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Regional and Urban Economics Lab

RECENT PRODUCTIVITY GROWTH AND REGIONAL INEQUALITY IN BRAZIL

Daniela Schettini
Carlos Roberto Azzoni

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Abrstract. This paper estimates the levels and the evolution of Total Factor Productivity (TFP) across 27 regions (states) in Brazil over the 1995-2009 period, for agriculture, manufacturing and services, as well as for total production. In the aggregate, there are no signs of productivity growth in the period, in spite of the substantive TFP growth exhibited by agriculture, and the modest growth observed in manufacturing. The regional results show that productivity levels replicate the regional inequality that marked the country's history through decades: all the states with low TFP levels belong to the poorest regions, mainly the Northeast region. Some sectoral differences are observed when analyzing regional TFP growth but, on average, high-productivity states tend to exhibit higher productivity growth. This indicates that inequality in productivity in the future tends to be even more pronounced than in the present.

1. Introduction

Productivity is a major indicator of competitiveness and it is an important determinant of regional economic prosperity (Kaldor, 1970). Recent models of economic growth base their discussion on the determinants of economic productivity growth. Regional inequality within a country is produced by decades of competitiveness differences among its regions, and changes in this scenario can only come out if the relative competitiveness of regions is altered in a significant way. Brazil is a well known case of a large country displaying quite stable levels of regional concentration and regional inequality (Baer, 2007). Recent changes in the economic environment within which its regional economies operate have a potential to introduce important elements to change the long lasting disparity scenario, such as the stabilization and the opening up of the economy, the important social programs associated to a growth path led by internal consumption, etc. (Silveira-Neto and Azzoni, 2012). This sets the background for this investigation, which is intended to measure the productivity levels of its regions, and how they have changed in recent years.

Bonelli and Fonseca (1998), Silva Filho (2001), Pinheiro et al. (2001), Gomes et al. (2003) and Bugarin et al. (2004) indicate a negative growth rate of Total Factor Productivity for the country during the 1980s, and a change in this scenario during the

1990s. Agriculture is a relevant case to look at, given the success of the country in terms of expanding its market share in the international markets. This sector showed TFP growth of 2.25% per year in the 1980s, 3.37% in the 1990s and 4.98% from 2000 to 2008 (Bragagnolo et al., 2010). Most studies typically analyze productivity at the country level, but very few are able to include the regional dimensions of the problem. Gasques and Conceição (2000) and Gasques et al. (2009) verified that nontraditional states in the Center-West (Mato Grosso and Mato Grosso do Sul) and Northeast (Piauí and Ceará) where the ones that enhanced TFP growth in agriculture between 1985 and 1995. Vicente (2011) also estimated agriculture TFP and efficiency for Brazilian states for 2006 and verified a process of regional convergence of TFP, as compared to 1995. Despite that, the states of the poor North and Northeast regions continue to present lower-than-average TFP performance. Bragagnolo et al. (2010) used a Stochastic Frontier model to estimate agricultural TFP for Brazilian states from 1975 to 2006. They concluded that strong technical progress and positive TFP growth were responsible for expanding the agricultural frontier in the Northeast and Center-West regions. Imori (2012) presents estimates of productivity levels in agriculture at the municipal level in 2006.

Studies for manufacturing at the national level stress the high impact of trade liberalization and monetary stabilization on TFP during the 1990s (Kupfer, 1998; Quadros et al., 1999; Feijó and Carvalho, 2002; Rossi and Ferreira, 1999; Bonelli and Fonseca, 1998; Schor, 2003). According to Bonelli (1992) and Rossi and Ferreira (1999), TFP had an annual increase of 0.8% from 1975 to 1985, and 2.15% from 1991 to 1997. Recent estimates, however, show a decline in performance. Barbosa Filho et al. (2010) observed an annual TFP growth of only 0.72% from 1992 to 2007. Squeff (2012) compares the GDP per capita growth of 1.9% per annum from 2000 to 2009, to the labor productivity growth of the economy of 0.8%; productivity in manufacturing decreased 1.2% per year, leaving to agriculture and services the job of keeping the path of productivity growth in recent years (4.3% and 0.5%, respectively). As for the regional dimensions of manufacturing, Schettini and Azzoni (2013) indicated that the traditional manufacturing centers are the ones with the highest productivity levels, and that there no signs of changes in this situation.

According to McMillan and Rodrik (2011), developing countries tend to show asymmetry of productivity indicators across sectors. As the results shown above indicate, this seems to be the case of Brazil. Therefore, it is important to consider the different performance of sectors in analyzing aggregate productivity growth. On the other hand, regions are heterogeneous and develop at different pace. Estimating productivity by state provides information on the levels and evolution of regional inequalities. This is the standpoint of this paper, since we consider levels and evolution of productivity in three sectors, across regions in Brazil. The objective of this paper is to estimate the levels and growth of TFP for agriculture, industry and services, based on a panel of 27 regions, for the period 1995- 2009.

The paper will be divided in 5 sections. After this introduction, section 2 presents the methodology used to obtain regional TFP estimates by sector. Section 3 shows the data and presents the descriptive statistics. Section 4 discusses the results and section 5 concludes.

2. Methodology

In order to calculate TFP estimates, it is necessary to specify a production function, which indicates the maximum output produced given certain amounts of inputs and technology. We use a Cobb Douglas production function, with the natural logarithm of GDP as the output and the natural logarithm of labor and capital as the inputs. Since we work with a panel data (regional sates over time), we calculate regional estimates of TFP as the non-observable component of the region, that is, the fixed effect that contains all factors, constant in time, that affect production but cannot be explained by its inputs. Therefore, regional (sectoral) TFPs are obtained from the estimated coefficients of regional (sectoral) dummy variables included in the regressions. To overcome the limitation introduced by the fact that fixed effects are constant in time, we include a general trend component and its interactions with regional (sectoral) dummies, resulting in annual productivity growth rates for sectors and regions. The general estimated model is:

$$y_{it} = \beta_0 + \beta_1 L_{it} + \beta_2 K_{it} + \beta_3 t + \beta_4 ds2 + \beta_4 ds3 + \beta_5 ts2 + \beta_6 ts3 + \sum_{k=1}^{K} \beta_k (t * dr_k) + \varepsilon_{it} \qquad (1)$$

where GDP is the output y_{it}, labor (L_{it}) and capital (K_{it}) are the inputs, all measured in natural logs, *t* is the trend and the subscripts *i* and *t* represent year and the unit observed from data. ds2 is the dummy for manufacturing; ds3 is the dummy for services; dr_k are regional dummies; t is the general trend; ts2 interacts the general trend and the dummy for manufacturing; ts3 interacts the general trend and the dummy for services; interactions with regional dummies are included in some models depending on the TFP we want to obtain: to estimate regional TFP levels (evolution) for each sector, we exclude (include) regional interactions with the trend and include (exclude) regional interactions with the specific sector.

