**Development accounting exercises for the Brazilian states: 1970 - 2000**

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Abstract

In the present article, the income per worker level development accounting for the Brazilian states were carried out for the 1970, 1980, 1990 and 2000 years. It was noticed that, in 1970, both types of capital stock and Total Productive Factor (TPF) gaps were associated with the Brazilian states lower relative income in comparison to São Paulo state. Over the decades up to the year 2000, the Brazilian states have pass through a relevant capital deepening process, which explain the income per work catch-up. However, the TPF gaps in relation to the reference state remains considerable and the reduction of these gaps are fundamental to the maintenance of the Brazilians states income per worker catching-up process. The conclusions remain when the analysis is carried out with the major Brazilian regions as units of analysis and for distinct *proxies* of physical and human capitals.

Keywords: level accounting; economic growth; total factor productivity

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1. **Introduction**

The income per worker decomposition – adaptation of Solow (1957) paper -, came to prominence with Hall & Jones (1999). The authors quantified the relative roles of physical capital, human capital and Total Factor Productivity (TFP) in the income inequality between countries, concluding that it is mainly associated to the difference in productivity.

The objective of this article is to carry out the development (or level) accounting exercise based on Solow (1957) and Hall & Jones (1999) for the census of 1970, 1980, 1999 and 2000, focused on the product evolution per worker, production factors and TFP of Brazilian states in relation to the São Paulo state (reference).

There are many studies that analyze the Brazilian TFP evolution in the attempt to verify the importance of each factor of production TFP in GDP, for example, Alston et al. (2010), Barbosa Filho et al. (2010), Ferreira, Ellery & Gomes (2008), Bacha & Bonelli (2005), Gomes, Pessôa & Veloso (2003), and Bonelli & Fonseca (1998). However, few development accounting studies were carried out for the Brazilian states. Thus, additional evidences help to understand the contribution of each production factor and TFP in the relative economic success or failure in each Brazilian state.

Another contribution of this study is to use different human capital *proxies* to add its qualitative aspect, in addition to testing a series of *proxies* for physical capital, due to the difficulty of measuring this variable for the Brazilian states. When comparing the results with the different *proxies* for both types of capital, it is possible to be more confident in the results found.

The empirical results indicate that there has been an approximation of GDP per worker of the Brazilian states comparing to that of São Paulo state basically through the increasing in the capital-product and capital-labor ratios. The relative human capital and relative TFP variations were very small in the Brazilian states average, between 1970 and 2000.

When introducing a *proxy* to measure qualitative aspect of human capital, it is noticed a greater gap of this production factor among the Brazilian states and the reference one. This is because the states with higher amounts of human capital are precisely those with better quality. For example, the state of São Paulo is one of those which have higher amounts of human capital and the state with better quality, in accordance with the Basic Education Development Index (IDEB) of 2005.

As a result, when we consider this production factor qualitative aspects, there is a gap reduction of the Brazilian States TFP in relation to the reference state, because the quality difference, when not considered in the analysis, ends up being captured by TFP. Even with the inclusion of human capital qualitative aspects, TFP continues being the main variable to explain the income differential between the Brazilian states, which complies with other empirical studies applied to the Brazilian states data, such as Ferreira (2010) and Tavares et al. (2001).

When using different *proxies* to measure physical capital stock, certain regularity is noticed in the results, such as the relative increase of the capital-product and capital-labor ratios, between 1970 and 2000. The exception is when it employed a physical capital *proxy* based on the Brazilian states industrial electric energy consumption, indicating that it does not accurately captures the productive physical capital in the Brazilian states. The *proxy* based on the industrial energy consumption can underestimate the productive capital of Brazilian states comparing to the reference state. The most appropriate *proxies* seem to be those based on the studies of Reis et al. (2005) and Coelho (2006).

In addition to this introduction, in the second section is presented the methodology, the data used and its corresponding sources, and the development accounting results, according to the Hall & Jones (1999) method. In the third section the results with the use of different *proxies* for human capital are presented considering this production factor qualitative aspects, whereas in the following section the results with the different *proxies* for physical capital are exhibited. In the fifth section, the Brazilian regions development accounting exercises are exposed and discussed.

**II – Development accounting for the Brazilian states: 1970-2000**

In this section, the results of the level decomposition (or level accounting) of the product per worker of the Brazilian states are presented. We show only the results of the theoretical accounting method used by Hall & Jones (1999). The exercise is carried out for the 1970-2000 period. In the annex, the algebraic accounting results are shown.

The algebraic exercise aims to quantify the relative importance of inputs and total factor productivity (or “Solow residual”) in income per worker. In the algebraic decomposition, any increase in the capital stock per worker is counted as a “capital per worker” component increase, while, in the theoretical decomposition (Hall & Jones, 1999, method), an increase of the component related to machinery and equipment only occurs when the growth of capital stock exceeds the product growth.

Capital deepening is associated, accordingly to the Solow Model (theoretical reference of this development account exercise), to transitional periods, i.e., when the economy grows at rates higher than the technological progress due to shocks in the determinants of long term income per worker (or by high marginal productivity stimulus of capital). In the long term, the capital-product ratio stability is expected, since both variables grow at the pace given by the sum of technological progress and the population growth rate.

Hall & Jones (1999) indicate that there are two reasons for working with the theoretical decomposition – equation (2): i) in the steady state, the K/Y ratio is proportional to the investment rate, therefore, this method allows to identify when the economy grows only due to technological progress; and ii) if there is an exogenous growth in productivity without changing the investment rate, the K/L ratio will grow over time as a result of an increase in productivity. Thus, part of the capital-labor ratio growth reflects productivity growth, which would be attributed to physical capital accumulation in the algebraic decomposition.

The state of São Paulo was considered as a reference and other federation states differences from this one in terms or product per worker, physical capital stock, human capital stock, and total productivity were analyzed.

**II.1 – Level decomposition of product per worker**

The development decomposition departs from the following specification of the Cobb-Douglas production function with constant returns to scale:

 (1)

where *Y*, *A*, *K*, *H* represent, respectively, product level, Harrod-neutral productivity, physical capital stock, and human capital stock. Dividing both sides of equation (1) by the labor factor of production (*L1-α*) and by the product *(Yα)*, it is obtained:

 (2)

being ; ;  and .

Thus,

 or  (3)

Where . Another possibility to carry out the accounting exercise is according to the following equation:

 (4)

The decompositions presented in accordance with equation (4) are named algebraic, while those based on equation (2) are named theoretical. The first informs that the product per worker (*yi*) is a function of the capital-labor ratio, human capital per worker, *h*, and of TFP or residual, *A*. The methodology based on equation (2) employs the capital-product ratio instead of the capital-labor ratio. Constant returns of scale to *k* and (*hA*) and positive and decreasing marginal returns to physical and human capitals are assumed. The human capital per worker is a function of the educational return average rate (*ϕ*) and years of schooling (*u*). In the Cobb-Douglas specification, *α* is the physical capital participation in income.

The product (Y) is the state GDP at 2000 constant prices (R$ thousand) from the Brazilian Institute of Geography and Statistics (IBGE). The total of employed workers was used for the calculation of GDP per worker (yi), which was elaborated by the Institute of Applied Economic Research (IPEA) based on the demographic census[[1]](#footnote-1). Average school years of the population with 25 years or more were used as *proxy* for human capital, having IPEA as the source. The capital stock (K) is the companies private capital stock (machinery and equipment and non-residential constructions) available on the IPEA website (http://www.ipeadata.gov.br/), based on Reis *et al*. (2005) for the years 1970 and 1980, updated for the years 1990 and 2000, following the methodology of Coelho (2006).

In relation to the parameter of capital participation in income, it is considered , in accordance with the studies previously carried out for the Brazilian case, such as Pereira (2012), Barbosa Filho et al. (2010), Coelho & Figueiredo (2007) and Gomes, Pessôa & Veloso (2003).

In Table 1, the results are presented for 1970 and 2000[[2]](#footnote-2). The TFP calculation was carried out in accordance to equation (3) and the results presented for each GDP per worker component are relative to the values of São Paulo state, based on equation (2). Therefore, the multiplication of the fourth, fifth and sixth columns of Table 1 results in the values displayed in the third one. In the results shown in this table, it is interesting to note that most of the states have caught up to the São Paulo state’s product per worker (Y/L) basically through physical capital deepening, in the period 1970-2000.

