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CONVERGENCE ANALYSIS OF PER CAPITA INCOME IN MUNICIPALITIES IN THE SOUTH REGION OF BRAZIL BETWEEN 1999 AND 2014

ANÁLISE DE CONVERGÊNCIA DE RENDA *PER CAPITA* NOS MUNICÍPIOS DA REGIÃO SUL DO BRASIL ENTRE 1999 E 2014[1]

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Abstract

This paper aims to identify possible changes in the disparity of income between the municipalities in southern Brazil, for the period from 1999 to 2014. We used a panel data analysis of the municipalities and observed whether the income differences showed a decreasing pattern. The model used two of the three main types of convergence - absolute, conditional, and club - focusing on absolute and conditional income convergence. The model was estimated twice, aggregating the municipalities in southern Brazil and aggregating the same municipalities per state of the region. The hypothesis of per capita income convergence was confirmed with statistically significant evidence for absolute and conditional convergence, both when considering the municipalities aggregated in the region and per state. In the analysis of the municipalities aggregated per state, the state of Santa Catarina had the highest speed of absolute income convergence. In contrast, the state of Rio Grande do Sul had the highest speed in the conditional convergence.

Keywords: Municipalities. Economic Growth. Income Convergence.

Resumo

Este artigo procurou identificar possíveis mudanças de disparidade de renda entre os municípios da Região Sul entre 1999 e 2014. Para isso, utilizou-se da modelagem em painel para examinar os dados dos municípios e assim auferir, ao longo dos anos analisados, se houve uma diminuição das

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desigualdades. Modelos de convergência se dividem principalmente em três tipos: convergência absoluta, condicional e de clubes. A modelagem utilizada neste artigo empregou-se de convergência absoluta e condicional de renda, e foi dividida em duas partes, na primeira, foram estimadas as regressões considerando toda a amostra com os três estados, a segunda parte foi feita separando cada estado para verificar possíveis diferenças entre os mesmos. Com evidências estatisticamente significativas, confirmou-se a hipótese de convergência de renda *per capita* absoluta e condicional entre os municípios sulistas, em ambas as formas estimadas. Quando a análise se deu por meio da desagregação dos estados da Região Sul, foram encontradas evidências dos diferentes comportamentos, ainda que a hipótese de convergência continuou sendo confirmada, por exemplo, na convergência absoluta o estado de Santa Catarina ganhou destaque tendo a maior velocidade de convergência. Já na análise condicionada, o Rio Grande do Sul teve a maior velocidade dentre os estados analisados.

Palavras-chave: Municípios. Crescimento Econômico. Convergência de Renda.

Introduction

Income inequality is one of Brazil's main challenges. The study on reducing such inequality may pose the idea that the agents will have an equivalent income, which can be analyzed using the hypothesis of income convergence. Solow (1956) explained the neoclassical model of economic growth and development, using a model the consists of two basic equations, including a production function and an equation of capital accumulation. The production function describes how inputs – capital and labor – must combine to generate the product, with constant returns to scale (i.e., if all inputs are duplicated, the product will double). The model assumes that rates of savings and population growth are exogenous and different for each country, which means that countries will have different levels of steady-state. Steady-state is the long-term equilibrium of an economy when the capital stock growth is equated to the labor force growth.

Many other authors in the field of economic growth have tried to modify and improve Solow's model of economic development, such as Romer (1986) and Lucas (1988), who built endogenous models and added other variables in the production function. Lucas, for example, included the accumulation of human capital to the economic growth model as an endogenous variable in two different ways, through schooling and learning-by-doing.

Based on the assumption that factors of production – capital and labor – grow at decreasing rates (i.e., present decreasing returns to scale), an increase of physical capital in countries that already present a high level of this capital, will not significantly change the product in comparison to countries with a low level of physical capital. This observation allows saying that poorer countries will grow faster or will have a higher growth rate than richer countries. Also, the per capita income gap between them will decrease, confirming the hypothesis of income convergence firstly studied by Baumol (1986). Baumol's study, however, cannot be generalized to all countries since it used statistics from a few of them, identifying convergence in some places.

Barro and Sala-i-Martin (1994) also analyzed convergence of income, advocating the importance of knowing the speed of convergence to understand the dynamics of economic growth and assess whether the economy is close to a steady-state. In addition to speed, the authors argued that the degree of homogeneity makes it more common to find significant convergence within regions of a given country than to find it using data from several nations.

