Working Paper No. 66, 2014

Historical Perspectives on Regional Income Inequality in Brazil, 1872-2000

Eustáquio J. Reis

Working Paper Series

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Published by **desiguALdades.net** International Research Network on Interdependent Inequalities in Latin America

Editing and Production: Barbara Göbel / Marianne Braig / Laura Kemmer / Paul Talcott

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Reis, Eustáquio J. 2014: "Historical Perspectives on Regional Income Inequality in Brazil, 1872-2000", **desiguALdades.net** *Working Paper Series 66*, Berlin: **desiguALdades.net** International Research Network on Interdependent Inequalities in Latin America.

The paper was produced by Eustáquio J. Reis during his fellowship at **desiguALdades.net** from 04/2013 to 05/2013.

Historical Perspectives on Regional Income Inequality in Brazil, 1872-2000

Eustáquio J. Reis[1]

Abstract

The paper provides historical perspectives on regional economic inequalities in Brazil making use of a database on Brazilian municipalities from 1872 to 2000. A suit of maps and graphs describe the geographic forces shaping the historical development of the Brazilian economy highlighting the role of transport costs, and its consequences for the spatial dynamics of income per capita and labor productivity. The next section estimates econometric models of growth convergence for municipal income per capita and labor. For the 20th century analyses are refined in two ways: first, by disaggregating the models for urban and rural activities; second, by enlarging the model to take account of the determinants of spatial growth convergence. Empirical results endorse the preeminence of geographic factors in contrast to institutional conditions. The final section summarizes the results and proposes research extensions. The Appendix describes the database.

Keywords: 20th century Brazil | regional inequality | growth convergence | productivity | income per capita

Biographical Notes

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1 Paper presented at the Colloquium of desiguALdades.net, Freie Universität Berlin, May 13, 2013. The author gratefully acknowledges hospitality and financial support from desiguALdades.net; as well as the support from IPEA, CNPq and FAPERJ/PRONEX to the Project Nemesis – Proc. E52 168.171/2006 (www.nemesis.org.br). He is also grateful for the computer assistance of Márcia Pimentel, Ana Isabel Alvarenga, and Maria do Carmo Horta.

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1. Introduction

Brazil is one of the most unequal societies in contemporary world. From 1970 to 2000 (period for which Census micro data are available), the Gini coefficients of income per capita distribution remained practically constant around 0.6, one of the highest levels recorded at the national level. In the last decade, inclusive growth policies made possible to bring Gini figures to something close to 0.5. For the future, the challenges are how to deepen redistribution with less dependence on income transfer policies.

In broad historical perspectives, both institutional and geographic factors played fundamental roles in the generation and reproduction of Brazilian inequality in space and time. Slavery has had and still has overwhelming implications for social equity. Concentration of income and wealth and the low levels of education prevailing today are, to a large extent, her legacies. Needless to say, this is not an excuse for the ostensible lack of social concerns of government policies during most of the 20th century.

Geographic factors were also decisive for spatial equity. The continental size and the geographic heterogeneity of the country compounded with very high transport costs to create wide regional disparities in the levels of productivity and income per capita (Azzoni 2003; Azzoni 1999; Azzoni and Ferreira 1997; Barros, Mendonça and Camargo 1995). The secular roots of regional disparities have been widely discussed in Brazilian historiography (Albuquerque and Cavalcanti 1976; Bértola et al. 2006; Buescu 1979; Cano 1997; Cano 1998; Castro 1969; Denslow Jr. 1977; Furtado 1968; Furtado 1970; Leff 1972; Leff 1973; Leff 1991). The discussion, however, ostensibly lacks an adequate empirical basis. Statistical evidence when available is restricted to sparse data at the state or macro-regional level. The sharp economic differences inside Brazilian states, not to mention regions, have been completely neglected.

The paper provides historical perspectives on regional economic inequalities in Brazil. For this purposes it analyzes the spatial patterns of Brazilian economic growth making use of a database on Brazilian municipalities from 1872 to 2000 organized by the Research Network on Spatial Models (www.nemesis.org.br) at the Institute of Applied Economic Research (www.ipea.gov.br) in Rio de Janeiro. The first section presents a succinct discussion of the geographic forces shaping the historical development of the Brazilian economy highlighting the evolution of transport costs. The second section uses a series of maps and graphs to describe the spatial progression of income per capita and labor productivity during the 20th century. In a more rigorous fashion, the third section estimates econometric models of growth convergence for municipal income per capita and labor productivity in the period 1872 to 2000. The econometric analysis for the period 1920 to 2000 is refined in two ways. Firstly, by disaggregating the model for urban and rural activities, and secondly, by enlarging it to take account of the factors conditioning the patterns of spatial growth convergence in the 20th century. The final section summarizes the results and proposes research extensions. The Appendix describes the database.

2. Geography and History

The main historical driver of the geographic patterns of economic development in Brazil was the prohibitive transport costs to hinterland imposed by the strong declivity of the coastal mountain range running parallel to the Atlantic shoreline (Ellis Jr. 1951; Goulart Filho and Queiroz 2011; Silva 1949; Summerhill 2003). The slope of the Serra do Mar – reaching 1000 meters 100 km away from the sea, combined with intense summer rainfall and the dense rainforest, slowed the development of a transportation infrastructure and therefore the economic settlement of the Brazilian hinterland (see Figure 1A).

The settlement of the mining areas of the Center-South region during the 18th century was made viable by the high specific value – negligible transport costs – of precious minerals (Cano 1977). But with historical hindsight, it is fair say that after the exhaustion of mines, high transport costs made economic development unsustainable.

Finally, in the Amazon region where navigable rivers sanctioned low transport costs, the wild vegetation, unhealthy climate, and the poor quality of soil precluded agrarian settlement up to the last quarter of the 20th century. Rubber extraction, however, sustained a thriving economy from 1850 to 1912 when competition from Asian plantations drove down both export volumes and prices (Andersen et al. 2002; Santos 1980).

The railroad investments in the end of the 19th century were crucial for the viability of agrarian settlements in the hinterland. Transport costs reduced approximately 80% pushing the coffee frontier towards the southwestern regions of São Paulo (Matos 1974; Milliet 1982; Summerhill 1997).Furthermore, the city of São Paulo, emerged as the most important hub (the node with minimum transport cost) of the railway network, thus pulling industries to exploit economies of scale and emerging as the sustainable industrial growth pole of the country in the beginning of the 20th century (see Figure 1B).

For other regions, however, the reduction in transport costs provided by railways had diverse consequences leading to the specialization in agriculture and to the loss of competitiveness in manufacturing and handcraft production which were previously protected by the high transport costs (Cano 1977; Martins 1983; Martins and Martins 1982; Reis and Monasterio 2010; Restitutti 2006; Stein 1957).

Starting in the 1890's, the concentration of industry in São Paulo was enhanced by the synergies and externalities provided by the agglomeration of technological knowledge and human capital of foreign immigrants (Cano 1998; Reis and Monasterio 2010; Versiani 1993). Conversely, subsidized foreign immigration aggravated the segmentation of the Brazilian labor market reducing their effectiveness in reducing regional disparities in productivity and income. Thus, until the 1930's, internal migration to São Paulo was relatively meager despite huge regional differences in productivity and income per capita (Graham 1972; Graham and Hollanda 1971).[2]

In the second half of the 20th century, government investment in transport infrastructure concentrated on roads which gradually replaced the railroads. The road option reinforced the hegemonic position of São Paulo and preserved regional disparities. Indeed, the interconnection of the road network strengthened the competitiveness of industry in São Paulo by reducing logistics costs of the distribution of manufactured goods in the domestic market compared to the costs of long distance transport required for the export of primary products. Additionally, the costs of internal migration were reduced, stimulating migration flows to large cities and ensuring a nearly unlimited supply of labor that dampened pressures for urban wage increases, particularly in Sao Paulo and Rio de Janeiro (Barat 1978; Castro 2004; Galvão 1999; Graham 1972; Graham and Hollanda 1971; Oliveira 1977).

During the sixties, the federal capital moved to Brasília and the federal government began to implement regional development policies, combining investments in infrastructure, fiscal and credit incentives. The priority given to roads in detriment of railways was an inefficient solution for the transportation requirements of the agricultural exports from the Cerrado flatland of the Center-West and North regions of the country. As consequence, the growth of agricultural productivity and output in these areas were retarded. Moreover, the low price of land fostered a highly dispersed pattern of settlement with reduced profitability of small farms leading to limited distributive impacts and excessive environmental costs in terms of tropical deforestation (Faminow 1998; Gasques and Yokomizo 1985; Reis and Margullis 1990; Reis, Igliori and Weinhold 1998; Silveira 1957).

2 The state of Rio Grande do Sul in the temperate zones of the extreme south of the country is a double exception. The flatlands of the Pampas were highly productive and had low transport costs. European immigration flows were significant since the mid-19th century.

Figures 1C to 1F illustrate the expansion of the road infrastructure and its effects on the transportation costs in Brazil during the last quarter of the 20th century. They show that the costs of moving one unit of cargo to São Paulo (as a proxy for the domestic market) were reduced by more than 40% from 1968 to 1995. Despite that, high transportation costs still remain as one of the most critical obstacles to Brazilian competitiveness and development.

For the Center-West and North regions, in addition to the reduction in transport costs, the profitability of economic activities was enhanced by the possibilities of mechanization in the flatlands. Last but not least, an important factor was agricultural research of the Empresa Brasileira de Pesquisa Agropecuária (Embrapa) which adapted new cultivars – in particular soybeans, rice, and cotton – to the ecological conditions prevailing in the *Cerrado* areas (Arantes and Souza 1993; Helfand and Rezende 1998; Homma 2003).

Figures 1A to 1F: Brazilian Terrain and Evolution of Transportation Infrastructure, 1910-1995

Figure 1A: Relief Map of Brazil

Figure 1B: Railroads in 1910

Figure 1C: Roads in 1970

Figure 1D: Transport Cost (R$/ton) to São Paulo 1970

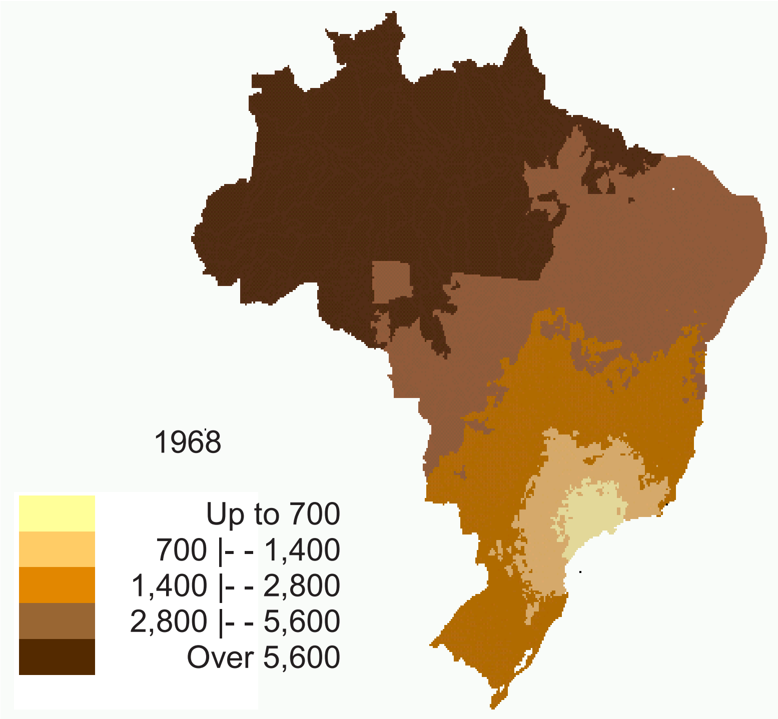
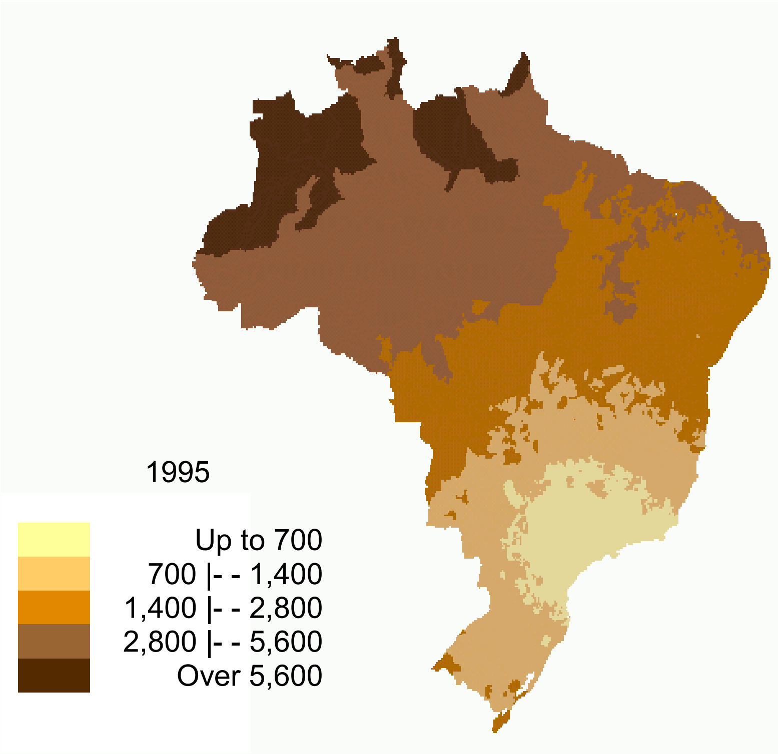


Figure 1E: Roads and Railroads in 1997

Figure 1F: Transport Cost (R$/ton) to São Paulo 1995



Sources for Figures 1A to 1F: Silva (1949, public domain); own elaboration based on Instituto Brasileiro de Geografia e Estatística (IBGE) and Instituto de Pesquisa Econômica Aplicada (IPEA) for Brazilian relief map; Ipeadata (2014) for transport costs.

