THE ROLE OF NON-MOVING FACTORS OF PRODUCTION IN BRAZILIAN REGIONAL DISPARITIES*

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RESUMO É comum pensar que qualquer tipo de desigualdade regional implica em ineficiências regionais. No entanto, é possível que essas desigualdades ocorram mesmo em condições de alocação eficiente de recursos. Nestes casos, a adoção de políticas públicas corretivas pode piorar ainda mais a alocação dos recursos. Este artigo esclarece esses conceitos e mostra que a existência de fatores de produção não móveis, tais como a distribuição espacial de infra-estrutura econômica não determinada pelo mercado e localização dos recursos naturais, pode levar a desigualdade regional. Evidências empíricas indicam que essas fontes desempenham um papel relevante para explicar as disparidades regionais no Brasil. Portanto, políticas públicas que pretendam reduzi-las podem aumentar a ineficiência no país e reduzir o bem-estar social, se não levarem em conta esse problema.

Código JEL: R10, R11

Palavras-chave: Desigualdade Regional, Alocação ineficiente, Políticas Públicas, Bem-estar Social

ABSTRACT It is common to think that any regional inequality implies in regional inefficiency. Nevertheless, it is possible such inequalities arise even under an efficient allocation of resources. In these cases, policies can actually worsen resources allocation. This paper clarifies these concepts and shows that the existence of non-moving factors of production, such as non-market led economic infrastructure spatial distribution and natural resources can lead to optimal regional inequality. Some empirical evidence indicates that such sources of regional disparities play a relevant role on regional inequalities in Brazil. Therefore, public policies to reduce them can raise inefficiency within the country and reduce social welfare, if they do not take into account such problem.

Key-words: Regional inequality; Inefficiency Allocation; .Public Policies, Social Welfare.

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1. Introduction

Brazil has tremendous regional disparities. While the most developed states and micro-regions have per capita GDP close to those of some European countries, there are some of them whose production per capita is similar to those of African countries. For example, the per capita GDP of Distrito Federal was US$ 26,049.75 in 2005, when corrected for purchasing power parity. It is higher than the one of Portugal (US$ 19,800.00) and Greece (US$ 24,000.00) in the same year. On the other extreme, the per capita GDP of Piauí, the poorest State in Brazil, was US$ 2.792,00 in 2005, when corrected for PPP, which is similar to the one of countries such as Gambia, Ghana and other African countries.

There are many versions for the origin of these per capita differences. They go from the availability of natural resources to the hypothesis that the region has been locked in by historical events[1] and that differences in human capital availability are responsible for most of the regional disparities.[2] More recently, the role of institutions has also been emphasized, although it is still not yet formalized academically. Most of these ideas are regional application of theories of development and disparities among countries to the Brazilian Regional Problem.

In spite of all the literature trying to explain regional disparities in Brazil, there is not much empirical tests of the relative role of the many potential sources pointed in the literature. Even the most basic ideas, which relies on the hypothesis that natural resources have a share of the blame for these disparities has not been properly tested until recently. Azzoni et. Al. (2000) has recently used a model in which some natural resource data, such as rainfalls, is included as one of the explanatory variables for per capita income differences and some positive results are found.

This paper focuses on the test of one of these potential sources of regional inequality in Brazil. Particularly, it stresses the role of non-moving factors of production, as land quality and non-economically determined economic infra-structure. A theoretical model is presented, which stresses the role of natural resources on regional income disparities, and some empirical tests are made to try to grasp the potential role of this factor on current inequalities. Before that, however, section 2 forwards a brief survey on the per capita GDP and personal income disparities in Brazil. Section 3 emphasizes the difference of regional disparity, inefficiency and problem, which is crucial to understand the real nature of regional problem in Brazil. Section 4 presents a model that stresses the role of the availability on non-moving factors of production on regional disparities and section 5 presents the method used to estimate the role of these factors on Brazilian State per capita GDP and some empirical results. Section 6 summarizes the major conclusions of the paper.

[1] See for example Furtado (1959) and Cano (1977).
[2] See for example Pessoa (1999).

2. Disparity in per capita GDP and personal disposable income

Per capita GDP in the many regions in Brazil have a long-term trend to converge. This can be seen in figure 1, which brings a dispersion index for this variable since 1940 to 2005. The dispersion index used is the rate of absolute values of deviations from average per capita GDP divided by average per capita GDP for all regions together. More formally, this index may be defined as:

$$Dispersion\ index = \frac{\sum_{i=1}^{n}\left|x_i - \frac{1}{n}\sum_{i=1}^{n}x_i\right|}{\sum_{i=1}^{n}x_i} \quad (1)$$

Where x_i is the per capita GDP of region i, n is the number of regions in the country, which is 5, and || defines the absolute value of the variable within it. This index calculates the average dispersion around the mean of the per capita GDP as a proportion of the average per capita GDP.

There are three time series for the dispersion index in figure 1. The one labelled as regional is calculated for average per capita GDP by region. The one labelled as All States includes all States for which there are data for the specific year in which the index is calculated. The one labelled as Selected States only includes the states for which there are time series for the whole period.[3]

The time series for all the three dispersion indexes clearly present a mild long term declining trend. Therefore, it is possible to say that there is a long-term convergence in State and regional per capita income in Brazil since 1940, although it is a very weak long-term trend. If the speed of fall in per capita GDP differences, as it was found between 1940 and 2005, prevails next years, full convergence between per capita GDP for the richest region (Southeast) and the poorest region (Northeast), will take 450 years. Therefore, the convergence rate found is very mild.

Although there is this mild long-term convergence, it is possible to identify five different periods in this series. The first one reveals an increase in the dispersion of regional per capita GDP. It goes from 1939 to 1951 in regional data and up to 1956 in States data. The second one goes from 1951 to 1961 in regional data and up to 1968 in State data. It had a fall in dispersion. This difference indicates that while regional dispersion had already ceased to fall, intra-regional disparities were still falling. In the third period there was an increase in dispersion of per capita GDP. It extends from 1961 to 1975 in regional data and from 1968 to 1976 in State data. The fourth period had a fall in the dispersion of regional per-

[3] Not all States have series for the whole period because some of them were created or transformed in States in the period covered by the Data. It indicates the States for which there are data for the whole period.

capita GDP and extends from 1975 to 1986 in regional data and goes from 1976 to 1987 in State data. From 1986 to 2005 there was no clear trend on the dispersion of per capita regional GDP, although State data seems to indicate a very mild increase in dispersion of per capita GDP.

There are many reasons forwarded in the literature to justify these different convergence behaviours along the recent Brazilian history. Table 1 brings a summary of the periodization of the convergence of per capita regional GDP and some of the causes pointed for the particular behaviour in each period. There are also references for each argument presented. Neither the arguments nor the references are exhaustive, but they already give a view of the ideas that could justify behaviours that differ from the simple convergence predicted by theory.[4]

Disparities in regional per capita GDP in Brazil are high. Figure 2 shows two different time series. The first one is for the share of this variable for Northeast, the poorest region within the country, in the national average. The second one is for this same share, but now calculated to the average of the richest region in the country, which is Southeast. While the first share is around 50% in the last years in the series, the second has been under 40% in the first years of the current century. The two poorest States in the country, Piauí and Maranhão, had per capita GDP that reached less than 20% the one of São Paulo and Rio de Janeiro the two most important States in Brazil.[5] This can be seen in figure 3, which brings the per capita GDP for the many Brazilian States in 2005. This same figure also indicates that all States in the lowest end of the ordered per capita GDP are either in Northeast or North. The only exception is Tocantins, which is often placed in North, instead of Center-West. All these statistics show that disparity in income is high in Brazil.