Against this backdrop, this paper seeks to test the income convergence among municipalities in the south of Brazil, a region comprised of three states (Rio Grande do Sul, Santa Catarina, and Paraná). The study uses the models of absolute convergence and conditional convergence and works with data from the period 1999-2014. The document has five sections, including this introduction. The next section briefly describes the theory of economic growth and convergence, followed by a section presenting the study's methodology. The fourth section shows the results obtained, and the fifth and final section brings the final considerations.

Income Convergence and Economic Growth

Economic Growth

The production function is a manner to explain an economy's sustained growth, in the long run, establishing the relationship between product level and inputs. In the traditional literature on economic growth, capital and labor are the commonly used inputs[5]. Solow (1956), however, includes an additional term in the production function, in the long run, A(t), which represents technological changes in a certain period, and means that more products will be generated based on the same amount of inputs. The equation to address long-term growth is:

$$Y(t) = A(t)F[K(t), N(t)] \quad (1)$$

where Y(t) represents the product, A(t) technological changes, K(t) the capital, and N(t) the labor.

The production function introduced in equation (1) presents a constant return of scale; thus, if inputs doubles, the product will also double, which is characteristic of a homogeneous function of degree one. In addition, each input – capital and labor – show decreasing marginal returns, that is, when a unit is added, the product grows at a lower rate than the unit.

Some of the reasons for studying economic growth, according to Jones and Vollrath (2016) are:

- there is a significant difference among the countries' per capita incomes
- there is a wide diversification in the economic growth rates among economies
- rates of economic growth are usually not constant over time
- a country's per capita income distribution in relation to the rest of the world is not immutable, a country can move from poor to rich and vice versa;
- GDP growth is strictly related to the volume of international trade
- skilled and unskilled workers tend to migrate from poor to wealthier regions

Therefore, according to Solow (1956), the assumptions related to the production function convey a conditional convergence – convergence to the steady-state that depends on the level of capital and labor – so that countries with a low capital-labor ratio tend to present a higher growth rate than those with higher capital-labor ratio. The issue of absolute and conditional convergence is widely discussed in the economic growth literature, subject of the next section.

Income Convergence

The concept of income convergence emerged to explain whether low-developed economies have higher rates of economic growth when compared to highly-developed economies. The 'absolute' and 'conditional' convergence are the types of convergence of income addressed in this study. According to Galor (1996), in the absolute convergence, the examined regions, based on their initial level of income per capita, converge in the long run to the same steady-state. In the case of conditional convergence, because regions or countries have different characteristics and tend to converge to different steady-states in the long run, it is necessary to set up some conditions.

Baumol (1986) was a pioneer in studying the convergence of income. In an article where he used data from sixteen developed and developing countries collected by Maddison (1982), Baumol found a high inverse correlation between the GDP per capita in 1870 – the first year observed by Maddison (1982) – and the GDP per capita in the following years examined. This suggested that countries that already have a high standard of living grow at lower rates than developing nations.

A few years later, Barro and Sala–i–Martin (1992) analyzed the convergence of income for 48 contiguous states in the US, using a neoclassical approach in their model of growth. The authors started the analysis from the year 1840 and found evidence of convergence of income in all states.

[5] See Romer (2012) and Froyen (2013).

In addition, they analyzed a sample of countries and found similar results when adopting conditions that allow the steady-state to vary according to the characteristics of each location – introducing the concept of conditional convergence of income.

In the same year, Mankiw, Romer, and Weil (1992) studied the consistency of Solow's model, comparing it with variations in the standard of living in different countries. They found evidence that the model presents high adherence to the countries' real data when incorporating human capital. When analyzing data from several countries, assuming population and capital growth as constant, the model has a good precision in estimating the convergence rate of countries.

Caselli, Esquivel, and Lefort (1996) sought to verify the convergence hypothesis using the data set studied by Barro and Lee (1994). The authors used the generalized method of moments (GMM) to identify convergence of income, correcting possible problems of correlated individual variables and endogeneity of variables. When examining the 96 countries, they found that the countries' levels of per capita income converge to the steady-state at a speed of ten percent per year.

Rey and Montouri (1999) studied the convergence of income in the US, adopting a spatial econometric method. The authors used this method due to the dissipation of random shocks from one state to neighboring states, complicating the transition dynamics of the process of convergence of income. The results confirmed the convergence of income between the states. Also, the findings showed that, although the states may converge to relative incomes, this is not done for each state independently, as a positive influence was observed of neighboring states.