3. Spatial Patterns of Growth, 1872-2000

This section uses a series of maps to illustrate the spatial patterns of Brazilian development during the 20th century. The number of Brazilian *municípios* (local government units) in Brazilian censuses increased from 642 in 1872 to 1,304 in 1920, 3,951 in 1970 and 5,507 in 2000. The changes in number and geographic boundaries of *municípios* preclude consistent inter-temporal analysis unless *municípios* are combined into Minimal Comparable Geographic Areas (MCA). Though *municípios* are the units of observation, MCA are the *de facto* geographic unit of analysis and unless otherwise specified, the term municipality refers to MCA 1872-2000 which are shown in Figure A1 of the Appendix. Note the North and Center-West regions, where settlement and creation of municipalities took place in recent times, the MCA are too few and too large, thus introducing both visual and statistical distortions.

The temporal benchmarks for the analysis are 1872-1919, 1919-1949, 1949-1980 and 1980-2000. Though primarily determined by the availability of census data, they provide a fairly broad characterization of the main phases of Brazilian development in the 20th century.

Up to 1920, growth was mainly driven by the export of primary commodities, particularly coffee and rubber. From 1920 to 1950, the country completed the first stage of an import substitution industrialization process based mainly upon a light consumer goods industry. From 1950 to 1980, based upon a strong urbanization process and high trade protection, import substitution industrialization deepened into durable consumer, basic raw material and capital goods industries. By the end of this period, Brazil was perhaps the most autarkic economy in the world with an import coefficient close to 5% of GDP, out of which non-oil imports represented less than 3%.

After 1980, several negative conditions occurred at the same time: the debt crisis, hyperinflation, and stagnation. In the ensuing decades, the unavoidable policies were stabilization, fiscal adjustment and liberalization which are still ongoing developments. Demographically, the country faced the end of the urbanization process and the beginning of rapid population ageing. During this period, agricultural and mineral exports were crucial for growth.

Given the above picture of major and fundamental economic changes, it would be reasonable to assume that patterns of spatial convergence of income per capital and labor productivity were significantly different in these various development phases of the 20th century (Reis et al. 2004).

Figures 2A to 2C map the geographic density of GDP in 1872, 1970 and 1996, respectively. They show that at least up to 1970, economic activity in Brazil was highly concentrated along the Atlantic coast. In 1872, the only significant incursion of economic activity into the Brazilian highlands occurred in the mining areas of the Center-South region which had already been settled during the 18th century. The maps show that during most of the 20th century the economic frontier moves in the southwest direction pushed by coffee plantations and industry. It was during this period that the city of São Paulo and its surroundings emerged as the dominant industrial pole of the country. After 1970, the density of economic activity turned towards the northwest, due to both the change in the location of the federal capital to Brasilia and the expansion of the agricultural frontier with the cultivation of cattle, rice, corn and soybeans.

Figures 3A to 3E show the spatial distribution of income per capita from 1872 to 2000. Since 1872, one observes wide regional disparities of income per capita levels in Brazil. The Northeast, in particular the semi-arid areas of the hinterland, was already the poorest region of the country. The richest areas were located around Rio de Janeiro, which was then the capital and the largest port of the country, and the cities of Rio Grande do Sul in the extreme south of the country which were then the main ports for the fertile areas of the Pampas. The high income per capita levels in the Amazon region are explained by the rubber boom.

In 1919, São Paulo, together with Rio Grande do Sul, had the highest income per capita levels; both areas combined a very productive agricultural sector with emerging manufacturing activities. By then, the rubber economy in the Amazon had collapsed.

The concentration of income per capita in São Paulo was intensified by the mid-century when the urbanization and import substitution industrialization processes reached their peaks. Supplementing the industrial boom of São Paulo, increased cultivation of coffee and soybeans explains the spread of high income per capita towards the southwest areas of São Paulo and Paraná.

After 1980, with the end of the urbanization and import substitution processes, the high levels of income per capita started to spread towards the agricultural frontier in the Center-West and North regions. But São Paulo and Rio Grande do Sul keep their leading position while the Northeast region lags far behind the rest of the country.

Figure 4A to 4E map the distribution of the labor productivity from 1872. The sequence of maps tells much the same story that Figures 4a to 4E do. The main difference is, perhaps, the more homogeneous geographic distribution of productivity levels compared to income per capita levels after 1980 which suggests that part of the differences in income per capita are possibly explained by demographic factors related to the dependency ratio. By 2000, both in terms of income per capita and labor productivity there was a clear dividing line in the country from the northwest to the southeast.[3]

Figure 5A presents Lorenz curves for the geographic distribution of GDP in census years 1872, 1919, 1940, 1980, and 2000. The curves display extreme levels of spatial concentration in economic activity which remains practically unchanged from 1872 to 2000, notwithstanding the process of territorial dispersion in the density of economic activity observed in Figures 2A to 2C. The explanation for this puzzle lies, to a large extent, in the patterns of industrialization and organization processes which were highly concentrated in relatively small areas. Due to its natural geographic concentration, mining activities (iron ore, in particular) played a subsidiary role. Agricultural activities were the

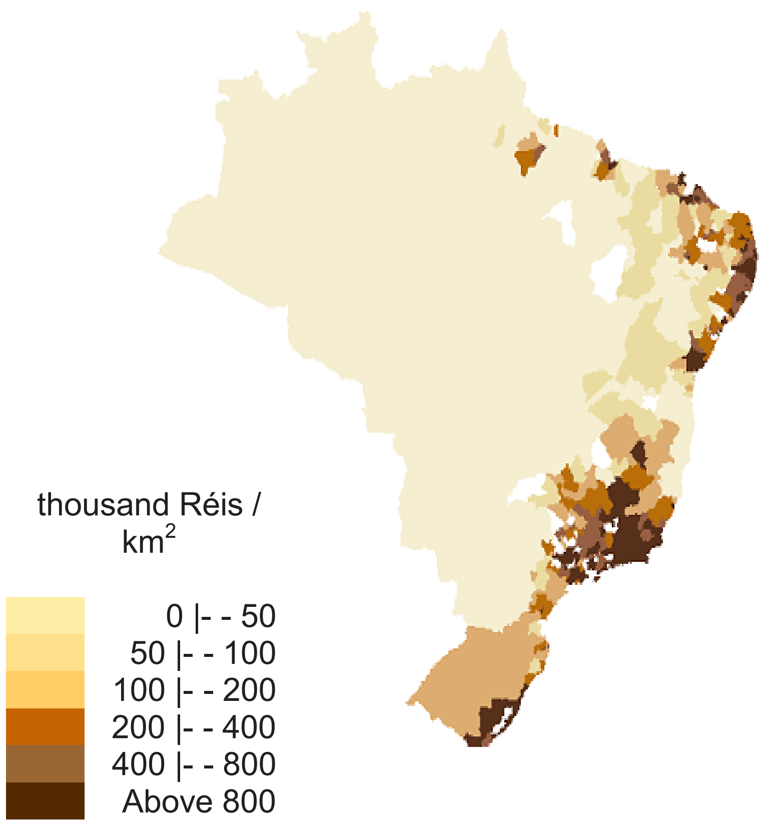
3 Curiously enough, this line coincides with the tropical convergence zone generated by the El-Niño/ Southern Oscillation (ENSO) climate event.

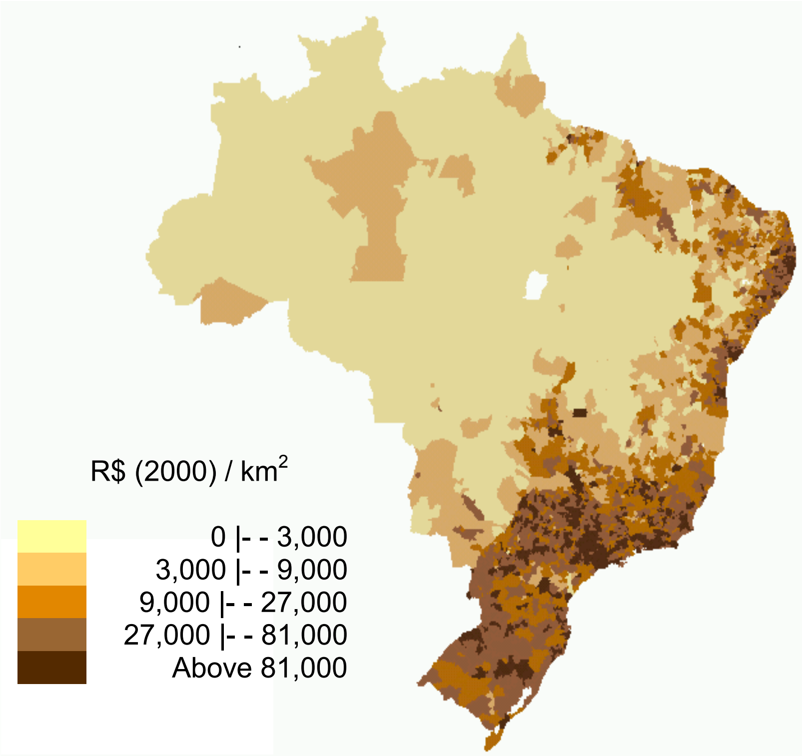
counteracting forces. Thus, a careful look at the graphs shows that concentration is slightly smaller in 1919 and 2000, in both cases after long periods of agricultural export led growth. The difference, however, is clearly not that significant.

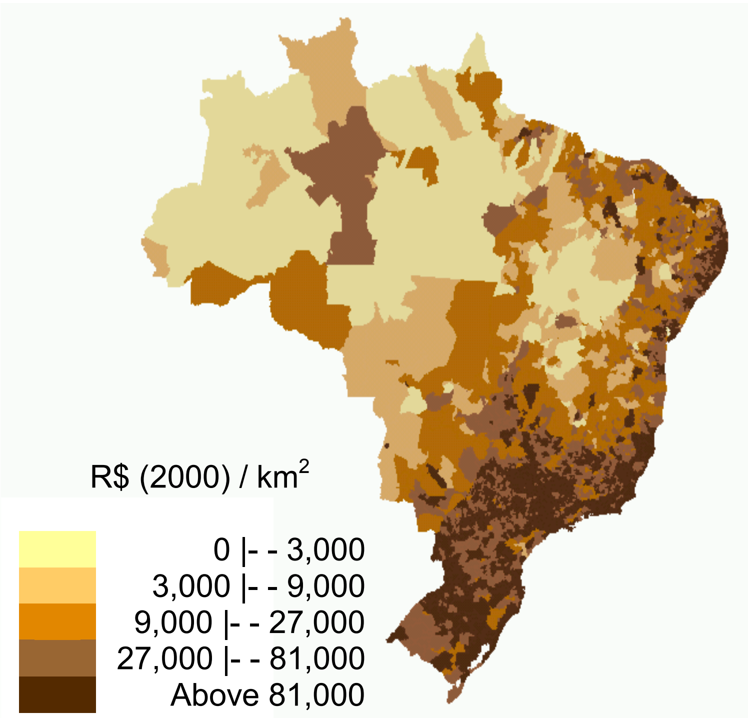
Finally, Figure 5B presents Lorenz curves for the municipal income per capita distribution for the same census years as before. In per capita terms, the highest levels of spatial concentration occurred in 1872. The Lorenz curve for this period practically dominates the curves for all the other years. Conversely, the lowest levels of spatial concentration occurred in 2000 which is practically dominated by the curves for all the other years.

The secular process of spatial dispersion of income per capita from 1872 to 2000 was far from monotonic, however. The Lorenz curves display a strong dispersion of the spatial distribution of income per capita in the periods 1872-1919, when the economy was driven by coffee and rubber exports, and in 1970-2000, when the expansion of the agricultural frontier in the Cerrado areas of the Center-West region combined with the emergence of government regional policies. In contrast, there is a strong concentration process from 1919 to 1970, during the heyday of the urbanization and import substitution industrialization processes. It should be kept mind, however, that growth rates of the economy were significantly higher during this later period.

Figure 2A to 2C: Geographic Density of GDP (R$/km^2) in 1872, 1970 and 1996







Source for Figures 2A to 2C: IPEA, Author's estimates. Maps for 1970 and 1996 use MCA 1970-2000 and map 1872 uses MCA 1872-2000.