**Table 1 – Development accounting comparing with the state of São Paulo values**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1970** | | | | | | **2000** | | | | | |
| **State** | **Class.** | **Y/L** | **(K/Y)α/(1-α)** | **H/L** | **A** | **Class.** | **Class. Var.** | **Y/L** | **(K/Y)α/(1-α)** | **H/L** | **A** |
| RJ | 2 | 0.93 | 0.71 | 1.07 | 1.22 | 1 | 1 | 1.01 | 0.86 | 1.04 | 1.13 |
| SP | 1 | 1.00 | 1.00 | 1.00 | 1.00 | 2 | -1 | 1.00 | 1.00 | 1.00 | 1.00 |
| AM | 9 | 0.40 | 0.62 | 0.88 | 0.75 | 3 | 6 | 0.88 | 0.82 | 0.88 | 1.22 |
| RS | 4 | 0.61 | 1.18 | 0.99 | 0.52 | 4 | 0 | 0.76 | 1.34 | 0.96 | 0.60 |
| SC | 6 | 0.49 | 1.18 | 0.94 | 0.44 | 5 | 1 | 0.72 | 1.49 | 0.94 | 0.51 |
| ES | 8 | 0.41 | 1.14 | 0.89 | 0.41 | 6 | 2 | 0.67 | 2.83 | 0.91 | 0.26 |
| PR | 11 | 0.38 | 1.17 | 0.88 | 0.37 | 7 | 4 | 0.66 | 1.53 | 0.92 | 0.47 |
| MG | 10 | 0.38 | 1.10 | 0.90 | 0.39 | 8 | 2 | 0.60 | 1.83 | 0.88 | 0.37 |
| MS | 12 | 0.36 | 1.56 | 0.87 | 0.27 | 9 | 3 | 0.57 | 2.11 | 0.89 | 0.30 |
| AP | 3 | 0.61 | 1.32 | 0.89 | 0.52 | 10 | -7 | 0.55 | 1.38 | 0.92 | 0.43 |
| MT | 13 | 0.33 | 1.10 | 0.86 | 0.35 | 11 | 2 | 0.54 | 2.04 | 0.87 | 0.30 |
| PE | 15 | 0.31 | 1.13 | 0.85 | 0.33 | 12 | 3 | 0.45 | 1.05 | 0.84 | 0.51 |
| BA | 18 | 0.26 | 1.15 | 0.82 | 0.28 | 13 | 5 | 0.43 | 2.09 | 0.79 | 0.26 |
| GO | 16 | 0.31 | 1.33 | 0.86 | 0.27 | 14 | 2 | 0.42 | 1.89 | 0.89 | 0.25 |
| RO | 5 | 0.49 | 0.73 | 0.86 | 0.79 | 15 | -10 | 0.41 | 1.64 | 0.82 | 0.31 |
| RN | 21 | 0.21 | 1.21 | 0.82 | 0.21 | 16 | 5 | 0.41 | 1.52 | 0.83 | 0.33 |
| SE | 19 | 0.26 | 1.11 | 0.82 | 0.29 | 17 | 2 | 0.39 | 1.73 | 0.81 | 0.28 |
| RR | 7 | 0.46 | 0.91 | 0.89 | 0.56 | 18 | -11 | 0.38 | 1.25 | 0.89 | 0.35 |
| AC | 14 | 0.32 | 0.69 | 0.82 | 0.56 | 19 | -5 | 0.37 | 1.01 | 0.80 | 0.46 |
| PA | 17 | 0.28 | 0.87 | 0.89 | 0.37 | 20 | -3 | 0.37 | 1.59 | 0.83 | 0.28 |
| CE | 22 | 0.18 | 1.10 | 0.82 | 0.20 | 21 | 1 | 0.33 | 1.19 | 0.78 | 0.35 |
| AL | 20 | 0.22 | 1.00 | 0.80 | 0.28 | 22 | -2 | 0.32 | 1.90 | 0.76 | 0.22 |
| PB | 23 | 0.17 | 1.23 | 0.81 | 0.17 | 23 | 0 | 0.31 | 1.10 | 0.78 | 0.36 |
| TO | 24 | 0.15 | 1.44 | 0.79 | 0.13 | 24 | 0 | 0.24 | 2.91 | 0.80 | 0.10 |
| PI | 26 | 0.12 | 1.18 | 0.79 | 0.13 | 25 | 1 | 0.21 | 1.59 | 0.75 | 0.18 |
| MA | 25 | 0.13 | 0.73 | 0.79 | 0.23 | 26 | -1 | 0.20 | 2.43 | 0.75 | 0.11 |
| **Average** |  | **0.38** | **1.07** | **0.87** | **0.42** |  |  | **0.51** | **1.62** | **0.86** | **0.42** |

Source: own elaboration from the data of IBGE, IPEA, Reis et. al. (2005) and Coelho (2006).

According to Minas Gerais results, for example, in 1970 it had 38% of the product per worker of São Paulo. In 2000, it achieved 60% of it. In 1970 and 2000, the physical capital intensity (*K/Y*) was 110% and 183% in relation to the reference state, respectively. The human capital per worker (H/L) was close to that of São Paulo, in 1970 (90%), and the distance remains stable over the period (88% in 2000). The TFP experienced a small reduction in relation to the reference state: from 39%, in 1970, to 37%, in 2000. Therefore, the decomposition exercise indicates that income convergence was largely due to the greater relative physical capital deepening.

In Table 1, last row, the simple averages of all states in relation to the reference state are exposed. It can be noticed that the states relative income average increased from 38% to 51%, between 1970 and 2000. In the beginning of the period, the physical capital intensity was 107%, and at the end it was considerably higher: 162%. When comparing the relative distances of human capital and TFP, it is noticed that they were almost constant over the decades.

Despite the convergence, three states, all in the North Region, are examples of “growth disasters”: Amapá; Rondônia; and Roraima. Amapá, that had the third highest GDP per worker, in 1970, goes to the tenth position, in 2000. This means a loss of seven positions, which can be noticed in the eighth column of Table 1 (Class.Var.). Rondônia lost ten positions and Roraima eleven. What explains these “growth disasters” is, above all, the TFP relative reduction.

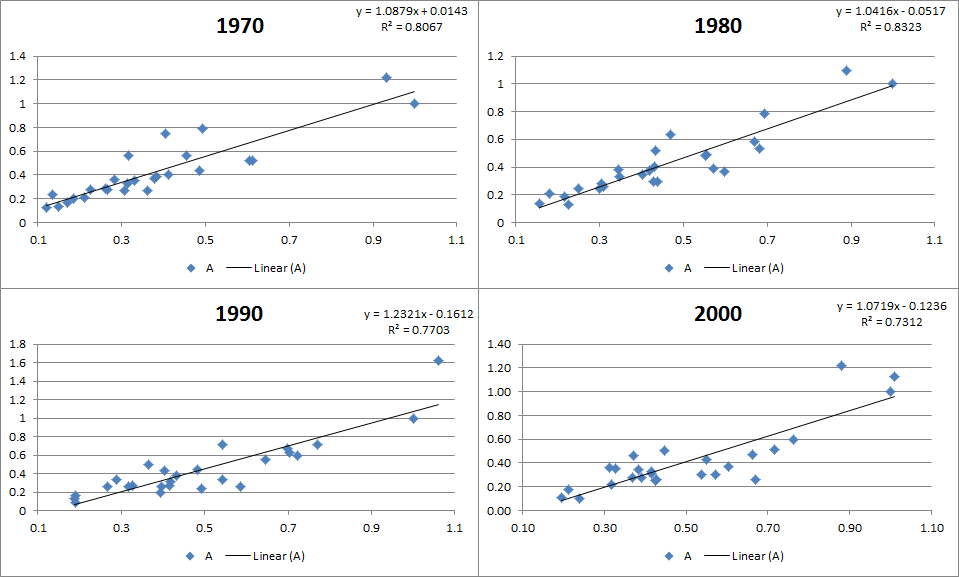
Some states stood out positively since they reduced the distance of GDP per worker in relation to the reference state and to the other states average, such as Amazonas, Paraná, Bahia and Rio Grande do Norte. In all cases, except in Bahia which gained positions exclusively based on the physical capital accumulation, TFP increase was crucial to explain their performance.

Therefore, despite the considerable catch-up of Brazilian states to the GDP per capita level in relation to the reference state, which occurred mainly as a result of the relative physical capital deepening, the classification change among them was primarily due to the TFP relative variation.

In this study, the causes of this relative gap of TFP between the Brazilian states were not discussed, but one of the potential elements to explain this phenomenon is the differential in the infrastructure quality among them. Some indexes point to the superiority in São Paulo infrastructure compared to the other Brazilian states, as in the reports of the Brazilian highways assessment conducted by the National Confederation of Transport (CNT), showing that the São Paulo highways are in much better conditions when compared with the national average (CNT, 2001, 2002). Mussolini & Teles (2010) find evidence of the infrastructure quality importance in determining the TFP in Brazil, using a measure of public and private capital ratio.

In Figure 1, it is plotted the relation between GDP per worker (horizontal axis) and TFP (vertical axis) in the Brazilian states. The States with higher relative levels of TFP are those closer to the GDP per worker of the reference state.

Figure 1 – TFP and GDP per worker in the Brazilian states in relation to the reference state



Source: own elaboration from the data of IBGE, IPEA, Reis et. al. (2005) and Coelho (2006).

According to the results presented in Figure 1, this relation is valid in the four years of analysis and quite stable over the time. The correlation between the two series is 0.86 when the four periods are jointly considered.

