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Growth, Inequality and Poverty: Some Empirical Evidence from Minas Gerais State, Brazil

Rosa Fontes[1], Elydia Silva[2], Luiz F. Alves[3] and Geraldo E.S. Júnior[4]

1. Introduction

This chapter is motivated by the fact that the Brazilian economy has one of the highest income inequality index in the world. According to Paes de Barros et al(2000), average income of the 10% richest people in Brazil is 28 times higher than the average income of the 40% poorest people. In Argentina, it is 10 times, 13 times in Costa Rica and 5 times in France. Brazilian growth did not benefit all classes and inequality is increasing since the 60´s. While the 10% richest people get 48% of total income, the 10% poorest people get 0,8% of total income.

The inequality problem also arises in the Brazilian regional income analysis. Minas Gerais is a rich and dynamic state with 300.000 km^2 divided into 10 different regions, 66 microregions and 853 towns. It is located in the Southeast developed part of the country and is responsible for 10% of Brazilian GDP. As the rest of Brazil, it has a dual economy with prosperity and poverty and social and economic heterogeneity.

This chapter empirically analyses the economic growth and income inequality behavior in Minas Gerais towns and microregions from 1970 to 2000, using the income convergence hypothesis. Convergence tests such as Barro and Sala-i-Martin(1992), σ-convergence, Drennan & Lobo(1999) and Quah(1993) are performed. The role of human capital in growth is analysed for Minas Gerais 66 microregions. A comparison is also made between very rich regions and very poor regions of this state to see the relationship between regional inequality and poverty.

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Results had shown that regional inequality is a fact in the whole state and arises both in rich and poor regions, although there had been a little income convergence and inequality reduction in the past 30 years confirmed by the σ-convergence test.

A negative and highly significant relation between initial income and the rate of income growth during the analysed period is obtained in most estimated equations, whether the data sample is related to Minas Gerais 10 regions or 853 towns, suggesting that, in general, poorer regions and towns grew more than the richer ones in the past decades. With respect to Minas Gerais 66 microregions, the results are controversial.

Further analyses had shown that conditional convergence seems to prevail, since proxies of human capital had played an important role in Minas Gerais income convergence and growth. Quah and Drennan and Lobo tests had suggested that Minas Gerais economies tend to different steady states. A significant number of microregions and towns tend to keep at low income situations in the long run. Public policies are specially needed for poor and very poor regions, microregions and towns that also show low growth behavior, such as Jequitinhonha/Mucuri region and Januária and Araçuai counties.

After this introduction, the chapter presents an overall view of Minas Gerais State. Section 3 shows the theoretical models and the analitical procedures. Section 4 has the results and section 5 concludes.

2. Overall View of Minas Gerais State

Minas Gerais has 10 planning regions, 66 microregions and 853 towns, having a high rate of production, income and population concentration. According to Fundação João Pinheiro (FJP, 2001), in 1999, Central and Sul de Minas regions were responsible for 58,5% of state GDP. Only 110 towns were responsible for 79,6% of production, while 743 towns had produced 20,4%.

The Central region, where the capital Belo Horizonte is located, presents the highest *per capita* production, industrialization and income rates, as well as the highest number of rich towns, opposed to Jequitinhonha/Mucuri and Norte de Minas regions, which have the worse income, productivity, population, schooling and health indicators.

With respect to population, the state average is 30,1 people/km², while the Central region has 76,8 people/km² and the Noroeste de Minas region has only 5,3 people/km².

The average *per capita* GDP, in 1999, was around R$4.904,58, being R$6.408,49 in the Central region and R$1.735,73 in the Jequitinhonha/Mucuri region.

With respect to regional production, the Central region has the highest GDP(R$ 39.471.814.000,00), corresponding to 45,6% of total state, while Jequitinhonha/Mucuri has only R$1.695.927.000,00, and Noroeste de Minas R$1.631.627.000,00, which corresponds to 1,9% and 2,0% of total production.

Sourced data from Fundação João Pinheiro reveals a huge income inequality among the 66 Minas Gerais microregions in 2000. While the poorest microregion, Araçuaí, has a *per capita* GDP of R$1.486,98, the richest microregion, Ipatinga, has a *per capita* GDP of R$11.414,05, more than 7 times higher than Araçuai.

For Minas Gerais towns, the *per capita* income inequality is much worse, with Chapada do Norte having a *per capita* GDP of only R$ 758,01, while Umburatiba has R$ 68.576,50, which is 90 times higher than Chapada do Norte *per capita* GDP.

The huge income inequality between planning regions, counties and towns in Minas Gerais had then motivated this paper. The intention here is to see if there is any trend of increasing or diminishing this disparity and whether growth is contributing to decrease this inequality. Most previous research on Minas Gerais inequality had detected a slight and slow reduction on income inequality in Minas Gerais state, although uncapable of incorporating all counties and regions in this process.

3. Theoretical and Empirical Models

3.1. β-Convergence Tests (Barro e Sala-i-Martin, 1992)

In analyses with cross-section data, the β-convergence hypothesis is traditionally tested by a simple linear regression model where the *per capita* income growth rate is estimated compared to the initial *per capita* income of the region, by the Ordinary Least Squares method. The basic equation of this test is expressed by:

$$\frac{1}{T}\ln\left(\frac{y_{i,T}}{y_{i,0}}\right) = \beta_1 + \beta_2 \ln\left(y_{i,0}\right) + \mu_i \qquad (1)$$

where $y_{i,0}$ and $y_{i,T}$ represent the *per capita* incomes of the initial and final periods, respectively; T corresponds to the number of years between the initial and final periods of the sample observation; μi is the random error.

The left-hand side of equation (1) refers to the *per capita* income growth rate. A negative correlation between the growth rate and the initial *per capita* income ($\beta_2<0$) indicates that there is absolute β-convergence[1].

One of the problems with the absolute β-convergence test is that regression (1) assumes that all the geographic units under analysis have the same level of *per capita* income in steady state and that the differences observed in the levels of current *per capita* income are due only to short term deviations in the stock of *per capita* physical capital of the regions compared to their level in a steady state. However, the regions may present differences in terms of human capital and other geographic, structural and institutional characteristics that affect the income level in steady state. Consequently the estimates of equation (1) are biased due to the omission of relevant variables to explain the regional growth rates.

When equation (1) is modified to include other regional characteristics important in the economic growth dynamic, the absolute β-convergence gives way to the conditional β-convergence. This hypothesis means that each region has its own level of *per capita* income in steady state, determined by its peculiarities in terms of preferences and technologies, and that the *per capita* income of a region tends to grow more quickly the farther it is from its level of steady state. Equation (2) is the base for the conditional β-convergence test:

$$\frac{1}{T}\ln\left(\frac{y_{i,T}}{y_{i,0}}\right) = \beta_1 + \beta_2 \ln\left(y_{i,0}\right) + \delta X + \mu_i \qquad (2)$$

where X represents a vector of regional variables relative to the stock of human capital and other geographic, structural and institutional characteristics. These variables are generally included in its value at the start of the sampling periods.

