next, the logarithms of both sides of equation (3) should be taken. Then, rearranging the terms, we obtain the following:

$$\mathscr{y}_t\;\equiv\;\ln \mathbb{Y}_t\,=\,\ln\left(1 - \,\frac{\sigma\,(\,a^h - a^l\,)\omega^P\,(D_t)}{a^h}\right) + \,\ln\left(\frac{X(G_t)}{X(0)}\right) + \,\ln a^h + \,\ln X(0) \tag{4}$$

It is important to emphasize that $G_t$ is a variable of choice that takes the value of 1 if $D_{t-1} = L$ and 0 if $D_{t-1} = H$. Thus, $X(G_t)$ can be written as $\frac{X(0)+\,\Delta X\,(H-\,D_{t-1})}{(H-L\,)}$. Using the expression for $X(G_t)$ and given that $\omega^P\;(D_t) = \;(1 - \,D_t)$ in equation (4), it is possible to obtain the following:

$$\mathscr{y}_t\,=\,\ln\left(1 - \,\frac{\sigma\,(\,a^h - a^l\,)\omega^P(D_t)}{a^h}\right) + \,\ln\left(1 + \,\frac{\Delta X}{X(0)}\frac{H - D_{t-1}}{H-L}\right) + \ln a^h + \ln X(0) \tag{5}$$

where $\mathscr{y}_t$ is a non-linear function of the indicators of asset inequality $D_t$ and $D_{t-1}$. Provided that the ratios $\frac{(a^h - a^l)}{a^h}$ and $\frac{\Delta X}{X(0)}$ are not very large, $\mathscr{y}_t$ can be closely approximated by a linear function, specifically:

$$\mathscr{y}_t\;\cong\;\theta_1 D_t + \,\theta_2 D_{t-1} + \,\mu, \tag{6}$$

where $\theta_1\;\equiv\;\frac{\sigma\,(\,a^h - a^l\,)}{a^h}$, $\theta_2 \equiv \;\frac{-\,\Delta X}{(X(0)(H-L))}$ and $\mu$ includes all of the constant terms.[6] Note that $\theta_1 > 0$ captures inequality's short-term positive effect, whereas $\theta_2 < 0$ shows its negative lagged effect.

The theoretical discussion presented includes two channels by which asset inequality affects economic performance. However, empirical models of inequality and growth such as those by Alesina and Rodrik (1991) and Alesina and Perotti (1996), including the model estimated in section 5, generally rely on measures of income inequality, mainly due to the availability of data. In our case, the two concepts are closely related. Consider the following measure of income inequality:

$$D_t^{\mathscr{y}} = \frac{\mathbb{Y}\,(\,D_t\,,G_t\,) - a^l\,\omega^P\,(\,D_t\,)\,X(G_t)}{\mathbb{Y}\,(\,D_t\,,G_t\,)} \tag{7}$$

which gives the relative difference between mean income and the poor individual's income and is therefore equivalent to the measure of asset inequality $D_t$. Using the functional form of $\mathbb{Y}$ given in equation (3) and given that $\omega^P\,(D_t) = \,1 - \,D_t$, this measure of income inequality can be approximated by the following linear function such that $D_t$:

[6] If the condition (C2) is violated, the level of the public good will never change. As a result, $\theta_2$ will be equal to 0 (while $\theta_1$ remains unchanged).

$$D_t^{\mathcal{Y}} = \frac{a^h - a^l}{a^h} + \frac{a^l}{a^h} D_t \tag{8}$$

The structure of equation (8) reflects the fact that income inequality is propelled by two different factors: rich individuals become richer, that is, $D_t > 0$, and rich individuals also obtain a better return on their wealth, which is shown by the constant on the right-hand side of (8). The approximation obtained in equation (8) is possible considering the fact that $\frac{a^h - a^l}{a^h}$, $\sigma$ and $\omega^P$ are close to 0.

Expression (8) allows us to relate the logarithm of the current level of production, $\mathcal{Y}_t$, to the current and past levels of income inequality. Isolating $D_t$ from equation (8) and substituting it into equation (6), we obtain the following:

$$\mathcal{Y}_t \cong \delta_1 D_t^{\mathcal{Y}} + \delta_2 D_{t-1}^{\mathcal{Y}} + v \tag{9}$$

where $\delta_1 \equiv \theta_1 \left(\frac{a^h}{a^l}\right) > 0$, $\delta_2 \equiv \theta_2 \left(\frac{a^h}{a^l}\right) < 0$, and $v$ includes all of the constants. It is valid to note that a simple linear relationship between $D_t^{\mathcal{Y}}$ and the Gini coefficient for income distribution exists: $GINI_t^{\mathcal{Y}} \cong \sigma D_t^{\mathcal{Y}}$.