Figures 3A-E and 4A-E: Geographic Distribution (MAC 1872-2000) of Income per Capita (GDP/Population) and of Labor Productivity (GDP/Labor force) in 1872, 1919, 1949, 1980 and 2000 (Units and Scale Variable)

Figure 3A: Income per Capita, by Municipalities, 1872 (GDP/Population)

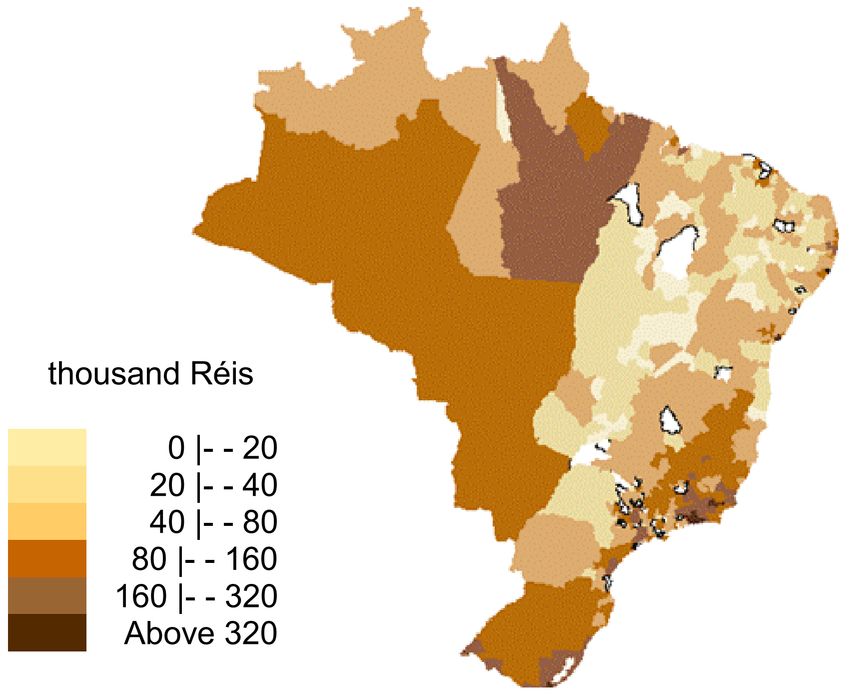


Figure 4A: Labor Productivity, by Municipalities, 1872 (GDP/Labor Force)

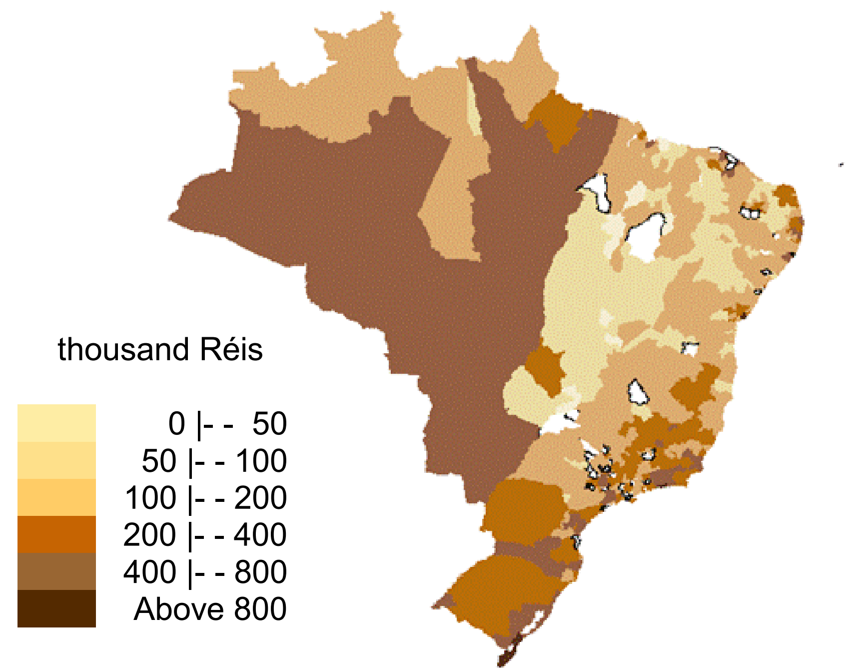


Figure 3B: Income per Capita, by Municipalities, 1919 (GDP/Population)

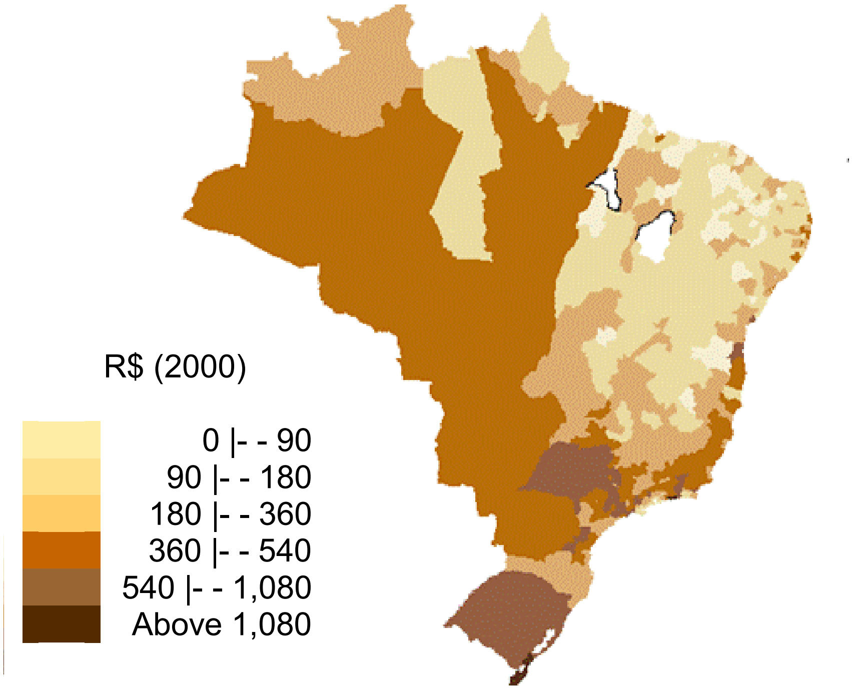


Figure 4B: Labor Productivity, by Municipalities, 1919 (GDP/Labor Force)

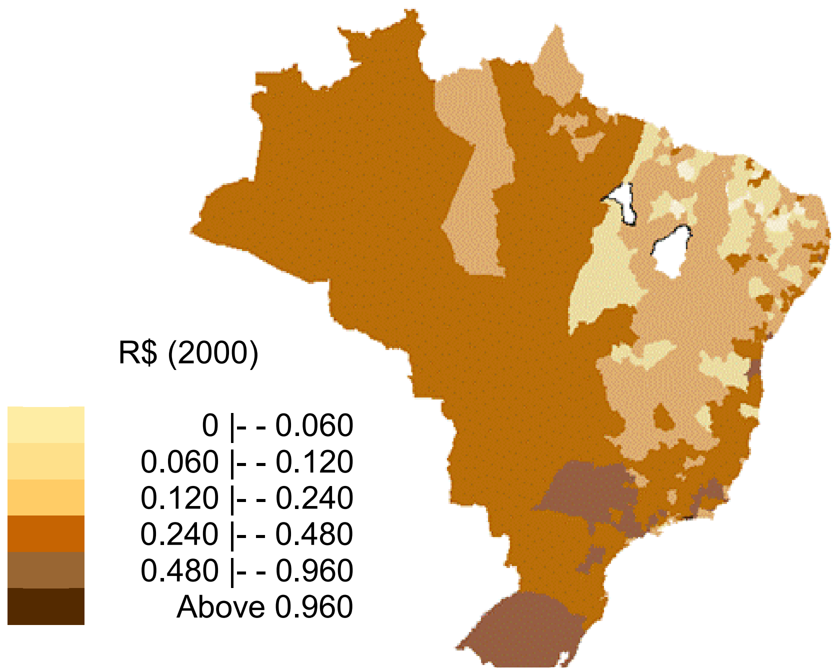


Figure 3C: Income per Capita, by Municipalities, 1949 (GDP/Population)

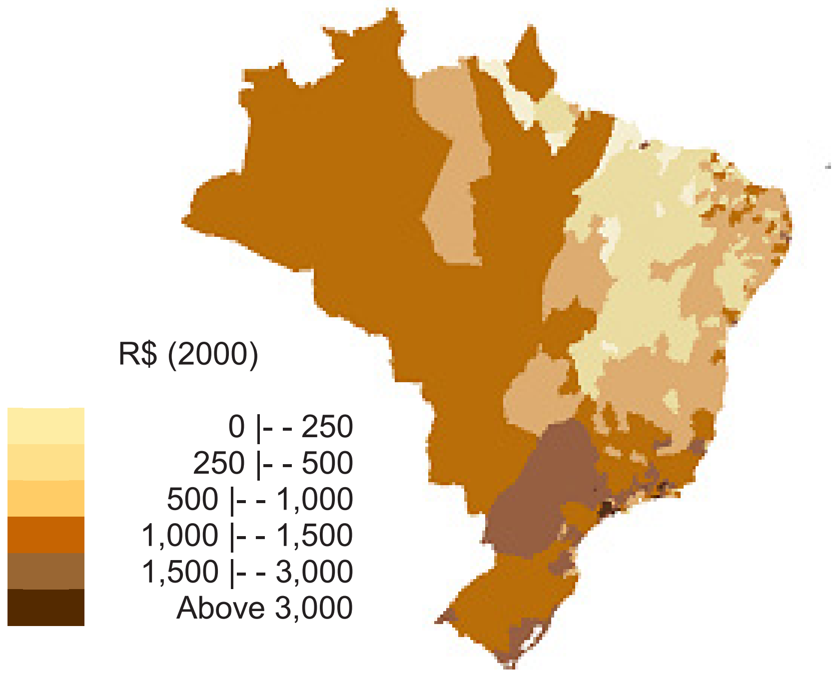


Figure 4C: Labor Productivity, by Municipalities, 1949 (GDP/Labor Force)

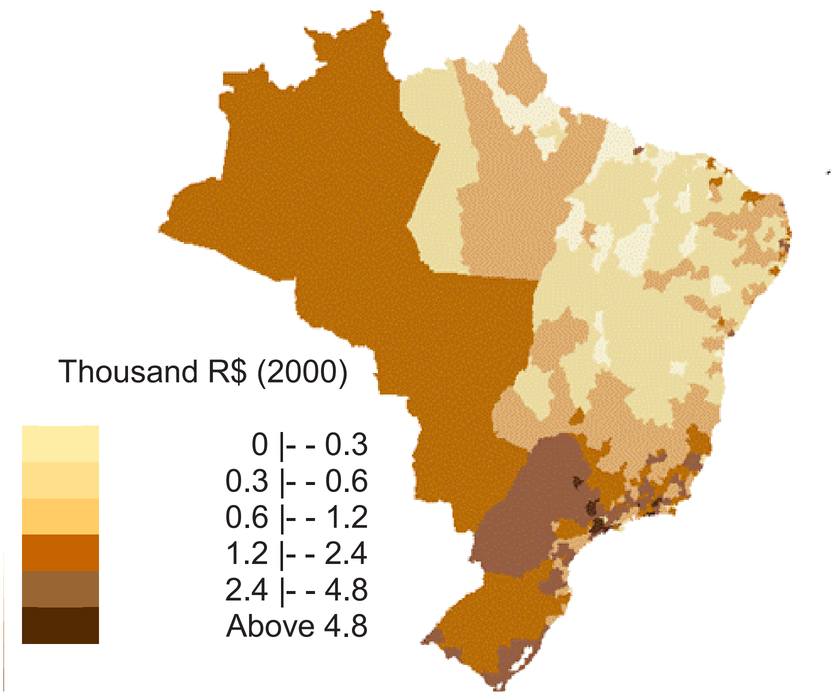


Figure 3D: Income per Capita, by Municipalities, 1980 (GDP/Population)

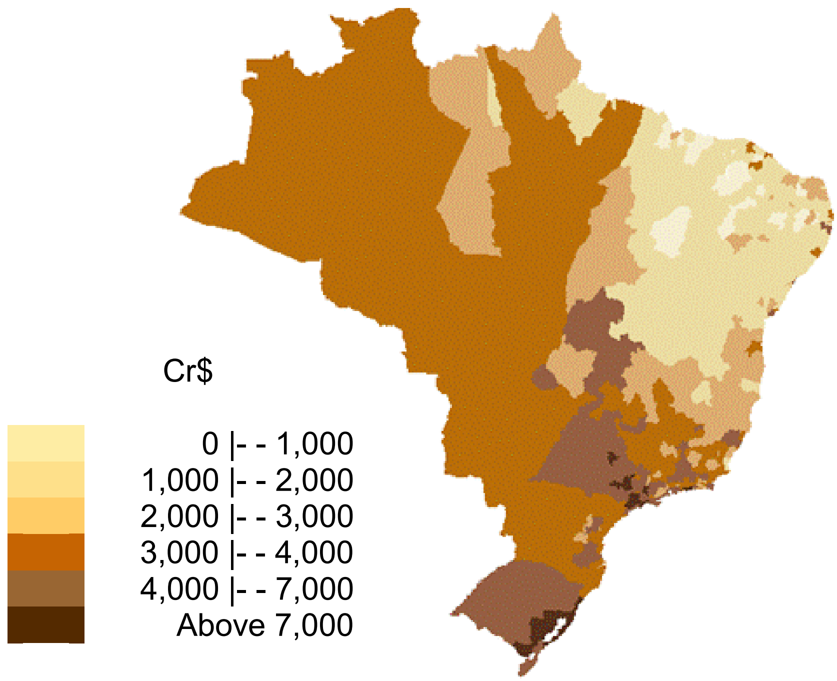


Figure 4D: Labor Productivity, by Municipalities, 1980 (GDP/Labor Force)