Figure 4 brings a comparison of two different statistics, per capita GDP and per capita income. They are both for 2005, the last year for which figures for GDP are available. It shows that all States that are poorer than São Paulo have a higher share of per capita income than they have of per capita GDP, when compared to the one prevailing in São Paulo. Amazonas, a relatively isolated state, is the only exception for this. Rio de Janeiro and Distrito Federal have a higher per capita GDP than São Paulo and they also have a larger share of per capita GDP than per capita income.

The major differences between per capita income and per capita GDP are transferences, which are generated by cross State properties of factors of production and income transferences made by the Federal Government, as retirement. As successful businesses in Brazil normally tend to expand to the largest markets in the country, which is normally in the richest States, there is a lot of non-residents that have property rights to capital invested in the richest States. This to some extent could explain this difference in per capita GDP and income. Nevertheless, companies originally settled in São Paulo or other richer states also tend to expand

[4] See Barro and Sala-i-Martin (1995) for a general presentation of the theoretical argument supporting the existence of convergence of per capita GDP.

[5] It is worth noting that Distrito Federal (DF), where the Brazilian capital is located, is the richest federative unit in the country. São Paulo and Rio de Janeiro are normally considered two be the richest states, as DF is not a State and its reality is very particular. That is why it was not considered as the parameter here.

to poorer states and regions in the country, so that there is a lot of property rights on capital employed in other States whose original ownership belongs to residents of the richest ones. Therefore, it is not clear if this cross state borders of capital ownership is the actual responsible for the pattern found in figure 4.

Figure 5 brings a dispersion graphic of the proportion of per capita income to GDP as a function of per capita GDP, all the variables measured as a proportion of it for the State of São Paulo. This figure also brings a trend line so that it is possible to see that the lower is per capita GDP, the higher is the proportion of income to GDP in the State. If cross border property of capital was the only explanation for this, it would be necessary to believe that the lower is the GDP in a State, the higher the share of capital property in other States its residents would have, so that the highest the ability to expand to other States the business settled in this state would have. As this hypothesis is counter-intuitive, it is more reasonable to suppose that government transferences, mainly through retirement, is the major responsible for the divergence between per capita GDP and per capita income in Brazilian States.

These differences between disparities in per capita GDP and income reduce substantially regional disparities. For example, the share of the non-weighted average per capita GDP on the three poorest states to the one in the three richest states was 17.8% in 2005. When this same share is calculated for per capita income, this simple inverse measure of regional disparity rises to 35.4%. Therefore, transferences and cross border properties reduce state disparities by half when they have this measure.

3. Concepts of regional problem, disparity and inefficiency

In the regional literature, it is common to confuse the concepts of regional disparity or inequality, regional problem and regional inefficiency. Only the two last situations would justify regional policies, as it is possible to improve standards of living through government interventions when they exist. This confusion leads to inadequate policy proposals and misplaced justification for them. Therefore, as the presentation of one source of regional disparity is the object of next sections, it is crucial to understand its consequence for the existence of regional problem and inefficiency.[6]

A regional disparity exists when:

$$x^a = \frac{1}{n}\sum_{i=1}^{n} X_i^a \neq \frac{1}{m}\sum_{i=1}^{m} X_i^b = x^b \qquad (2)$$

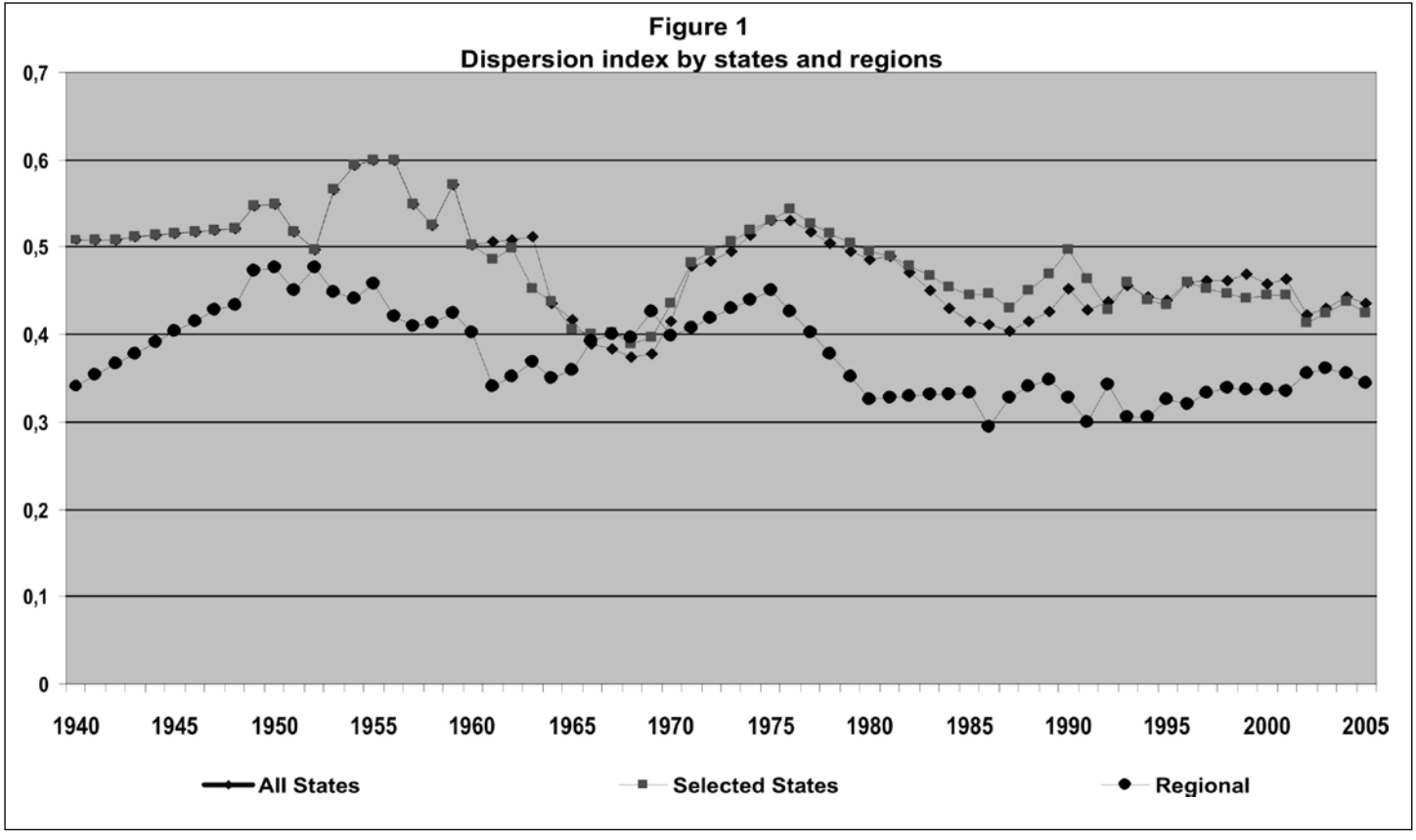
[6] See Barros (2004) for a formal and detailed discussion of the differences on these concepts.