**II.2 –Counterfactual exercises**

By the largest relative gap of TFP in relation to the factors of production, the former is the main element to explain the relative backwardness of Brazilian states comparing to the São Paulo state, a result also found in other studies as in Ferreira (2010) and Tavares et al. (2001). The results presented in Table 2 are a counterfactual estimation of the income variation for each state if its components (TFP and factors of production) were the same of the reference state.

For example, because the state of Rio de Janeiro had a TFP greater than the reference state, in 1970, if the former state TFP was changed to be at the same level presented by the latter, its GDP per worker would be decreased by 18%. Meanwhile Rio Grande do Sul would have an increase in its relative GDP per worker in 93%, because its TFP was only 52% of that presented by the reference state, in 1970 (Table 1).

In relation to the relative capital-product ratio of Rio de Janeiro, if it was 1, the product per worker would increase in 40%. For the human capital, there would be a reduction of this variable in 7%.

**Table 2 – Brazilian states income variation considering that one of their product per worker components is the same as that of the São Paulo state**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **1970** | | | **1980** | | | **1990** | | | **2000** | | |
| **State** | (K/Y)SP | hSP | ASP | (K/Y)SP | hSP | ASP | (K/Y)SP | hSP | ASP | (K/Y)SP | hSP | ASP |
| RJ | 40% | -7% | -18% | 33% | -8% | -9% | -2% | -7% | 42% | 16% | -4% | -11% |
| SP | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| AM | 62% | 14% | 34% | -1% | 14% | 28% | 32% | 15% | -38% | 21% | 14% | -18% |
| RS | -15% | 1% | 93% | -23% | 1% | 88% | -21% | 3% | 71% | -25% | 4% | 68% |
| SC | -16% | 6% | 129% | -17% | 5% | 71% | -15% | 6% | 56% | -33% | 7% | 95% |
| ES | -12% | 13% | 146% | -39% | 11% | 158% | -61% | 11% | 296% | -65% | 10% | 285% |
| PR | -14% | 14% | 170% | -21% | 12% | 104% | -23% | 11% | 83% | -34% | 9% | 112% |
| MG | -9% | 12% | 156% | -22% | 12% | 108% | -45% | 13% | 197% | -45% | 13% | 169% |
| MS | -36% | 15% | 274% | -46% | 14% | 173% | -57% | 12% | 318% | -53% | 12% | 230% |
| AP | -24% | 13% | 91% | 22% | 11% | 58% | -8% | 11% | 39% | -27% | 8% | 132% |
| MT | -9% | 16% | 186% | -43% | 17% | 242% | -57% | 16% | 394% | -51% | 14% | 232% |
| PE | -11% | 17% | 206% | -19% | 19% | 200% | -10% | 20% | 132% | -5% | 20% | 97% |
| BA | -13% | 22% | 256% | -31% | 26% | 186% | -50% | 28% | 274% | -52% | 27% | 285% |
| GO | -25% | 16% | 275% | -39% | 13% | 237% | -41% | 12% | 278% | -47% | 13% | 296% |
| RO | 38% | 16% | 27% | -2% | 22% | 92% | -27% | 21% | 155% | -39% | 22% | 224% |
| RN | -17% | 22% | 371% | -33% | 23% | 303% | -31% | 22% | 262% | -34% | 21% | 203% |
| SE | -10% | 22% | 247% | -32% | 25% | 283% | -39% | 23% | 216% | -42% | 24% | 255% |
| RR | 9% | 13% | 78% | -17% | 14% | 145% | 17% | 16% | 31% | -20% | 12% | 189% |
| AC | 45% | 22% | 78% | -11% | 25% | 161% | 8% | 25% | 102% | -1% | 25% | 118% |
| PA | 14% | 13% | 174% | -22% | 15% | 165% | -22% | 20% | 120% | -37% | 20% | 257% |
| CE | -9% | 22% | 391% | -23% | 26% | 312% | -21% | 27% | 274% | -16% | 27% | 186% |
| AL | 0% | 25% | 255% | -29% | 30% | 256% | -36% | 31% | 276% | -47% | 31% | 354% |
| PB | -18% | 23% | 486% | -31% | 26% | 431% | -10% | 27% | 203% | -9% | 29% | 175% |
| TO | -31% | 27% | 666% | -56% | 32% | 658% | -64% | 31% | 1000% | -66% | 24% | 882% |
| PI | -15% | 26% | 678% | -32% | 31% | 620% | -35% | 34% | 508% | -37% | 34% | 462% |
| MA | 37% | 26% | 331% | -12% | 31% | 386% | -49% | 35% | 686% | -59% | 33% | 831% |
| **Average** | **-7%** | **15%** | **136%** | **-25%** | **16%** | **136%** | **-34%** | **17%** | **121%** | **-38%** | **16%** | **138%** |

Source: own elaboration from the data of IBGE, IPEA, Reis et. al. (2005) and Coelho (2006).

In 1970, if TFP was the same of the reference state for all states, the average GDP per worker would increase 136%, while for the same level of human capital, the increase would be 15%. As the capital-product ratio average in the Brazilian states was already higher than that of São Paulo, in 1970, the effect of its equalization would be a reduction in the product per worker level in 7%. On the states average, the relative increase of capital-product ratio has become more pronounced over the decades, what explains the approximation of GDP per worker in relation to the reference state.

The TFP equalization effect is remarkable in some cases, such as in Alagoas, Paraíba, Rio Grande do Norte, Tocantins, Piauí and Maranhão. For these states, in any year, the effect on GDP per worker would be of more than 200%, except in the case of Paraíba, in 2000, because it experimented a significant process of TFP catch-up in relation to the reference state.

Even in the Midwest region states, which are relatively developed and presented a considerable approximation of the product per worker in relation to the reference state, between 1970 and 2000, the TFP equalization effect on GDP per worker is over 200% in almost every year, with no clear trend to reduce the gap.

Thus, what explains the relative delay of Brazilian states is, most of all, the low TFP. The states with lower relative income levels are also those with lower TFP in relation to the reference state, with concentration in the states of the Northeast region, being these results similar to those found by Ferreira (2010) and Tavares et al. (2001).

**III - Human capital robustness**

A point to be considered when using *proxies* for human capital in the development accounting exercises is that the quality gap can be substantial among the states. If this is the case, the use of a purely quantitative *proxy* tends to underestimate the human capital gap among the states if those with a greater quantity are the same with the best quality. In this section, two *proxies* that capture qualitative aspects of human capital are used to observe how the results change.

**III.1 – Proxy that considers the quality effect based on the IDEB**

Following Schoellman (2013), in this section, the quality effects of the educational system in the development accounting exercise was considered. The author uses the wage return of each school year of immigrants in the United States to measure the educational quality gap between the countries. The assumption is that the education return gap reflects the immigrant origin country educational system quality.

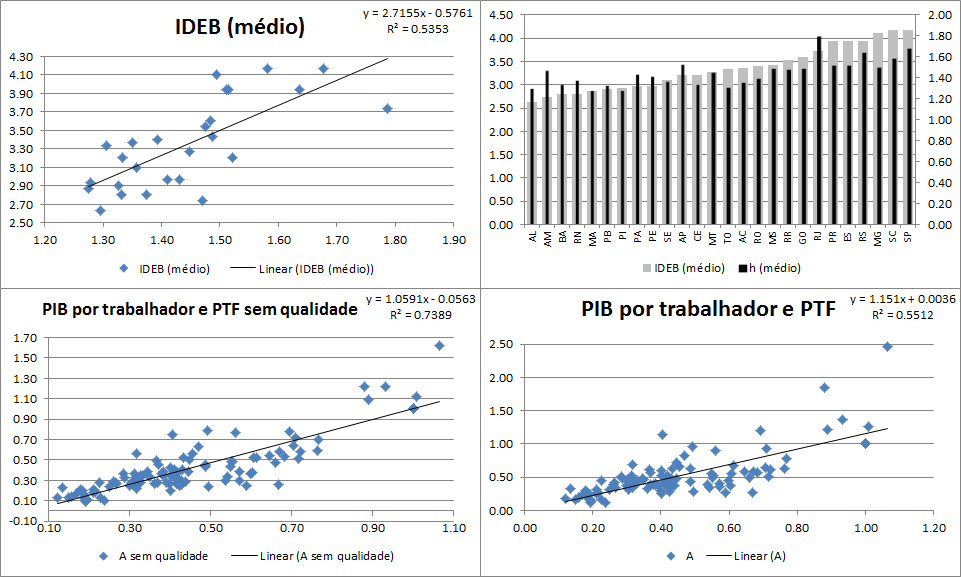
In the present study, for introducing the educational quality effect, an assumption that there is an interaction between human capital quality and quantity and that the quality gap does not change over time is made. This assumption of the same gap of the educational system quality among Brazilian states is necessary since the tests that evaluate the students’ performance are recent. For example, the Basic Education Development Index (IDEB) was created in 2005 by the National Institute of Educational Studies and Researches Anísio Teixeira (INEP), which is used to measure the state educational system quality.

For incorporating the human capital variable qualitative aspects, the human capital *proxy* of the previous exercise was multiplied by each state average IDEB (simple average of the fifth and ninth years of elementary school and third year of high school grades).