In order to prevent multicollinearity, one state must be excluded, what poses the question of choosing the state to set as the benchmark for the comparison. In order to provide useful results, it would be interesting to compare each region (sector) to the national average, which led us to adopt the following procedure. Initially, we have estimated 27 regressions with all states included, with a sole dummy for one individual state at a time, thus identifying how that state is different from the average of all states. By analyzing the estimated 27 regional dummies, we have chosen the state whose behavior is most similar to the national average to take as the representative of the group of states as a whole. We did that by taking the non-significant dummy coefficient closest to zero, indicating that the state is not different from the national average and, thus, could be used as the benchmark for the set of all states. Finally, we have estimated one general regression including all regional dummies but the one referring to the state chosen in the previous step. This way, all states are compared to the omitted state; since that state is the closest to the average, the estimated regional dummies can be interpreted as relating to the national average.

3. Data

The database is a panel composed of 27 Brazilian states (regions), 3 economic sectors (agriculture, manufacturing and services), over the period 1995-2009, resulting in 1,215 observations. We used the Value Added for each sector/state as the output[1]. As for labor, we used the number of employees. We took the numbers for census years and used data from annual surveys to interpolate these figures for intermediate years. For agriculture, we used the censuses of 1996 and 2006; for manufacturing and services, the population censuses of 2000 and 2010. For the interpolations, we used data from RAIS, a yearly survey applied to the universe of firms[2]. Due to the lack of better data, the consumption of electricity is used as a proxy for capital in manufacturing and services[3]. The proxy for capital in agriculture is the total number of tractors and agricultural machinery. The stocks measured in the 1996 and 2006 agriculture censuses were interpolated by the annual sales of tractors in each state[4]. In order to correct for the different measures of capital (energy for manufacturing and services, and tractors for agriculture), we have included dummy variables for manufacturing and services, both interacting with capital. We expect that, by doing so, we take into account the capital characteristics of each sector.

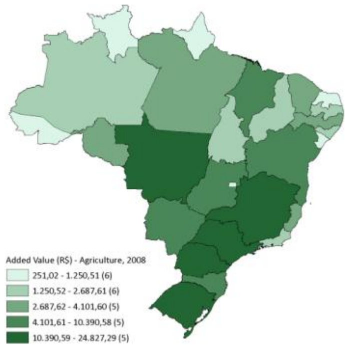
Table 1 in the Appendix B presents some descriptive statistics of Value Added (VA), Labor (L) and Capital (K). Some highlights will be presented in the remaining part of this section. Chart 1 shows maps displaying Value Added, Labor and Capital levels for states in 2008[5]. We observe the concentration of outputs and inputs for production mainly in the coastal area, mostly in the states of the Southeast region (São Paulo, Minas Gerais, Espírito Santo and Rio de Janeiro). In agriculture, we verify the importance of the Center West in Value Added, especially in Mato Grosso, but the distribution of inputs for this sector follows basically the regional distribution of the other sectors. Amazonas, in the north region, hosts a Free Trade Zone, basically assembling electronic and automotive products. The neighboring state of Pará is rich in minerals, and hosts an important mining sector.

[1] Data from IBGE - Brazilian Institute of Geography and Statistics, the official statistics office. GDP Value Added is measured in BRL millions of 1995.
[2] RAIS – Relação Anual de Informações Sociais is produced by the Ministry of Labor and Employment. It covers the universe of businesses over a certain size. It leaves aside firms which have not requested a formal license, mostly small. We have used RAIS variations in employment by sector/region to interpolate Census data. Labor is measured in 1,000 employees.
[3] Data from Ipea, Ministry of Planning, and Statistical Yearbook of Electrical Energy (Ministry of Mines and Energy). Electricity is measured in 1,000 MWH.
[4] Data from the Yearbook of the Brazilian Automotive Industry of Anfavea (National Association of Automobile Manufacturers).
[5] We chose not to use 2009, our most recent year, to avoid any distortions caused by the financial crisis of 2008, felt in Brazil mainly in 2009. Instead, we present information for 2008.

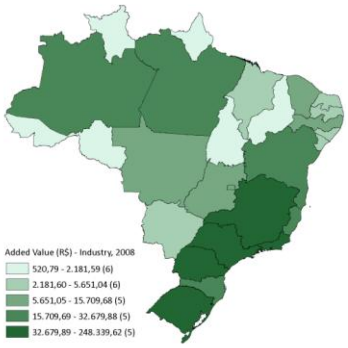
Chart 1. Value Added, Labor and Capital across States, 2008