Table 1
Periodization of trend in the Brazilian Regional inequality

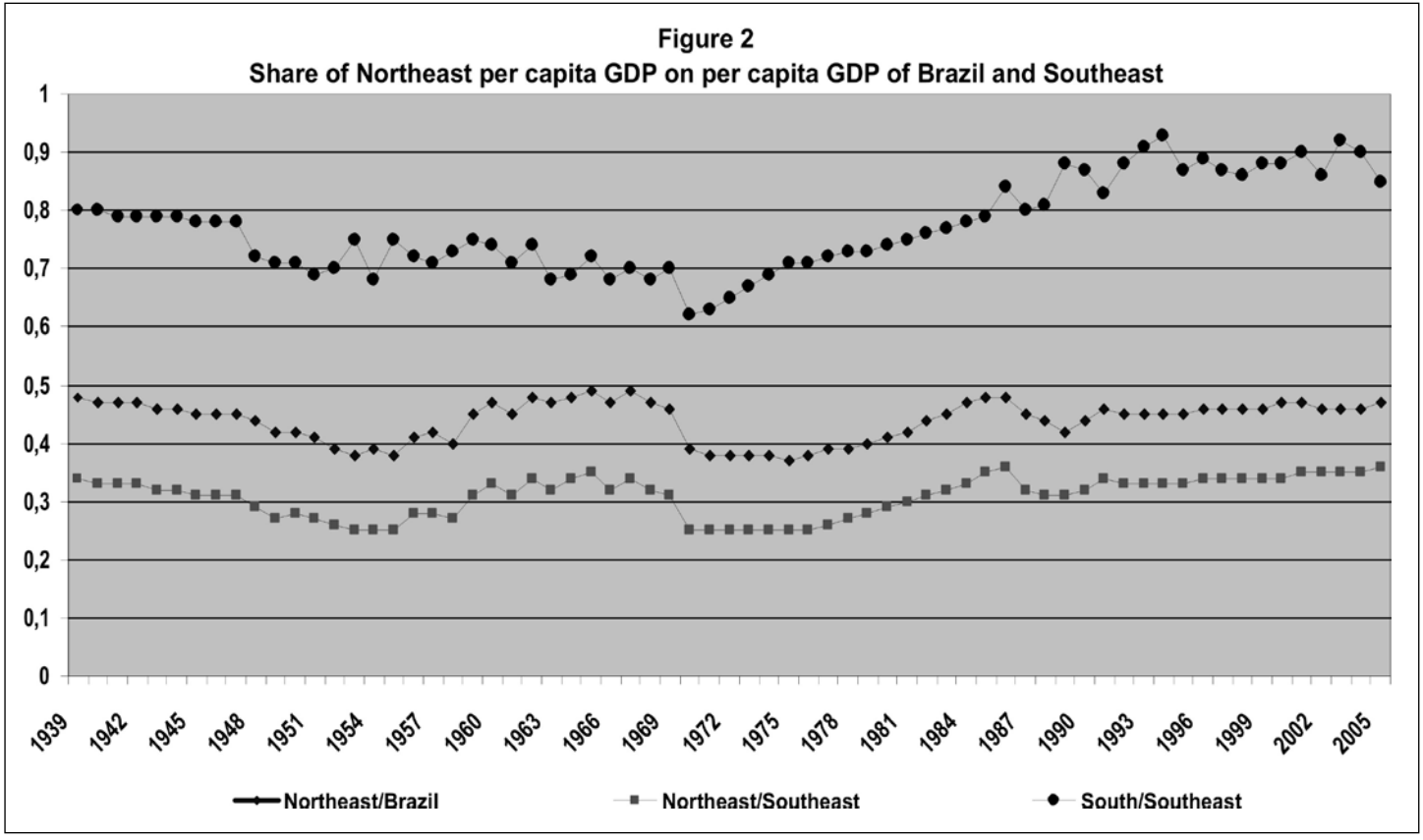
Period	Duration (years)	Convergence	Possible explanation	References
1939-1951	12	Divergence	Industrialization in São Paulo led to nationalization of industrial markets and closing of local industrie s. This led to concentration of GDP in São Paulo and losses in other regions.	Furtado (1959) and Wilson Cano (1977).
1951-1961	10	Convergence	Expansion of other regions to produce goods to São Paulo and natural trend to convergence.	
1961-1975	14	Divergence	New upper hill cycle of industrial expansion in São Paulo with import substitution of intermediate and capital goods focusing in the national market. Industrial expansion led GDP growth within this national logic.	Conceição Tavares (1973)
1975-1986	11	Convergence	Regional development policies had a positive impact on disparity reduction.	Ferreira Irmão and Gomes (1992).
1986-2005	17	No trend	New model of development incorporating technologies more human capital intensive, which were more available in the richest regions offset propensity to convergence as pointed by theory.	Barros (1994).

Source: Authors estimations.
Note: All models estimated by ordinary least squares (OLS) had correction for heteroskedasticity by the method of White (1980).