At the Figure 2 top left, the positive relation between average IDEB grade (vertical axis) and the quantitative *proxy* for human capital average value[[3]](#footnote-3) (horizontal axis) is shown. The correlation coefficient between the two variables is 0.73, indicating that the higher the amount of human capital of a state, the better is the quality of its educational system. The same information can be seen in the upper right side of the same Figure, with the difference that the two variables are classified according to the ascending order of state average IDEB (vertical left axis). The state with the lowest average IDEB is Alagoas, while the state with the highest average IDEB is São Paulo.

By the positive correlation between the two variables that measure human capital (quantity and quality), the human capital gap between the states is greater in relation to the purely quantitative *proxy* used in the previous exercise. In the bottom of Figure 2, it is noticed that the association between GDP per worker and TFP of each state is reduced when human capital quality is considered because part of the GDP per worker that was being explained by the educational system quality gap was being captured by TFP. In fact, the correlation coefficient between the two variables decreases from 0.86 to 0.75.

Figure 2 – Education Quality by IDEB, TFP and GDP per worker in the Brazilian states comparing with São Paulo



Linear (A)

Linear (A without quality)

A without quality

h (average)

IDEB (average)

Linear (IDEB (average))

IDEB (average)

**GDP per worker and TFP without quality**

**GDP per worker and TFP**

**IDEB (Average)**

Source: own elaboration from the data of IBGE, IPEA, INEP, Reis et. al. (2005) and Coelho (2006).

In Table 3 are exposed the development accounting results using the *proxy* for human capital that considers the quality gap. The GDP per worker and the capital product ratio results were not presented because they are the same as of the previous exercise. What is noticed, by the results, is an increase in the human capital factor gap in the Brazilian states in relation to São Paulo state because it had the highest IDEB average grade in 2005. Even the state of Rio de Janeiro that had a human capital level greater than the base state, according to the previously used *proxy*, had a lower level of human capital when considered its quality aspect.

On the states average, the human capital ratio decreases from 86% to 70% compared to the reference state, which represents a relevant increase of this production factor gap, being the results similar to those found by Schoellman (2013). By the author’s results, the gap difference increase of the human capital variable between the countries, when considering the quality gap, increase the contribution of this factor to explain the income gap from 10% to 20%.

By the quality gap increase, the Brazilian states TFP average goes from 42% to 52% compared to the state of São Paulo, in the majority of the analyzed years, being the average of the Brazilian states TFP gap still substantial.

**Table 3 – Development accounting in relation to São Paulo state - IDEB**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **1970** | | **1980** | | **1990** | | **2000** | |
| **State** | **H/L** | **A** | **H/L** | **A** | **H/L** | **A** | **H/L** | **A** |
| RJ | 0.96 | 1.36 | 0.97 | 1.22 | 0.96 | 0.79 | 0.93 | 1.26 |
| SP | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| AM | 0.58 | 1.14 | 0.58 | 1.19 | 0.57 | 2.47 | 0.58 | 1.85 |
| RS | 0.93 | 0.55 | 0.93 | 0.56 | 0.92 | 0.62 | 0.90 | 0.63 |
| SC | 0.94 | 0.44 | 0.95 | 0.59 | 0.94 | 0.64 | 0.94 | 0.51 |
| ES | 0.84 | 0.43 | 0.85 | 0.41 | 0.85 | 0.27 | 0.86 | 0.28 |
| PR | 0.83 | 0.39 | 0.85 | 0.52 | 0.85 | 0.58 | 0.87 | 0.50 |
| MG | 0.88 | 0.40 | 0.88 | 0.49 | 0.87 | 0.34 | 0.87 | 0.38 |
| MS | 0.72 | 0.32 | 0.72 | 0.44 | 0.74 | 0.29 | 0.74 | 0.37 |
| AP | 0.68 | 0.68 | 0.69 | 0.82 | 0.69 | 0.93 | 0.71 | 0.56 |
| MT | 0.67 | 0.45 | 0.67 | 0.37 | 0.67 | 0.26 | 0.69 | 0.38 |
| PE | 0.61 | 0.46 | 0.60 | 0.47 | 0.59 | 0.60 | 0.60 | 0.71 |
| BA | 0.55 | 0.42 | 0.53 | 0.52 | 0.52 | 0.40 | 0.53 | 0.39 |
| GO | 0.74 | 0.31 | 0.77 | 0.34 | 0.77 | 0.31 | 0.77 | 0.29 |
| RO | 0.70 | 0.97 | 0.67 | 0.64 | 0.67 | 0.48 | 0.67 | 0.38 |
| RN | 0.55 | 0.32 | 0.54 | 0.37 | 0.55 | 0.41 | 0.56 | 0.49 |
| SE | 0.61 | 0.39 | 0.60 | 0.35 | 0.60 | 0.43 | 0.60 | 0.38 |
| RR | 0.75 | 0.66 | 0.74 | 0.48 | 0.73 | 0.90 | 0.75 | 0.41 |
| AC | 0.66 | 0.69 | 0.65 | 0.47 | 0.65 | 0.61 | 0.64 | 0.57 |
| PA | 0.63 | 0.51 | 0.62 | 0.53 | 0.59 | 0.64 | 0.59 | 0.39 |
| CE | 0.63 | 0.27 | 0.61 | 0.32 | 0.60 | 0.35 | 0.60 | 0.46 |
| AL | 0.51 | 0.45 | 0.49 | 0.44 | 0.48 | 0.42 | 0.48 | 0.35 |
| PB | 0.56 | 0.25 | 0.55 | 0.27 | 0.55 | 0.47 | 0.54 | 0.52 |
| TO | 0.63 | 0.16 | 0.60 | 0.16 | 0.61 | 0.11 | 0.64 | 0.13 |
| PI | 0.56 | 0.18 | 0.54 | 0.20 | 0.53 | 0.23 | 0.53 | 0.25 |
| MA | 0.55 | 0.34 | 0.53 | 0.30 | 0.51 | 0.18 | 0.52 | 0.16 |
| **Average** | **0.70** | **0.52** | **0.70** | **0.52** | **0.69** | **0.57** | **0.70** | **0.52** |

Source: own elaboration from the data of IBGE, IPEA, INEP, Reis et. al. (2005) and Coelho (2006).

As earlier stated, in Table 3, the quality gap is kept constant according to the IDEB scores in 2005. In the last line of this table it is possible to see the average stability of the average human capital in the Brazilian states in relation to the base state (about 70% in the four years examined). As there is a positive correlation between the human capital quality and quantity and the first remains relatively constant among the states over time, the assumption that the quality gap is constant between 1970 and 2000 is reasonable.

**III.2 IPEA *proxy* for human capital**

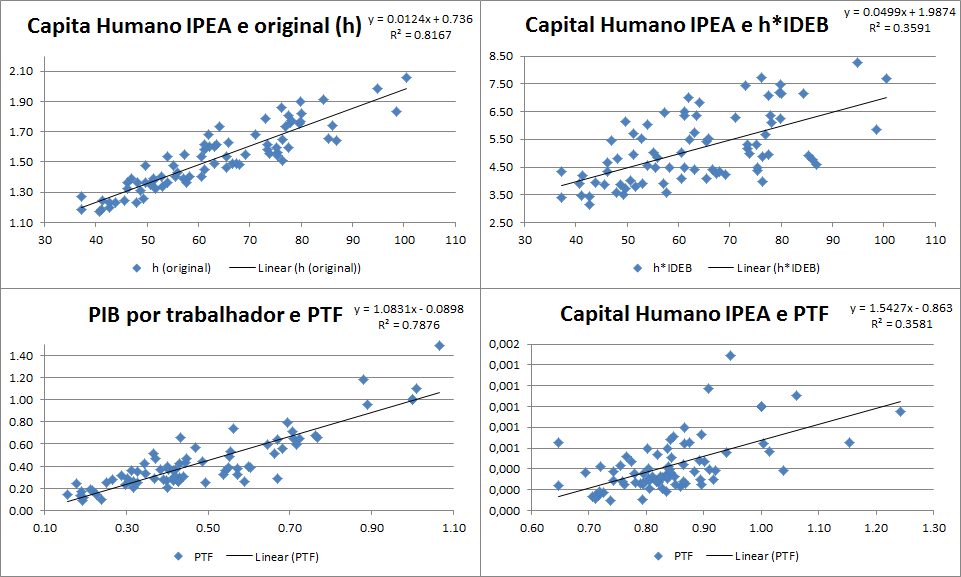
Another possibility for testing the results robustness is using the *proxy* for the Brazilian states human capital elaborated by the Brazilian Institute of Applied Economics (IPEA) available for 1980, 1991 and 2000. It is in constant values (R$ of 2000). This variable was developed based on the annual income expected values associated with the education and experience (age) of the active age population (15-65 years), with a discount rate of 10% per year[[4]](#footnote-4). The advantage in using such *proxy* is that it already captures the educational system quality, since it is based on the wages return in accordance to the individuals’ years of schooling and experience. A problem with this *proxy* is that it is also affected by the supply and demand of that factor, in addition to its interaction with the other production factors and the productivity.