Value Added

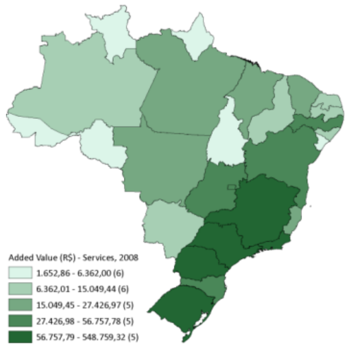
Agriculture



Manufacturing

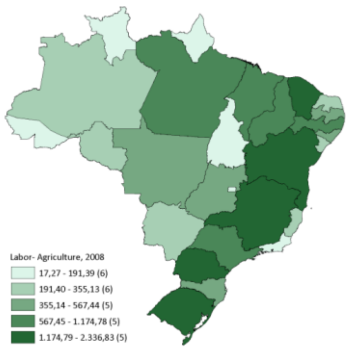


Services

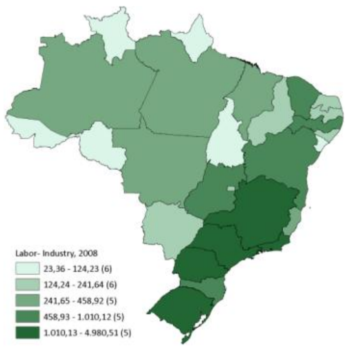


Labor

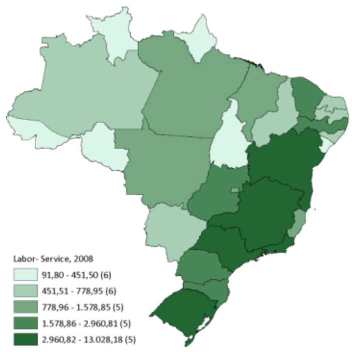
Agriculture



Manufacturing

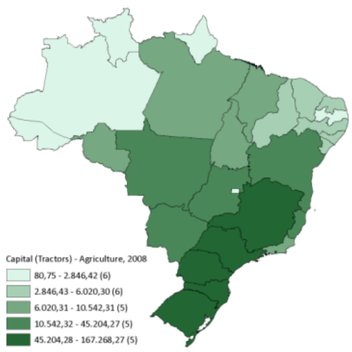


Services

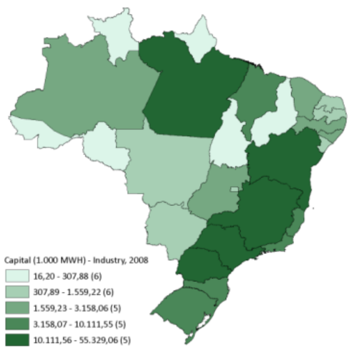


Capital

Agriculture



Manufacturing



Services

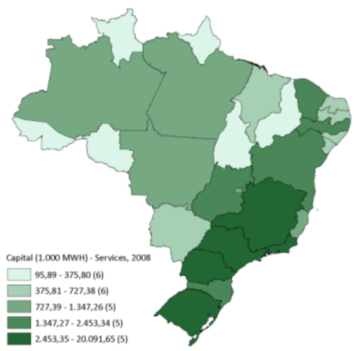
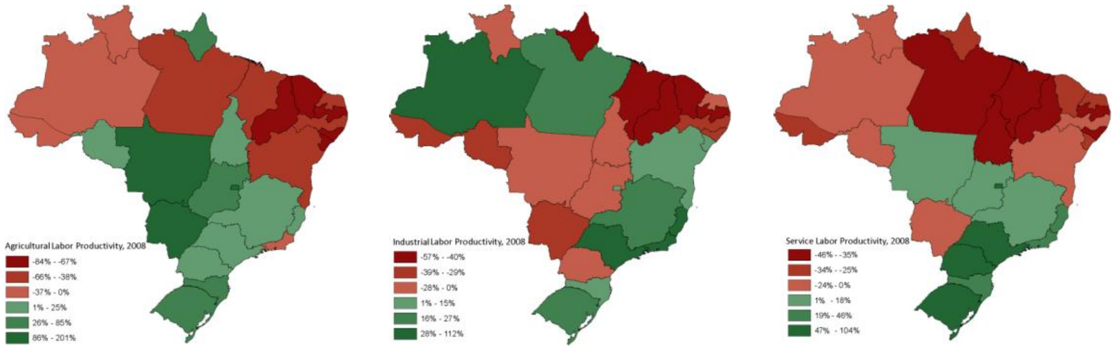


Chart 2 shows labor productivity in 2008 (output/labor, in relation to the national level). It is clear that the poorer the state, the less productive it tends to be, as most of the states in the North and Northeast regions have labor productivity below the national average. In agriculture, we observe high levels of labor productivity in the Center West region: Mato Grosso, Mato Grosso do Sul and Goiás are 3, 2 and 2.5 times more productive than the national average, respectively. All states of the Northeast region have productivity levels below the national average. Piauí state, for example, is more than 6 times less productive than the national average.

Chart 2. Labor Productivity in relation to the National Average, 2008 (%)

Agriculture Manufacturing Services



In manufacturing, Amazonas (north), Rio de Janeiro and Espírito Santo (southeast) are 2 times more productive than the national average, mainly due to the Free Trade Zone in the first case and the expansion of the petroleum industry in the other cases. The richest state, São Paulo, is above national average. Only Bahia and Sergipe, in the poor northeast region, show productivity levels above the national average: in the first case, due to a government-lead petrochemical complex; in the second, due to government-lead oil and gas extracting activities. Again, Piauí is the worst case: 2.3 times less productive than the national average. In services, we clearly observe the division of Brazil in two portions: the poor North and Northeast regions against the rich South and Southeast regions.

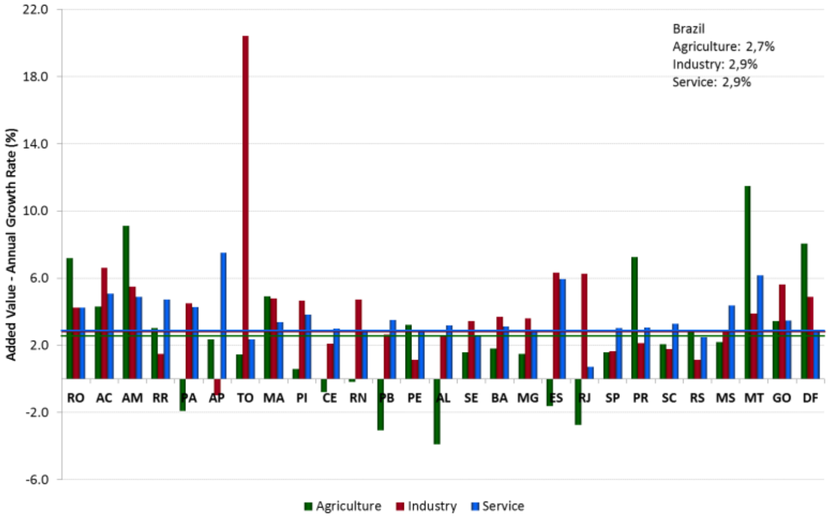
Chart 3 shows the annual average growth rates of Added Value, Labor and Capital among Brazilian states from 1995 to 2008[6]. Rondônia and Acre (north), Maranhão (northeast) and Mato Grosso (center-west) had above national average growth rates in agriculture (in terms of VA, L and K), while Paraíba and Alagoas (northeast) and Rio de Janeiro (southeast) performed below the national average. Traditional states in manufacturing, with the exception of Minas Gerais, had growth rates below the national average. This indicates a expansion of this sector in nontraditional states such as Bahia and Rio Grande do Norte (northeast), Mato Grosso and Mato Grosso do Sul (center-west), Pará and Amazonas (north). São Paulo and Pernambuco performed below the average. Services presented high growth rates in almost all states of the North and Center-West regions; Pernambuco, Rio de Janeiro and Rio Grande do Sul performed below the national average.