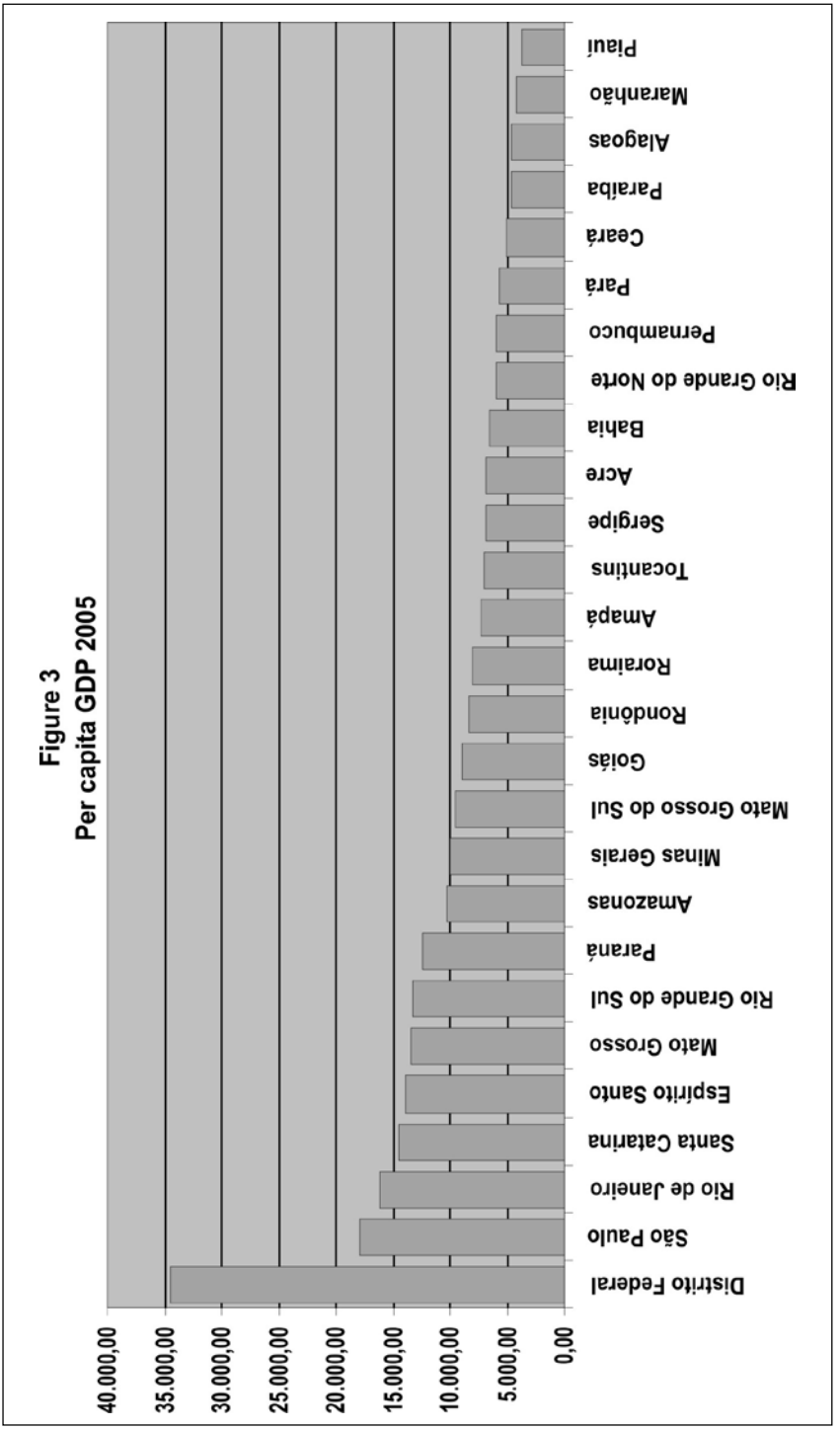
Figure 1
Dispersion index by states and regions



Source: Authors elaboration with data from IPEADATA.

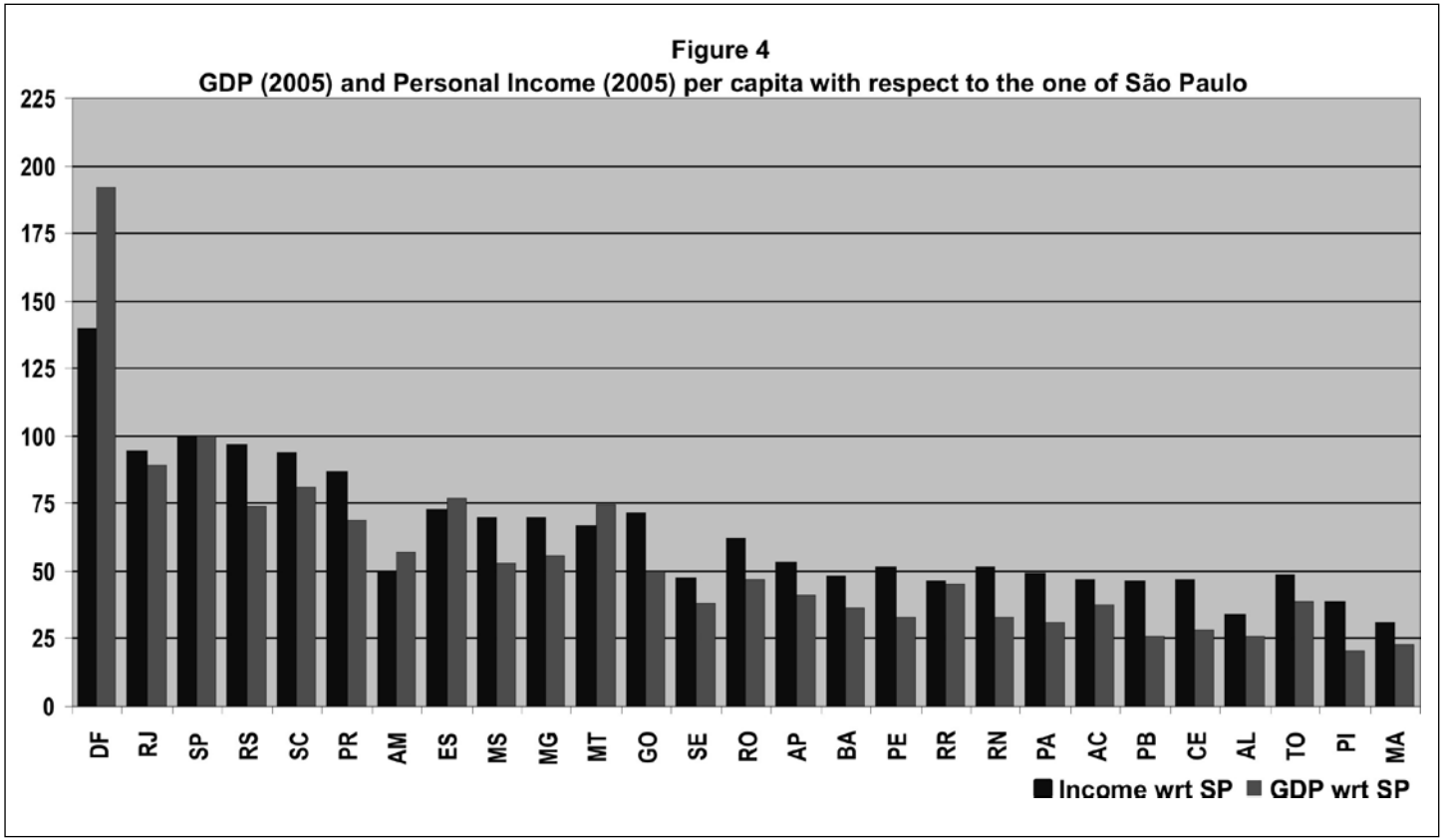


Sources: Calculated with date from IPEA and IBGE.



Source: IBGE: Regional Accounts, new series.

Figure 4
GDP (2005) and Personal Income (2005) per capita with respect to the one of São Paulo



Source: GDP per capita is from Regional Accounts IBGE and Personal income is from PNAD-IBGE.