Conditional β-convergence is indicated by a negative ratio between the *per capita* income growth rate and its initial value ($\beta_2<0$), after controlling the regional differences in terms of the variables included in X (with $\delta\neq0$). It is emphasized that the occurrence of conditional

β-convergence does not mean that the regional inequalities in terms of *per capita* income are being reduced or that they tend to disappear over time (Sala-i-Martin, 1996). On the contrary, it means that the economies tend to a situation of equilibrium in the long term where, because they present different steady states, the regional disparities will persist. The regions with a low stock of human capital, for example, should present a low level of *per capita* income in steady state compared to the regions with a high stock of human capital.

3.2. σ-Convergence Test

σ-convergence consists of observing the dispersion of the GDP per inhabitant in the towns of each group, in successive years. The sufficient condition for σ -convergence is that a fall is detected in this dispersion. σ -convergence can be tested by the coefficient of variation analysis (C.V.), given by the ratio between the standard deviation and the arithmetic mean of the GDP per inhabitant of the towns. Zero values for C.V. mean perfect equality in the income distribution among the microregions or towns.

3.3. Drennan and Lobo Test (1999)

The test for (absolute)β-convergence proposed by Drennan and Lobo (1999) consists of testing the hypothesis of independence between two events, A and B , that are defined in function of the initial *per capita* income and its growth rate[2].

Event A depends on the ratio between the *per capita* income of the microregion (or town) and the *per capita* income of the state in period t. The result A_1 is observed when this ratio is less than one and the result A_2 when the ratio is greater than one. That is,

$$A_1 : \frac{Y_{i,t}}{Y_{MG,t}} < 1 \tag{3}$$

$$A_2 : \frac{Y_{i,t}}{Y_{MG,t}} > 1 \tag{4}$$

where Yi represents the *per capita* income of the microregion (or town) i; Y_{MG} is the *per capita* income of the state.

Event B depends on the ratio between the *per capita* income growth rates of the microregion (or town) and the state *per capita* income growth rate between periods t and T

(T>t). This event presents result B_1 when the ratio is less than one, or result B_2 when the ratio is greater than one. That is,

$$B_1 : \frac{G_i}{G_{MG}} < 1 \tag{5}$$

$$B_2 : \frac{G_i}{G_{MG}} > 1, \tag{6}$$

where G_i is the *per capita* income growth rate of the microregion (or town) i; G_{MG} is the state *per capita* income growth rate.

The absolute convergence hypothesis establishes that the economies with *per capita* incomes lower than the mean state income would grow at greater rates than the set of the whole state, while economies with *per capita* incomes greater than the state mean would grow at lower rates than the state. The conditional probability test is applied to four possible results:

B_1A_1: regional income growth less than the state income growth, and initial regional income less than the state income.

B_1A_2: regional income growth lower than the state income growth, and initial regional income greater than the state income.

B_2A_1: regional income growth greater than the state income growth, and initial regional income less than the state income.

B_2A_2: regional income growth greater than the state income growth, and initial regional income greater than the state income.

If the independence hypothesis between events A and B is rejected, there will be evidence in favor of β-convergence hypothesis.

3.4. Quah Test(1993)

Quah (1993) proposed to analyze the process of *per capita* income convergence using probability models based on Markov chains. The geographic units are classified in K strata of *per capita* income and the performance of *per capita* income of the regions is described by an infinite sequence of vectors of state probabilities p(0), p(1),...p(t)..., and a matrix of transition probabilities among states (M). A vector of state probabilities (p(t)) represents

the distribution of the regions among the income strata, that is, a component of vector p(t) represents the probability $p_i(t)$ of a region belonging to the income strata i in period t, where $\Sigma_i p_i=1$. The elements of the transition probability matrix (M) indicate the probability $m_i(t)$ of a region belonging to income strata i in the period t changing to income strata j in the period t + 1, where $\Sigma_i m_{ij}=1$ (that is, the sum of the elements of a line from M is equal to 1).

A Markov chain describes a stochastic process for discrete and finite cases (in the present context, the income strata), with the property that the probability of changing from one state (income strata i) to another state (income strata j) in the next period is independent from how the chain reached the current state. That is, the percentage distribution of regions among the income strata at a determined point of time only depends on the same distribution in the immediately previous period.

Assuming that the transition probabilities do not change over time and ordering them as a matrix transition of K order:

$$p(t+1) = p(t)M = p(0)M^t \tag{7}$$

where: p(t) is a vector line 1 x k whose elements are the probabilities $p_i(t)$ and M^t is the product of t identical M matrixes.

An important aspect in income convergence analysis is the long-term performance of the regional *per capita* income distribution. Assuming that, after many periods, the vector of state probabilities p(t+1) is equal to the vector p(t) and also independent from the initial state vector p(t). This vector would be, thus, a long-term equilibrium vector, that can be called vector of probabilities in steady state, p. That is, the steady state vector (if it exists) is the vector p so that:

$$p = pM \tag{8}$$

The vector p (1 x k) characterizes the probable long-term distribution of the inter-regional *per capita* income and does not depend on the initial distribution of the regions among the income strata but depends only on the transition probabilities matrix. Once the M matrix has been found, the distribution limit of the regional *per capita* income is the vector p that

solves the expression (8), with the additional restriction that the sum of vector p components is equal to 1[3].

A crucial step to implement the Quah test is to obtain the transition probabilities matrix, M. However, it is pointed out that the choice of the income strata number is arbitrary and that results may be sensitive to the M matrix used. Quah (1993) considered five relative income stratas (k = 5). Ferreira (1999) performed two exercises using data from Brazilian states, using k = 5 and k= 6 , corresponding to relative income strata.

4. Main Results

This section will present and discuss results of the empirical convergence tests carried out for the microregions and towns in Minas Gerais state from 1980/2000. Prior to this, however, the performance of the *per capita* GDP in Minas Gerais planning regions will be examined.

4.1. β-Convergence Test for Minas Gerais Planning Regions

The state of Minas Gerais has 10 planning regions: the Central Region, Triângulo Mineiro, Zona da Mata, Rio Doce, Sul de Minas, Centro-Oeste Region, Noroeste de Minas, Alto Paranaíba, Norte de Minas and Jequitinhonha/Mucuri. Figure 1 shows the *per capita* GDP logarithm of the Minas Gerais Planning regions between 1985 and 2000. In spite of the distance that still separates them, there is an apparent trend of approximation of these regions incomes.

Figure 1 shows that the Jequitinhonha/Mucuri and Norte regions had a considerably lower *per capita* income than the rest of the state, throughout the period, and furthermore that they are far from reaching them, especially regarding Jequitinhonha/Mucuri. This last region is the poorest in the state and was distant throughout the period from the other regions, continuing relatively poorer, which indicates, as already demonstrated by Alves and Fontes (1998), that this region is moving to a lower *per capita* income level than the other regions. This emphasizes the need for governmental actions to vitalize it.

Noroeste de Minas region calls attention because of its growth, which is greater than the rest of the state. It was the third poorest region in 1985 and was distant from the others. However, in 1999, it had already overtaken the Zona da Mata and in 2000 was the fifth richest region in the state.

The Central and Triângulo de Minas regions remain in a relatively superior position and, although they have come closer, the first region also seems to be moving to a different *per capita* income level from the others.