Equation (8) expresses the level of the production logarithm $\mathcal{Y}_t$ as a function of inequality. To find the standard specification used in the empirical literature, we must add a multiplicative parameter $A_t$ into the production function that does not depend on the use of productive assets, represented by $A_t = (\mathbb{Y}_{t-1})^{\varphi}$, with $\varphi \in [0,1)$. Thus, the relationship between product growth and inequality is given as follows:

$$\mathcal{Y}_t - \mathcal{Y}_{t-1} \cong \gamma \mathcal{Y}_{t-1} + \delta_1 D_t^{\mathcal{Y}} + \delta_2 D_{t-1}^{\mathcal{Y}} + \eta \tag{10}$$

where $\gamma \equiv \varphi - 1 < 0$. The equation above is the basis for the empirical model that is estimated in the following section, and it is similar to the empirical models commonly used in the literature on inequality and growth. Thus, the implication is that both current and past inequality can affect growth.

## 4 Methodological procedures

### 4.1 Empirical strategy

The short- and long-term effects of inequality on growth are estimated by transforming equation (10) into a panel data model, which can be represented as follows:

$$y_{it} - y_{it-1} = \gamma y_{it-1} + d_{it} + d_{it-1} + \delta' x_{it-1} + \zeta_t + (\eta_i + v_{it}) \tag{11}$$

where $i = 1, \dots, N$ denotes one of the 27 states Brazilian that comprise the data sample and $t = 1, \dots, T$ is time.

On the left-hand side, $y_{it}$ represents the log of real *per capita* GDP and shows an approximate rate of growth. On the right-hand side, in addition to the lagged *per capita* GDP are the terms that represent the current and lagged value of income inequality, represented by $d_{it}$ and $d_{it-1}$, respectively. Additionally, there is the vector $x_{it-1}$, which is composed of variables that characterize each state, such as education level, gross fixed capital formation, and market distortions, as proposed by Halter et al. (2014); a period-specific effect $\zeta_t$ used to capture productivity changes common to all the countries; a country-specific effect $\eta_i$ that captures non-observed and time-invariant characteristics of a country; and an idiosyncratic error term $\nu_{it}$.

It is important to emphasize that before proceeding with the estimation of equation (11), the unit root tests proposed by Hadri (2000) and Levin et al. (2002) are applied.

For the case where the series present the same order of integration, the next step is to verify the possibility of cointegration between economic growth and the other variables. If the series are cointegrated, then the discussion turns to the analysis proposed by Frank et al. (2005). This analysis seeks to present the mean group (MG) estimator and the pooled mean group (PMG) proposed by Pesaran et al. (1999), which combines both the poolings and the means of the data and the dynamic fixed effect (DFE) estimator. Now, the strategy is to study the magnitude of the long-term relationship between the inequality-growth binomial, differentiating this study from the strategy adopted by Halter et al. (2014).

### 4.2 Description and source of the data

This section presents the variables used in the empirical model, in addition to the sources from which they were drawn and the expected signs, as shown in Table (3). The dataset used in this analysis is composed of annual figures for real *per capita* GDP, the Gini index, investment or gross fixed capital formation, and political instability over the period from 1994 to 2011.

Table 3. Description of the variables

| Variables | Symbol | Expected sign | Source |
|---|---|---|---|
| Economic growth rate | $[y_t - y_{(t-1)}] * 100$ | | IPEA |
| Gini coefficient | $d_{i,t}$ | ( - ) | IPEA |
| *Per capita* GDP | $y_{(t-1)}$ | ( - ) | IPEA |
| Education level | $edu_{(t-1)}$ | ( + ) | IPEA and PNAD |
| Investment | $inv_{(t-1)}$ | ( + ) | Ministry of Finance |
| Political instability | $PI_{(t-1)}$ | ( - ) | IPEA |
| Corruption | $Corrup_{(t-1)}$ | ( - ) | Boll (2010) |
| Energy | $Energ_{(t-1)}$ | ( + ) | IPEA |

**Source:** Authors.

It is important to highlight some observations about the data: 1) The choice of variables is based on the work of Halter et al. (2014); 2) the choice of this time period was made due to the availability of data; 3) the capital spending of states was used as a proxy for investment; 4) homicide rates were used as a proxy for political stability; 5) the education level was calculated as the mean number of years of schooling among people 25 years of age and older.