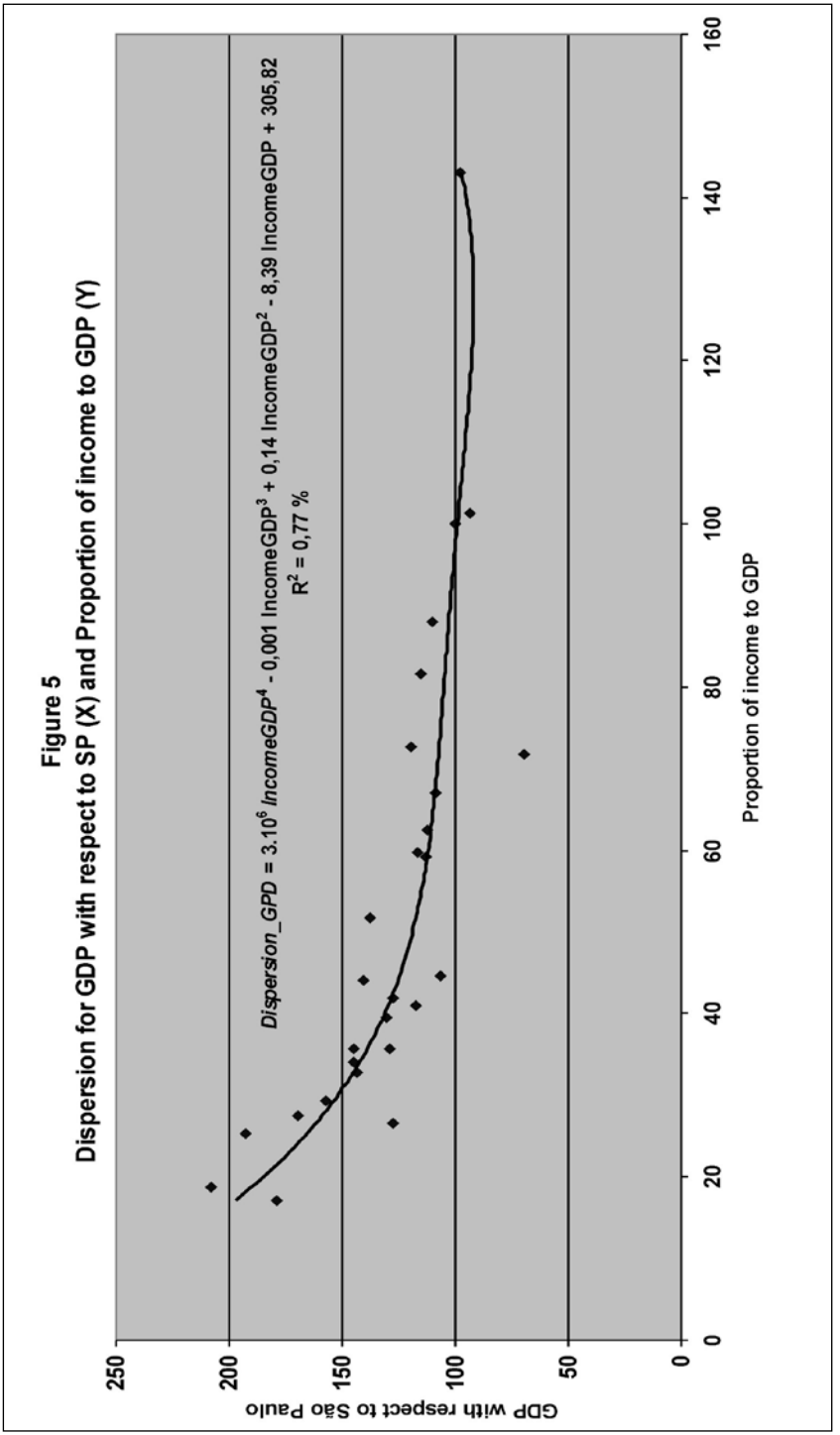


Figure 5
Dispersion for GDP with respect to SP (X) and Proportion of income to GDP (Y)
Dispersion_GPD = 3.10^6 IncomeGDP^4 - 0,001 IncomeGDP^3 + 0,14 IncomeGDP^2 - 8,39 IncomeGDP + 305,82
R^2 = 0,77 %
GDP with respect to São Paulo
Proportion of income to GDP
250
200
150
100
50
0
0
20
40
60
80
100
120
140
160

Where X_i^a and X_i^b are representing the incomes of all n and m individuals living in regions *a* and *b*, respectively. Therefore, x^a and x^b are per capita income in these two regions. In words, this means that there is a regional disparity when average per capita income differs in the two regions. It should be noticed that under this concept it is possible that $x^a > x^b$, although the GDP per capita in region *a* is smaller than the GDP per capita in region *b*. If there are only two regions in the economy, this would happen if a reasonable share of the per capita GDP in region *b* becomes income for agents in region *a*. Property of factors of production by such agents working in region *a* would justify such reversion. Nevertheless, although this possibility is not irrelevant, it will not be the focus here.[7]

Regional inefficiency, in its turn, exists when there is at least one alternative allocation of factors of production among regions that could make at least one agent better off than he/she is on the current one, without making anyone else worse off, relying only on distribution of additional production or redefinition of total bundle of goods and services produced.

The notion of regional problem focuses on the set of individual attributes, rather than on efficiency of resources allocation. Let us assume that there are two non-negligible sets of individuals, A and B. Everyone within each one of them lives in the same region, but those in set A live in region A, while those in set B live in region B. Furthermore, each one of these sets is formed by people who would prefer to have the standard of living of people with all their attributes, but living in the other region. If one of these sets is bigger than the other, then it is possible to say there is a regional problem. Therefore, the concept of no regional problem differs from the one of efficiency because it allows a non-Pareto optimal allocation of resources, as long as the existing inefficiencies do not bias relative income so that it offsets the role of local amenities on welfare.

4. Failure in the free flow of all factors of production

Free flow of factors of production is a basic assumption to generate equality of per capita GDP in Arrow-Debreu models type. Nevertheless, this assumption is only an approximation, as in reality there is always some transaction costs to move any factor of production among regions. Transport and contractual costs, or even taxes, are some of these costs. Whenever labour is the factor of production to move, transport is the most obvious cost, if the assumption of full information is still enforced, although re-location costs, such as transaction costs for house purchase/rent, car and all durable goods purchases are also important. Capital movement normally leads at least to taxes and contractual costs. Often it also implies in transport costs, if it is embodied in goods that can be used productively. Natural resources, whenever they can be moved, demand transport costs. Therefore, in reality all movements of factors of production have some cost. If there is not free

[7] In the literature on the Brazilian regional disparities, the regional disparities often relies on both of these concepts, taking into account per capita GDP or per capita personal disposable income.

flow of factors of production, it is possible to have different equilibrium per capita GDP. Furthermore, the emerging disparity depends on the relative availability of the fixed factors of production.

A simple model can show that inequality can emerge in a static framework, when there is not free flow of at least one factor of production. Suppose there is a country with two regions, which will be called here as region *a* and region *b*, respectively. Each one of them produces two goods, which will be called output 1 and output 2. There is only one firm producing each of the goods in each region. Firms of both regions face similar production functions for each good, which are defined as:

$$Y_{1i} = A_{1i}^{\alpha} K_{1i}^{\beta_1} L_{1i}^{1-\alpha-\beta_1} \tag{3}$$

And:

$$Y_{2i} = A_{2i}^{\alpha} K_{2i}^{\beta_2} L_{2i}^{1-\alpha-\beta_2} \tag{4}$$

Where Y_{ji} is the output of good j in region i, K_{ji} is the amount of capital used in production of good j in region i, and L_{ji} is the amount of labour used in production of good j in region i. In this economy there is a third factor of production, which cannot move among regions. It can be the available natural resources or infrastructure, for example, represented by A_{ji} in equations (3) and (4).[8] Both these potential factors represented by A_{ji} could have this same logical representation, as neither of them moves from one region to the other. All the variables are non-negative to have economic meaning, so that by assumption, $Y_{ji} \geq 0$ $A_{ji} \geq 0$, $K_{ji} \geq 0$, and $L_{ji} \geq 0$.