It is also interesting to note the performance of Zona da Mata region, that tended to distance itself a little from the others, reinforcing the idea that this region is in a relative economic decline.

The general tendency of Minas Gerais planning regions to convergence is confirmed by Figure 2 that shows a negative and significant relationship between income in 1985 and income growth rate in 1985/2000 period. This figure is divided into two parts. The first part considers all the regions but in the second the Noroeste region is excluded, considered as an outlier. In both the results are similar and indicate convergence of the *per capita* income levels. However, in the second figure, the regression fitted better and the R^2 value increased considerably, although the convergence speed decreased.

Therefore it can be concluded that the planning regions tend to converge. However, this convergence occurs more slowly when Noroeste de Minas region is not considered.

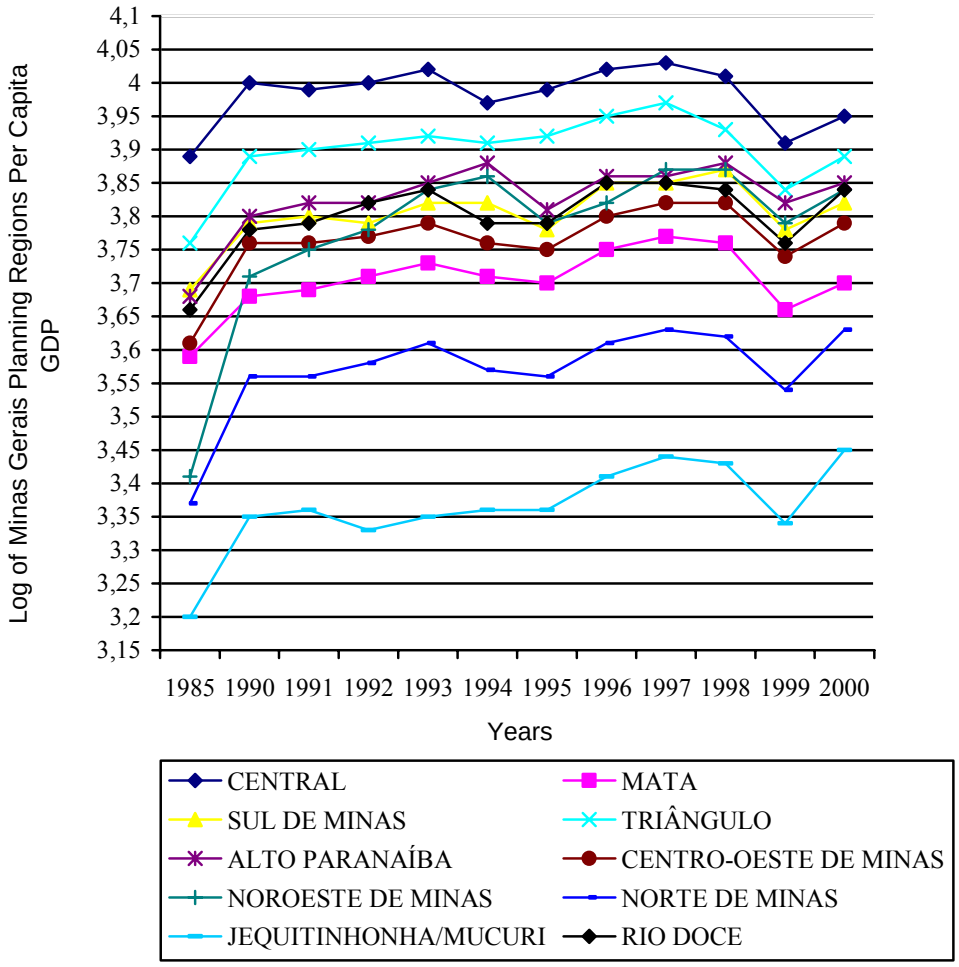
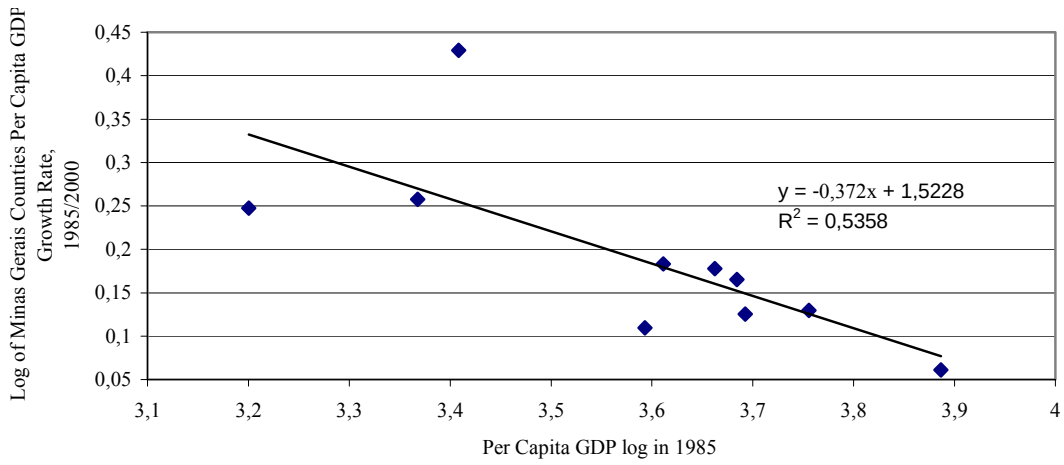


Figure 1: Log of Minas Gerais Planning Regions *Per Capita* GDP, 1985 to 2000.



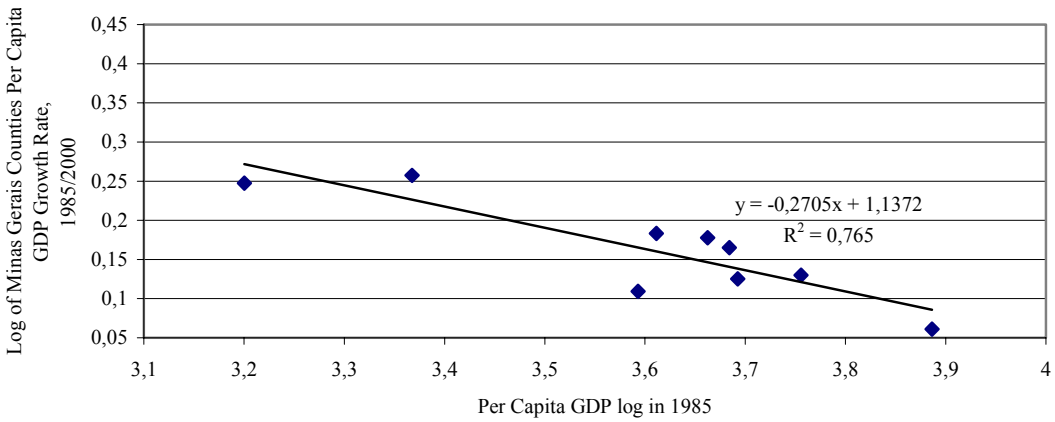


Figure 2: Absolute Income β-Convergence among Minas Gerais Planning Regions, 1985/2000.