In addition, the capital spending series and the number of homicides were substituted by industrial energy consumption (in $kWh$) and corruption indices, as proposed by Boll (2010), with the intention of verifying the robustness of the results. Series of regional dummies and the degree of trade openness were also used as control variables; the inclusion of these terms is discussed in more detail in section 5.

Finally, all of the series were treated as natural logarithms and calculated as means of the previous three years. In this regard, this study differs from Halter et al. (2014), who treated these variables as means of the previous five years. The use of three-year means rather than five-year means is related to data availability, and the purpose of using means for the variables is to capture the past effects of the lagged explanatory variables on economic growth.

## 5 Discussion and analysis of the results

The discussion of the relationship between economic growth and its determinants starts with the analysis of the mean behavior of the studied series during the period from 1994 to 2011. Table 4 shows the mean value of the series of *per capita* GDP, investment, the Gini index, political instability, and education level for each of the Brazilian states and the Federal District.

As Table 4 shows, the Brazilian states are a heterogeneous group. The Federal District, for example, has a *per capita* GDP of R$ 50.41 and mean educational level of 8.6 years of schooling. By contrast, Piauí has a *per capita* GDP of R$ 5.49 (only 11% of that of the Federal District) and a mean educational level of 4.2 years of schooling. These regional differences are also evident in the other variables.

Table 4. Mean value of the *per capita* GDP, investment, Gini index, political instability, and education level series

| State | *Per capita* GDP (in thousands of reais) | Investment (in millions of reais) | Political instability (in units) | Gini Index | Education level (in years of schooling) |
|---|---|---|---|---|---|
| AC | 9.36 | 8.47 | 117.44 | 0.59 | 5.97 |
| AL | 6.71 | 8.34 | 1057.00 | 0.60 | 4.35 |
| AM | 13.80 | 8.82 | 572.81 | 0.55 | 6.62 |
| AP | 10.64 | 8.11 | 172.44 | 0.54 | 6.72 |
| BA | 8.76 | 9.08 | 2373.31 | 0.58 | 4.67 |
| CE | 7.54 | 8.97 | 1382.00 | 0.59 | 4.69 |
| DF | 50.41 | 8.78 | 766.81 | 0.61 | 8.63 |
| ES | 18.17 | 9.06 | 1574.00 | 0.56 | 6.16 |
| GO | 13.23 | 8.68 | 1131.94 | 0.54 | 5.95 |
| MA | 5.56 | 8.62 | 646.31 | 0.57 | 4.27 |
| MG | 14.90 | 9.33 | 2701.81 | 0.55 | 5.87 |
| MS | 14.42 | 8.53 | 661.00 | 0.55 | 6.08 |
| MT | 15.06 | 8.63 | 835.75 | 0.55 | 5.86 |
| PA | 8.91 | 8.79 | 1385.31 | 0.54 | 5.68 |
| PB | 6.66 | 8.38 | 648.38 | 0.60 | 4.78 |
| PE | 8.59 | 8.88 | 4022.75 | 0.59 | 5.18 |
| PI | 5.49 | 8.38 | 266.88 | 0.59 | 4.18 |
| PR | 16.89 | 9.11 | 2289.50 | 0.54 | 6.31 |
| RJ | 22.49 | 9.19 | 7112.31 | 0.56 | 7.46 |
| RN | 8.73 | 8.52 | 372.50 | 0.58 | 5.14 |
| RO | 10.97 | 8.35 | 478.13 | 0.54 | 5.88 |
| RR | 12.01 | 8.17 | 108.38 | 0.52 | 6.52 |
| RS | 19.87 | 8.93 | 1807.63 | 0.53 | 6.63 |
| SC | 21.63 | 8.79 | 535.75 | 0.49 | 6.62 |
| SE | 9.59 | 8.42 | 425.44 | 0.58 | 5.29 |
| SP | 25.24 | 9.80 | 11.426.31 | 0.53 | 7.20 |
| TO | 9.32 | 8.74 | 181.06 | 0.57 | 5.05 |

**Source:** Authors.

In addition, this initial analysis does not clarify the influence of income inequality on economic growth. It can be observed that the highest mean concentration of income and the lowest mean *per capita* GDPs are found in the states of Piauí, Maranhão, Alagoas, and Paraíba.