In Brazil, Ferreira and Ellery Jr. (1996) sought to identify whether Brazilian states were reducing inequality in relation to each other. They found evidence that confirms the hypothesis of convergence, even though it was a slower convergence than that by Barro and Sala–i–Martin (1992) for the states in the US. Abitante (2007) did something similar, but applying conditional convergence of income and using conditions to vary the steady-state the Brazilian states could achieve. As Ferreira and Ellery Jr (1996), the author also found evidence of convergence among the states.

Another study in Brazil is the work by Gomes and Esperidião (2016), who verified the hypothesis of convergence for the Brazilian states in the period 1995-2009, using data in a dynamic panel. The research verified the hypothesis of absolute and conditional convergence of income for four different samples. They considered Brazil as a whole, the states of southeast and south regions, states of the mid-west, and states of the north and northeast of the country. For the β-absolute, only the states of the mid-west and north of the country did not show significant results, not adhering to the hypothesis of convergence for the years analyzed. As for β-conditional, the authors developed three models, adding one conditional variable per model. For the model using the variable illiteracy rate, the sample with the states in the mid-west and north, and the sample considering Brazil as a whole, did not show significant results. The model using the variable rate of the population enrolled in high school showed significant results for all samples. Finally, the model with the variable years of schooling showed no significant result for the sample comprised by the states of the mid-west and the sample with the states of the north and northeast regions of Brazil.

The estimation using the Markov matrix is another strategy adopted in the convergence of income models. Fochezatto and Stülp (2008) used a Markov matrix to analyze the convergence of per capita income between the municipalities of Rio Grande do Sul in the period 1985-1998. The authors found convergence of per capita income, attributing the phenomenon to population growth, which was higher in the wealthiest municipalities.

In the Brazilian state of Minas Gerais, Perobelli, Faria, and Ferreira (2003) studied the convergence of per capita income in the municipalities of the state for the period from 1975 to 2003. The authors carried out an exploratory analysis using spatial data and a panel divided into three periods. The results did not show a convergence of income in the period, i.e., there was an increase in municipal disparities in Minas Gerais. But when considering the period from 1996-2003, the disparities among the municipalities decreased, confirming the hypothesis of convergence of per capita income.

Amorim, Scalco, and Braga (2008) used the production functions of Solow's growth models to explain the pattern of per capita income in Brazilian states. The authors analyzed the period from 1980 to 2000, verifying the dynamics of aggregated GDP and, subsequently, the GDP for the sectors of agriculture, industry, and services separately. The results suggested absolute convergence of income for the aggregated GDP and the GDP in the sectors of industry and services and conditional convergence only for the industry sector.

This research was based on the works by Raiher (2015), who analyzed convergence of income of regions in the state of Paraná, and by Gomes and Esperidião (2016), who analyzed the Brazilian states. This paper focused on identifying absolute and conditional convergence in municipalities in the south of Brazil, in the period from 1999 to 2014. The research carries out, firstly, an estimate for the entire region, comprising the states of Paraná, Santa Catarina, and Rio Grande do Sul. Subsequently, the study offers estimates of the municipalities aggregated per state.

Methodology

The municipalities were aggregated following the method by Ehrl (2017), in which the emancipated territories were grouped with their original municipality. The sample comprised the municipalities of the three states in the south of Brazil (Paraná, Santa Catarina, and Rio Grande do Sul) that had information on the variable used as a proxy for physical capital – total electricity consumption, subtracting the residential consumption. The municipalities that presented total electricity consumption equal to their residential consumption were excluded from the sample.

This paper analyzes the convergence of per capita income in the municipalities in the south of Brazil, using panel data to estimate absolute and conditional convergence. The analysis for the three states in southern Brazil (Paraná, Santa Catarina, and Rio Grande do Sul) considered the period from 1999 to 2014, with three-year data. The next subsections present the data sources and describe the econometric model adopted in this study.

Database: Absolute Convergence

The database was built using the information on the GDP of municipalities, retrieved from the SIDRA (Automatic Recovery System of the Brazilian Institute of Geography and Statistics – IBGE), based on Table 21 (corresponding to the years 1999 and 2002) and Table 5938 (for the years 2002 to 2014). The study used the two tables due to the absence of the year 1999 in Table 5938. To use the year 2002, we used an average for the data offered in the two tables presented by the IBGE's system. The population series was built in two parts, firstly by compiling the data on municipal population estimates obtained through the SIDRA for the years 2002 to 2014. Then, the information for the year 1999 was obtained through IBGE since the data for the year was not available in the SIDRA. After collecting data, the GDP was divided by the population to obtain the municipal GDP per capita, and the growth rate of each year in comparison to the previous one was established. All monetary values have been deflated and are shown in 2014 prices.