4.2. β-Convergence Test for Minas Gerais Microregions

First, the linear regression test proposed by Barro & Sala-i-Martin (1992) was performed for the Minas Gerais microregions and results were controversial.

The first regression was estimated for 66 Minas Gerais microregions for the 1985-2000 period and considering the income growth rate (*per capita* GDP) as dependent variable and the initial income (GDP in 1985) as explicative variable. Figure 3 shows the results of this test.

The income considered presents negative and significant relationship, at the level of 1%, with income growth rate. This means that, in general, the poorer counties grew more than the richest between 1985 and 2000. That is, the absolute β-convergence hypothesis of

per capita income would be accepted as true, for the Minas Gerais microregions. The adjusted determination coefficient is 44%, the convergence speed is around 2% and the half-life is approximately 29 years. That is, Minas Gerais counties would take around 29 years to reduce by half the income disparities that exist among them.

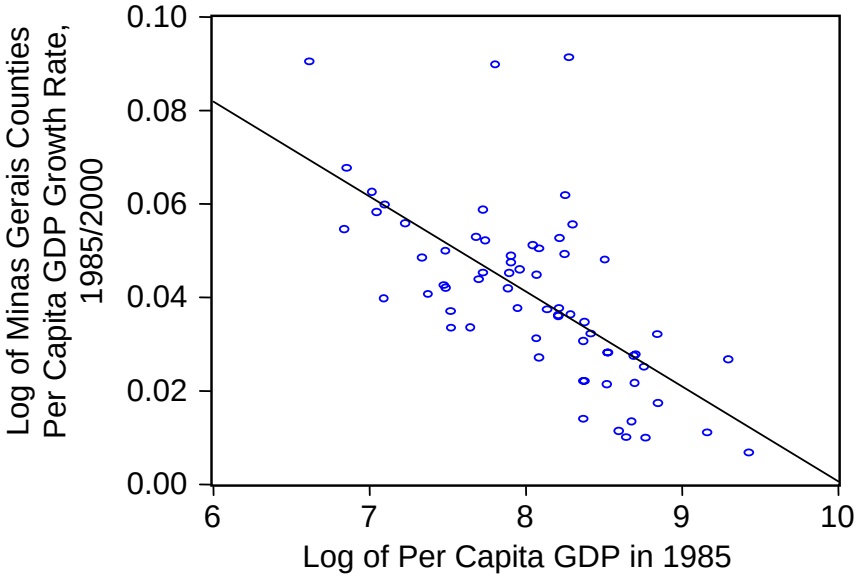


Figure 3: Absolute Income β-Convergence among Minas Gerais Counties,1985/2000.

However, this same regression was estimated for the period 1980-1996 (Table 1) with 63 microregions and excluding three that were very different from the others and then the income variable had presented a positive sign 10% significant. From this result one could infer that there was not an absolute income β-convergence for the 1980-1996 period and the microregions with more *per capita* GDP grew more than the ones with less.

Table 1. Absolute Income β-convergence Test for 63 Minas Gerais Microregions in 1980-1996 period.

Dependent Variable: *Per capita* GDP Growth Rate, 1980-1996	
Explained Variable	Coefficient
β_2	-0.020191 ^{ns}
	(-1.297507)
Log of *per capita* GDP in 1980	0.004695*
	(1.802813)
Convergence Velocity	No convergence
Adjusted R^2	0.035021
F test	3.250136*
Number of observations	63

t statistic in parenthesis; *ns*- not significant; * significant at 10%; ** significant at 5%; *** significant at 1%.

Considering now the human capital[3] as explained variable and testing for the conditional β-convergence, results suggest that human capital is an important variable for Minas Gerais microregions growth. Table 2 shows the results after estimating equation 2.

Table 2. Conditional β-convergence Test for 66 Minas Gerais Microregions, 1980-1996.

Dependent Variable: *Per capita* GDP Growth Rate, 1980-1996	
Explained Variable	Coefficient
β_2	-0.047**
	(-2.223)
Log of *per capita* GDP in 1980	-0.005269*
	(-1.706577)
Log of *per capita* Human Capital in 1980	0.031880***
	(2.812593)
Convergence Velocity	0,0050442
Half Life	125,92 Years
Adjusted R^2	0.086837
F test	4.090581
Number of observations	66

t statistic in parenthesis; *ns*- not significant; * significant at 10%; ** significant at 5%; *** significant at 1%.

With human capital in the equation, the income variable is negative and 10% significant and the *per capita* stock of human capital in 1980 is positive and highly significant(1%). The convergence velocity is low and the half life is 126, meaning that it would be necessary 126 years to reduce to half the distance of poor microregions that separates them from

the richer ones. Although human capital is important to reduce inequality, there seems to have other factors that need to be equalized for convergence to be faster.

Next table(Table 3) shows the results of the same conditional convergence test excluding the state capital region, Belo Horizonte, since it has quite different conditions from the other regions. The income variable is negative and 5% significant and the human capital variable has positive sign and 1% significant. The convergence velocity increases and the half life drops to 81 years. The disparity is then considerably less when the Central region is not considered.

Table 3. Conditional β-convergence Test for 65 Minas Gerais Microregions, 1980-1996.

Dependent Variable: *Per capita* GDP Growth Rate, 1980-1996	
Explained Variable	Coefficient
β_2	-0.042457*
	(-0.0214)
Log of *per capita* GDP in 1980	-0.008020**
	-2.313381
Log of *per capita* Human Capital	0.035829***
in 1980	3.134655
Convergence Velocity	0,008533
Half Life	80,75 Years
Adjusted R^2	0.136824
F test	4.913897**
Number of observations	65

t statistic in parenthesis; *ns*- not significant; * significant at 10%; ** significant at 5%; *** significant at 1%.

Both physical capital and human capital are important in determining Minas Gerais microregions growth rate. When only physical capital is considered, there is not a clear evidence of convergence among these counties.

However, when human capital is taken into account, the results change. For Minas Gerais state to have an income convergence path, it is necessary first to achieve a human capital equalization, since microregions with more human capital tend to have higher growth rates.

4.3. β-Convergence Test for Minas Gerais Towns

The results obtained for towns had showed that the conditional β-convergence hypothesis was a better fit to their growth process in the period from 1985 to 2000.

Figure 4 shows graphically the results found in the absolute β-convergence test carried out for 756[4] towns. According to this test, the absolute β-convergence hypothesis was accepted. The variables considered had presented positive and significant coefficient at the level of 1% significance. That is, it can be said that for Minas Gerais towns, generally, the poorest grew more than the richest in the studied period. The determination coefficient was 34%, the convergence speed was close to 4.8% and the half life was approximately 14.5 years.