The parameters α and β_j are the output elasticity for good j, with respect to A_j and K_j, respectively. They satisfy the restrictions $0<\alpha<1$, $0<\beta_1<1$, $0<\beta_2<1$, $\alpha+\beta_1<1$ and $\alpha+\beta_2<1$, so that all factors of production have a positive contribution for total output. As technology flows freely among regions (assumption of free flow of information), the parameters α and β_j are the same for the two regions. Nevertheless, the availability of natural resources (or economic infrastructure) may differ in the two regions, as they cannot flow from one region to the other. Therefore, it is expected that $A_{ja} \neq A_{jb}$, for both j =1 or j=2. Nonetheless, a simplifying assumption is introduced here and the following equality is supposed to hold:

$$A_{2a} = A_{1b} = A_{2b} = 1 \tag{A1}$$

Also it is assumed that $A_{1a}>1$ so that the difference in availability of factors of production A_1 is settled. Furthermore, as $\beta_1>\beta_2$ by assumption, good one is more capital intensive. It is worthwhile noting that such good is also the one which

[8] If A_{ji} represents the stock of infrastructure, it is reasonable to assume that non-economic factors determined its spatial distribution. Politics normally is this determinant.

counts with higher availability of the natural resources used in its production in region A. Such an assumption can show the effect of a higher elasticity of output with respect to capital in the region that has a higher availability of the non-moving factor of production A_1.

Another important simplifying assumption is that both goods are tradeables and they have their prices settled in the world market, such that $P_{1a}=P_{1b}=P_{2a}=P_{2b}=1$. Of course, the particular assumption that prices are equal to one is not restrictive, as a re-definition of units could lead to such equality.

Some equilibrium restrictions are also introduced, as labour and capital can move between regions and sectors, but the total available amount of each one of these factors is previously fixed, as there is no rule for factor accumulation. Therefore,

$$L_{1a} + L_{2a} + L_{1b} + L_{2b} = L_T \tag{5}$$

And:

$$K_{1a} + K_{2a} + K_{1b} + K_{2b} = K_T \tag{6}$$

Where K_T and L_T are both fixed and positive.

Given the production functions defined in equations (3) and (4), it is possible to determine the following arbitrage conditions in the labour market, which arise from first order condition of profit maximization by firms:

$$(1-\alpha-\beta_1)\frac{Y_{1a}}{L_{1a}} = w \tag{7a}$$

$$(1-\alpha-\beta_1)\frac{Y_{1b}}{L_{1b}} = w \tag{7b}$$

$$(1-\alpha-\beta_2)\frac{Y_{2a}}{L_{2a}} = w \tag{7c}$$

$$(1-\alpha-\beta_2)\frac{Y_{2b}}{L_{2b}} = w \tag{7d}$$

Where w is the real wage rate and the other variables and parameters are as previously defined.

The market for the fixed factor of production also is susceptible to arbitrage. As the production functions are all homogeneous of first degree, Euler Equation assures that they all generate zero profit when there is payment of factors

of production by their marginal product. Therefore, no entrepreneur could pay more than its marginal product for the fixed factor of production, otherwise he/she will not be able to pay the marginal product for the other factors of production. In the same way, under perfect competition, they will not be able to pay the fixed factor less than its marginal product, otherwise other entrepreneurs will profit from a marginal bidding for this factor. Therefore, the equilibrium price for the fixed factor is also its marginal product. Furthermore, if there is no cost to move labour and capital between regions, and the price of the fixed factor of production is higher in one region than in the other, entrepreneurs will move its production from the region with higher cost for this factor to the region with lower cost. Therefore, only the same cost for these factors in the two regions will be an equilibrium. These conclusions imply that:

$$\alpha \frac{Y_{1a}}{A_{1a}} = \alpha \frac{Y_{1b}}{A_{1b}} = \rho_1 \tag{8a}$$

$$\alpha \frac{Y_{2a}}{A_{2a}} = \alpha \frac{Y_{2b}}{A_{2b}} = \rho_2 \tag{8b}$$

Where ρ_1 and ρ_2 are the returns to the fixed factors of production 1 and 2, respectively. Arbitrage assures that these returns are exactly the same in the two regions, for each of the fixed factors of production. Nevertheless, there is no reason to suppose that $\rho_1=\rho_2$, so that the most general case is that they actually differ.

Assumption (A1) and equation (8) implies that:

$$Y_{1a} = A_{1a} Y_{1b} \tag{9}$$

And:

$$Y_{2a} = Y_{2b} \tag{10}$$

Consequently, from equations (9), (10) and (7):

$$L_{2a} = L_{2b} \tag{11}$$

And:

$$L_{1a} = A_{1a} L_{1b} \tag{12}$$

Remind that there is only one firm producing each of the outputs in each region and define regional disparity as σ, such that:

$$\sigma = \frac{Y_{1a} + Y_{2a}}{L_{1a} + L_{2a}} - \frac{Y_{1b} + Y_{2b}}{L_{1b} + L_{2b}} \tag{13}$$

This concept is as straight as possible. Regional disparity is defined mathematically as the difference of per capita output in the two regions. Of course this becomes disparity in per capita income only if there is no cross property of factor of production between the two regions. All the property of factors of production employed in one region belongs to agents in that same region. The literature normally relies on per capita GDP to unveil disparity, so that the idea of per capita output is a good theoretical concept to build the representation of regional disparity, as done in equation (13).

Using equations (9) to (12) to substitute for Y_{1b}, Y_{2b}, L_{1b}, L_{2b}, it is possible to get:

$$\sigma = \frac{Y_{1a} + Y_{2a}}{L_{1a} + L_{2a}} - \frac{Y_{1a} + A_{1a}Y_{2a}}{L_{1a} + A_{1a}L_{2a}} \tag{13´}$$

Rearranging terms, this equation can be re-written as:

$$\sigma = \frac{(A_{1a} - 1)(Y_{1a}L_{2a} - Y_{2a}L_{1a})}{(L_{1a} + L_{2a})(L_{1a} + A_{1a}L_{2a})} \tag{13´´}$$

Substituting Y_{1a} and Y_{2a} from equations (7a) and (7c) in this equation:

$$\sigma = \frac{(A_{1a} - 1)wL_{1a}L_{2a}\left(\frac{1}{1-\alpha-\beta_1} - \frac{1}{1-\alpha-\beta_2}\right)}{(L_{1a} + L_{2a})(L_{1a} + A_{1a}L_{2a})} \tag{14}$$

As $A_{1a}>1$, as determined by assumption, the fact that all variables only have an economic meaning when they are positive implies that $\sigma>0$ if $\beta_1>\beta_2$.[9] Furthermore, there is no regional disparity only if $\beta_1=\beta_2$ and the production functions of both goods are equally intensive in capital. It is also possible to see that if $\beta_1<\beta_2$, the region with higher availability of one of the fixed factor of production has lower per capita output. These conclusions support the following statement:

Proposition 1: An economy with two regions that produces two different goods can generate regional disparity if one of these goods is more

[9] In fact variables have economic meaning when they are non-negative. Nevertheless, Inada conditions for optimization of firms in models with Cobb-Douglas production functions assure that the equilibrium values of all factors of production, in each firm and in each region, are positive.

capital intensive in its production function and there is different availability of a factor of production that cannot move between the two regions.