Database: Conditional Convergence

The database for conditional convergence used the GDP per capita of municipalities in the three Brazilian southern states. The explanatory variables comprise the initial per capita income of each period and the conditions: a) growth rate of the economically active population, using data from the population formally employed retrieved from the RAIS (Brazilian Annual Social Informations Report), represented by *ln(pea)*; b) physical capital, adopting as a proxy the growth rate of total electricity consumption, subtracting the residential consumption. The data was retrieved from IPARDES (Institute of Economic and Social Development of the State of Paraná), FEE (The Foundation of Economics and Statistics of the State of Rio Grande do Sul), and CELESC (Electricity Company of the State of Santa Catarina). The physical capital is represented by *ln(ee)*; c) human capital, using the lagged average years of schooling of the population[6], information retrieved from RAIS referring to the population formally employed; and finally, d) lagged population density, variable obtained by dividing the population by the size of the municipality's area. The data for density was retrieved from IBGE (Brazilian Institute of Geography and Statistics).

Econometric Model

As mentioned before, this paper analyzes the process of absolute and conditional income convergence in the municipalities of the Brazilian states of Paraná, Rio Grande do Sul, and Santa Catarina. The estimated model for absolute income convergence that depends only on the initial per capita income of each municipality, regardless of their conditions, follows equation (2):

[6] Lagged variables are the initial condition of each period of the panel data.

$$\frac{1}{T}\ln\left[\frac{y_{i,t}}{y_{i,t-1}}\right] = \alpha + \beta\ln(y_{i,t-1}) + \xi_{i,t} \quad (2)$$

In equation (2), $y_{i,t-1}$ is the per capita income of municipality i in 1999 when the year is 2002; and 2002 is the initial condition when the year is 2005, and so on; $y_{i,t}$ represents the per capita income of municipality i in year t; T is equal to three, representing the interval in years between observations; $\ln\left[\frac{y_{i,t}}{y_{i,t-1}}\right]$ is the growth rate of per capita income; α and β are parameters, and β is the parameter of interest, if negative and statistically significant, it will provide evidence of absolute income convergence among the municipalities in the south of Brazil; and $\xi_{i,t}$ is the model's random error.

The estimated model for conditional convergence of income depends on the conditions of the municipalities, which implies relaxing the hypothesis of convergence for the same steady-state. It follows the equation (3):

$$\frac{1}{T}\ln\left[\frac{y_{i,t}}{y_{i,t-1}}\right] = \alpha + \beta\ln(y_{i,t-1}) + \eta X_{i,t} + \xi_{i,t} \quad (3)$$

In equation (3), $y_{i,t-1}$ represents the per capita income of the municipality i in 1999 when the year is 2002; and 2002 represents the initial condition when the year is 2005, and so on; $y_{i,t}$ is the per capita income of municipality i in year t; T is the interval in years between observations (which is three); $\ln\left[\frac{y_{i,t}}{y_{i,t-1}}\right]$ represents the growth rate of per capita income; α and β are parameters, and β is the parameter of interest, if negative and statistically significant, it will provide evidence of conditional income convergence among the municipalities in the south of Brazil; and $\xi_{i,t}$ is the model's random error. The matrix $X_{i,t}$ represents the conditions of the municipalities, with their characteristics:

- growth rate of electricity consumption, as a proxy for physical capital;
- growth rate of the economically active population;
- average years of schooling of the population;
- population density;

From the estimation of the parameter β, it is possible to calculate the speed of convergence – equation (4) – and the time required for a given economy to be halfway of reaching its steady-state (called 'half-life') – equation (5).

$$\theta = \frac{\ln(1+T\beta)}{T} \quad (4)$$

$$\tau = \frac{-\ln(2)}{\ln(1+\beta)} \quad (5)$$

The database characterizes a panel since there is the observation of several individuals and their evolution over time. Panel data regression can be a resource to address the problem of data heterogeneity, eliminating the bias that comes from the individual characteristics of each municipality, and possibly increasing its efficiency. Therefore, the study adopted a panel data analysis with fixed and random effects.