However, the Federal District shows the highest mean Gini index and the highest mean *per capita* GDP. Thus, this initial analysis does not make explicit the possible sign or effect of inequality on growth. This effect is only captured in the empirical analysis.

Thus, this initial analysis does not make explicit whether inequality has a positive or negative effect on growth, nor does it clarify the size of the effect, which is only captured in the empirical analysis. Before proceeding, the estimates from the panel data models are subjected to the unit root tests proposed by Hadri (2000) and Levin et al. (2002). The idea is to compare the results obtained from tests that have different null hypotheses. In the case at hand, the test proposed by Hadri (2000) takes the absence of a unit root as the null hypothesis, whereas the test of Levin et al. (2002) takes the presence of a unit root as the null hypothesis. The results of these tests reject the hypothesis of a unit root for the series, concluding that they are integrated on the same order I(0), as shown in Table 5.

Table 5. Panel unit root test

| Variable | Levin, Li and Chu | Hadri | Conclusion |
|---|---|---|---|
| GDP | -4.05 | -4.71 | *I (0)* |
| *p-value* | (0.00) | (0.99) | |
| Gini | -5.97 | -4.36 | *I (0)* |
| *p-value* | (0.00) | (0.99) | |
| Investment | -22.32 | -4.64 | *I (0)* |
| *p-value* | (0.00) | (0.99) | |
| Education level | -25.39 | -4.57 | *I (0)* |
| *p-value* | (0.85) | (0.99) | |
| Political instability | -8.76 | -4.69 | *I (0)* |
| *p-value* | (0.00) | (0.99) | |

**Source:** Authors.

Table 6 shows four distinct methods of estimating the relationship between economic growth and the determinants proposed in this article (educational level, income inequality, investment, and political instability). The estimates obtained from the panel models with fixed and random effects are shown in the second and third columns, respectively. The Hausman test indicates that the random effects model is preferable to the fixed effects model (at a 5% level of significance).

The following columns show the estimates obtained by estimating with instrumental variables, with Model B incorporating the state's trade openness and Model C including both the state's trade openness and regional dummies.

The results of Table 6 show that political instability is the only non-significant variable. The estimates of models B and C reinforce the consistency of the random effects model. It is notable that the lagged *per capita* GDP negatively affects the mean growth rate. In contrast to the observations made in section 2, this result suggests a process of absolute income convergence among the states. The coefficients that measure the effect of inequality suggest that, as expected, current inequality ($d_t$) has a negative effect on growth but the coefficient of past inequality ($d_{t-1}$) has a positive effect on growth.

Table 6. Panel models with fixed and random effects and instrumental variables

| | Model A | | Model B | Model C |
|---|---|---|---|---|
| | Fixed effect | Random effect | | |
| Constant | - | -37.93 | -26.95 | -21.46 |
| *p-value* | - | (0.00) | (0.11) | (0.02) |
| $y_{(t-1)}$ | -15.87 | -8.69 | -8.443 | -5.25 |
| *p-value* | (0.01) | (0.00) | (0.00) | (0.02) |
| $d_t$ | -0.28 | -0.21 | -0.49 | -0.75 |
| *p-value* | (0.04) | (0.05) | (0.05) | (0.00) |
| $d_{(t-1)}$ | 0.05 | 0.11 | 0.46 | 0.75 |
| *p-value* | (0.68) | (0.32) | (0.08) | (0.00) |
| $inv_{(t-1)}$ | 0.02 | 0.01 | 0.01 | 0.01 |
| *p-value* | (0.01) | (0.00) | (0.30) | (0.09) |
| $edu_{(t-1)}$ | 0.15 | 0.18 | 0.20 | 0.13 |
| *p-value* | (0.02) | (0.00) | (0.00) | (0.00) |
| $PI_{(t-1)}$ | 0.02 | 0.001 | -0.004 | -0.007 |
| *p-value* | (0.12) | (0.94) | (0.54) | (0.18) |
| Hausman test | - | 11.17 | - | - |
| Significance level | - | 0.08 | - | - |
| No. observations | 135 | 135 | 135 | 135 |
| No. of groups | 27 | 27 | 27 | 27 |
| Chow F-test | 3.7 | - | - | - |
| Significance level | 0 | - | - | - |
| $R^2$ (within) | 0.53 | - | - | - |