This proposition can be generalized to more than two regions and more than three factors of production used by each firm, with more than one fixed. It would, then state:

Proposition 2: An economy with many regions that produces many different goods can have regional disparity if there are different availability of non-moving factors of production that generate regional specializations such that the bundles of goods produced in the many regions have different capital intensities among them.

5. Measuring differences in availability of non-moving factors of production

The model presented before is static, as it focuses on a potential equilibrium of per capita income among regions. A dynamic framework would indicate that, at least while the economy does not reach equilibrium with full use of all natural resources, the regions with higher availability of natural resources, either in quantity or quality, would grow faster.

Natural resources for Economics have a different meaning from its intuitive concept. The same amount of a still non-explored given mineral, say crude oil, would not have the same economic value if it is placed in distinct regions whose access and cost for channelling it for effective use in society is not the same. An oil reserve in the middle of the Amazon forest, with no access, has a value completely different from the same reserve near the producing region in Bahia. Therefore, all the time, while economic infrastructure is changing, natural resources availability is also changing.

Therefore, the stock of economically evaluated natural resources is not fixed in any region. Actually, the process of development expands the access to the many sources of natural resources. Roads and electricity access expansions, new cities in new areas, and the consequent easier access to labour force to explore some natural resources dependent activities are some of the major sources expanding the effective base of natural resource in any region. This is mostly true in a country with a still opened agricultural frontier, as Brazil.

The case of quality of land is an important one under this dynamic concept, as land is the most economically relevant natural resource. Two regions with different quality of lands tend to have different prices for their lands. These prices will be determined by the present value of future returns these lands can offer. Therefore, the relatively more productive land tends to have higher price.

This relative productivity has two determinants. The first one is its physical quality, which includes, soil features, access to water, rainfall distributions, among other factors. The second determinants are its locational attributes, such as road and electricity access, proximity to labour and goods markets, among others. While the former tends to change little, the second can change radically as a consequence of human action.

In a dynamic economy, there is always the need to expand the used land, as population and welfare grow. Whenever there is a need to expand access to new lands and there is free flow of capital and labour from one region to the other, the new expansion, through infrastructure building, will be directed to the relatively more productive land. Nevertheless, while this happens, the newly usable land in the most productive region get further and further from the major markets. Therefore, its economic efficiency tends to fall, as production and transport costs rise. Eventually, it becomes more efficient economically to expand infrastructure in the technically relatively less efficient region, as costs there become lower than in the former region. Eventually the economic marginal efficiency of lands tends to be the same in both regions.

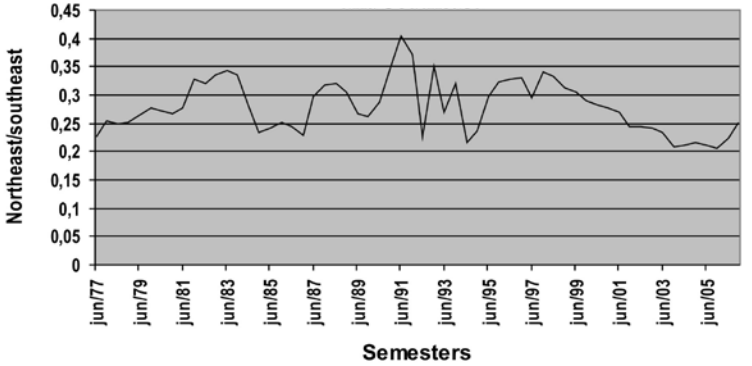
While the economy keeps expanding, the two regions will have their agricultural frontiers expanded. Nevertheless, the region with physically better lands will continue to pay higher rent for lands and consequently to have higher prices for their land. Whenever, the price of land increases relatively in one region, because of higher demand, it gets cheaper to expand in the other region. If transport costs are low proportionally, it is possible to have relative prices of lands quite stable over time. Figure 5 shows the relative prices of land in Northeast and Southeast Brazil, the two most populous regions in the country. It can be seen that between 1977 and 2006, these prices were relatively stable. Whenever it departed too much from its long-term equilibrium, there was a trend reversion.

Given this possibility, the test of the impact of natural resources on regional disparity in Brazil started with a cross section regression on State data for the equation:

$$y_t = \alpha_0 + \alpha_1 Y_{t-n} + \alpha_2 \ln E_{t-n} + \alpha_4 \ln L_{t-n} + \alpha_5 \ln P_{t-n} + e \qquad (15)$$

Where y_t is the average growth rate of per capita GDP within the period, which is 1985 to 2005, Y_{t-n} is the natural logarithm of per capita GDP in 1985, ln E_{t-n} is the natural logarithm of average schooling years in 1985, ln L_{t-n} is the natural logarithm of land prices for crops in 1985 and ln P_{t-n} is the natural logarithm of State population in 1985. This regression is able to give the role of the quality of natural resources, which has price of land as its proxy, on the average growth rate of per capita GDP.

Figure 6
Relative prices of lands in two Brazilian regions: Northeast and Southeast



Source: Data from FGVDADOS.

Data for per capita GDP and average schooling comes from IBGE. Data for land prices came from FGVDADOS. It is collected twice a year (June and December) and the price for each year was the average for these two samples, with deflation by IGP-DI (índice geral de preços, disponibilidade interna).

Table 2 brings the results of estimations of equation (15). Some alternative results are presented, with versions of this equation, including or excluding some variables and under alternative estimation procedures (OLS with correction for heteroskedasticity by the method of White (1980) and Least Absolute deviations). The results indicate that the hypothesis that land prices affect the average growth rate of State per capita GDP is quite robust for the method of estimation or the model specification. In all estimated equations this price always has a positive impact on the growth rate, which is positive and significantly different from zero, given standard p-values.