In agriculture, Pará, Paraíba, Alagoas, Espírito Santo and Rio de Janeiro decreased around 2.6% per year in Added Value. On the other hand, Espírito Santo, Rio de Janeiro and Acre had the highest growth rate in manufacturing (6.6%) and Espírito Santo, Amapá e Mato Grosso in the service sector (6.5%). Agriculture was the only sector that decreased in terms of labor in the majority of the states. It is important to note that, in general, the very high annual growth rates observed in some states is mainly because they had low levels in 1995.

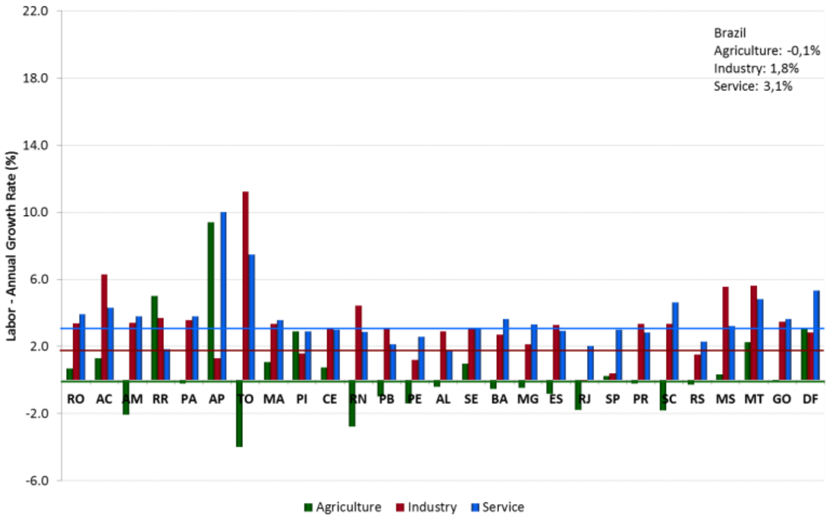
[6] Due to the 2008 international crisis, which was felt mainly in 2009 in Brazil, we have chosen to use 2008 as the ending year of the period for these calculations.

Chart 3. Annual Growth Rates, 1995-2008

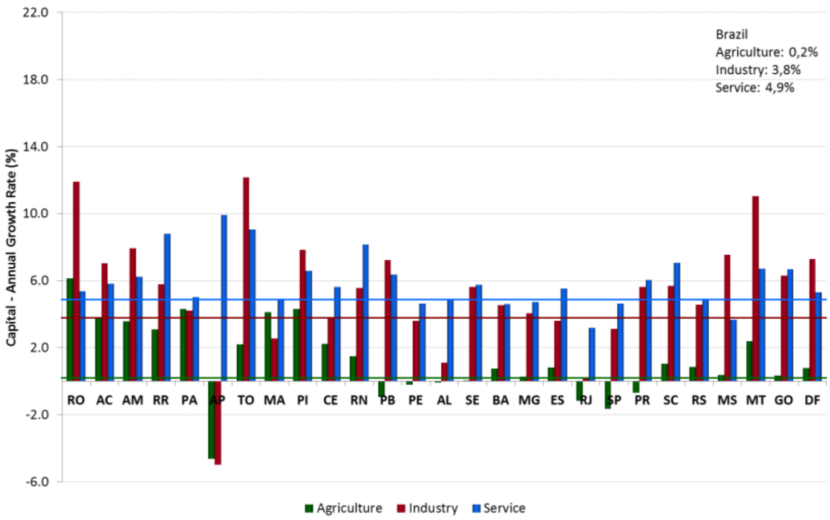
Value Added



Labor



Capital



Horizontal lines display the national growth rates

4. Results

4.1. National

Table 2 reports the estimates of the Cobb-Douglas production functions. The first model considered labor and capital as inputs and a trend effect to account for national macroeconomic shocks in the economy. But we noticed an unexpected result for the capital coefficient and related it to the fact that we used different definitions of proxies to measure capital for the three sectors. We correct this problem by inserting sectoral dummies interacting with capital, as Model 1 shows. As can be seen in the table, the results for capital coefficients became reasonable. The coefficient for the trend in this model is not significantly different from zero, indicating that aggregate national productivity did not grow in the period.[7]

In Model 2 we include intercept dummies for manufacturing and services. Therefore, the general constant becomes the TFP for agriculture (the omitted sector), and the TFP for manufacturing and services are given by adding the sectoral dummy coefficients to the general intercept. All input coefficients are positive and significant, and the general trend remains non-significant, as in Model 1. The significant sectoral intercept indicate that there are differences among sectors other than the use of inputs that are not being taken into account by the model. But introducing these differences does not change the previous conclusion of no TFP growth, and the importance of capital and labor are not too different from the previous model.