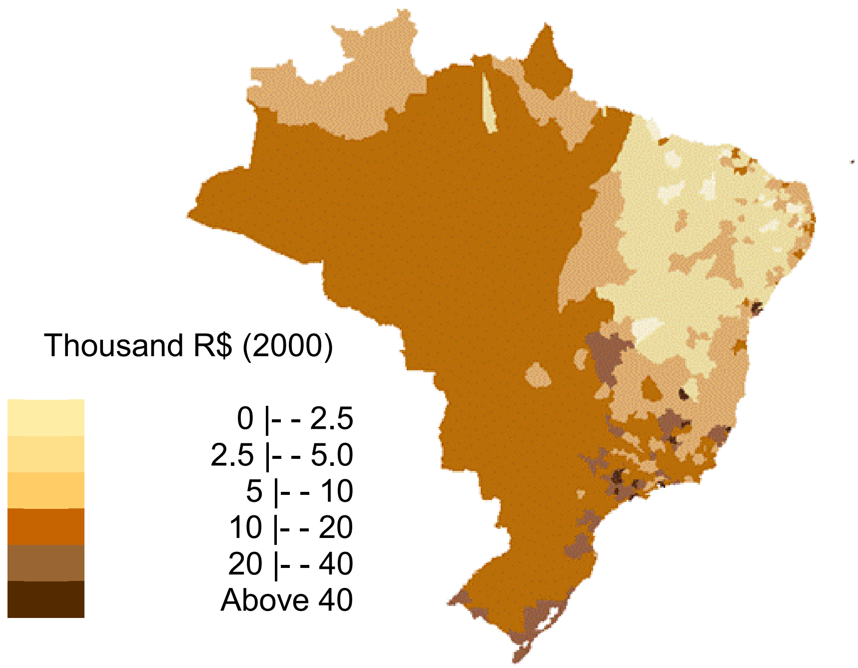


Figure 3E: Income per Capita, by Municipalities, 2000 (GDP/Population)

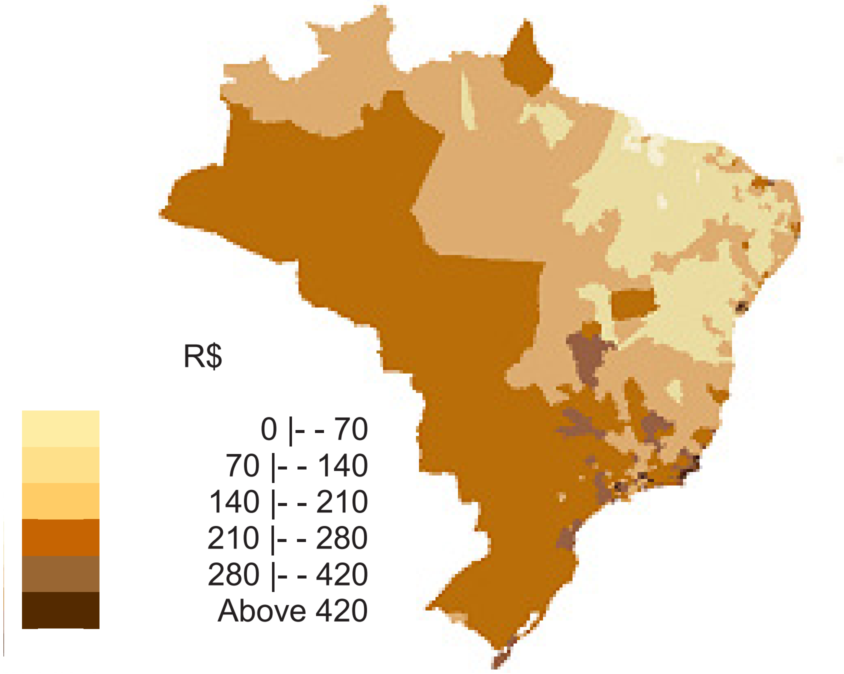
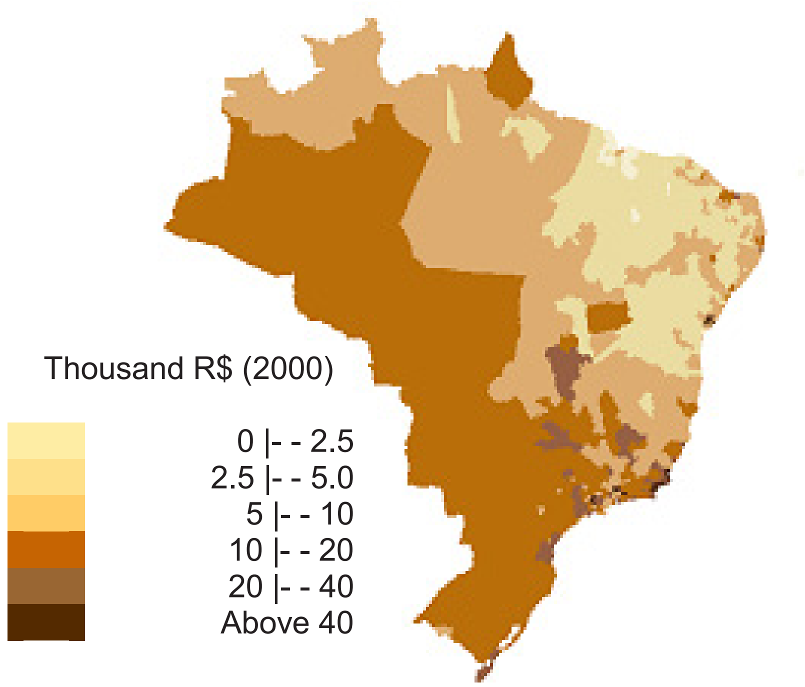


Figure 4E: Labor Productivity, by Municipalities, 1980 (GDP/Labor Force)



Source for Figures 3A-E and 4A-E: IBGE and author estimates.

Figure 5A: Lorenz Curves for the Distributions of Municipal GDP according to Geographic Areas of Municipalities, 1872-2000

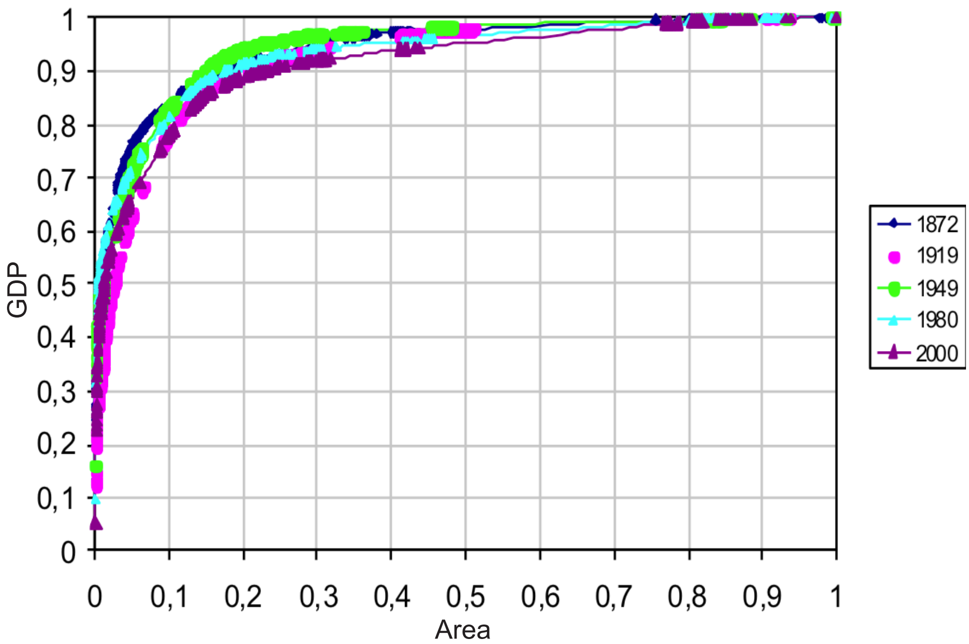
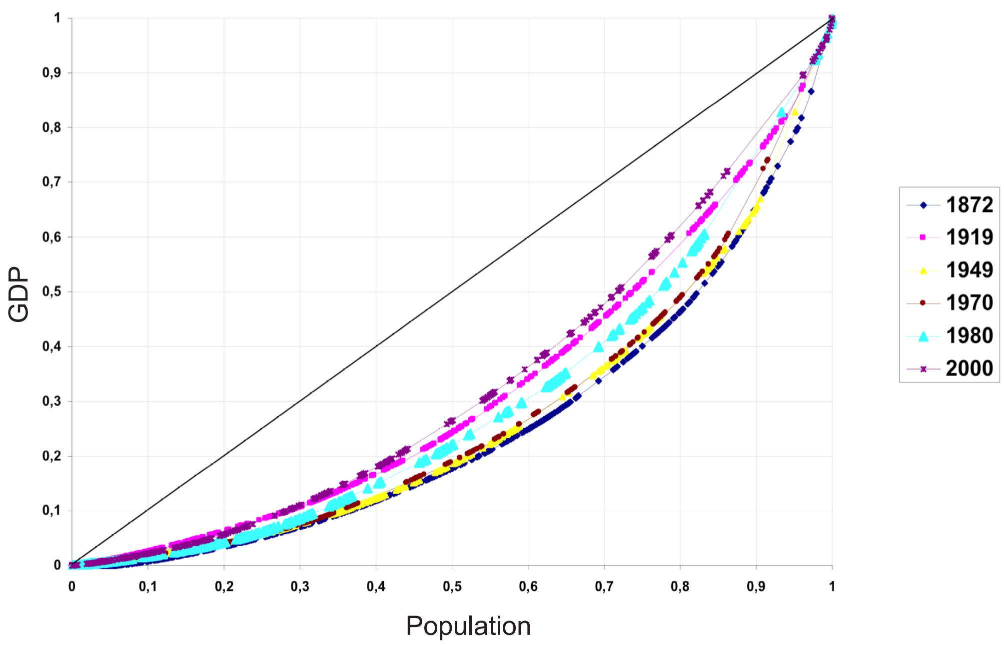


Figure 5B: Lorenz Curves for the Municipal Distributions of GDP according to Municipal Population, 1872-2000



Source for Figures 5A and 5B: Dataset complied by author from IBGE and own estimates.

4. Secular Convergence of Labor Productivity and Income per Capita in Brazil, 1872-2000

This section estimates econometric models of spatial convergence of income per capita and labor productivity in Brazil from 1872 to 2000. Specifications were restricted to simple models of spatial convergence.

In the simple growth equations specified, for each dependent variable – income per capita or labor productivity – the growth rate is a simple function of the level of the variable in the initial period. The basic specification of the convergence model is thus:

(1) $\log (y_{i,t} / y_{i,t-n})^{1/n} = \alpha + \beta \cdot \log (y_{i,\,t-n})$

where

$y_{i,t} = (Y_{i,t} \,/\, Pop_{i,t})$ is GDP per capita (or GDP per labor force) in municipality i, census year t

$Y_{i,t}$ is GDP per capita in municipality i, census year t

$Pop_{i,t}$ is population (or labor force) in municipality i, census year t

β is a estimated coefficient that measures the speed of convergence of income per capita (or labor productivity) of municipalities; when the value is negative, poorer municipalities grow faster and thus the municipal distribution of income per capita converges; conversely, when the value is positive, richer municipalities grow faster and thus the municipal distribution of income per capita diverges.

Estimation was made for the sample of minimum comparable areas of Brazilian municipalities in the period 1872 to 2000 (MAC 1872-2000) and separately for the main Brazilian regions, as well for the sub-periods 1872-1919, 1919-1949, 1949-1980 and 1980-2000 for Brazil as whole. The results of OLS (Ordinary Least Square) estimations are presented in Tables 1 to 4 below.

Table 1 shows a quite good adjustment – corrected R^2 equal to 0.43 – for the growth of income per capita for the period from 1872 to 2000. That is, 43% of the growth of income per capita of Brazilian municipalities in the period 1872-2000 is explained solely by the level of income per capita in 1872. The estimated speed of convergence, β, is -0.0046, negative and highly significant, thus implying convergence in the distribution of income per capita of Brazilian municipalities from 1872 to 2000. The value of estimates say that 1% more of income per capital in 1872 brings a reduction of 0.0046% in the annual average growth rates of the municipality in the period 1872-2000.