For Wooldridge (2010), fixed effects estimation seeks to eliminate the specificity of each individual, discounting the general average of the variables at each period t, which corrects the problem of heterogeneity. When considering the initial year as fixed in 1999, the fixed effects model omits the main parameter since it suppresses the elements that do not vary over time. Therefore, the fixed effect is useful only if the initial condition varies. In the estimation using random effects, the specificity of each municipality is assumed to be randomly distributed. If the assumption is correct, the individual effects are minimized.

Finally, the Hausman test (1978) was carried out to decide between fixed and random effects. The test assumes the null hypothesis that the individual effect is not correlated with the explanatory effects, thus testing whether the fixed and the random effects estimators are statistically different. All models were estimated using the software Stata.

Results

This section is divided into two subsections, one for the aggregate analysis of municipalities in the south and the other with the analysis of the municipalities aggregated per state.

Analysis of Municipalities Aggregated - South of Brazil

The analysis was conducted under the β-absolute and β-conditional convergences. Table 1 shows the results for the municipalities in the south, referring to the model of absolute convergence.

Table 1: Results for Absolute Income Convergence.

	Fixed Effects	Random Effects
$\ln(y_{i,t-1})$	-0,0915***	-0,0294***
	(0,0035)	(0,0019)

Source – Elaborated by the authors in 2019 (using Stata).
Note: *** H0 rejected at the 1% level (t-test), standard errors in parenthesis.

The negative parameter associated with the independent variable, which represents the logarithm of the initial per capita income in period *t*, demonstrates the absolute convergence among the municipalities for the period of the parameter. The result shows that the rate of economic growth per capita, on average, was higher for municipalities that had lower initial per capita income each period. Thus, the GDP per capita of the municipalities converges to a steady-state. As for the conditional convergence, the results of the models are presented in Table 2.

Table 2: Results for Conditional Income Convergence.

	Fixed Effects	Random Effects
$\ln(y_{i,t-1})$	-0.1478***	-0.0327***
	(0.0039)	(0.0019)
Δln(pea)	0.0197***	0.0377***
	(0.0042)	(0.0040)
Δln(ee)	0.0199***	0.0264***
	(0.0038)	(0.0036)
Schooling	0.0534***	0.0158***
	(0.0019)	(0.0014)
Density	0.0002***	-1.42e-06
	(0.0000)	(3.45e-06)

Source – Elaborated by the authors in 2019 (using Stata).
Note: *** H0 rejected at the 1% level (t-test), standard errors in parenthesis.

The negative parameter associated with the independent variable, which represents the logarithm of the initial per capita income in period *t*, demonstrates conditional convergence of per capita income among municipalities for the period of the parameter. The imposed conditions relax the hypothesis of convergence to the same steady-state. Each municipality, therefore, converges to a different steady-state, according to its characteristics regarding economically active population – represented by Δln(pea) –, physical capital – represented by Δln(ee) –, human capital – represented by schooling –, and density.

Table 2 shows the confirmation of the hypothesis of convergence, which was statistically significant for all models. This result implies that the rate of economic growth per capita, on average, was higher for the municipalities that had lower initial per capita income for each period. The analysis of conditional parameters only considered if they were positive or negative, and was not interpreted according to their value. When the coefficients are positive, they mean that the more the observed variable grows, the higher the rate of GDP growth per capita, and vice versa.

The Hausman specification test was used to analyze the model, assessing whether the difference between the parameters of fixed and random effects is statistically significant. The results show a p-value very close to 0, indicating the rejection of the null hypothesis – which considers that the difference is not significant – and inferring that the model of random effects will be biased. Therefore, the fixed-effect model is considered the most efficient.

According to equation (4), it is possible to calculate the annual speed of convergence for municipalities to achieve their steady-state. According to the β-absolute model, considering the period from 1999 to 2014, the speed of convergence for the parameter unbiasedly estimated using the fixed effects model is 10.70% per year. Consequently, municipalities in the south reach half the level of per capita income of the steady-state in approximately seven years. On the other hand, using the β-conditional model, considering the period from 1999 to 2014, the speed of convergence for the estimated parameter is 19.53% per year. The municipalities of the south would reach half the level

of per capita income in approximately four years. The results obtained for the speed and the half-life index can be seen in Tables 3 and 4.

Table 3: Results of the Speed of Convergence and Half-Life Index for β-Absolute.