In Model 3we interact the sectoral dummies with the general trend, in order to establish the sectoral trends. Again, agriculture is the omitted sector, and therefore the general coefficient indicates the trend for this sector. The trends for the other sectors are given by the sum of that trend to the sectoral dummy coefficient. The results indicate that a 1% increase in labor causes an increase of 0.45% in output. An increase of 1% in capital leads to an increase of 0.67% in output for services (0.3729 + 0.2943), 0.42% for manufacturing, and 0.38% for agriculture. This is our preferred specification and it will

[7] The complete results with the t-Student statistics and estimation performance for all the models we run in section four are reported in Appendix C.

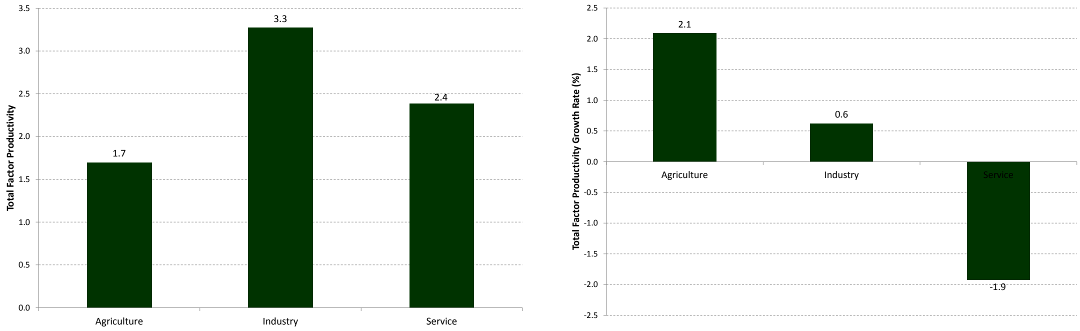
be employed in the subsequent regional estimations. The constant and the intercept dummies for the sectors (ds2 and ds3) represent the annual average level of TFP for each sector, and are shown in Figure 1. The constant indicates the TFP level for agriculture, 1.6967; the level for manufacturing is the sum the general intercept and the coefficient of ds2, resulting in 3.27; for services, the result is 2.39. Thus, manufacturing is the most productive sector Brazil; the service sector is 30% less productive and agriculture is 50% less productive than manufacturing.

Table 2. National Production Functions Results

	Model 1	**Model 2**	**Model 3**
log(L)	0.4568***	0.4508***	0.4484***
log(K)	0.2864***	0.3798***	0.3799***
ds2*log(K)	0.2113***	0.0417**	0.0423***
ds3*log(K)	0.3118***	0.2803***	0.2943***
Trend	0.0028	0.0028	0.0209***
ds2		1.4623***	1.5747***
ds3		0.4575***	0.6890***
ts2			-0.0147**
ts3			-0.0401***
Constant	2.6668***	1.8280***	1.6967***
R^2	0.9343	0.9429	0.9449
F	3303.9***	5235.8***	5250.6***

The results represent the average levels for the whole 1995-2009 period, but do not inform about changes occurring within the period. The literature has been pointing out that agriculture is showing symptoms of increasing productivity and that manufacturing might be going in the opposite direction, especially in recent years. Figure 1 also exhibits the sectoral annual average TFP growth rates estimated from Model 3. The general trend coefficient indicates that agriculture experienced the strongest productivity growth, 2.09% per year; the interactions of sectoral dummies with the trend indicate that manufacturing presented a modest grow of 0.6% per year (0.0209 – 0.0147), very close to the estimates of Barbosa et al. (2010), and services presented a sharp decrease of 1.9% per year. Agriculture presented the lowest TFP level, but the highest TFP growth rate. Manufacturing had a shy, but still positive, annual growth, while services is the only sector to exhibit a negative growth rate. These sectoral differences explain the non-significant general aggregate TFP growth rate.

Figure 1.National TFP Levels and TFP Growth Rates by Sector – (% per year)



4.2. Regional[8]

4.2.1. Total Factor Productivity Levels

To obtain the general TFP for each region, we excluded sectoral and included regional dummies in Model 3. In the 27 regressions including one regional dummy at a time, the state of Rondônia presented the non-significant coefficient closest to zero. Therefore, that state was chosen to be the benchmark and all other state dummies refer to that state, as if it were the national average. The aggregate results are reported in the first column of Table 3[9]. The constant represents the national TFP level average among Brazilian states, since we are using Rondônia as the national average. Therefore, positive (negative) and significant regional dummy coefficients represent states that have general TFP above (below) national average. Bold figures indicate that the coefficient is significant at 1% and 5%; non-bold figures indicate non-significant coefficients. The same logic is applied to agriculture, industry and service sectors, presented in the other columns of the table. Santa Catarina was considered representative of the national average TFP for agriculture, while Mato Grosso and Espírito Santo were considered for industry and services, respectively. In the general model, the regional dummies were just included without any interaction. In the estimates of specific sectors, regional

[8] State's abbreviations are in Appendix A.
[9] Coefficients in bold mean that they are significant at 5% not in bold mean they are not significant.

coefficients are obtained by interacting the regional dummy with the dummy for the specific sector.