Table 2 presents analogous results for the productivity of labor (income per worker) of Brazilian municipalities from 1872 to 2000, in this case, with R^2 equal to 0.15 and β equal to -0.0037. The smallest speed of convergence for productivity suggests that the growth of the ratio population/labor force (dependency ratio) was in some way divergent during the same period.

Estimations of the model for the selected sub-periods show that in all of them there was convergence of income per capita among Brazilian municipalities. The values of β were significantly negative in all sub-periods. The absolute magnitude of the parameters show that the speed of convergence was significantly larger in the periods 1872-1920 and 1980-2000 when the absolute value of β is larger than 0.01. In the other two sub-periods, the speed of convergence was smaller, particularly in the period 1919-49 when the absolute value of β is approximately 0.0057.

The interpretation suggested is that import substitution phases were associated with urban concentration and exploitation of economies of scale as well as of agglomeration thus implying relatively slow decrease in the municipal inequality of both labor productivity and income per capita. On the other hand, export led growth phases were characterized by intense use of land and other natural resources and the spatial dispersion of economic activities thus implying a much faster convergence of labor productivity and income per capita of municipalities. It should be observed, however, that average growth rates were much higher in the import substitution phases.

Table 1: Brazil: Convergence of the Municipal Distribution (AMC 1872-2000) Income per Capita (GDP/Population) for Selected Sub-Periods from 1872 to 2000

Dependent variable	Log (GDP/POP)	Log (GDP/POP)	Log (GDP/POP)	Log (GDP/POP)	Log (GDP/POP)
Region	Brazil	Brazil	Brazil	Brazil	Brazil
Period	1872-2000	1872-1919	1919-1949	1949-1980	1980-2000
N	380	380	427	430	431
R^2 corr.	0.43	0.36	0.038	0.45	0.01
Beta	-0.0046	-0.012	-0.0058	-0.013	-0.002
Std. error	-0.0003	-0.0008	-0.0014	-0.0007	-0.0008

Table 2: Brazil and regions: Convergence of the municipal distribution (AMC 1872-2000) of income per capita (GDP/Population) for main regions in the period 1872-2000

Dependent variable	Log (GDP/ POP)	Log (GDP/ POP)	Log (GDP/ POP)	Log (GDP/ POP)	Log (GDP/ POP)	Log (GDP/ POP)
Region	Brazil	North	Northeast	Center-South	South	Center-West
Period	1872-2000	1872-2000	1872-2000	1872-2000	1872-2000	1872-2000
N	380	14	190	134	20	18
R^2 corr.	0.43	0.59	0.73	0.77	0.83	0.25
Beta	-0.0046	-0.007	-0.006	-0.007	-0.006	-0.006
Std. error	-0.0003	-0.0015	-0.0003	-0.0003	-0.0006	-0.0021

Table 3: Brazil: Convergence of the municipal distribution (MAC 1872-2000) of labor productivity (GDP/Labor force) for selected sub-periods from 1872 to 2000

Dependent variable	Log (GDP/LF)	Log (GDPLF)	Log (GDP/LF)	Log (GDP/LF)	Log (GDP/LF)
Region	Brazil	Brazil	Brazil	Brazil	Brazil
Period	1872-2000	1872-1919	1919-1949	1919-1980	1980-2000
N	380	380	n.a.	427	431
R^2 corr.	0.15	0.20	n.a.	0.09	0.18
Beta	-0.0034	-0.011	n.a.	-0.0042	-0.014
Std. error	-0.0005	0.001	n.a.	-0.0006	-0.0014

Table 4: Brazil and regions: Convergence of the municipal distribution (MAC 1872-2000) of labor productivity (GDP/Labor force) for main regions in the period 1872-2000

Dependent variable	Log (GDP/LF)	Log (GDP/LF)	Log (GDP/LF)	Log (GDP/LF)	Log (GDP/LF)	Log (GDP/ PEA)
Region	Brazil	North	Northeast	Center-South	South	Center-West
Period	1872-2000	1872-2000	1872-2000	1872-2000	1872-2000	1872-2000
N	380	14	190	134	20	18
R^2 corr.	0.15	0.59	0.23	0.27	0.74	0.13
Beta	-0.0034	-0.007	-0.004	-0.005	-0.008	-0.005
Std. error	-0.0005	-0.0017	-0.0006	-0.0007	-0.0001	-0.0027

Source for Tables 1-4: Dataset compiled by author from IBGE and own estimates. Note: labor force in 1949 was not compiled when estimations were made.

A complementary observation is that absolute values of β in all sub-periods are significantly larger than the one estimated for the 1872-2000 period as a whole. Thus, the processes of convergence of income per capita in the different sub-periods are not reinforcing but reversing themselves.

Compared to other countries, the historical process of convergence of municipal income per capita in the Brazilian economy seems quite slow. Indeed, estimates of β are close to -0.02, both in the case of personal income in the US states in the period 1950-80 and of income per capita in Japan in the period 1955-87 (Barro and Sala-i-Martin 1995). Equivalent estimates for income per capita of municipalities in Japan are -0.025 for the period 1951-70, and -0.003 for the period 1970-2000. Despite all the differences in variables, units of observation, and methods of estimation, the estimates (except for Italy in recent decades) are twice the magnitude of those estimated for Brazil in the periods 1950-80 and 1980-2000.

For the whole period 1872-2000, estimations were disaggregated by main regions. North (NO), Northeast (NE), Center-South (CS), South (SU) and Center-West (CO) – to get a more detailed picture of geographic patterns of convergence of income per capita and labor productivity.

Table 3 and 4 present the regional decomposition of the analysis of convergence of income per capita for the whole period 1872-2000. Though the samples in the case of the North and North regions are relatively small, including 14 and 18 observations, respectively, estimates of β are negative and significant for all regions (at 8% for the Center-West, however).

Comparing the magnitudes of β in Table 4, the speed of convergence was significantly higher in the South region where β is estimated to be equal to -0.0086, compared to -0.0069 in the North Region and even lower in the remaining three regions where estimated values are very similar ranging from -0.0053 and -0.0055.

In all the regions, however, the speed of convergence was higher (β were larger) than in Brazil as a whole. That implies a process of regional divergence which counteracts the processes of spatial convergence inside each region. The concentration of import substitution industrialization in the Center-South region of the country and the marked regional contrasts in soil quality and agricultural development were undoubtedly major factors in the slow process of regional convergence.

5. Sectorial Growth Convergence, 1920-2000

In what follows, the analysis of growth convergence for 1920-200 will be detailed in two ways. First, by the disaggregation of the analysis for urban and rural activities. And, second, by the specification of a conditional model which uses variables like infrastructure, geographical attributes, institutions, and human capital, among other, to explain the growth of municipalities from 1920 to 2000.[4]

For the period 1920-2000, the economic censuses allow the estimation of separate convergence equations for labor productivity in rural (agriculture) and urban (non-agricultural) activities. The sectorial disaggregation is not performed for income per capita simply because the Census of 1920 did not collect data on rural and urban population despite collecting data on labor force (economically active population, PEA) according to major economic activities.

Before coming to the regression results it is interesting to observe that in the period 1920-2000, average municipal growth rates were higher for income per capita (3.3% p.a.) than for labor productivity (3.0% p.a.) thus, indicating that, on average, the labor force grew faster than the population, that is, the average dependency ratio decreased.

4 It was not possible to extend the analysis to1872 because to estimate income per capita for this year it was necessary to use all the conditional variables available, thus unavoidably introducing problems of endogeneity.

Another interesting finding is that average growth of labor productivity was higher in agriculture (2.6% p.a.) than in urban activities (2.4% p.a.). To a large extent the explanation lies in the weight of the service sector and all kinds of low productivity informal activities in the growth of urban output and employment.

OLS results for convergence equation are presented in Table 5. Adjusted correlation coefficients are small compared to the estimates obtained for 1872-2000.The speed of convergence was negative and significant as attested by the t-statistics. Convergence was faster for labor productivity than for income per capita, both, however, were extremely low in comparison to other countries. The faster convergence of labor productivity is difficult to interpret without further analysis of demographic patterns of growth (that is fertility, mortality and migration rates) in rural and urban areas during this period.

Table 5: Brazil: Convergence of Income per Capita (GDP/Population) and of Labor Productivity (GDP/Labor Force) in Urban and Rural Activities in the Period 1872-2000

Dependent variable	Log (GDP/POP)	Log (GDP/LF)	Log (GDP/LFR)	Log (GDP/LFU)
N	430	430	427	429
R^2 Corr.	0.07	0.12	0.18	0.12
LOG_GDP/POP_1920	-0.0030			
* t-value	-5.7681			
LOG_GDP/LABOR FORCE_1920		-0.0040		
* t-value		-7.7621		
LOG_GDP/LABOR FORCE_AGR_1920			-0.0051	
* t-value			-9.8677	
LOG_GDP/LABOR FORCE_URB_1920				-0.0067
* t-value				-7.6907

Source: Analysis of dataset compiled by author from IBGE and own estimates.

Convergence equation for the growth of labor productivity in rural and urban activities in the 1920-2000 period show that the speed of convergence was much faster for urban activities, though both still very low compared to international standards. This result sounds reasonable given the relatively footloose characteristics of urban activities, while agriculture depends on the availability of adequate soils and climate which are concentrated in some areas in the South and Center-West regions.

Finally, it is interesting to observe that both rural and urban activities show a higher speed of convergence than aggregate labor productivity in the economy, thus suggesting that there were synergies and cross-correlations between the processes of growth in labor productivity in both sectors. Rural and labor productivity grew faster or slower in the same areas, thus characterizing patterns of growth high-high or low-low in both sectors.

6. Factors Conditioning Convergence Patterns, 1920-2000

To analyze the determinants of the growth pattern of the Brazilian economy in the period 1920-2000, the specifications of the growth convergence equations are enlarged to incorporate the determinants of steady state growth rates of Brazilian *municípios*. By assumption, the steady state growth of the *municípios* depend on major economic, social, and geographic conditions prevailing in each municipality in 1920.

In the case of the growth of GDP per capita the model to be estimated becomes:

(2) $\mathbf{\log (y_{i,t}/y_{i,t-n})^{1/n} = \alpha + \beta \cdot \log (y_{i,t-n}) + \gamma \cdot X_{i,t-n}}$

where

$y_{i,t} = Y_{i,t} / Pop_{i,t}$ (or $Y_{i,t} / Labor_{i,t}$) is the total, urban, or rural GDP per capita (per labor force) of *município* i in year t,

$Y_{i,t}$ is total, urban, or rural GDP of *município* i in year t,

$Pop_{i,t}$ is total, urban or rural population of *município* i in year t.

$Labor_{i,t}$ is total, urban or rural labor force of the *município* i in year t.

$X_{i,t-n}$ = matrix of explanatory variables including all the arguments that condition the steady-state rate of growth of Brazilian municipalities from 1920 to 2000

The variables included as conditioning or explanatory factors are listed in Table 6. The list includes major characteristics of the municipalities in terms of geography (area, latitude, longitude, altitude, temperature, precipitation, soil types, etc.), demography (population, foreign population, labor force), economy (GDP by sectors, landownership concentration, electricity generation, area of farms, share of coffee in cultivated area), accessibility and transport (existence and age of railway station, distance to sea, distance to capital, potential market index), human capital and education (literacy, enrollment in and number of primary schools) and a few institutional dimensions like the number of slaves in 1872 and the number of voters in 1910. Most of the variables refer to 1920. The exceptions are schools and voters which were not available for 1920 and, for obvious reasons, slavery and geographic conditions. A detailed description of their definition and measurement is presented in the database appendix.

Estimation results presented in Table 7 show that initial socio-economic conditions in 1920 explain more that 50% of the variance of the growth rates of Brazilian municipalities in the period 1920-2000. Note that the simple growth convergence equation of Table 5 explains around 15%.

The speed of convergence is approximately equal to 1 for both income per capita and labor productivity. Thus, municipalities which were 1% richer in 1920 show, on average, a rate of growth 0.01% smaller in the period 1920-2000. For urban and agricultural activities, the estimates for GDP per worker are 1.2, approximately. These values are relatively small given that we are talking about conditional growth. That is, comparing municipalities which had the same initial conditions. Thus, even in this case, the speed of convergence is slow in comparison with other countries.

To identify the most important growth conditioning factor we use the threshold of 5% significance level for the t-statistics. In Table 6, the variables which pass the threshold criteria and therefore are considered significant growth factors are highlighted. A careful look shows that population in 1920 is not significant in all the equations (marginally in the case of the growth labor productivity) but is kept as a normalizing variables for all the other variables demographic variables. Some variables with a high incidence of null observations, however, were specified in per capita terms.

The most important variable is the dummy for the existence of a railway station in 1920. *Ceteris paribus*, that would imply an increase of 14% per annum in average growth rates from 1920-2000. This has a huge impact, hardly believable, but results were double checked.