**Source:** Authors.

With regard to the coefficient of past inequality, two observations may be made. First, the positive effect on growth may be understood as a consequence of income inequality's creation of an incentive for effort. According to Mirrless (1971), the possibility of obtaining a relatively higher income as a reward for greater effort acts as an incentive for individuals with different skill levels to achieve greater productivity. The second observation is related to the fact that Halter et al. (2014) address the effect of past inequality to show the long-term effects of inequality on economic growth, using the methodology proposed by Frank et al. (2005) and Herzer and Vollmer (2012) to capture this effect.

The coefficients of the investment and education level variables yield the expected results. However, the effect of public investment on growth is small, which may be due to the states' limited capacity for investment. During the period studied, the states' mean investment is only 3% of the state GDP.[7] The magnitude of the education level coefficient reflects the importance of human capital. The results ratify the idea that educating the workforce has a direct relationship with gains in productivity and, consequently, with economic growth.

It should be noted that in addition to the exercises displayed in Table 6, corruption and energy consumption are also employed as proxy variables to represent political instability and investment, respectively, with the same results achieved.

[7] Data from the National Treasury Secretariat (Secretaria Nacional do Tesouro – STN) and IBGE

## 5.1 Cointegrated panel and its long-term relationship

In addition to the discussion presented above, it is important to test the hypothesis of cointegration between the terms studied, which is the most common method of expressing the long-term relationship between the variables proposed in the study. This stage of the research limits itself to analyzing the long-term effects of income inequality and education level on growth because these variables have the greatest explanatory influence on growth in Brazilian states. First, cointegration tests for panel data based on Pedroni (2004) are applied to determine whether there is a long-term relationship between the variables described in the preceding paragraph.

Table 7. Pedroni's test (2004) for cointegration in panels

| Test *within* | Test statistics | Critical value |
|---|---|---|
| Statistic - v | -0.62 | 2.19 |
| Statistic - $\rho$ | 4.97 | 2.19 |
| Statistic - PP | -5.98 | 2.19 |
| Statistic - ADF | 5.67 | 2.19 |
| Test *between* | | |
| Statistic - $\rho$ | 6.95 | 2.19 |
| Statistic - PP | -8.87 | 2.19 |
| Statistic - ADF | 17.66 | 2.19 |

**Source:** Authors.

The test results suggest a relationship of cointegration between economic growth, income inequality, and education level, given that the null hypothesis of no cointegration is rejected by all of the tests. Thus, the cointegration tests indicate long-term equilibrium between these terms. With this done, the next stage is limited to capturing the long-term effect of inequality and educational level on economic growth.

Assume an autoregressive distributed lag (ARDL) dynamic panel $(p, q_1, \dots, q_k)$ that takes the following form:

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij} X_{i,t-j} + \mu_i + \varepsilon_{it} \quad (12)$$

where the number of groups $i$ = 1, 2, ..., N; the number of periods is $t$ = 1, 2, ..., T; $X_{it}$ is a vector $k\ x$ 1 of explanatory variables; $\delta_{it}$ are the coefficients of the vectors $k\ x$ 1; $\lambda_{ij}$ are the scalars; and $\mu_i$ is a group-specific effect.

Imposing a lag on all of the terms of the autoregressive distributed lag equation (1,1,1) yields the following:

$$y_{it} = \gamma_i + \delta_{10i} esc_{it} + \delta_{11i} esc_{i,t-1} + \delta_{20i} d_{it} + \delta_{21i} d_{i,t-1} + \lambda_i y_{i,t-1} + \varepsilon_{it} \quad (13)$$

where $y_{it}$ represents the logarithm of real *per capita* income, $edu_{it}$ represents the logarithm of educational level, and $d_{it}$ represents the level of income inequality.