Table 3. Regional TFP Level Estimates

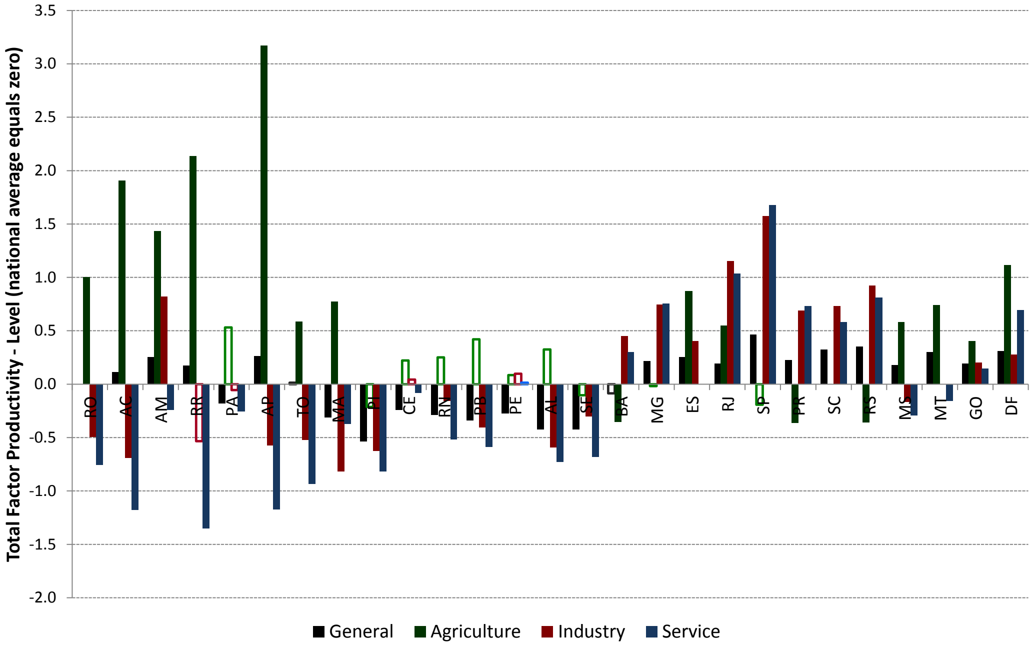
		General	Agriculture	Manufacturing	Services
	log(L)	**0.598**	**0.720**	**0.340**	**0.465**
	log(K)	**0.179**	**0.578**	**0.438**	**0.371**
	ds2*log(K)	**0.186**	**-0.318**	**-0.163**	**0.041**
	ds3*log(K)	**0.283**	-0.134	**0.328**	**-0.264**
	trend	**0.010**	**0.016**	**0.021**	**0.021**
	ds2		**5.143**	**2.942**	**1.571**
	ds3		**4.256**	**0.711**	**4.220**
	ts2	0.007	**-0.011**	-0.004	**-0.015**
	ts3	**-0.025**	**-0.034**	**-0.041**	**-0.012**
	RO		**0.999**	**-0.491**	**-0.757**
	AC	**0.113**	**1.906**	**-0.687**	**-1.177**
	AM	**0.252**	**1.431**	**0.818**	**-0.239**
N	RR	**0.173**	**2.133**	-0.534	**-1.350**
	PA	**-0.179**	0.531	-0.055	**-0.252**
	AP	**0.263**	**3.169**	**-0.571**	**-1.172**
	TO	0.014	**0.582**	**-0.522**	**-0.931**
	MA	**-0.310**	**0.769**	**-0.816**	**-0.374**
	PI	**-0.533**	-0.213	**-0.624**	**-0.814**
	CE	**-0.241**	0.223	0.043	**-0.082**
	RN	**-0.286**	0.251	**-0.156**	**-0.514**
NE	PB	**-0.339**	0.420	**-0.403**	**-0.585**
	PE	**-0.275**	0.084	0.098	0.013
	AL	**-0.424**	0.325	**-0.592**	**-0.728**
	SE	**-0.423**	-0.104	**-0.301**	**-0.681**
	BA	-0.086	**-0.350**	**0.448**	**0.301**
	MG	**0.216**	-0.018	**0.744**	**0.752**
SE	ES	**0.253**	**0.870**	**0.401**	
	RJ	**0.190**	**0.546**	**1.151**	**1.031**
	SP	**0.463**	-0.193	**1.573**	**1.676**
	PR	**0.224**	**-0.361**	**0.687**	**0.729**
S	SC	**0.319**		**0.727**	**0.578**
	RS	**0.351**	**-0.359**	**0.922**	**0.811**
	MS	**0.176**	**0.579**	**-0.164**	**-0.291**
CW	MT	**0.299**	**0.740**		**-0.154**
	GO	**0.193**	**0.403**	**0.200**	**0.146**
	DF	**0.311**	**1.113**	**0.273**	**0.694**
	Constant	**2.710**	**-2.209**	**1.809**	**1.680**

Column 1 indicates that there is a very well defined difference in TFP levels between the states of the poor Northeast region and the rest of Brazil. With the exception of Bahia (BA), which does not differ from the national average, all the Northeast states have productivity levels below the national average. On the other side, all the states of the richer Southeast, South and Center-West regions have productivity levels above the national average. The states of the North region also have a great performance, with the exception of Pará (below the average) and Tocantins (same as the national average). It is possible also to verify that São Paulo has the highest productivity level, followed by Rio Grande do Sul and Santa Catarina (both in the south); Piauí has the lowest productivity level, followed by Alagoas and Sergipe (all in the northeast).

These estimates are important to summarize regional performance of all economic activities, but they are too general, in the sense that an aggregate positive result may be produced by an exceptional result in just one sector. A richer framework of economic regional performance is produced with separate estimates of TFP levels for agriculture, industry and services for each region, as in columns 2, 3 and 4. The negative performance of Pará, for example, is due to the service sector, since agriculture and industry perform at the national average; Amazonas has a negative performance also in the service sector, counterbalancing its positive results in agriculture and industry; Mato Grosso and Mato Grosso do Sul show positive general productivity, but only because of their great performance in agriculture. The general negative performance of the poor Northeast states are not caused by agriculture, since they are able to perform at the national average in that activity, but it is due to industry and services.

That repeats the general inequality scenario of Brazilian economic activities: northeastern states of Brazil perform badly, while southern states perform much better. An interesting exception is Amazonas, with an impressive positive result in industry, due to government incentives in Zona Franca de Manaus. But the positive performance in that sector does not spillover to the service sector. Figure 3 presents the estimated regional productivity levels for the aggregate and for the three sectors.

Figure 3. Estimated Regional TFP Levels (national average = zero)



Bars not fully colored represent non-significant coefficients

As shown in Figure 3, TFP estimates for the sectors are consistent with the aggregate results in all regions, except for the state of Pernambuco, which has a general negative TPF but is not different from the average in all three sectors. The productivity levels in the Southeast states are above the national average in all sectors; it is just not significant for agriculture in Minas Gerais and in São Paulo. São Paulo is the most productive state in Brazil, almost 20% more productive than the national average; its manufacturing and service sectors are also the most productive (33% and 28% larger than the respective national averages). In the northeast region, only agriculture in Maranhão and manufacturing and services in Bahia have productivity levels above the national average, but this is not strong enough to revert the overall negative result in the first, and the non-significant overall effect in the latter. In the South, Paraná and Rio Grande do Sul are 0.16 times less productive than the national average in agriculture, but manufacturing and services more than compensate this bad result, leading to an overall position above the national average. In the center-west, agriculture pulls the overall results above the national average, especially for Mato Grosso and Mato Grosso do Sul. Finally, in the states of the North region, the above average productivity observed is mainly due to agriculture, with the exception of Amazonas, in which manufacturing has a good performace, better than more traditional states like Minas Gerais, Paraná and Santa Catarina.