Barbosa Filho et al. (2010) used a similar strategy to calculate the TFP evolution in Brazil, between 1992 and 2007. The authors calculated the human capital marginal productivity to build the human capital *proxy* and found results that changed the conclusions of other studies: while merely quantitative *proxies* captured a considerable increase of this production factor in the period, the same did not occur with its marginal productivity.

At the top of Figure 3, it is noticed that the IPEA *proxy* is more similar to the human capital variable used in the first development accounting exercise (top left) than that adjusted according to the IDEB scores (top right). While the correlation coefficient between the first and the IPEA *proxy* for human capital is 0.90, the coefficient between the second and this one is 0.60.

At the bottom left of Figure 3, it is presented the relation between the TFP of this third exercise and the GDP per worker. Again, it is noticed the high association between these two variables (correlation coefficient of 0.89), indicating the TFP importance to determine each state per worker GDP classification.In the bottom right of Figure 3 is the dispersion chart between TFP and the IPEA *proxy* for human capital. It shows that there is a significant interaction between these two variables, even TFP being a residual already discounted from human capital.

Figure 3 – *Proxies* for human capital, TFP and GDP per worker in the Brazilian states in relation to São Paulo state



TFP

TFP

Linear (TFP)

Linear (TFP)

**IPEA Human Capital and TFP**

**IPEA Human Capital and h\*IDEB**

**GDP per worker and TFP**

**IPEA Human Capital and original (h)**

Source: own elaboration from the data of IBGE, IPEA, Reis et. al. (2005) and Coelho (2006).

In Table 4, the development accounting results are presented using the IPEA *proxy* for human capital. It is noticed that the Brazilian states human capital levels are closer to the state of São Paulo values (about 84%, in the states average) in relation to the *proxy* elaborated using years of schooling and the IDEB scores. Rio de Janeiro (RJ) and Amapá (AP) have a higher level of human capital relative to the reference state in the three years considered. It is worth noting the human capital level relative stability for each state in relation to the reference one. Therefore, these results provide additional evidence of this variable relative steadiness over time among the states, also being consistent with the quality gap stability over the analyzed years.

**Table 4 – Development accounting results in relation to São Paulo state - IPEA**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **1980** | | **1990** | | **2000** | |
| **State** | **H/L** | **A** | **H/L** | **A** | **H/L** | **A** |
| RJ | 1.24 | 0.96 | 1.15 | 0.65 | 1.06 | 1.10 |
| SP | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| AM | 0.87 | 0.79 | 0.95 | 1.49 | 0.91 | 1.18 |
| RS | 0.94 | 0.56 | 0.88 | 0.65 | 0.84 | 0.68 |
| SC | 0.87 | 0.64 | 0.85 | 0.71 | 0.80 | 0.60 |
| ES | 0.92 | 0.38 | 0.87 | 0.26 | 0.82 | 0.29 |
| PR | 0.82 | 0.53 | 0.84 | 0.59 | 0.84 | 0.51 |
| MG | 0.89 | 0.48 | 0.84 | 0.36 | 0.84 | 0.39 |
| MS | 0.80 | 0.40 | 0.85 | 0.25 | 0.82 | 0.33 |
| AP | 1.01 | 0.56 | 1.00 | 0.65 | 1.04 | 0.38 |
| MT | 0.80 | 0.31 | 0.83 | 0.21 | 0.81 | 0.32 |
| PE | 0.85 | 0.33 | 0.91 | 0.39 | 0.90 | 0.47 |
| BA | 0.74 | 0.37 | 0.78 | 0.27 | 0.80 | 0.26 |
| GO | 0.89 | 0.29 | 0.86 | 0.27 | 0.82 | 0.27 |
| RO | 0.65 | 0.66 | 0.75 | 0.43 | 0.69 | 0.36 |
| RN | 0.86 | 0.23 | 0.90 | 0.25 | 0.92 | 0.30 |
| SE | 0.79 | 0.26 | 0.84 | 0.31 | 0.82 | 0.28 |
| RR | 0.84 | 0.43 | 0.90 | 0.73 | 0.84 | 0.37 |
| AC | 0.72 | 0.43 | 0.77 | 0.52 | 0.77 | 0.47 |
| PA | 0.88 | 0.37 | 0.86 | 0.44 | 0.81 | 0.29 |
| CE | 0.76 | 0.25 | 0.76 | 0.28 | 0.78 | 0.35 |
| AL | 0.74 | 0.29 | 0.79 | 0.26 | 0.81 | 0.21 |
| PB | 0.83 | 0.18 | 0.83 | 0.31 | 0.79 | 0.36 |
| TO | 0.71 | 0.14 | 0.74 | 0.09 | 0.79 | 0.10 |
| PI | 0.72 | 0.15 | 0.72 | 0.17 | 0.72 | 0.19 |
| MA | 0.65 | 0.24 | 0.71 | 0.13 | 0.71 | 0.11 |
| **Average** | **0.84** | **0.43** | **0.85** | **0.45** | **0.84** | **0.43** |
| **Standard Deviation** | **0.13** | **0.23** | **0.10** | **0.31** | **0.09** | **0.28** |

Source: own elaboration from the data of IBGE, IPEA, Reis et. al. (2005) and Coelho (2006).

With the human capital average approximation in relation to the reference state when comparing with the previous exercise, the gap of the average Brazilian states’ TFP in relation to São Paulo state increases again, becoming about 44% of the reference state in the three analyzed years. This result was expected by the high correlation between the first *proxy* used for human capital (which only measures quantitative aspects) and the one used in this exercise (elaborated by IPEA).

By Table 4 last row results, it is possible to notice an even greater TFP relative variation among the states in relation to human capital, according to the standard deviation. In addition, the former is more unstable over the decades in relation to the latter when considering each state separately.

Regarding the development accounting exercises conducted previously with the three distinct *proxies* of human capital, it is observed this variable relative stability (comparing with São Paulo) over time in addition to the TFP importance to explain the income gap among the Brazilian states.

Part of what is in TFP, in the first accounting exercise, is the quality differential in the Brazilian states educational systems, being greater the importance of this human capital aspect to explain the state product gap the more realistic is the hypothesis that the IDEB scores is a good variable to measure the quality differential of the Brazilian states educational systems.

**IV. Physical capital robustness**

Another difficulty for carrying out the development accounting in Brazil is the lack of proper measure of the physical capital stock. Due to this difficulty, some authors have made efforts in order to estimate the physical capital stock, such as, for example, Hofman (1992), who estimated it for Argentina, Brazil, Chile, Colombia, Mexico, and Venezuela, for the 1950-1989 period, using the perpetual stock method, Morandi & Reis (2004), Pinheiro & Matesco (1989), and Doellinger & Bonelli (1987) who estimated the capital stock for the Brazilian economy, Coelho (2006) for the Brazilian munipalities, and Kroth & Dias (2012) for the municipalities in the southern States of Brazil.

The states capital stocks estimates are available for 1970 and 1980, being those estimates elaborated by Reis et al (2005). However, there is no reference available for 1990 and 2000. For testing how much of our result depends on the used *proxy*, the development accounting exercises were carried out with various *proxies* for physical capital, such as:

1. Net Capital of Non-Residential Companies estimated by Reis et al (2005) for 1970 and 1980, and the methodology of Coelho (2006) applied to the other years (K1). Coelho (2006) calculates the ratio between total private capital (non-residential + residential) and the residential capital, in each Brazilian municipality, in 1985 (last year of Reis et al., 2005 series). The authors assume that this ratio remains constant and, using the IPEADATA series for the municipalities’ residential capital, they estimate their total capital in 1990 and 2000.

Therefore, the ratio between residential capital (Kr) and total private capital (Kt), for each state, in 1985, was calculated using this ratio to estimate the private total capital stocks for 1990 and 2000. It is necessary, for the *proxy* construction, to use the residential state capital series, available in IPEADATA. It was estimated, for each state according to:

K1, 1990= [Kr1990\* (Kt1985/Kr1985)]-Kr1990;

K1, 2000= [Kr2000\* (Kt1985/Kr1985)]-Kr2000.

This was the *proxy* used in the previously development accounting exercises.

1. Non-residential Private Capital of Brazil distributed among the states according to their residential capital: the companies’ private capital series of year t was used and it was assumed that the capital is distributed in proportion to the residential capital – (available by State, K2).
2. Non-Residential Private Capital (Ipeadata) distributed according to the energy consumption of the states: a series of non-residential private capital of Brazil was used, and it was assumed that the industrial energy consumption was proportional to the capital stock (K3).
3. Companies State Capital estimated by Reis et al. (2005) until 1980, updating the data according to the industrial energy consumption growth in each state, as suggested by the authors (K4).
4. Companies and Families Machinery and Equipment estimated by Reis et al. (2005) only available for 1970 and 1980 (K5).

Table 5 shows the relative evolution (Brazilian states average in relation to the reference state) of capital and TFP, in 1970, 1980, 1990 and 2000. The difference between the table top and bottom is that on the top are the simple average evolution results of the Brazilian states while, at the bottom, are the weighted average by the employed population participation in each State in relation to the employed total population in the country.