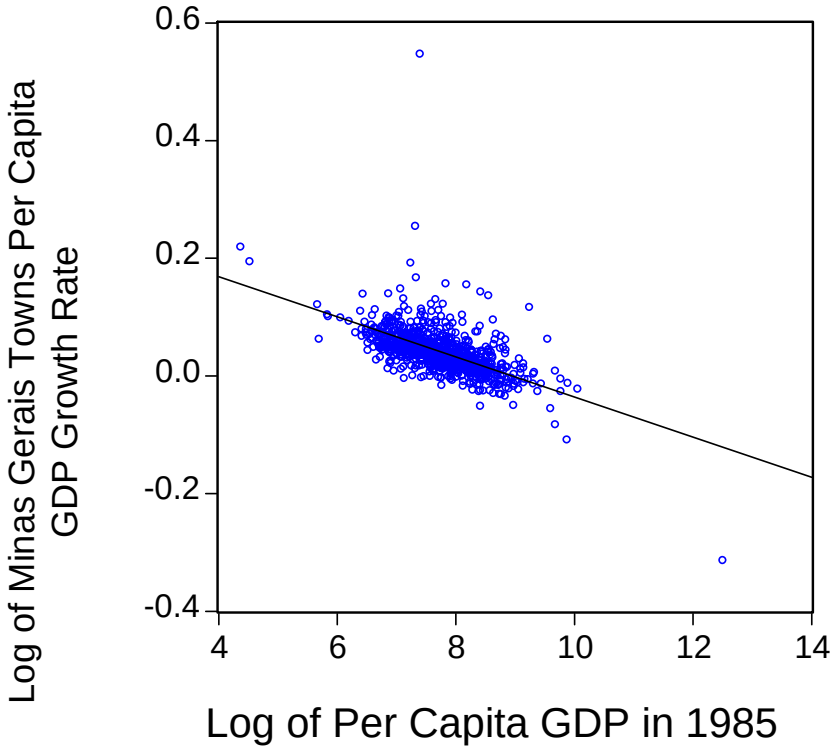


Figure 4: Absolute Income β-Convergence among Minas Gerais Towns, 1985/2000

The conditional β-convergence test had as explained variables the illiteracy rate, the mean number of years of study and life expectancy at birth, used as proxy of the municipal human capital in 1985.

Life expectancy at birth, that represents the level of health of the labor force, was not significant.

The illiteracy rate presented negative and significant coefficient(1%), compared to the dependent variable of *per capita* GDP growth rate. That is, towns that had a lower illiteracy rates grew more. When this variable was included, the adjusted determination coefficient increased to approximately 36.5%, the convergence speed increased to 6.34% and half life decreased to approximately 10.93 years.

The regression that included the variable mean number of years of study performed similarly to the previous ones. The coefficient calculated for this variable was positive and significant, at the level of 1%, so that towns with a greater study mean grew more than those with less schooling. In this regression, the determination coefficient increased to about 36%, the conversion speed to 6.3% and the half-life decreased to 10.87 years.

The relationship of *per capita* GDP and GDP *per capita* growth rate in 1985 was negative and significant, at the level of 1%, in all the regressions estimated for Minas Gerais towns.

These results suggest that, although the poorer towns generally have grown more than the richer ones, the conditional β-convergence hypothesis is more suitable to explain their growth process, since the growth rate is affected by its stock of human capital. That is, if differences in the towns stock of human capital were overcome, they would then equalize more quickly, as can be seen by the reduction in the estimated half-life.

As the accepted hypothesis was conditional convergence, it cannot be expected that the towns are moving to the same long-term steady state. Probably Minas Gerais towns will have different *per capita* income levels in their steady state, which will be investigated in our further discussions.

4.4. σ-Convergence Test for Microregions and Towns

Table 4 shows results of the σ-convergence test. This table presents the coefficient of variation of the *per capita* income of Minas Gerais microregions and towns. These results

had indicated that there was an income σ-convergence process in the state. That is, the level of inequality among the municipal and microregions had decreased.

The microregions income inequalities had increased in 1990, 1992 and 1993 compared to 1985. However, from 1992 onwards there was a constant and gradual reduction in these inequalities, and in 2000 the lowest coefficient of variation was reached, and, consequently, the best level of equalization among the economies.

The municipalities had showed reduction in the level of inequality during the 1990s, compared to 1985. Analyzing the annual performance of this decade, there has been some oscillations around this reduction trend and the lowest value was observed in 1998 and a slight increase in the two following years.

Table 4 – Income σ-Convergence among Minas Gerais Microregions and Towns, 1985 to 2000.

Anos	Microregions	Towns
1985	0,608	3,02
1990	0,609	1,45
1991	0,572	1,39
1992	0,635	1,41
1993	0,623	1,43
1994	0,551	1,41
1995	0,532	1,38
1996	0,524	1,43
1997	0,514	0,84
1998	0,481	0,79
1999	0,479	0,86
2000	0,469	0,96
Observations	66	756

The results obtained from this test suggest that, although income distribution in the state was still very unequal, it tended to decrease in the last decades. The existence of σ-convergence also confirmed the existence of β-convergence since the second is a condition

for the first. Thus it can be stated that the poorer towns and microregions, from 1985 to 2000, generally tended to grow more than the richer ones, so that inequalities in *per capita* income among them had decreased.

The tests presented up to now have shown the general tendencies of the state and also that Minas Gerais economies had tended to approach one another, so that the degree of inequality among them had decreased. However, these tests did not reveal whether all the economies considered were following the same trend or whether some were excluded from the process. They also did not inform whether the reduction in inequalities would be a continuous process or whether there will still be a certain level of regional disparity. The two following tests, besides giving a general vision of the state economy, permitted a prediction of the long-term steady states for microregions and towns.

4.5. Drennan and Lobo Test for Microregions and Towns

In this test, the microregions and municipalities were divided into four groups, where each group represents a growth dynamic to be studied.

The division of the microregions among groups is shown in Table 5, where the events that happened most frequently were A_1 and B_1; this means that, in 1985, there were more microregions with *per capita* GDP below the mean than above it; and in the period considered, most grew less than the mean. Because of this, A_1B_1 was the most common group, which is a cause for concern since it represents the initially poor regions that have become relatively poorer, diverging downwards and distancing themselves from the mean state income.

Most of the microregions in group B_2 had originated in group A_1. The microregions that form the A_1B_2 group(upward convergence) are those that were initially poor and had converged to the state mean. The microregions belonging to group A_2B_1 also converged to the mean so that, contrary to group A_1B_2, this convergence was downwards, that is, the microregions were relatively richer but grew less than the state mean. The microregions that diverged upwards belong to group A_2B_2, that is, they became relatively richer than the other microregions in the state.

Table 5 – Number of Occurrences of Events from Minas Gerais Microregions

	B1 (*Per capita* GDP growth rate less than state average, 1985 to 2000)	**B2** (*Per capita* GDP growth rate more than state average, 1985 to 2000)	**Total**
A1 (*Per capita* GDP less than state average in 1985)	29	9	38
A2 (*Per capita* GDP more than state average in 1985)	25	3	28
Total	54	12	66

From the performance presented by each one of the microregions, the probabilities of occurrence of each group can be calculated and the hypothesis test on the independence between the income growth rate in the period and the initial income of the microregions can be formulated. Table 6 shows this test and presents the results.

Table 6 – Independence Test between Minas Gerais Microregions *Per Capita* GDP Growth Rate in 1985-2000 and *Per Capita* GDP in 1985.