4.2.2. Regional Total Factor Productivity Growth Rates

The same procedure applied to obtain regional TFP levels is applied to the estimation of regional TFP growth rates. In this case, we include interaction terms between the trend and the regional dummies. As in the previous section, we have ran 27 regressions, introducing one state at a time and selecting as the benchmark the one with the growth rate closest to the national average. From the 27 regressions, four states had no significant dummy coefficients and, among them, Rondônia presented the coefficient closest to zero. Therefore, that state was selected as the representative of the national average growth rate, with all 26 state dummies in the single equation model expressed in relation to it. Positive (negative) and significant regional dummy coefficients represent states that have general TFP growth rates above (below) the national average. The same procedure was applied to the sectoral regressions, with the states of Paraná, Bahia and Minas Gerais chosen as the national representatives of agriculture, manufacturing and services, respectively. The results are reported in Table 4[10].

[10] Coefficients in bold mean that they are significant at 5% or 1%; not in bold mean they are not significant.

Table 4. Estimated Regional TFP Annual Growth Rates

		General	Agriculture	Manufacturing	Services
	log(L)	**0.554**	**0.573**	**0.371**	**0.462**
	log(K)	**0.314**	**0.294**	**0.421**	**0.373**
	ds2*log(K)	**0.051**	**0.054**	0.043	**0.041**
	ds3*log(K)	**0.228**	**0.275**	**0.318**	**0.272**
	trend	0.004	**0.028**	**0.021**	**0.021**
	ds2	**1.310**	**1.374**	**1.616**	**1.572**
	ds3	**0.547**	**0.488**	**0.705**	**0.795**
	ts2		**-0.022**	-0.015	**-0.015**
	ts3		**-0.047**	**-0.041**	**-0.037**
N	RO		**0.020**	**-0.018**	**-0.012**
	AC	**0.019**	**0.033**	0.011	0.007
	AM	**0.038**	0.022	**0.077**	-0.001
	RR	**0.020**	0.016	**0.030**	0.007
	PA	**-0.021**	-0.011	**-0.048**	**-0.023**
	AP	**0.030**	**0.063**	0.008	0.006
	TO	0.003	-0.004	**0.021**	**-0.010**
NE	MA	**-0.028**	0.010	**-0.112**	-0.005
	PI	**-0.050**	**-0.102**	**-0.027**	**-0.017**
	CE	**-0.027**	**-0.046**	**-0.015**	**-0.018**
	RN	**-0.029**	**-0.059**	**-0.017**	**-0.021**
	PB	**-0.033**	**-0.051**	**-0.043**	**-0.013**
	PE	**-0.026**	**-0.048**	**-0.012**	**-0.022**
	AL	**-0.044**	**-0.059**	**-0.070**	**-0.022**
	SE	**-0.041**	**-0.101**	**-0.034**	**-0.009**
	BA	**-0.013**	**-0.035**		**-0.010**
SE	MG	0.010	**0.025**	0.005	
	ES	**0.020**	**0.023**	**0.018**	0.003
	RJ	0.015	**-0.028**	**0.076**	**-0.006**
	SP	**0.032**	**0.018**	**0.070**	**0.012**
S	PR	0.010		**0.019**	**0.009**
	SC	**0.017**	0.006	**0.024**	**0.017**
	RS	**0.019**	0.005	**0.040**	**0.014**
CW	MS	0.005	**0.027**	**-0.018**	0.000
	MT	**0.023**	**0.069**	-0.005	-0.002
	GO	0.011	**0.033**	0.001	0.002
	DF	**0.027**	-0.026	**0.045**	**0.055**
	_cons	**1.810**	**1.742**	**1.777**	**1.683**

Column 1 shows general estimates of aggregate growth productivity rates for each state. The trend coefficient is not significantly different from zero, meaning that productivity did not increase in the period in the country as a whole. However, different states presented distinct results as the state interaction coefficients indicate. Most of the zero growth rate states are distributed among the Southeast, South and Center-West. The clear pattern of regional inequality observed in Brazil is also evident in terms of growth rates: all Northeast states and Pará exhibit negative productivity growth rates, the worst case being Piauí, the poorest state; it is followed by Alagoas and Sergipe, repeating their ranking in terms of productivity levels. Among the positive and significant growth rates, Amazonas is the leader, followed by São Paulo and Amapá.

The results allow us important considerations. For decades, the Northeast region experienced low performance indicators, while the Southeast led the high performance of the country. The numbers indicate that the Northeast continues to perform badly. There is a redistribution of the positive growth rates, since states in the South and, specially, the Center-West, present high productivity rates. These are the cases of Mato Grosso and Santa Catarina, while Rio de Janeiro and Minas Gerais had zero annual performance. In the North, most of the positive behavior is due to the low level of activities in the beginning of the period.

From Table 2, it is also clear that the aggregate null growth rate is not repeated in the sectoral estimates. As presented before, and as depicted in columns 2, 3 and 4 in Table 4, agriculture and manufacturing showed positive growth rates (2% to 3%, and of 0.6%, respectively) while services showed a negative performance (around -1.6% to -2%). By inserting interaction dummies between sectoral trends and regional dummies, we estimated regional and sectoral growth productivity rates, as presented in the table.