Model	Speed (%)	Half-Life Index (years)
Fixed Effects	10.70	7.22
Random Effects	3.08	23.23

Source – Elaborated by the authors in 2019 (using Stata).

Table 4: Results of the Speed of Convergence and Half-Life Index for β-Conditional.

Model	Speed (%)	Half-Life Index (years)
Fixed Effects	19.53	4.33
Random Effects	3.45	20.80

Source – Elaborated by the authors in 2019 (using Stata).

The speed of convergence of municipalities in the south of Brazil, using the fixed effects model, is much higher than that calculated by Gomes and Esperidião (2016), who found a speed of 3.14% per year when studying Brazilian states in general. Thus, the municipalities of the south reach their steady-state faster than what Gomes and Esperidião had observed.

Analysis of Municipalities Aggregated per State

The analysis of the convergence of income when observing the municipalities aggregated per state contributed to verify whether there is a difference in convergence among the three states, due to possible heterogeneities. Table 5 shows the results of the absolute convergence of per capita income for the southern Brazilian states.

Table 5: Results for Absolute Income Convergence – municipalities aggregated per state.

	Paraná		Santa Catarina		Rio Grande do Sul	
	FE	RE	FE	RE	FE	RE
$\ln(y_{i,t-1})$	-0.0627*** (0.0051)	-0.0242*** (0.0028)	-0.1168*** (0.0061)	-0.0482*** (0.0040)	-0.0968*** (0.0068)	-0.0253*** (0.0034)
Observations	1995		1390		2155	

Source – Elaborated by the authors in 2019 (using Stata).
Note: *** H0 rejected at the 1% level (t-test), standard errors in parenthesis.

The results were significant at the level of 5%, showing absolute convergence of per capita income in all southern states. Therefore, for the period analyzed, the rate of economic growth per capita was higher for municipalities that had lower initial per capita income each period, showing the convergence of income to a steady-state.

Using more controls allows relaxing the hypothesis of convergence to the same steady-state. Each municipality in each state converges to a different steady-state, according to its characteristics. Table 6 shows the results with the parameters of each condition used per state.

Table 6: Results for Conditional Income Convergence – municipalities aggregated per state.

	Paraná		Santa Catarina		Rio Grande do Sul	
	FE	RE	FE	RE	FE	RE
$\ln(y_{i,t-1})$	-0.1512***	-0.0310***	-0.1971***	-0.0514***	-0.1995***	-0.0227***
	(0.0063)	(0.0029)	(0.0074)	(0.0042)	(0.0073)	(0.0033)
Δln(pea)	0.1283***	0.0277***	0.0148***	0.0308***	0.0160***	0.0409***
	(0.0067)	(0.0065)	(0.0065)	(0.0069)	(0.0071)	(0.0073)
Δln(ee)	0.0398***	0.0549***	0.0130***	0.0209***	0.0126***	0.0204***
	(0.0083)	(0.0079)	(0.0056)	(0.0059)	(0.0059)	(0.0060)
Schooling	0.0657***	0.0168***	0.0734***	0.0109***	0.1082***	0.0248***
	(0.0032)	(0.0020)	(0.0045)	(0.0029)	(0.0045)	(0.0027)
Density	0.0002***	0.0000	0.0002***	0.0000	0.0000	0.0000
	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)
Observations	1995		1390		2155	

Source – Elaborated by the authors in 2019 (using Stata).
Note: *** H0 rejected at the 1% level (t-test), standard errors in parenthesis.

The negative signal of the parameter, together with its statistical significance both for fixed and random effects, associated with the independent variable of interest – which represents the logarithm of per capita income in period t – confirms the hypothesis of conditional convergence of per capita income in the three states. The result shows that there was a reduction in disparities among the municipalities from 1999 to 2014.

The control variables used confirmed that the municipalities of each state are converging their income to a steady-state. This is different for each municipality due to the differences posed by the conditions. The rate of growth of per capita income is seen as higher, each period, for municipalities that had lower initial per capita income.

The conditional parameters are interpreted based on whether they are negative or positive. As they were all positive, this means that the more one of the conditions grows, the higher the rate of growth of per capita income.

The Hausmann specification test was used to select which model brings the most efficient and unbiased result. The test observes whether the fixed and random effects models are the same. Based on the p-value, the fixed effect was considered the most efficient model, and it was, therefore, used for the analysis.