H0	p	π	σ	Z
P(B1/A1)=P(B)	0,7632	0,8182	0,0155	-3,5562
P(B1/A2)=P(B)	0,8929	0,8182	0,0113	6,6340
P(B2/A1)=P(B)	0,2368	0,1818	0,0155	3,5562
P(B2/A2)=P(B)	0,1071	0,1818	0,0113	-6,6340

According to the value obtained for Z test, the independence hypothesis between the *per capita* GDP growth rate of the microregions from 1985 to 2000 and the initial *per capita* GDP was rejected, at the level of 1%, for all four groups tested in favor of the absolute β-convergence hypothesis. This means that the *per capita* GDP growth rates of the microregions depended on the initial *per capita* GDP, in all four groups. That is, within each group studied, the poorer microregions generally grew more than the richer ones.

Although the hypothesis of independence between the growth rate and initial income was rejected in favor of the absolute β-convergence hypothesis, in each group, this result

demands further investigation, based on Table 5 that showed that two microregions groups did not follow the state convergence process. The reasons for this fact have still to be understood and whether there is evidence of a long-lasting trend of this (divergent) movement.

Tables 7 and 8 present the same previous test for 756[4] municipalities, from 1985 to 2000. The results were similar to those obtained for Minas Gerais microregions.

Table 7. Number of Occurrences of Events from Minas Gerais Towns

	B1 (*Per capita* GDP growth rate less than state average, 1985 to 2000)	**B2** (*Per capita* GDP growth rate more than state average, 1985 to 2000)	Total
A1 (*Per capita* GDP less than state average in 1985)	293	197	490
A2 (*Per capita* GDP more than state average in 1985)	245	21	266
Total	538	218	756

Table 8 - Independence Test between Minas Gerais Towns *Per Capita* GDP Growth Rate in 1985-2000 and *Per Capita* GDP in 1985.

H0	P	π	Σ	Z
P(B1/A1)=P(B1)	0.5980	0.7116	0.0178	-6.3708
P(B1/A2)=P(B1)	0.9211	0.7116	0.0098	21.3385
P(B2/A1)=P(B2)	0.4020	0.2884	0.0178	6.3708
P(B2/A2)=P(B2)	0.0789	0.2884	0.0098	-21.3385

Table 7 shows the number of occurrences of events for Minas Gerais towns. Similarly to the microregions, most grew below the mean (B_1) and a considerable part remained stagnant in the period (A_1B_1), indicating that they have become distant from the richest, since they were relatively poor and grew below the state mean. It is interesting to observe that approximately half of the initially poor municipalities were able to improve their conditions, while the other half obtained a low growth dynamic and worsened relatively. It can also be stated that the number of municipalities that converged (group A_1B_2 + group

A_2B_1) led the results of the tests carried out up to now to be positive, in favor of the convergence hypothesis, although divergence was frequent among the towns.

Table 8 presents the test result. According to the Z test, the independence hypothesis between the *per capita* GDP growth rate of the municipalities from 1985 to 2000 and the initial *per capita* GDP was rejected at the level of 1%, for all four groups, in favor of the absolute β-convergence hypothesis. This means that, within each group, the *per capita* GDP growth rates depended on the initial *per capita* GDP. Therefore by this test it can be stated that, generally, there was absolute β-convergence among the towns and microregions in the state. However, analysis of the configuration of these economies among the groups alerts to the problem that this convergence does not reach all the microregions and all the municipalities. The analyses in Tables 5 and 7 show a series of microregions and towns caught in some kind of poverty trap (group A_1B_1), that kept them in a low growth dynamic throughout these 15 years.

Thus it is believed that, although there is dependence between the income growth rate and the initial income, other variables are also important in determining the growth of the state, so that the conditional β-convergence may explain better the dynamic of growth in Minas Gerais. Since the richer economies tended to train their human capital better and also to attract human capital from the poorer regions, due to their better structure and salaries, they managed to reach a superior steady state to that of the poorer economies. These, in turn, because they have a low initial income, have low savings and low human capital, and cannot reach the level of wealth of the relatively more developed regions in spite of the decreasing returns on capital, are expected to have lower steady states of *per capita* income. Therefore the study of a possible long-term configuration of Minas Gerais economy is extremely important, since the persistence of these regional problems will require actions of equalization policies to reduce the degree of disparity already detected.

4.6.Quah Test(1993)

This test permits the analysis of whether the differences in the long-term would tend to be maintained, given the performance presented in the studied period, or whether the economies would be moving to a situation where the differences are naturally overcome. However, as the study period was only 15 years, the results of the configuration of the long-term steady state should be assessed with caution.

Per capita GDP data of the Minas Gerais microregions and towns were used for this test for the years 1985- 2000, defined in five *per capita* income strata: very poor (below 40% of the mean), poor (between 40% to 80% of the mean), medium (between 80% and 120% of the mean), rich (between 120% and 160% of the mean) and very rich (above 106% of the mean).

Table 9 shows the configuration of these data. It can be ascertained that most of the microregions are in the three intermediate groups (poor, medium and rich) and that there was a concentration tendency in these three groups, from 1985 to 2000, while the two other groups (very poor and very rich) decreased, suggesting a decrease in the degree of income disparity among the microregions. Table 9 also shows Minas Gerais microregions probability vector in steady state, if the same tendency of the studied period had continued. The results obtained do not point to the existence of absolute convergence among the microregions since there was no evidence that the disparities historically presented in the state decreased. Thus, in the long term, the difference between the income groups seem to remain and there may be conditional but not absolute convergence. In a situation of absolute income convergence, the microregions should move to the same steady state, which is not happening in Minas Gerais. Supposedly, its microregions are forming convergence clubs, among which the inequalities would be maintained.

Table 9 – Minas Gerais Microregion Probability Vector in Steady State

Per capita Income Classification	*Per capita* Income Limits	Proportion of Microregion by *Per capita* Income Classification		
		1985	2000	Long Run
Very Poor(1)	Below 40% of Average	0,1212	0,0303	0,00
Poor (2)	[40% and 80%) of Average	0,3030	0,3333	0,17
Medium (3)	[80% and 120%) of Average	0,3030	0,3636	0,52
Rich (4)	[120% and 160%) of Average	0,1515	0,1970	0,26
Very Rich (5)	More than 160% of Average	0,1212	0,0758	0,05
	Sum	1.00	1.00	1.00

Table 10 shows the β-convergence test for 756 municipalities and the configuration of inter-municipality income distribution in Minas Gerais in the years 1985, 2000, in the long-run and also its changes. Although these changes have not been of sufficient magnitude to

end inequality among towns, they have not remained stationary in the same strata for 15 years. According to the Table, the number of very poor towns fell from 17.46% of the total number of towns existing in 1985 to 8.07% in 2000 and will decrease to 4% in the long run, *ceteris paribus*; the number of poor municipalities increased from 34.26% to 43.25% in the period and suggests in the long run it will be around 46%; the medium towns increased from 21.69% to turn 26.72% and will be around 29% of the total in the long run; the rich municipalities decreased from 12.43% to 11.38% and would tend to 11%; and finally, the very rich towns decreased from 14.15% to 10.58% and tend to 10% in the long run.