Table 6: Factors Conditioning Municipal Convergence Patterns, 1920-2000

Variable label	Definition
AE20_THEIL_T	Theil index of landownership inequality in 1920
ANO_DUMMY_ ESTACAO_FERR	Dummy for the inaugural year of railway in the municipality
ANO_DUMMY_GER_ENERGIA	Dummy for the inaugural year of electricity in the municipality
DIST_CAP_UF	Geodesic distance to the state capital (in km)
DSHOR	Geodesic distance to the sea (in km)
DUMMY_CAPITAL	Dummy for state capital
DUMMY_ESTACAO_FERR	Dummy for the existence of railway station in 1872
DUMMY_GER_ENERGIA	Dummy for the existence of electricity generation station in 1872
ELEITORESPC1910	Number of registered voters in 1914/Population in 1920
ESCOLAS_EP_EST_PC_1910	Number of state primary schools in 1920 / Population in 1920
ESCOLAS_EP_MUN_PC_1910	Number of private primary schools in 1920 / Population in 1920
LAT_GRAUS	Latitude of seat of municipality
LOG_AEAGP20	LOG (Area of agricultural establishments in 1920)
LOG_ALFAB1920	LOG (Literates in 1920)
LOG_AREAMUN	LOG (Geographic area of MAC)
LOG_ESTR1920	LOG (Foreigners in 1920)
LOG_PEA1920	LOG (PEA1920)
LOG_PEAAGR1920	LOG (PEAAGR1920)
LOG_PEAMANUF1920	LOG (PEAMANUF1920)
LOG_PIBPC_19	LOG (PIBPC1919)
LOG_PIBPC_19_00	LOG ((PIBPC2000 / PIBPC1919) ** (1/(2000-1919)))
LOG_PIBPEA_19	LOG (PIBPEA1919)
LOG_PIBPEA_19_00	LOG ((PIBPEA2000 / PIBPEA1919) ** (1/(2000-1919)))
LOG_PM_PIB1919	LOG (PM_PIB1919)
LOG_POP1920	LOG (POP1920)
LONG_GRAUS	Longitude of municipality seat
MATR_EP_EST_PC_1910	Students enrolled in public primary school 1920/Population 1920
MATR_EP_MUN_PC_1910	Students enrolled in private primary school 1920/Population 1920

MOTORES_NUMERO	Number of electrical motors in municipality 1920
MOTORES_POTENCIA	Power of electrical motors in municipality 1920 (Kwh)
NUM_EMPRESAS	Number of enterprises generating hydroelectricity 1920
PAC_CAF20	Crop area of coffee 1920 / Area of farms 1920
PALT1	Share of municipal area with elevation 0 to 99 m
PALT3	Share of municipal area with elevation 200 to 499 m
PALT4	Share of municipal area with elevation 500 to 799 m
PALT5	Share of municipal area with elevation 800 to 1199 m
PALT6	Share of municipal area with elevation 1200 to 1799 m
PALT7	Share of municipal area with elevation 1800 to 3000 m
PERO1	Share of municipal area with moderate erosion (7.5 to 15% declivity)
PERO2	Share of municipal area with strong erosion (30 to 45% declivity)
PRE30DJF	Average precipitation Dec-Feb 1961-90
PRE30JJA	Average precipitation Jun-Aug 1961-90
PRE30MAM	Average precipitation Mar-May 1961-90
PRE30SON	Average precipitation Sep-Nov 1961-90
PSOLO1	Share of municipal soil in class 1
PSOLO10	Share of municipal soil in class 10
PSOLO11	Share of municipal soil in class 11
PSOLO12	Share of municipal soil in class 12
PSOLO2	Share of municipal soil in class 2
PSOLO3	Share of municipal soil in class 3
PSOLO4	Share of municipal soil in class 4
PSOLO5	Share of municipal soil in class 5
PSOLO6	Share of municipal soil in class 6
PSOLO7	Share of municipal soil in class 7
PSOLO8	Share of municipal soil in class 8
PSOLO9	Share of municipal soil in class 9
SLVRY_POP_1872	Share of slaves in total population 1872
TMP30DJF	Average temperature Dec-Feb 1961-90
TMP30JJA	Average temperature Jun-Aug 1961-90
TMP30MAM	Average temperature Mar-May 1961-90
TMP30SON	Average temperature Sep-Nov 1961-90

Table 7: Brazil: OLS Estimation of Conditional Growth Convergence of GDP per Capita and Labor Productivity in Urban and Rural Activities, 1920-2000 (pib14si)

#	Statistics and explanatory variables	LOG_ GDP/ POP 2000/1920	LOG_ GDP/ LF 2000/1920	LOG_ GDP/ LFR 2000/1920	LOG_ GDP/ LFU 2000/1920
1	N	397	397	395	397
2	F-value	7.19	6.90	8.60	6.63
3	R^2	0.55	0.54	0.60	0.53
4	Adj. R^2	0.48	0.46	0.53	0.45
5	Dependent Mean	0.03	0.03	0.03	0.02
6	Root MSE	0.01	0.01	0.01	0.01
7	Coeff. Var	16.57	18.42	32.07	22.85
8	Variable				
9	Intercept	-0.1880	-0.1546	-0.0650	-0.0981
10	* t-value	-2.7283	-2.2951	-0.6184	-1.4449
11	* Pr > |t|	0.0067	0.0223	0.5367	0.1494
12	LOG_PIBPC_19	-0.0104			
13	* t-value	-10.4918			
14	* Pr > |t|	0.0000			
15	LOG_PIBPEA_19		-0.0102		
16	* t-value		-10.4672		
17	* Pr > |t|		0.0000		
18	LOG_PIBPEA_AGR_19			-0.0121	
19	* t-value			-14.5184	
20	* Pr > |t|			0.0000	
21	LOG_PIBPEA_URB_19				-0.0124
22	* t-value				-10.8452
23	* Pr > |t|				0.0000
	LOG_POP1920	-0.0041	-0.0054	-0.0055	-0.0028
	* t-value	-1.3512	-1.8475	-1.2113	-0.9613
	* Pr > |t|	0.1775	0.0655	0.2266	0.3371
24	DUMMY_CAPITAL	0.0050	0.0038	0.0004	0.0032
25	* t-value	2.6211	2.0429	0.1498	1.6723
26	* Pr > |t|	0.0092	0.0418	0.8810	0.0954
27	DIST_CAP_UF	0.0000	0.0000	0.0000	0.0000
28	* t-value	0.1261	0.5330	3.5012	-0.2923
29	* Pr > |t|	0.8997	0.5944	0.0005	0.7702
30	DUMMY_ESTACAO_FERR	0.1484	0.1414	-0.0663	0.1531

#	Statistics and explanatory variables	LOG_ GDP/ POP 2000/1920	LOG_ GDP/ LF 2000/1920	LOG_ GDP/ LFR 2000/1920	LOG_ GDP/ LFU 2000/1920
31	* t-value	2.5635	2.4984	-0.7484	2.6820
32	* Pr > |t|	0.0108	0.0129	0.4547	0.0077
33	ANO_DUMMY_ESTACAO_FERR	-0.0001	-0.0001	0.0000	-0.0001
34	* t-value	-2.5662	-2.5010	0.7755	-2.6941
35	* Pr > |t|	0.0107	0.0129	0.4386	0.0074
36	DUMMY_GER_ENERGIA	0.2772	0.2982	0.2539	0.3402
37	* t-value	1.4047	1.5456	0.8487	1.7460
38	* Pr > |t|	0.1610	0.1231	0.3966	0.0817
39	ANO_DUMMY_GER_ENERGIA	-0.0001	-0.0002	-0.0001	-0.0002
40	* t-value	-1.4045	-1.5459	-0.8417	-1.7478
41	* Pr > |t|	0.1611	0.1231	0.4005	0.0814
42	NUM_EMPRESAS	0.0011	0.0011	-0.0002	0.0012
43	* t-value	2.0624	2.0448	-0.2723	2.1862
44	* Pr > |t|	0.0399	0.0416	0.7856	0.0295
45	MOTORES_NUMERO	-0.0007	-0.0007	-0.0001	-0.0007
46	* t-value	-1.8516	-1.8946	-0.1493	-1.8589
47	* Pr > |t|	0.0650	0.0590	0.8814	0.0639
48	MOTORES_POTENCIA	0.0000	0.0000	0.0000	0.0000
49	* t-value	2.0081	2.1814	-1.2458	2.1887
50	* Pr > |t|	0.0454	0.0298	0.2137	0.0293
51	LOG_POP1920	-0.0041	-0.0054	-0.0055	-0.0028
52	* t-value	-1.3512	-1.8475	-1.2113	-0.9613
53	* Pr > |t|	0.1775	0.0655	0.2266	0.3371
54	LOG_ESTR1920	0.0011	0.0009	0.0020	0.0006
55	* t-value	2.6290	2.3265	3.4160	1.6652
56	* Pr > |t|	0.0090	0.0206	0.0007	0.0968
57	LOG_ALFAB1920	0.0005	0.0001	0.0043	-0.0023
58	* t-value	0.3315	0.0771	1.8698	-1.5275
59	* Pr > |t|	0.7404	0.9386	0.0624	0.1276
60	LOG_PEAMANUF1920	-0.0001	0.0000	-0.0006	0.0004
61	* t-value	-0.1340	-0.0603	-0.4930	0.5034
62	* Pr > |t|	0.8935	0.9519	0.6224	0.6150
63	LOG_PEAAGR1920	0.0017	0.0015	0.0116	0.0004
64	* t-value	0.8397	0.7703	3.4936	0.1869
65	* Pr > |t|	0.4017	0.4416	0.0005	0.8518
66	LOG_PEA1920	-0.0002	0.0017	-0.0138	0.0030

#	Statistics and explanatory variables	LOG_ GDP/ POP 2000/1920	LOG_ GDP/ LF 2000/1920	LOG_ GDP/ LFR 2000/1920	LOG_ GDP/ LFU 2000/1920
67	* t-value	-0.0703	0.4981	-2.4563	0.8538
68	* Pr > |t|	0.9440	0.6188	0.0145	0.3938
69	LOG_AEAGP20	0.0010	0.0010	0.0024	0.0007
70	* t-value	1.7687	1.7760	2.7657	1.3756
71	* Pr > |t|	0.0778	0.0766	0.0060	0.1699
72	PAC_CAF20	-0.0053	-0.0065	0.0080	-0.0008
73	* t-value	-0.6211	-0.7814	0.6178	-0.0930
74	* Pr > |t|	0.5349	0.4351	0.5371	0.9260
75	SLVRY_POP_1872	0.0067	0.0063	0.0004	0.0064
76	* t-value	1.6343	1.5810	0.0696	1.5911
77	* Pr > |t|	0.1031	0.1148	0.9445	0.1125
78	ELEITORESPC1910	-0.0111	-0.0045	-0.0701	0.0017
79	* t-value	-0.4764	-0.1986	-2.0039	0.0754
80	* Pr > |t|	0.6341	0.8427	0.0459	0.9399
81	LOG_PM_PIB1919	0.0071	0.0066	-0.0025	0.0058
82	* t-value	3.5692	3.3935	-0.7406	2.9531
83	* Pr > |t|	0.0004	0.0008	0.4594	0.0034
84	AE20_THEIL_T	0.0003	0.0003	0.0001	0.0001
85	* t-value	0.4087	0.5182	0.1491	0.2283
86	* Pr > |t|	0.6830	0.6047	0.8815	0.8195
87	MATR_EP_EST_PC_1910	-0.1276	-0.1082	0.0181	-0.0773
88	* t-value	-1.5949	-1.3828	0.1488	-0.9765
89	* Pr > |t|	0.1117	0.1676	0.8818	0.3295
90	MATR_EP_MUN_PC_1910	0.0843	0.0819	0.1579	0.1057
91	* t-value	0.5047	0.5016	0.6266	0.6433
92	* Pr > |t|	0.6141	0.6163	0.5314	0.5205
93	ESCOLAS_EP_EST_PC_1910	2.3003	1.9783	0.4872	0.7550
94	* t-value	0.7290	0.6414	0.1017	0.2416
95	* Pr > |t|	0.4665	0.5217	0.9191	0.8093
96	ESCOLAS_EP_MUN_PC_1910	3.3128	2.5821	-0.6837	-0.8993
97	* t-value	0.4645	0.3704	-0.0637	-0.1281
98	* Pr > |t|	0.6426	0.7113	0.9493	0.8981
99	LOG_AREAMUN	0.0003	0.0005	-0.0009	0.0002
100	* t-value	0.5187	0.7604	-0.8914	0.3229
101	* Pr > |t|	0.6043	0.4475	0.3733	0.7470
102	LAT_GRAUS	-0.0003	-0.0002	-0.0015	0.0000