The calculation of the speed of convergence and the half-life index was carried out for the municipalities aggregated in the three states. The results considering absolute and conditional convergence are shown in Tables 7 and 8, respectively.

Table 7: Results for the Speed of Convergence and the Half-Life Index for β-Absolute – municipalities aggregated per state.

	Paraná		Santa Catarina		Rio Grande do Sul	
	FE	RE	FE	RE	FE	RE
Speed (%)	6.95	2.51	14.38	5.21	11.44	2.63
Half-Life Index (years)	10.70	28.29	5.58	14.03	6.81	27.05

Source – Elaborated by the authors in 2019 (using Stata).

Table 7 shows the results of the absolute income convergence, and the different speeds and half-life index among the states are clear, which can be explained by their characteristics. In the case of β-absolute, and considering the fixed-effects models, Santa Catarina has the highest speed of convergence and the smallest half-life index, followed by Rio Grande do Sul, and then, Paraná. The half-life index indicates the time in years, on average, needed for a given economy to reach half of its steady-state. For example, for Santa Catarina, municipalities take an average of 5.58 years to reach half of their steady-state.

Table 8: Results for the Speed of Convergence and the Half-Life Index for β-Conditional – municipalities aggregated per state.

	Paraná		Santa Catarina		Rio Grande do Sul	
	FE	RE	FE	RE	FE	RE
Speed (%)	20.15	3.25	29.83	5.58	30.42	2.35
Half-Life Index (years)	4.23	22.01	3.16	13.14	3.11	30.19

Source – Elaborated by the authors in 2019 (using Stata).

The results for the speed of convergence and the half-life index calculated from the parameters of conditional convergence are different from those calculated based on the absolute convergence. When analyzing the fixed effects model, the state of Rio Grande do Sul shows the highest rate of convergence of per capita income to the steady-state, with a speed of 30.42% per year, taking 3.11 years to reach half of its steady-state. Santa Catarina is the second fastest to converge (29.83%) and a lower half-life rate (3.16 years).

The results found in this paper corroborate the findings of Fochezatto and Stülp (2008), who analyzed the convergence of per capita income among the municipalities of Rio Grande do Sul, evidencing the hypothesis of convergence of income. Raiher (2015), when examining the convergence of income for regions of the state of Paraná, also confirmed the hypothesis of convergence, showing that disparities among regions decreased in the analyzed period (1995-2009). In Santa Catarina, Mendes, Nishimura, and Rodrigues (2014) found similar results for the period from 2001 to 2012. According to the authors, the inequality among municipalities decreased, and, based on the results of absolute convergence of income, it would take nine years for the municipalities to reach half of their steady-state. Thus, the results of this paper confirm the hypothesis of convergence of per capita income – both for municipalities in the region as a whole, or aggregated per state – and corroborate the findings of previous studies.

Final Remarks

This study analyzed whether there was a convergence of per capita income in municipalities of the three states in the south of Brazil during the period from 1999 to 2014. The study carried out a panel analysis of two models, considering the municipalities aggregated as a region, encompassing the three states in the south of Brazil, and the municipalities aggregated per state.

As mentioned in the introduction, one of the major problems in Brazil is the level of income inequality, which is a topic studied using the economic growth approach through the study of convergence of income. When countries, states, or municipalities show that income is converging to a steady-state, there is a reduction of disparities and, therefore, of income inequality.

The literature review on the income convergence and economic growth shows that, in recent years, there has been a reduction in regional disparities both in Brazil and internationally. This study addressed this issue emphasizing the convergence of income and found inequality reduction among the municipalities of the states of Paraná, Santa Catarina, and Rio Grande do Sul. Also, the research offered an estimate of the states' both speed of convergence and the half-life index needed to reach their steady-state. The results confirmed the hypothesis of income convergence and corroborated previous studies.

The analysis using absolute convergence showed unrealistic results that used only the explanatory variable of the rate of GDP growth per capita, following the hypothesis that all municipalities converge to the same steady-state. The analysis adopting conditional convergence, on the other hand, presented more realistic results. The findings show that the state of Rio Grande do Sul stood out in comparison to Santa Catarina and Paraná since its municipalities converge faster to the steady-state, which varies according to the conditional characteristics of each municipality.

Future research on this matter may improve the model used in this paper, including elements such as spatial correlations that may exist between the municipalities. In addition, the analysis may extend to σ-convergence to study a possible behavior to reduce the dispersion of per capita income in the analyzed areas over time.

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