Thus with the persistence of the tendency presented in the period, it can be concluded from the analysis of the long run configuration that Minas Gerais municipalities will not converge to the same income strata. Although the inequalities are reduced and the number of very rich and very poor towns tends to decrease, there will be no concentration of these municipalities in the medium income strata, as would be compatible with a situation of absolute convergence. On the contrary, the results indicate that there are convergence clubs forming among the municipalities in Minas Gerais so that they are moving to different long-term steady states.

It can be stated that the towns situation would be even worse than that of the microregions, because the degree of disparity maintained between them is much greater. Half of Minas Gerais municipalities tend to remain poor or very poor, which could be attributed to the fact that many do not have a financial and economic base and are almost totally dependent on receiving state government funds[6]. The low economic dynamic presented by these municipalities shows the impossibility of their release from the poverty trap in which they seem to be inserted and the need for adequate public policies to overcome these obstacles and permit greater income equalization in the state.

Thus it seems Minas Gerais is moving to a long-term configuration where income differences will be maintained among microregions and municipalities. Actions are therefore needed that can interfere in this tendency of maintaining disparity among the economies so that they enter into a process of integration and equalization. These actions or economic policies should act principally on the regions that tend to remain relatively poorer than the state mean, and that are trapped in a circle of long run low dynamism that needs to be broken.

Table 10 – Probability Vector in Steady State for Minas Gerais Towns

Per capita Income Classification	*Per capita* Income Limits	Proportion of Towns by *Per capita* Income Classification		
		1985	2000	Long Run
Very Poor (1)	Below 40% of Average	0,1746	0,0807	0,04
Poor (2)	[40% and 80%) of Average	0,3426	0,4325	0,46
Medium (3)	[80% and 120%) of Average	0,2169	0,2672	0,29
Rich (4)	[120% and 160%) of Average	0,1243	0,1138	0,11
Very Rich (5)	More than 160% of Average	0,1415	0,1058	0,10
	Sum	1.00	1.00	1.00

4.7. Visual Analysis based on Drennan and Lobo (1999) and Quah (1993) Tests

Figures 5 and 6 show maps according to the Drennan and Lobo test (1999) and Quah test (1993) to better visualize the dynamic of each microregion and municipality.

Figure 5 shows the divisions of the microregions and municipalities according to the methodology by Drennan and Lobo (1999). The first group A_1B_1 corresponds to the economies that diverged downwards, had *per capita* GDP lower than the state mean and grew less than this mean. In the intermediate groups are those that converged to the state mean and in the fourth group are those that present an income dynamic superior to that of the rest of the state, because they had become relatively richer diverging upwards.

Figure 6 presents a division of the state economies according to the Quah test (1993). The microregions and towns are divided into very poor, poor, medium, rich and very rich, according to the *per capita* income that they possessed from 1985 to 2000.

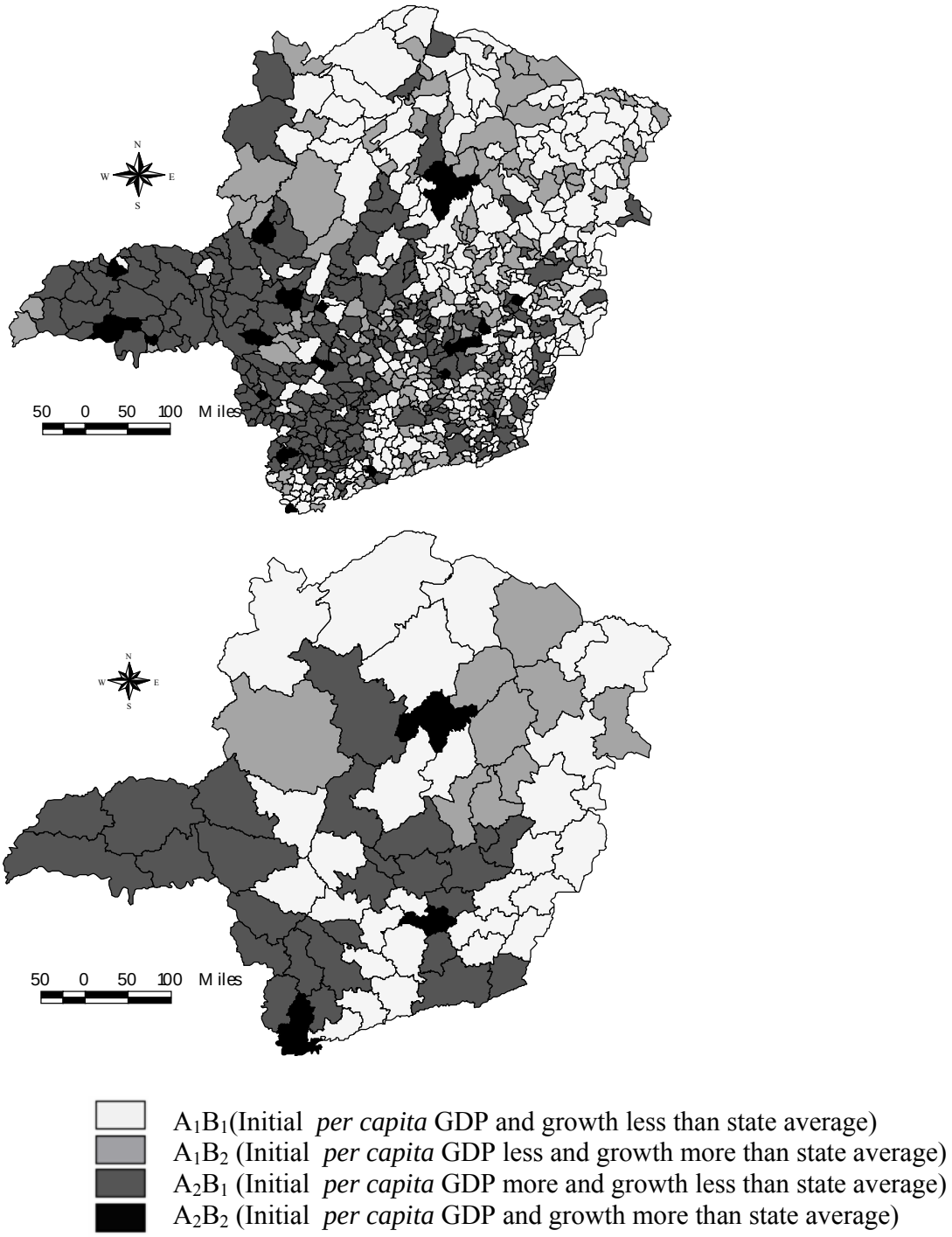


Figure 5: Maps of Minas Gerais Microregions and Towns according to Drennan and Lobo Test, 1985-2000.