#	Statistics and explanatory variables	LOG_ GDP/ POP 2000/1920	LOG_ GDP/ LF 2000/1920	LOG_ GDP/ LFR 2000/1920	LOG_ GDP/ LFU 2000/1920
103	* t-value	-1.3391	-0.9964	-3.9801	-0.1052
104	* Pr > |t|	0.1814	0.3197	0.0001	0.9163
105	LONG_GRAUS	0.0001	0.0001	0.0002	0.0000
106	* t-value	0.2703	0.5982	0.4958	-0.0713
107	* Pr > |t|	0.7871	0.5501	0.6204	0.9432
108	DSHOR	0.0000	0.0000	0.0000	0.0000
109	* t-value	2.0176	2.1437	0.6032	0.8593
110	* Pr > |t|	0.0444	0.0328	0.5468	0.3908
111	TMP30DJF	-0.0021	-0.0014	-0.0061	0.0004
112	* t-value	-1.3517	-0.9068	-2.5980	0.2564
113	* Pr > |t|	0.1774	0.3652	0.0098	0.7978
114	PRE30DJF	-0.0001	0.0000	0.0000	0.0000
115	* t-value	-2.1889	-1.5315	0.8177	-1.7019
116	* Pr > |t|	0.0293	0.1266	0.4141	0.0897
117	TMP30MAM	0.0019	0.0011	0.0055	-0.0014
118	* t-value	1.2284	0.7619	2.3496	-0.8907
119	* Pr > |t|	0.2202	0.4467	0.0194	0.3737
120	PRE30MAM	0.0000	0.0000	0.0000	0.0000
121	* t-value	1.8216	1.2725	0.0645	0.1999
122	* Pr > |t|	0.0694	0.2041	0.9486	0.8416
123	TMP30JJA	-0.0013	-0.0004	-0.0051	0.0009
124	* t-value	-1.0428	-0.3344	-2.6939	0.7548
125	* Pr > |t|	0.2978	0.7383	0.0074	0.4509
126	PRE30JJA	0.0000	0.0000	0.0001	0.0000
127	* t-value	-2.1740	-1.2450	3.3882	-1.0425
128	* Pr > |t|	0.0304	0.2140	0.0008	0.2979
129	TMP30SON	0.0010	0.0001	0.0074	-0.0006
130	* t-value	0.7146	0.0675	3.4985	-0.4359
131	* Pr > |t|	0.4754	0.9462	0.0005	0.6632
132	PRE30SON	0.0000	0.0000	-0.0001	0.0000
133	* t-value	0.5981	0.0027	-1.4641	0.9197
134	* Pr > |t|	0.5502	0.9979	0.1441	0.3584
135	PERO1	-0.0057	-0.0054	-0.0057	-0.0032
136	* t-value	-1.4720	-1.4237	-0.9685	-0.8435
137	* Pr > |t|	0.1419	0.1555	0.3335	0.3995
138	PERO2	-0.0047	-0.0044	-0.0061	-0.0035

#	Statistics and explanatory variables	LOG_ GDP/ POP 2000/1920	LOG_ GDP/ LF 2000/1920	LOG_ GDP/ LFR 2000/1920	LOG_ GDP/ LFU 2000/1920
139	* t-value	-1.2234	-1.1717	-1.0330	-0.9225
140	* Pr > |t|	0.2220	0.2421	0.3023	0.3569
141	PALT1	0.0070	0.0068	0.0056	0.0086
142	* t-value	3.1364	3.1016	1.6783	3.8945
143	* Pr > |t|	0.0019	0.0021	0.0942	0.0001
144	PALT3	-0.0019	-0.0028	0.0017	-0.0007
145	* t-value	-0.8273	-1.2581	0.5007	-0.3295
146	* Pr > |t|	0.4087	0.2092	0.6169	0.7420
147	PALT4	0.0006	0.0003	0.0079	0.0025
148	* t-value	0.2297	0.1348	2.0563	0.9805
149	* Pr > |t|	0.8185	0.8928	0.0405	0.3276
150	PALT5	0.0016	0.0001	0.0005	0.0014
151	* t-value	0.4553	0.0364	0.0854	0.3910
152	* Pr > |t|	0.6492	0.9710	0.9320	0.6960
153	PALT6	-0.0074	-0.0052	0.0063	-0.0017
154	* t-value	-0.6311	-0.4524	0.3551	-0.1460
155	* Pr > |t|	0.5284	0.6513	0.7227	0.8840
156	PALT7	-0.1314	-0.1265	0.1054	-0.1253
157	* t-value	-0.9169	-0.9030	0.4877	-0.8881
158	* Pr > |t|	0.3599	0.3671	0.6261	0.3751
159	PSOLO1	0.1581	0.1435	0.0616	0.0935
160	* t-value	2.5355	2.3542	0.6540	1.5234
161	* Pr > |t|	0.0117	0.0191	0.5136	0.1286
162	PSOLO2	0.1598	0.1449	0.0577	0.0954
163	* t-value	2.5638	2.3786	0.6131	1.5552
164	* Pr > |t|	0.0108	0.0179	0.5402	0.1208
165	PSOLO3	0.1436	0.1285	0.0536	0.0802
166	* t-value	2.2623	2.0701	0.5591	1.2846
167	* Pr > |t|	0.0243	0.0392	0.5764	0.1998
168	PSOLO4	0.1498	0.1363	0.0565	0.0871
169	* t-value	2.3977	2.2332	0.5998	1.4172
170	* Pr > |t|	0.0170	0.0262	0.5490	0.1573
171	PSOLO5	0.1487	0.1346	0.0483	0.0906
172	* t-value	2.3903	2.2142	0.5144	1.4810
173	* Pr > |t|	0.0174	0.0275	0.6073	0.1395
174	PSOLO6	0.1559	0.1414	0.0606	0.0916

#	Statistics and explanatory variables	LOG_ GDP/ POP 2000/1920	LOG_ GDP/ LF 2000/1920	LOG_ GDP/ LFR 2000/1920	LOG_ GDP/ LFU 2000/1920
175	* t-value	2.5000	2.3194	0.6436	1.4932
176	* Pr > |t|	0.0129	0.0210	0.5203	0.1363
177	PSOLO7	0.1598	0.1451	0.0590	0.0957
178	* t-value	2.5555	2.3740	0.6255	1.5557
179	* Pr > |t|	0.0110	0.0182	0.5321	0.1207
180	PSOLO8	0.1578	0.1432	0.0581	0.0944
181	* t-value	2.5109	2.3317	0.6121	1.5273
182	* Pr > |t|	0.0125	0.0203	0.5409	0.1276
183	PSOLO9	0.1606	0.1479	0.0833	0.0839
184	* t-value	2.4596	2.3179	0.8450	1.3062
185	* Pr > |t|	0.0144	0.0211	0.3987	0.1924
186	PSOLO10	0.1562	0.1412	0.0580	0.0916
187	* t-value	2.4996	2.3110	0.6149	1.4899
188	* Pr > |t|	0.0129	0.0214	0.5390	0.1372
189	PSOLO11	0.1462	0.1310	0.0550	0.0833
190	* t-value	2.3627	2.1662	0.5892	1.3682
191	* Pr > |t|	0.0187	0.0310	0.5561	0.1722
192	PSOLO12	-0.0486	-0.0682	0.3090	-0.1591
193	* t-value	-0.1176	-0.1687	0.4948	-0.3904
194	* Pr > |t|	0.9064	0.8661	0.6211	0.6965

Source: Author´s estimation (regrpib09sia). The suffix p denotes percent of population or area. Coefficients significant at 5% level are highlighted in grey.

One possible explanation would be that railroad stations are capturing the effects of omitted variables related to transportation costs, accessibility, and other previous locational advantages. Note, however, that the huge effect is restricted to urban activities; growth rates of agricultural productivity were not significantly affected by the existence of a railroad in 1920. The age of the railway station also have a small but significant positive effect on the average growth rate. Municipalities gaining early access to railways have had a lasting growth advantage. To be a state capital was also an important factor for the secular growth rate of both income per capita and labor productivity. The increase in average growth rates in the period 1920-2000 are 0.5% for GDP per capita and 0.4% for GDP per worker. Surprisingly, when we disaggregate the analysis for labor productivity, the effect is only marginally significant in the growth for urban activities, and as expected, not significant for the growth of agricultural productivity. The distance to a state capital, however, had a positive effect on the growth rate of labor productivity in agriculture but none on the other dependent variables. It looks like as the consequence of home markets effects or some form of access to technology since capital cities are both richer and more populated and also sources of knowledge and human capital.

Other infrastructure variables with significant effects have to do with electricity generation. Both the number of companies of electricity generation installed in a municipality in 1920 and their capacity of generation (in kw) in that same year had a significant positive effect on the secular growth rate of GDP per capita and per worker. Each additional company brings 0.1% of increase in the annual average secular growth of the municipality. The effect is wholly due to industry. Growth rates of GDP per worker in agriculture are not affected by electricity infrastructure, as we should expect given the fact most of the energy infrastructure is located in urban centers. Apart from infrastructure, the other important factor is the potential market of the municipality in 1920 measured by the average GDP of Brazilian municipalities weighted by the inverse of their geographic distances to the municipality in case. Each percent implied 0.001% more of average growth rates in 1920-2000. Thus, municipalities that were close to rich markets in 1920 grew more in the 1920-2000 period. Thus, agglomeration effects were important and demand as well as historical accidents could have been important factors of growth.

The foreign born population was also an important factor of productivity and income per capita growth. Interestingly, however, the effect was mainly felt in the growth of agricultural productivity. For the growth of urban productivity it was not significant. Suggested explanations for its importance in agriculture are capital, technology, human capital as well as institutional innovations brought by immigrants. It could as well be that migrants anticipated the agricultural prospects of the areas for where they migrated. Note, however, that coffee as percent of agricultural establishments is not significant. In addition, if their long run growth prospection methods were not likely to be accurate, especially if we consider that they were relatively ignorant about the country. Agricultural activities also tend to show some inertial or cumulative features in that the growth of agricultural productivity was higher in the municipalities with a larger labor force in agriculture and areas with a larger share of agricultural establishments in 1920. Note, however, that the size of total labor force tends to decrease the growth of agricultural productivity.

Geographic variables have some expected effects and other quite surprising. Temperature and precipitation on income per capita and, moreover, soil quality are significant for per capita growth, suggesting that a state dummy that should be introduced. See the joint significance tests in Table 8 below.

Finally, the model tests the importance of some institutional conditions of the municipalities. As proxies of institutional conditions were included the share of slaves in total population in 1872; Theil index for land ownership concentration in 1920; a group of variables related to education including the literacy rate of population in 1920, and four other variables describing the availability of schools as well as the attendance of schools in 1907; and, finally, political participation in 1914 as measured by the share of registered voters in total population.

Surprisingly, however, all the institutional proxies selected, when considered in isolation or jointly, were not statistically significant (at the 5% level) for the growth of Brazilian municipalities in the 20th century. The only institutional proxy significant was the share of foreign born population in 1920.

To test the institutional hypothesis, three groups of variables were distinguished as follows:

(1) Slavery in 1872; registered voters in 1910; and land ownership concentration in 1920

(2) Education condition described by literacy rate in 1920; students enrolled in public and private schools in 1910; and the number of primary schools public and private in 1910.

(3) The share of foreign born population in 1920.

Table 8: Tests of Joint Significance for the Conditional Growth Equations of GDP per Capita and Labor Productivity, 1920-2000

	Growth of GDP per capita		Growth of labor productivity All activities		Agriculture		Non-Agricultural activities	
	F-Value	Pr > F	F-value	Pr > F	F-value	Pr > F	F-value	Pr > F
A. Slave + Politic + Farm Theil Index	1.02	0.38	0.34	0.42	1.37	0.25	0.87	0.46
B. Education	1.78	0.11	1.37	0.24	1.24	0.29	1.27	0.28
C. A+B	1.51	0.15	1.23	0.28	0.96	0.47	1.13	0.34
D. A + B+ foreign	2.67	0.01	2.08	0.03	3.21	0.00	1.34	0.22
E. Temperature	0.56	0.69	0.44	0.78	6.84	0.00	0.71	0.59
F. Precipitation	1.77	0.14	1.07	0.37	7.33	0.00	1.35	0.25
G. Declivity	1.15	0.32	1.09	0.34	0.53	0.59	0.43	0.65
H. Altitude classes	3.93	0.00	4.38	0.00	1.60	0.15	4.61	0.00
I. Soil geo-morphology	2.30	0.01	2.31	0.01	0.67	0.78	1.73	0.06

Source: Author´s estimation (regrpib09sia). Coefficients significant at 5% level are highlighted in grey.

As shown in Table 8, F-tests for the joint significance of A, B, A+B and A+B+C were conducted with the result that, at 5% confidence level, A, B, A+B are not significant in all cases. Only A+B+C is significant which is not surprising given that the share of foreign born population was already significant when considered alone. But in the case of the growth of labor productivity in urban activities, even A+B+C is not significant.

7. Conclusions and Extensions

The basic hypothesis of this paper is the overwhelming role played by the geographic factors, especially transport costs, in the historical generation and reproduction of spatial inequalities in Brazil. Empirical evidence is given by the analysis of the spatial patterns of growth of labor productivity and income per capita of the Brazilian municipalities from 1872 to 2000.

The main result of the analysis is that spatial inequalities in the density of economic activity, income per capita and labor productivity remained practically unchanged – with negligible reductions – from 1872 to 2000. The maps show clearly the secular persistent northwest-southeast divide of the country.