Given these results, an exercise was made. An original benchmark was fixed in 1850, year in which the coffee boom in Brazil was still starting. This boom is often seen as the source of regional disparities within the country, as it generated the conditions for industrialization in São Paulo. The per capita GDP was fixed as the same for all states within the country, and consequently, for all regions, in this initial year. Since then, the growth rates of these per capita GDP were also fixed as the same plus a premium defined by the term $(\alpha_4 \ln L_{t-n})$ from estimations in equation (15). More rigorously, all state per capita GDP growth rates were fixed as:

$$g_{yi} = g_0 + \alpha_4 \, Ln \, L_i \qquad (16)$$

Table 2
Estimation results of alternative specification of equation 13

Estimation procedure		Constant	Y_{t-n}	Ln E	Ln L	Ln P	Dummy for Mato Grosso	Dummy for Sergipe	R^2
Estimation by Least Absolute Deviations	Coefficient	0.1337	-0.0210	0.0058	0.0060	-0.0001	0,0246		
	T-Statistics	3.71	-3.28	0.69	2.16	-0.04	3.49		
	p-value	0.0017	0.0045	0.4970	0.0455	0.9658	0.0028		
OLS	Coefficient	0.0982	-0.0200	0.0101	0.0044	0.0022	0.0268		0,70
	T-Statistics	2.82	-2.91	1.20	1.71	1.47	17.58		
	p-value	0.0049	0.0036	0.2314	0.0871	0.1426	0.0000		
OLS	Coefficient	0.0828	-0.0126	-0.0027	0.0040	0.0004	0.0263	-0,0166	0,76
	T-Statistics	2.53	-2.07	-0.41	1.93	0.34	17.96	-3,91	
	p-value	0.0113	0.0385	0.6800	0.0540	0.7311	0.0000	0,0001	
OLS	Coefficient	0.1281	-0.0239	0.0117	0.0064	0.0012			0,40
	T-Statistics	2.92	-2.90	1.25	1.97	0.69			
	p-value	0.0035	0.0037	0.2112	0,0491	0.4889			
OLS	Coefficient	0.1395	-0.0234	0.0091	0.0072				0,39
	T-Statistics	3.42	-2.73	1.00	2.26				
	p-value	0.0006	0.0064	0.3165	0.0237				
OLS	Coefficient	0.0849	-0.0120	-0.0043	0.0043		0.0260	-0,0177	0,76
	T-Statistics	2.86	-1.99	-0.62	1.98		24.34	-4,75	
	p-value	0.0043	0.0466	0.5336	0.0479		0.0000	0,0000	
OLS	Coefficient	0.1196	-0.0194	0.0056	0.0059		0.0254		0,66
	T-Statistics	3.31	-2.55	0.65	2.13		21.37		
	p-value	0.0009	0.0108	0.5131	0.0334		0.0000		
Estimation by Least Absolute Deviations	Coefficient	0.1324	-0.0210	0.0060	0.0060				
	T-Statistics	3.29	-2.64	0.63	1.88				
	p-value	0.0039	0.0162	0.5369	0.0754				

Source: Authors estimations.
Note: All models estimated by ordinary least squares (OLS) had correction for heteroskedasticity by the method of White (1980).

Where g_{yi} is the growth rate of per capita GDP in state i, g_0 is a basic growth rate, which is equal for all states and α_4 and Ln L_i are as previously defined. The basic growth rate g_0 was set so that the average growth rate of per capita GDP for all states together, the national growth rate, was equal to the yearly average growth rate of this variable for the period 1901-2006. The results for such exercise appear in table 3.

The results indicate that the proportion of Northeast to Southeast per capita GDP under these assumptions would be between 19.34% and 39.18%. The real number in 2005 was 39.3%, quite close to the estimated results. It should be stressed that the simulated model assumed that:

i. There was no regional disparity in 1850.
ii. All regional disparity emerging since 1850 could be explained by the relative productivity of lands.
iii. The relative prices of land in the many states in Brazil in 1985 reflected the differences in relative productivity of lands as they were in the whole period between 1850 and 2005.

If these assumptions are close to reality, comparison between the estimated proportion between per capita GDPs and the actual value found in reality would indicate that if not all, at least a large share of current differences of per capita GDP could be explained by differences on quality of lands. The estimated extreme values for this share according to values in table 3 would be 99.7% and 49.2%. In either case, the role of quality of lands is high and no analysis of regional disparities in Brazil should disregard the role of natural resources availability as one of its major determinants.

Table 3

Estimated share of per capita GDP for Northeast and South under the assumption that these variables were the same for all states in 1850 and the growth rate of this variable for the whole country was the equal to the average found for the period 1901 to 2006

Coefficient for natural logarithm of land prices	Share of Northeast on Southeast per capita GDP (%)	Share of South on Southeast per capita GDP (%)	Basic growth component for all States
0.004	39.18	107.01	0.01291
0.005	31.56	109.35	0.00462
0.006	25.54	111.93	-0.00373
0.007	19.34	115.81	-0.06062

Source: Estimated by the author.
Note: The assumption that the share of each state in national population in 1850 was the same as in 2005 was introduced to make the aggregation for the whole country from per capita GDP for individual states.

Data for a comparison of per capita GDP in the South region to the one of Southeast was also included in Table 3. This data says that if the assumptions made are correct, per capita GDP in South should be between 107.01% and 115.81% of

the one of Southeast. The actual figure for 2005 was 96.3%. This would indicate that under these assumptions South Region would have had a relative loss on its potential growth, given the quality of its land.

6. Conclusions

Many are the potential sources of regional disparity the literature has presented. Among them, there are differences in availability of natural resources, as recently stressed by Barros (2007). Nevertheless, whenever this is the only cause of regional disparity, a public sector that moves some factors of production from one region to the other, what could be done through taxes and subsidies, for example, will generate a new allocation of resources that will not be socially optimal. Decreasing marginal return for each factor of production assures that the region which gets more moving factors of production will add up to its total output, given the prevailing world prices, less than the region that loses factors of production will face in reduction of its output, as a consequence of this fall in the availability of factors of production. Therefore, there is no way to gain economic efficiency through regional policies in this case. This implies that there is not *regional inefficiency* in this economy, though there is *regional disparity*.

Although very popular journalistically, the hypothesis that regional disparity in Brazil emerges from differences in availability of natural resources has been disregarded as relevant by the literature on regional inequality in Brazil, but with almost no reliance on empirical support. The simple argument that other countries have developed over a poor natural resources basis is the major argument to scratch this hypothesis. Nevertheless, its theoretical support implies that the actual role of such source has to be better analyzed and, if possible, estimated so that a better understanding of the regional problem in the country is understood.

This paper has made some exercises indicating that the role of regional availability of natural resources in explaining Brazilian regional disparity is not negligible. It actually can easily respond for half of the major difference, which is the comparison of per capita GDP in Northeast and Southeast, the two most populous regions in the country. Therefore, its role cannot be disregarded when policy instruments are proposed.

Under these circumstances, it is worth noting that the regional disparity emerging from differences in natural resources availability does not lead to the existence of a *regional problem*. By arbitrage, all individuals that move from one region to the other will be able to get the same income as before migration. As the payments for capital and labour are exactly the same in the two regions, by the assumption of perfect arbitrage among regions, these two factors of production belonging to any individual will have the same income, if he/she is employing them in any of the regions in the country. Therefore, if amenities are exactly the same in the two regions, there is no reason someone would prefer the standard of living of any person with the same attributes that lives in the other regions.

Nevertheless, the existence of natural resources availability as a major source of regional disparities in Brazil does not mean that no regional policy is

the ideal policy. It was argued that the economic meaning of natural resources can change as a consequence of public policies. To build economic infrastructure, such as roads, ports, airports, energy supply infrastructure and access to water in dry regions are some of the actions that can increase the productivity of local natural resources in the poorest regions. Such policies can offset part of the regional inequality with no negative effect on social welfare, as long as the allocations of resources for such actions are economically efficient.

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