In each of the lines exposed in Table 5, the results are derived using each one of the five *proxies* to measure the state physical capital stock. The results are relative to the state of São Paulo and presented only for the capital-product and TFP relation.

The results using K4 are similar to those obtained with the *proxy* used in the previous analysis: K1. The average values of capital-product ratio are similar, and they present an increasing trend over the decades in both cases, and TFP is relatively stable over the time. These *proxies* have in common the use of the best information available for the first two years (REIS et al. (2005)) and used either the methodology suggested by Reis et al. (2005) or the one of Coelho (2006) to estimate the capital stock in 1990 and 2000.

The results presented with K3 are the only case in which the capital-product ratio, in the Brazilian states average, is lower than that of São Paulo state in all examined years. Although this is the series that showed the highest capital-product ratio relative evolution, it is still below the value shown by the reference state in 2000. Therefore, this *proxy* seems to underestimate the relative physical capital stock regarding the Brazilian states. These are the only results in which TFP appears above the reference state and falling over the analyzed period precisely by the strong capital-product ratio expansion. Thus, the results presented with this *proxy* distune from the others.

In addition, other studies do not corroborate with the Brazilian state average TFP being greater than that of the São Paulo state, such as Ferreira (2010) and Tavares et al. (2001). It is important to stress this point, because several applied studies to the Brazilian economy use this *proxy* to measure physical capital, such as Linhares et al. (2012), Cangussu et al. (2010), Nakabashi & Salvato (2007) and Tavares et al. (2001). However, the results with the weighted average – which seem to be more appropriate – are closer to those presented with the other *proxies* for physical capital, as it will be soon presented.

The development accounting exercise results with the use of the K2 *proxy* is the only one that does not show a tendency to increase the relative capital-product ratio, between 1970 and 2000.There is also a considerable approximation of TFP in relation to the reference state. Therefore, the trend results using this *proxy* distunes from the others, being compatible with a scenario in which the real estate market rent (used to build the *proxy*) in the state of São Paulo has grown faster than in other states.

In turn, the decomposition with K5, also based in Reis et al. (2005), and which uses a narrower concept of capital, also shows a strong increase trajectory between 1970 and 1980. However, the series was interrupted.

**Table 5 – Development accounting with different *proxies* for physical capital – Hall & Jones (1999) method**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Simple Average** | | | | | | | | |
|  | **(K/Y)** | | | | **A** | | | |
|  | **1970** | **1980** | **1990** | **2000** | **1970** | **1980** | **1990** | **2000** |
| **K1** | 1.07 | 1.34 | 1.51 | 1.62 | 0.42 | 0.42 | 0.45 | 0.42 |
| **K2** | 1.12 | 1.02 | 0.97 | 1.03 | 0.40 | 0.54 | 0.65 | 0.60 |
| **K3** | 0.47 | 0.67 | 0.92 | 0.96 | 1.14 | 1.27 | 1.04 | 0.95 |
| **K4** | 1.07 | 1.31 | 1.59 | 1.78 | 0.42 | 0.42 | 0.42 | 0.43 |
| **K5** | 0.75 | 1.16 |  |  | 0.58 | 0.47 |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| **Weighted Average** | | | | | | | | |
|  | **(K/Y)** | | | | **A** | | | |
|  | **1970** | **1980** | **1990** | **2000** | **1970** | **1980** | **1990** | **2000** |
| **K1** | 1.05 | 1.20 | 1.38 | 1.45 | 0.57 | 0.61 | 0.57 | 0.59 |
| **K2** | 1.15 | 1.05 | 1.03 | 1.05 | 0.51 | 0.65 | 0.69 | 0.71 |
| **K3** | 0.75 | 0.90 | 1.09 | 1.11 | 0.84 | 0.86 | 0.75 | 0.78 |
| **K4** | 1.05 | 1.27 | 1.50 | 1.61 | 0.57 | 0.59 | 0.55 | 0.58 |
| **K5** | 0.86 | 1.12 |  |  | 0.65 | 0.64 |  |  |

Source: own elaboration from the data of IBGE, IPEA, Reis et. al. (2005) and Coelho (2006).

Table 5 bottom provides the results using the Brazilian states weighted average by the employed population participation. The results hardly differ, but it is worth noticing some discrepancies. The magnitudes and trends with the use of *proxies* for physical capital K1 and K4 are even closer. The TFP evolution becomes positive in both cases. The differences in the results derive, partially, from the poorest regions faster growth based on the increase in physical capital investments, in which weights are smaller because they are less populous. Another difference is that even with the use of the K3 *proxy*, the capital-product ratio is above that of the state of São Paulo, in 1990 and 2000, and the TFP below, in all analyzed years. So, despite being the only series that still shows a reduction in relative TFP, the results are closer to those found using the other *proxies*. Thus, the non-residential energy consumption behavior in the less populous states was distorting, at least partially, the results previously found. Finally, it is worth noticing that even with the K5 *proxy*, there is no relevant TFP reduction between 1970 and 1980, which is also closer to the results obtained with the other *proxies* for physical capital.

In Table 6, the development accounting exercises were carried out based on the same *proxies* for physical capital. The difference is that the decomposition exercises are based on equation (4) specification, what is called algebraic decomposition. The justification is that the capital-product ratio does not reveal the capital ratio per worker in each state. Even with many Brazilian states showing a capital-product ratio above that of the reference state, the same does not occur with the capital-labor ratio, being this relation also relevant for the states comparison in terms of development.

Some results presented in Table 6 are sensitive to the use of the distinct *proxies*. When using the K1 and K4 *proxies*, the average Brazilian states capital stock per worker is similar to the state of São Paulo, at the end of the period. But with the K2 and K3 *proxies*, the results indicate that there still is a significant gap of physical capital, on average, in relation to the reference state, even in 2000.

For all *proxies*, on the states average, the capital-labor ratio evolution was considerable between 1970 and 2000, which explains the product approximation of the Brazilian states in relation to the reference state. In most scenarios, TFP was relatively stable over time, as well as human capital.

**Table 6 – Development decomposition varying *proxies* for physical capital – algebraic accounting**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Simple Average** | | | | | | | | |
|  | **(K/L)** | | | | **A** | | | |
|  | **1970** | **1980** | **1990** | **2000** | **1970** | **1980** | **1990** | **2000** |
| K1 | 0.67 | 0.83 | 0.91 | 0.97 | 0.57 | 0.58 | 0.59 | 0.57 |
| K2 | 0.69 | 0.71 | 0.71 | 0.75 | 0.55 | 0.67 | 0.74 | 0.71 |
| K3 | 0.42 | 0.56 | 0.66 | 0.68 | 1.01 | 1.07 | 0.94 | 0.91 |
| K4 | 0.70 | 0.85 | 0.97 | 1.04 | 0.60 | 0.60 | 0.58 | 0.58 |
| K5 | 0.55 | 0.77 |  |  | 0.71 | 0.62 |  |  |
| **Weighted Average** | | | | | | | | |
|  | **(K/L)** | | | | **A** | | | |
|  | **1970** | **1980** | **1990** | **2000** | **1970** | **1980** | **1990** | **2000** |
| K1 | 0.76 | 0.89 | 0.96 | 1.01 | 0.68 | 0.72 | 0.69 | 0.70 |
| K2 | 0.81 | 0.83 | 0.83 | 0.86 | 0.64 | 0.76 | 0.79 | 0.80 |
| K3 | 0.63 | 0.76 | 0.84 | 0.85 | 0.86 | 0.88 | 0.81 | 0.84 |
| K4 | 0.76 | 0.91 | 1.00 | 1.05 | 0.68 | 0.70 | 0.67 | 0.69 |
| K5 | 0.69 | 0.86 |  |  | 0.75 | 0.74 |  |  |

Source: own elaboration from the data of IBGE, IPEA, Reis et. al. (2005) and Coelho (2006).

Despite the low capital-labor ratio when using the K3 *proxy* with simple average, the results with the weighted average are closer to those using the other *proxies* (Table 6). This ratio was 0.85 in 2000, not so far from the reference state. Additionally, the TFP is below that of the reference state and reasonably constant between 1970 and 2000.

The results arising from the use of K1 and K4 *proxies* are the most reliable, because: a) use directly and/or result from the best data available for the Brazilian states elaborated by Reis et al. (2005); b) by comparing these *proxies’* results with those obtained for 1970 and 1980 using K5. The mean of the Brazilian states machinery and equipment per worker value (K5), also estimated by Reis *et al.* (2005), and based on the economic censuses was already, in 1980, 86% of the state of São Paulo value. This is the same difference found, in 2000, for the non-residential private capital total value, when estimated by K2 and K3.

For this capital gap to remain stable from 1980 and 2000, there could be no relative stock growth of private capital in these 20 years; a result that contradicts the information on capital evolution obtained with K2 and K3. All series indicate relative growth of capital stock per worker in the Brazilian states.