The following equation results from the error correction model:

$$\Delta y_{it} = \phi_i \left[ y_{i,t-1} - \theta_{0i} - \theta_{1i} edu_{i,t-1} - \theta_{2i} d_{i,t-1} \right] + \delta_{11i} \Delta edu_{i,t-1} + \delta_{21i} \Delta d_{i,t-1} + \varepsilon_{it}$$

(14)

where $\theta_{0i} = \frac{\gamma_i}{1-\lambda_i}$, $\theta_{1i} = \frac{\delta_{10i}+\delta_{11i}}{1-\lambda_i}$, $\theta_{2i} = \frac{\delta_{20i}+\delta_{21i}}{1-\lambda_i}$, and $\phi_i = -(1-\lambda_i)$.

The terms $\theta_{1i}$ and $\theta_{2i}$ capture the long-term effects and represent the effects of educational level and income inequality, respectively. The parameter $\phi_i$ represents the error-corrected speed of adjustment. If the variables show a return to long-term equilibrium, then this parameter will be significantly negative because as the error correction term measures deviations from long-term equilibrium between the variables. If the term $(1-\lambda_i)$ is positive, then a negative correction should occur in the following period, ensuring that the system returns to equilibrium. If $\phi_i \geq 0$, then there would be no evidence for a long-term relationship.

Table 8 shows the three estimates that attempt to measure these effects, namely: a) MG estimates that impose no restrictions; b) PMG estimates that impose common long-term effects; and c) DFE estimates that require that all slope coefficients and all error variances be the same.[8]

Table 8. Alternative Pooled Estimates

| ARDL (1,1,1) | MG | PMG | DFE |
|---|---|---|---|
| Education level effect ($esc_{it}$) | 0.02052 | 0.00911 | 0.03188 |
| Standard deviation | (0.0197) | (0.00712) | (0.01353) |
| Inequality effect ($d_{it}$) | -0.00153 | -0.0018 | -0.19031 |
| Standard deviation | (0.00009) | (0.0004) | (0.09445) |
| Speed of adjustment ($\emptyset_{it}$) | -0.62394 | -0.53966 | -1.68874 |
| Standard deviation | (0.07557) | (0.06482) | (0.12355) |
| Log likelihood | -133.91 | -160.48 | -69.29 |
| No. of parameters estimated | 77 | 57 | 17 |

**Source:** Authors.

Table 8 shows that the effects of income inequality and education level do not change in the long-term analysis, which reinforces the idea that an increase in inequality negatively affects growth and, conversely, higher education levels positively affect growth. This result is robust, considering that all of the cointegrating coefficients tied to long-term effects are shown to be significant.

With regard to the parameter that represents the speed of adjustment of the error correction, it can be observed that the estimates obtained from the MG and PMG estimators ($\phi_{MG}$ = -0.62 and $\phi_{PMG}$ = -0.54) indicate short-term dynamics that are different, significant, and smaller than those obtained by pooling estimates. These estimators suggest, for example, that the speed of convergence to the equilibrium is approximately 62% per year for the MG estimator, 54% for the PMG estimator, and 169% for the DFE estimator.

## 6 Conclusion

The discussion about the transmission channel for the effects of income inequality on economic growth is not new, and over the years, it has drawn the attention of researchers who attempt to explain the importance of this relationship. This study, for example, uses the theoretical model proposed by Halter et al. (2014), in which a theoretical model with a non-

[8] Baltagi (2008) notes that the DFE standard-errors are corrected by the heteroscedasticity of the error variances among countries; the non-corrected values are substantially smaller. The robust heteroscedasticity of the standard errors are calculated by means of a general covariance matrix of the disturbances $\varepsilon_{it}$ among the individuals *i*.

monotonic adjustment trajectory leads to a linear model that represents the inequality-growth relationship.

The empirical results suggest that, among all of the factors studied, only the effects of education level and income inequality are analyzed in both the short term and the long term. The main conclusion drawn from these analyses is that regardless of which method is adopted (panel model with fixed effects, random effects, instrumental variables and cointegration analysis), education level and income inequality affect economic growth positively and negatively, respectively, and that these factors are able to explain some of the differences in growth rates among different regions of Brazil.

A future discussion will address the effects of statistical predictability on economic growth and income inequality using the Granger test of causality. The importance of this analysis is that causality suggests that changes in economic growth are able to predict changes in inequality, and vice versa, an element that has been little explored in the literature. In addition, the Brazilian states will be divided into two groups (those with higher and lower indices of inequality) for the purpose of verifying whether the effect of inequality on growth remains valid or whether other factors become more relevant in explaining the economic growth of these states.

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