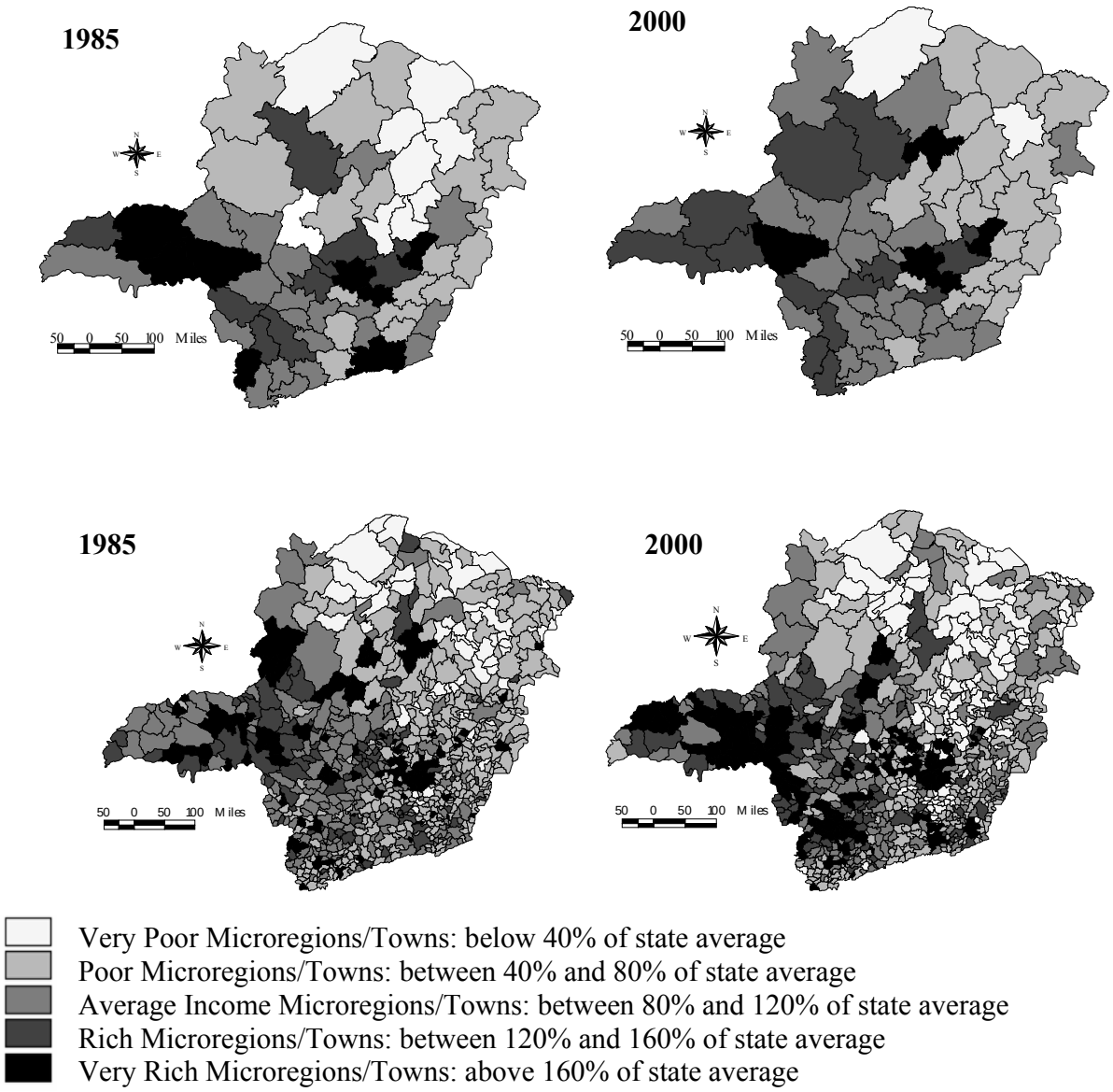


Figure 6 – Maps of Minas Gerais Microregions and Towns according to Quah Test, 1985 and 2000.

5. Conclusions

Regional income inequality is a characteristic present in Minas Gerais state that needs to be broken. According to the present chapter, although the regional inequality of *per capita* income is still very accentuated, there has been a reduction in this differential in the last 30 years, shown by the σ-convergence test. This reduction, although it tends to continue, has not taken the states to total equalization, and public policies should be applied to remove some regions from the apparent poverty trap in which they are caught.

According to the β-convergence tests performed, there is dependency between *per capita* GDP growth rate and its initial value, so that generally the poorer economies grow more than the richer ones. Thus economic growth has acted positively in the sense of reducing the disparities of *per capita* income among the regions and towns. This conclusion can be inferred from the regressions and the β-convergence test that accept as significant the hypothesis of negative relationship between the growth rate and initial income for regions and towns.

However, from the estimated regressions, it was detected that the variables representative of human capital would also be important in determining the growth rate of the Minas Gerais microregions and towns. When the human capital variables were included in the model, the convergence speed and the determination coefficient increased, while the half-life was reduced. Thus, according to the Barro and Sala-i-Martin test, the hypothesis of conditional β-convergence is more suited to explain the growth dynamic of state income in the microregions and towns in the period from 1985 to 2000.

The Drennan and Lobo test showed that two groups of microregions and municipalities remained at the edge of the convergence process (groups A_1B_1 and A_2B_2). The economies in group A_2B_2 showed superior performance to the state mean, while the economies in group A_1B_1 presented an inferior performance and probably moved to a lower steady state income level than the others.

The Quah test, carried out for the period from 1985 to 2000, confirmed that Minas Gerais economies are moving to different steady states, indicating that the conditional β-convergence hypothesis fitted better the dynamic of income growth among the Minas Gerais microregions and towns. Thus, although the income inequalities have decreased, a certain level of inequality will be maintained. This will occur because the initial level of

per capita income of their economies is not the only factor that influences the growth rate in the Minas Gerais microregions; as already mentioned, other factors also determine this rate, including the level of human capital.

A significant number of microregions and towns tend to remain in a low income situation in the long-term. This tendency shows their inability to escape from the poverty trap in which they seem to be inserted, and the need for adequate public policies to overcome this obstacle and permit greater income equalization in the state. These policies should act mainly on the economies that remained poor or very poor and presented a low economic growth dynamic. Thus so that the disparities in regional income can be overcome, the structural parameters of the Minas Gerais economies should be equalized previously, especially regarding the level of human capital.

6. Footnotes

1. The convergence speed (β) is obtained from the expression $\beta_2 = 1 - \frac{e^{-\beta T}}{T}$. Therefore the β calculated in this way should be interpreted as an approximation, because the relationship between β_2 and β is not linear.
2. The conditional probability of occurrence of the event B is: $p = P(B|A) = \frac{P(B \cap A)}{P(A)}$. A Z test is performed on the following hypothesis H_0: P(B | A)=P(B); H_A: P(B | A)≠P(B) and the statistic is calculated by the expression: $Z = \frac{p - \pi}{\sigma} = \frac{P(B|A) - P(B)}{\sigma}, \sigma = \sqrt{\frac{p(1-p)}{n}}$, where n is the number of observations.

3. The human capital statistics is obtained at Instituto de Pesquisa Econômica e Aplicada (IPEA) and represents the expected present value of annual income (discounted with the 10% rate per year) associated with population scholarship and experience (age) for sample in activity age (from 15 to 65 years). The stock of human capital is the result of the difference between income from labor market and the prediction of income achieved by a worker without scholarship and experience.

4. For the data to be homogeneous, the towns were re-grouped according to their division in 1985.

5. The vector p corresponds to the eigenvector associated to the eigenvalue 1 of the matrix M. Because it is a probability vector, it should be normalized so that the sum of its components is equal to 1.

6. See Oliveira, Fortes and Andrade (2000) for details.

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