The algebraic decomposition results are not directly comparable to those of Ferreira (2010), because the author employs the theoretical exercise. These differences in results between algebraic and theoretical decompositions are also found in the results for Brazil (Bacha & Bonelli, 2005; Gomes *et al*, 2003).

With these results, it is concluded, therefore, that an important part of the state’s investment does not result from productivity increases, which would keep the capital-product ratio constant. The growth was “transitional”, that is, as a result of the growth of relative capital stock per worker at positive rates, but decreasing. There is an increase of the relative capital-labor and capital-product ratios.

**V – Analysis by Major Regions**

In this section, the development decomposition is presented according to the five major Brazilian regions. The results presented in Table 7 were developed according to the weighted average of each Brazilian region and using the methodology of Hall & Jones (1999)[[5]](#footnote-5). Our analysis focuses on the results concerning the calculations using the non-residential private capital stock, i.e., the K1 *proxy*.

The North, Northeast and Midwest, in the period 1970-2000, deepen its capital, i.e., there is an intense relative increase of the relative capital-product ratio. In turn, the relative TFP rises, in the 70s, in the Northeast and Midwest Brazilian regions, and in the 80s, in the North region. The latter is the only region to show TFP reduction already in the next decade. The Northeast and Midwest are able to maintain their relative productivity level achieved in 1970, but these are the regions with lower TFP relative level.

**Table 7 – Development accounting for the major Brazilian regions with weighted average – Hall & Jones (1999) method**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **North** | | | | | | | | | | |
|  | **(K1/Y)** | **(K2/Y)** | **(K3/Y)** | **(K4/Y)** | **(K5/Y)** | **A1** | **A2** | **A3** | **A4** | **A5** |
| **1970** | 0.88 | 1.07 | 0.26 | 0.88 | 0.65 | 0.45 | 0.36 | 1.64 | 0.45 | 0.58 |
| **1980** | 1.28 | 0.86 | 0.31 | 0.87 | 1.08 | 0.46 | 0.66 | 2.22 | 0.65 | 0.54 |
| **1990** | 1.30 | 0.77 | 1.00 | 2.80 |  | 0.66 | 1.03 | 1.35 | 0.45 |  |
| **2000** | 1.53 | 0.90 | 1.29 | 3.65 |  | 0.47 | 0.74 | 0.99 | 0.34 |  |
| **Northeast** | | | | | | | | | | |
|  | **(K1/Y)** | **(K2/Y)** | **(K3/Y)** | **(K4/Y)** | **(K5/Y)** | **A1** | **A2** | **A3** | **A4** | **A5** |
| **1970** | 1.09 | 1.22 | 0.55 | 1.09 | 0.73 | 0.25 | 0.22 | 0.56 | 0.25 | 0.38 |
| **1980** | 1.35 | 1.14 | 0.86 | 1.58 | 1.13 | 0.28 | 0.33 | 0.47 | 0.26 | 0.33 |
| **1990** | 1.57 | 1.11 | 1.26 | 1.63 |  | 0.28 | 0.39 | 0.43 | 0.28 |  |
| **2000** | 1.66 | 1.14 | 1.30 | 1.68 |  | 0.30 | 0.40 | 0.47 | 0.30 |  |
| **Midwest** | | | | | | | | | | |
|  | **(K1/Y)** | **(K2/Y)** | **(K3/Y)** | **(K4/Y)** | **(K5/Y)** | **A1** | **A2** | **A3** | **A4** | **A5** |
| **1970** | 1.35 | 1.17 | 0.26 | 1.35 | 0.85 | 0.28 | 0.33 | 1.79 | 0.28 | 0.45 |
| **1980** | 1.71 | 0.99 | 0.42 | 1.79 | 1.37 | 0.31 | 0.57 | 1.43 | 0.36 | 0.39 |
| **1990** | 1.98 | 1.04 | 0.64 | 2.17 |  | 0.24 | 0.46 | 0.81 | 0.23 |  |
| **2000** | 1.98 | 1.07 | 0.68 | 2.59 |  | 0.28 | 0.55 | 0.84 | 0.23 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| **Southeast** | | | | | | | | | | |
|  | **(K1/Y)** | **(K2/Y)** | **(K3/Y)** | **(K4/Y)** | **(K5/Y)** | **A1** | **A2** | **A3** | **A4** | **A5** |
| **1970** | 0.97 | 1.14 | 1.04 | 0.97 | 0.90 | 0.87 | 0.73 | 0.86 | 0.87 | 0.90 |
| **1980** | 1.04 | 1.08 | 1.11 | 1.08 | 1.02 | 0.88 | 0.81 | 0.86 | 0.85 | 0.88 |
| **1990** | 1.26 | 1.07 | 1.17 | 1.29 |  | 0.75 | 0.80 | 0.77 | 0.74 |  |
| **2000** | 1.26 | 1.04 | 1.10 | 1.21 |  | 0.84 | 0.88 | 0.89 | 0.85 |  |
| **South** | | | | | | | | | | |
|  | **(K1/Y)** | **(K2/Y)** | **(K3/Y)** | **(K4/Y)** | **(K5/Y)** | **A1** | **A2** | **A3** | **A4** | **A5** |
| **1970** | 1.18 | 1.08 | 0.59 | 1.18 | 0.99 | 0.44 | 0.48 | 0.93 | 0.44 | 0.53 |
| **1980** | 1.26 | 0.92 | 0.70 | 1.47 | 1.28 | 0.53 | 0.73 | 0.97 | 0.45 | 0.52 |
| **1990** | 1.26 | 0.89 | 0.79 | 1.30 |  | 0.58 | 0.83 | 0.94 | 0.57 |  |
| **2000** | 1.44 | 1.01 | 0.92 | 1.56 |  | 0.53 | 0.76 | 0.84 | 0.49 |  |

Source: own elaboration from the data of IBGE, IPEA, Reis et. al. (2005) and Coelho (2006).

In general, the results are similar to those presented for the Brazilian states average, namely, the relative capital-product ratio increase and the constancy or slight decline of relative TFP. What can be clearly seen is that some regions had strong relative capital-product ratio evolution, such as the Northeast, Midwest and, above all, the North of the country, regions which also have the highest gaps of capital relative productivity.

The results are similar when employing the physical capital best *proxies*: K1, K4 and K5. The most diverse results are derived with the use of K2. The K3 *proxy* generates smaller discrepancies in the North, Northeast and Midwest regions analysis.

The results with the *proxies* considered more appropriate indicating that, in the North and Midwest of Brazil, the increased investment is associated with the TFP reduction; in the South and Southeast regions, the transition growth occurred with the TFP maintenance; while in the Northeast there were capital and TFP relative increase.

**VI - Conclusions**

The income level per worker decomposition was carried out according to two methodologies: the algebraic and theoretical. The exercises were carried out for 1970, 1980, 1990 and 2000. With the two methodologies, it is concluded that the Brazilian states income per worker differentials in relation to São Paulo state arise mainly from the gaps of Total Factors Productivity (TFP). In 1970, the states had a lower GDP per worker than São Paulo, both from differentials of capital per worker stock (physical and human), and TFP. In the thirty years of the empirical analysis, there is a strong growth in relative capital stock, especially in poorer states (beta convergence), reducing the income per worker inequalities in Brazil. However, no progress was made in reducing the inequality between the TFPs.

Despite the human capital smaller gap among the Brazilian states in relation to São Paulo state, there was also no convergence of this production factor. When controlling the quality, the results indicate the possibility of a gap increase. On average, the human capital in the states is 30% less than that of the São Paulo state, in 2000.

Our results point out that it is necessary to be careful with the *proxy* of physical capital based on the electric energy consumption, very common in the Brazilian growth empirical literature: comparing the physical capital *proxy* with the *proxies* directly or indirectly based on the economic census data, it is noticed that the *proxy* based on electric energy underestimates the capital stock in the Brazilian states in relation to São Paulo.

With the development accounting results, it is also possible to notice that the only Brazilian Region that did not have a TFP relative decrease was the Northeast. The final conclusion is that for the states to make the *catch-up* with the reference state, it is essential for then to have improvements in TFP.