Estimations of econometric models of growth convergence provide a more rigorous test of the hypotheses. The estimates reported here show, first of all, that the speed of convergence of both income per capita and labor productivity was very slow compared to other countries. Disaggregation of the analysis by sub-periods, regions and sectors show, respectively, that phases of export led growth were more dispersive than the import substitution phases; convergence was faster inside each region and thus regional disparities reinforced spatial inequalities in the country as a whole; and convergence of labor productivity was faster in urban activities than in rural activities.

More notably, the parameter estimates in this paper show that conditions of access to infrastructure in 1920 – measured by the proxy of the existence of a railway station in the municipality – was by far the most important factor conditioning the growth of Brazilian municipalities during the 20th century. Other variables related to accessibility like the distance to the state capitals, and the market potential of the municipality also played roles in the long run growth of municipalities. This strong result corroborates the perception that Brazilian development strategies during the second half of 20th century had misguidedly disregarded investment in railway infrastructure which therefore remains as a crucial obstacle of steady growth.

In contrast, institutional factors – as measured by the proxy of importance of slavery (in 1872), education and human capital, political participation, and land ownership concentration – did not play a significant in long run growth of income per capita or labor productivity of Brazilian municipalities. Even jointly tested, their coefficients remain insignificant. The only exceptional role is perhaps the institutional innovations brought with Europeans immigrants since the share of foreign born population in 1920 had a significant positive effect on the secular rates of growth both labor productivity and income per capita, especially in agricultural activities.

Needless to say, the results are still preliminary and further extensions and scrutiny are required. Obvious extensions of the analyses are to disaggregate them for each of the 10 inter-census periods as well as economic activities available to estimate in more rigorous way the interplay between factors conditioning growth of Brazilian municipalities. One priority in this way is to update the analyses for 2000-2010 to disentangle the role played by spatial inequalities in the recent redistributive process (Rodrigues-Silveira 2012).

In this way the tasks ahead are to complete the historical database on the conditioning factors, in particular on demographic aspects related to migration and dependency ratio; urban and transportation infrastructures; education and human capital; political participation, etc. – for the periods from 1920 and 1960 when data are still in printed format.

Another line of scrutiny would be a more rigorous econometric treatment of problems like spatial correlation, seemingly unrelated equations, and endogenous variables in the model. A couple of examples illustrate the relevance of these issues. The existence of railroad station is a poor proxy for transportation infrastructure to the extent that they tend to be located in localities that had previous locational advantages and for that reason were likely to grow faster in the long run. Thus, they are endogenous and to that extent their importance and significance are biased. A solution proposed is to use as instrumental variables on transport accessibility prior to railways. An example is the distance to main seaports by mule train in 1870 which is now being gathered.

Analogously, slavery in 1872 gives a biased picture of the secular and persistent effects of the institution because concentration of the slave population in the booming coffee areas took place in the short period of a few decades during the mid-19th century.[5] To that extent the share of slaves became endogenous to the development prospects of this region. One suggestion to circumvent this problem would be to use the data on black population in 1872 and in 1890 as instrumental variables. The rationale is that the share of blacks (*pardos* and *pretos livres* in 1872) in the population is a better proxy for the persistent long run effects of slavery in the municipality.

5 The time elapsed from 1872 to the abolition in 1888 does not pose a major problem for the analysis to the extent that several institutional changes like laws passed which gave freedom to infants born to slaves and sexagenarians; the creation of emancipation funds; voluntary manumission and the abolitionist movement have contributed to distort the spatial picture on the importance of the economic and social legacies of slavery.

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9. Appendix: Database

(1) Sources of data

Municipal data came both from the demographic and economic censuses. The first demographic census took place in 1872. With diverse quality and frequency, other demographic censuses followed in 1890, 1900, and 1920. In 1940, IBGE started to conduct demographic censuses on a decennial basis. The last one was undertaken in 2010, though 2000 is the final date of our analysis. The economic censuses started in 1920; became decadal from 1940 to 1970; quinquennial from 1975 to 1985, when they were discontinued, except for the Agricultural Census which was undertaken in 1996 and 2007.

Starting in 1995, IBGE made available data at municipal level based upon representative panel of enterprises in major activities: the Cadastro Central de Empresas, CEMPRE which are conducted annually. Three other municipal surveys undertaken by IBGE since 1973 are the Pesquisa Agrícola Municipal (PPA) and the Pesquisa Pecuária Municipal (PPM) and Pesquisa da Extração Vegetal e Silvicultura (PEVS). At the state level, IBGE publishes the Pesquisa Nacional de Amostra por Domicílios (PNAD) since 1973.

Transport data came from various sources including *Enciclopédia dos municípios brasileiros* (IBGE 1957), *Ferrovias do Brasil* 1946 and 1956 (IBGE 1948 and 1958), DGE 1872, CNI 19007 Ferrovias.

(2) *Municípios* and MCA

Brazilian *município* is the basic geographic unit of observation of the data. The number of Brazilian *municípios* in Brazilian censuses increased from 642 in 1872 to 1,304 in 1920, 3,951 in 1970 and 5,507 in 2000. The changes in number and geographic boundaries of *municípios* preclude consistent intertemporal analysis unless municípios are combined in Minima Comparable Geographic Areas (MCA). Thus, though *municípios* are the units of observation, MCA are the *de facto* geographic unit of analysis (Reis et al. 2011).

The number of MCA changes depending on the inter-censuses period in case. Thus, for the inter-censuses period 1872-2000 there are 432 MCA and for 1970-2000 the number is 3659. Table A1 compares the number of municipalities in each Census year since 1872 with the number of MCA for the respective inter-census period ending in 2000.

The analyses made in this paper are based upon the Minima Comparable Areas in the period from 1972 to 2000. Thus, unless otherwise specified the term municipality refers to MCA 1872-2000 Figure A1 presents the MCA 1872-2000. It is possible to see that in the North and West regions, were settlement took place in recent times, the MCA are too few and too large thus posing problems of statistical representativity. Note also that the State of Acre is excluded from map of Brazil because in 1872 it was still part of Bolivian territory. It was only in 1905 that it was incorporated to Brazilian territory.

(3) GDP

In terms of data generation, the major contributions of this project are the estimates of municipal GDP. The project estimated municipal GDP for Census years from 1872 to 1996 (Reis et al. 2005). The database is supplemented by the annual estimates of municipal GDP for major sectors of activities undertaken by IBGE since 1999.

Estimates of municipal income for 1872 are based upon econometric models which combine data on wages of civil servants in 1876 with the 1872 Census demographic data (Reis 2008). The models assume that wages of municipal civil servants reflected the labor productivity which was determined by the demographic conditions (distribution of population according to sex, age, occupation and the free or slave condition) as well as by the geographic characteristics (distance to sea, altitude, climate and soil attributes) of each municipality. The idea is to estimate municipal labor productivity by filtering the idiosyncratic factors that affect average wages of municipal civil servants with the available information on the productive structure of the municipality. Given the municipal labor productivity and labor force it is possible to estimate municipal GDP but, unfortunately, not to disaggregate it into rural and urban GDP.

For Census years 1920, 1940, 1950, 1960, 1970, 1975, 1980, 1985 and 1996, GDP estimates are based on Census data for major sectors of economic activity (Industry, Trade, Services, and Agriculture). For each sector and year, the estimation procedure was to calculate proxies of valued added at municipal level which were then normalized by the respective Brazilian GDP figures in the National Accounts.

In the 1920 Census there are no data on industrial and services output at the municipal level and thus estimates were made by distribution of state level data on output according to employment. Agriculture estimation were based upon municipal data on major crops output.

After 1985, economic censuses were discontinued, except for agriculture which was realized in 1996 and 2007. The discontinuation of the other economic censuses after 1985 was circumvented by the use of data from annual surveys based upon CEMPRE as well as by some methodological adaptations. For that reason, the comparison of municipal GDP figures for 1996 with the other Census years requires additional care.

Finally, from 1999 on, IBGE started publishing yearly estimates of municipal GDP for the major sectors of economic activity.

(4) Labor force (PEA)

The labor force or economically active population (PEA) is not consistently measured across different censuses. Since 1970, the definition provided by the Demographic censuses include all the persons that were employed as well as those involuntarily unemployed defined as the persons older than 10 years of age which have searched for employment in the two months preceding the Census date of reference. The population out of the labor force (NPEA or non-economically active population as IBGE names it) includes voluntarily unemployed; occupied with unpaid domestic services in their own homes, retired persons, rentiers, students without jobs, and persons in jail. The PEA and NPEA are measured in both rural and urban households.

For the Censuses from 1940 to 1960, the definition of economic active population excludes both voluntary and involuntary unemployment. The labor force is then equal to employed population and thus can be disaggregated according to major sector of activities (agriculture, industry, trade and others services). The non-economically active population includes persons doing domestic services in their own homes, retired persons, rentiers, students without jobs, and jailed persons.

In the 1920 Census, the economic active population includes all persons with a declared profession. The population out of the labor force includes persons without profession or with undeclared profession representing 47% of the population; and persons with an ill-defined profession representing 2% of the population. These categories, in its turn, probably include retired persons, rentiers, students, jailed persons, as well as those doing domestic services in their own households since declared domestic servants represent only 4% of women older than 15 years of age.

In the 1872 Census, there is no explicit definition of labor force though population was surveyed according to professions. The criteria adopted in this survey, however, seems quite different from the other censuses since counting every person with a declared profession, the labor force adds up to six million people, approximately, or 60% of total population. This figure is extremely high when compared to the other censuses. Thus, the share of the population in the labor force remains between 30% and 33% in the censuses from 1920 to 1970, and thanks to increased labor force participation, jumps to 36%, 40%, and 46%, respectively, in the censuses of 1980, 1991, and 2000.

To circumvent this problem, the definition of labor force adopted in the analyses is the sum of free male population between 16 and 60 years old with male and female slave population between 11 and 60 years old. For the whole country, this hypothesis implies a labor force equivalent of 34% of total population. The differences between the two definitions are thus quite significant and the last definition is preferred because it sounds more reasonable when compared to other census years. One should keep in mind, however, that the age classes adopted in the definition of the labor force as well as the exclusion of free women are quite arbitrary assumptions.

(5) Human capital

Proxies of human capital are given by simple literacy ratio of the labor force (16-60 years of age) available in the Demographic Censuses since 1872.

(6) Geographic variables

Up to the 1991 Census, geo-referenced information at municipal level for Brazil was scarcely available.[6] Thus, the geographic variables available at municipal level were restricted to latitude (LAT_GMS), longitude (LONG_GMS), altitude (ALT_M) and the distance to the sea (DSHOR) of the seat of municipalities. For the censuses of 1991 and 2000 it became possible to superimpose geographical attributes on the maps of municipal networks and, thus, by the aggregation of municipalities in minimum comparable areas (MCA) it is possible to obtain other geographic variables for all for different inter-census periods.

Soil attributes were obtained from IBGE/EMBRAPA geo-referenced interpretations of satellite images from recent decades (Reis et al. 2007). The variables available for the analysis are the geographic area in square kilometer; the proportion of the area in 7 classes of altitude in meter (PALTx); in 3 classes of soil susceptibility to erosion or declivity (in degrees) (PEROx); in 4 classes of soil agricultural quality (PPTNCx); in 13 classes of soil geo-morphological conditions (PSOLOx).

Georeferenced climate data were obtained from interpolation of historical observations from Brazilian meteorological stations constructed by the Climatic Research Unit of the University of East Anglia (CRU/EA). Historical data from 1900 to 2006 include data on the average precipitation (PRE30) and temperature (TMP30) of municipalities in the different seasons of the year, namely, summer (December to February), autumn (March to May), winter (June to August), and spring (September to November). More precise measures given the larger number of meteorological stations are the seasonal averages for the period 1961-90 (Reis et al. 2007). Since the figures are average values for a thirty years period, for most of the analysis it is fair to assume that they are time invariant as other geographic variables.

Finally, variable dummies were used to capture the differential fixed effects of states (DUFxx where xx refer to the IBGE state code and RJ (Rio de Janeiro) is defined as default for dummies)

6 By the end of this year, IBGE is expected to publish georeferenced database on municipal division in Census years since 1872 (IBGE 2011)

Table A1: Brazil: Number of Municipalities in Census Years and of Minimal Comparable Areas (MCA) in Inter-Census periods, 1872-2000

Census years	Number of municipalities	Inter-census periods	Number of MCA
1872	643	1872-2000	432
1920	1305	1920-2000	952
1940	1575	1940-2000	1275
1950	1891	1950-2000	n.d.
1960	2768	1960-2000	2407
1970	3974	1970-2000	3659
1980	3991	1980-2000	3692
1991	4491	1991-2000	4267
2000	5507		-

Source: IBGE and IPEA.

Figure A1: Brazil: Minimum Comparable Areas for Census years 1872 and 2000

Source: Reis et al. (2007)

Obs.: The MCA for the period 1872-2000 does not include the State of Acre because it was part of the territory of Bolivia in 1872.

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