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**ANNEX**

**Table A.1 – Development accounting comparing with the state of São Paulo**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1980** | | | | | | **1990** | | | | | |
| **State** | **Class.** | **Y/L** | **(K/Y)α/(1-α)** | **H/L** | **A** | **Class.** | **Class. Var.** | **Y/L** | **(K/Y)α/(1-α)** | **H/L** | **A** |
| RJ | 2 | 0.89 | 0.75 | 1.08 | 1.10 | 3 | -1 | 0.77 | 1.02 | 1.07 | 0.70 |
| SP | 1 | 1.00 | 1.00 | 1.00 | 1.00 | 2 | -1 | 1.00 | 1.00 | 1.00 | 1.00 |
| AM | 3 | 0.69 | 1.01 | 0.88 | 0.78 | 1 | 2 | 1.06 | 0.76 | 0.87 | 1.62 |
| RS | 4 | 0.68 | 1.29 | 0.99 | 0.53 | 4 | 0 | 0.72 | 1.27 | 0.97 | 0.59 |
| SC | 5 | 0.67 | 1.20 | 0.95 | 0.59 | 6 | -1 | 0.71 | 1.17 | 0.94 | 0.64 |
| ES | 7 | 0.57 | 1.63 | 0.90 | 0.39 | 8 | -1 | 0.59 | 2.58 | 0.90 | 0.25 |
| PR | 8 | 0.55 | 1.26 | 0.90 | 0.49 | 7 | 1 | 0.64 | 1.30 | 0.90 | 0.55 |
| MG | 9 | 0.55 | 1.28 | 0.90 | 0.48 | 10 | -1 | 0.54 | 1.81 | 0.89 | 0.34 |
| MS | 6 | 0.60 | 1.86 | 0.88 | 0.37 | 11 | -5 | 0.49 | 2.31 | 0.90 | 0.24 |
| AP | 10 | 0.47 | 0.82 | 0.90 | 0.63 | 5 | 5 | 0.71 | 1.09 | 0.90 | 0.72 |
| MT | 11 | 0.44 | 1.76 | 0.85 | 0.29 | 16 | -5 | 0.40 | 2.30 | 0.86 | 0.20 |
| PE | 17 | 0.35 | 1.23 | 0.84 | 0.33 | 17 | 0 | 0.40 | 1.12 | 0.84 | 0.43 |
| BA | 16 | 0.40 | 1.45 | 0.79 | 0.35 | 15 | 1 | 0.42 | 2.00 | 0.78 | 0.27 |
| GO | 14 | 0.43 | 1.63 | 0.89 | 0.30 | 18 | -4 | 0.40 | 1.68 | 0.90 | 0.26 |
| RO | 12 | 0.43 | 1.02 | 0.82 | 0.52 | 13 | -1 | 0.44 | 1.37 | 0.83 | 0.39 |
| RN | 21 | 0.30 | 1.48 | 0.81 | 0.25 | 20 | 1 | 0.33 | 1.45 | 0.82 | 0.28 |
| SE | 19 | 0.31 | 1.47 | 0.80 | 0.26 | 14 | 5 | 0.42 | 1.64 | 0.81 | 0.32 |
| RR | 13 | 0.43 | 1.20 | 0.88 | 0.41 | 9 | 4 | 0.56 | 0.85 | 0.86 | 0.77 |
| AC | 18 | 0.34 | 1.12 | 0.80 | 0.38 | 19 | -1 | 0.37 | 0.92 | 0.80 | 0.49 |
| PA | 15 | 0.42 | 1.28 | 0.87 | 0.38 | 12 | 3 | 0.49 | 1.28 | 0.84 | 0.45 |
| CE | 22 | 0.25 | 1.30 | 0.79 | 0.24 | 23 | -1 | 0.27 | 1.27 | 0.79 | 0.27 |
| AL | 20 | 0.30 | 1.40 | 0.77 | 0.28 | 21 | -1 | 0.32 | 1.57 | 0.76 | 0.27 |
| PB | 24 | 0.22 | 1.44 | 0.79 | 0.19 | 22 | 2 | 0.29 | 1.11 | 0.79 | 0.33 |
| TO | 23 | 0.23 | 2.27 | 0.76 | 0.13 | 24 | -1 | 0.19 | 2.76 | 0.76 | 0.09 |
| PI | 26 | 0.16 | 1.48 | 0.76 | 0.14 | 25 | 1 | 0.19 | 1.54 | 0.75 | 0.16 |
| MA | 25 | 0.18 | 1.14 | 0.76 | 0.21 | 26 | -1 | 0.19 | 1.98 | 0.74 | 0.13 |
| **Average** |  | **0.46** | **1.34** | **0.86** | **0.42** |  |  | **0.50** | **1.51** | **0.86** | **0.45** |

Source: own elaboration from Ipeadata

**Table A.2 – Development accounting for the major Brazilian regions with weighted average – algebraic accounting**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1970** | | | | | | | | | | | | |
|  | **(K1/L)** | **(K2/L)** | **(K3/L)** | **(K4/L)** | **(K5/L)** | **(A1)** | | **(A2)** | | **(A3)** | **(A4)** | **(A5)** |
| **N** | 0.56 | 0.64 | 0.29 | 0.56 | 0.48 | 0.61 | | 0.53 | | 1.30 | 0.61 | 0.71 |
| **NE** | 0.58 | 0.61 | 0.38 | 0.58 | 0.45 | 0.43 | | 0.40 | | 0.70 | 0.43 | 0.56 |
| **MW** | 0.76 | 0.70 | 0.27 | 0.76 | 0.58 | 0.47 | | 0.51 | | 1.39 | 0.47 | 0.61 |
| **SE** | 0.87 | 0.96 | 0.90 | 0.87 | 0.84 | 0.9 | | 0.81 | | 0.89 | 0.90 | 0.93 |
| **S** | 0.82 | 0.79 | 0.54 | 0.82 | 0.74 | | 0.61 | | 0.64 | 0.95 | 0.61 | 0.68 |
| **1980** | | | | | | | | | | | | |
|  | **(K1/L)** | **(K2/L)** | **(K3/L)** | **(K4/L)** | **(K5/L)** | **(A1)** | | **(A2)** | | **(A3)** | **(A4)** | **(A5)** |
| **N** | 0.82 | 0.65 | 0.37 | 0.69 | 0.75 | 0.61 | | 0.76 | | 1.56 | 0.77 | 0.67 |
| **NE** | 0.73 | 0.66 | 0.56 | 0.79 | 0.66 | 0.46 | | 0.51 | | 0.63 | 0.44 | 0.51 |
| **MW** | 1.02 | 0.73 | 0.44 | 0.99 | 0.89 | 0.5 | | 0.71 | | 1.21 | 0.52 | 0.57 |
| **SE** | 0.94 | 0.97 | 0.97 | 0.96 | 0.94 | 0.91 | | 0.87 | | 0.90 | 0.89 | 0.92 |
| **S** | 0.96 | 0.79 | 0.67 | 1.05 | 0.96 | 0.68 | | 0.83 | | 0.98 | 0.62 | 0.67 |
| **1990** | | | | | | | | | | | | |
|  | **(K1/L)** | **(K2/L)** | **(K3/L)** | **(K4/L)** |  | **(A1)** | | **(A2)** | | **(A3)** | **(A4)** |  |
| **N** | 0.87 | 0.64 | 0.72 | 1.39 |  | 0.73 | | 0.96 | | 1.09 | 0.56 |  |
| **NE** | 0.83 | 0.67 | 0.70 | 0.84 |  | 0.46 | | 0.56 | | 0.59 | 0.46 |  |
| **MW** | 1.06 | 0.72 | 0.53 | 1.12 |  | 0.43 | | 0.63 | | 0.87 | 0.41 |  |
| **SE** | 1.03 | 0.95 | 0.99 | 1.04 |  | 0.82 | | 0.87 | | 0.84 | 0.81 |  |
| **S** | 0.99 | 0.80 | 0.75 | 1.01 |  | 0.72 | | 0.89 | | 0.96 | 0.71 |  |
| **2000** | | | | | | | | | | | | |
|  | **(K1/L)** | **(K2/L)** | **(K3/L)** | **(K4/L)** |  | **(A1)** | | **(A2)** | | **(A3)** | **(A4)** |  |
| **N** | 0.89 | 0.66 | 0.76 | 1.47 |  | 0.59 | | 0.79 | | 0.89 | 0.45 |  |
| **NE** | 0.88 | 0.71 | 0.72 | 0.88 |  | 0.48 | | 0.57 | | 0.61 | 0.48 |  |
| **MW** | 1.13 | 0.77 | 0.59 | 1.31 |  | 0.46 | | 0.69 | | 0.89 | 0.41 |  |
| **SE** | 1.05 | 0.97 | 0.98 | 1.03 |  | 0.88 | | 0.92 | | 0.92 | 0.89 |  |
| **S** | 1.09 | 0.88 | 0.83 | 1.14 |  | 0.68 | | 0.85 | | 0.90 | 0.65 |  |

Source: own elaboration from the data of IBGE, IPEA, Reis et. al. (2005) and Coelho (2006).

1. In the census, it was considered as occupied or employed the person who worked in the last 12 months preceding the census reference date, or part of it. The person who did not work in the last 12 months preceding the census reference date but that, in the last 2 months, took some action to find work, was considered as unoccupied or unemployed. http://www.ipeadata.gov.br/. [↑](#footnote-ref-1)
2. The results for 1980 and 1990 are in the annex. [↑](#footnote-ref-2)
3. Average value of each state in the four decades analyzed, i.e., average value of *h* considering the years 1970, 1980, 1990 and 2000. [↑](#footnote-ref-3)
4. The human capital stock is calculated by the difference between the income obtained in the labor market and the estimate of that obtained by a worker with no schooling and experience. For estimating the expected future income, the return coefficient to education and experience were estimated using the Demographic Census data for the years 1980, 1991 and 2000. [↑](#footnote-ref-4)
5. The results using the traditional methodology or the algebraic breakdown are shown in the annex. [↑](#footnote-ref-5)