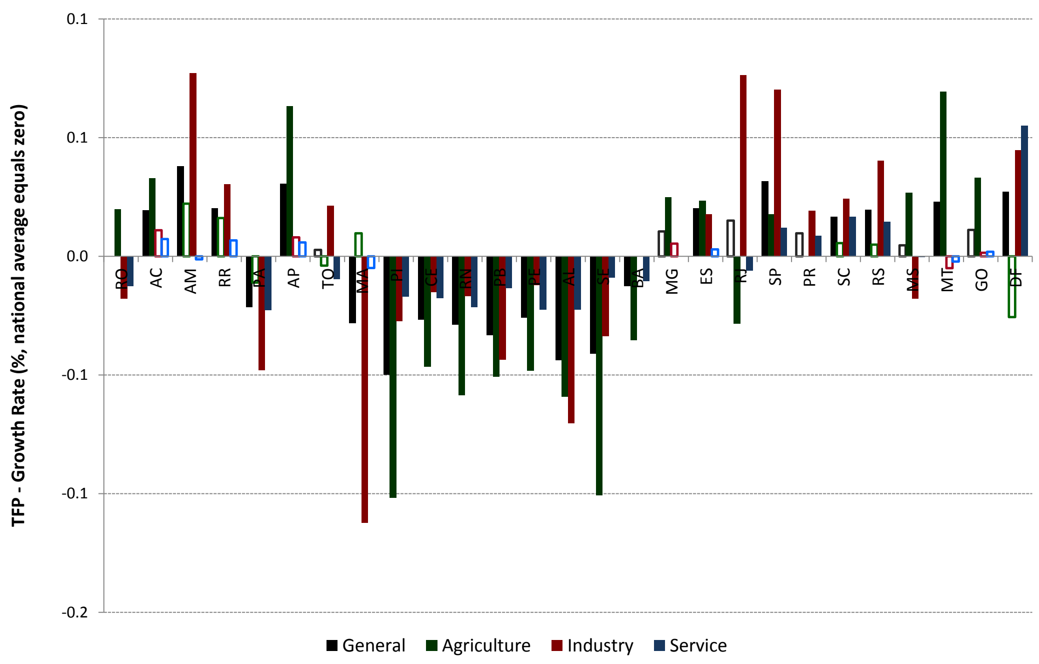
The sectoral performances tend to replicate the general result, but there are some adjustments. The Center-West states present productivity growth in agriculture; the highest rate is for Mato Grosso (4 percentage points above the national average). Amazonas is again an interesting case, since its general positive performance is entirely due to its manufacturing sector, which has the highest growth rate in Brazil. Amazonas, however, is closely followed by Rio de Janeiro (5.5 percentage points above national average), the only sector that showed positive performance in that state. Most of the negative growth rates for manufacturing are still concentrated in the Northeast, being Maranhão the worst case (9 percentage points below the national average), followed by Alagoas.

The service sector tells us a similar story. While most of the northern states oscillate between zero and negative growth rates, all the Northeast states perform negatively, being Pará, in the north, and Alagoas and Pernambuco, in the northeast, the worst cases. Few states actually have positive rates when compared to the national average, and these are concentrated in the South region, besides São Paulo and Distrito Federal, which has the highest productivity growth rate (7 percentage points above national average).

Figure 4 presents the estimated TFP trends. As in Figure 3, non-shadowed columns indicate that the coefficient is not significantly different from zero. The estimated sectoral trends for each state are compatible with the estimated trends for their aggregate TFP growth. As an example, São Paulo state, the most important state in the Brazilian economy, presents an aggregate rate of TFP growth of 3.2%, and its sectoral growth rates are: 1.8% for agriculture; 7,0% for manufacturing; and 1.2% for services. The state of Rio de Janeiro, with significant negative rates for agriculture and services (-2.8% and -0.6%, respectively), and a significant positive rate for manufacturing (7.6%), ends up with a non-significant coefficient for the aggregate.

Figure 4. Regional TFP Annual Growth Rate by Sector

(%, national average = zero)



In Espirito Santo, Santa Catarina, Rio Grande do Sul and Distrito Federal, the above-average aggregate growth rates are lead by the performance of two sectors only (agriculture and industry in the first case, and industry and services in the others). Mato Grosso, Amapá and Acre have a positive growth rate only because of the performance of agriculture, while Amazonas and Roraima are led by manufacturing. Negative growth rates in the Southeast are only experienced by Rio de Janeiro in agriculture and services. In the poor northeast region, the bad performance is present in all sectors, but typically agriculture shows the worst performance, contrasting with its good performance in TFP. Maranhão is the only exception in the region, with manufacturing with the lowest TFP growth.

4.2.3. Is there TFP convergence?

In the previous sections, indicators of TFP levels and growth rates for each state were presented. Table 5 presents a summary of the results. A plus sign indicates an above-average performance; a minus sign indicates a below-average performance; blank cells indicate a performance not significantly different from the national average.

Table 5. Comparative TFP Levels and TFP Growth

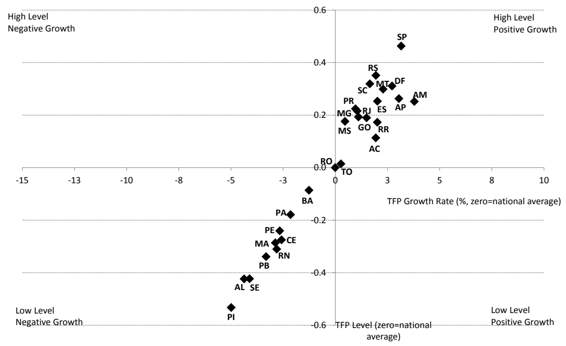
		TFP Levels				TFP Growth			
		General	Agriculture	Manufacturing	Services	General	Agriculture	Manufacturing	Services
N	RO		+	-	-		+	-	-
	AC	+	+	-	-	+	+		
	AM	+	+	+	-	+		+	
	RR	+	+		-	+		+	
	PA	-			-	-		-	-
	AP	+	+	-	-	+	+		
	TO		+	-	-			+	-
NE	MA	-	+	-	-	-		-	
	PI	-		-	-	-	-	-	-
	CE	-			-	-	-	-	-
	RN	-		-	-	-	-	-	-
	PB	-		-	-	-	-	-	-
	PE	-				-	-	-	-
	AL	-		-	-	-	-	-	-
	SE	-		-	-	-	-	-	-
	BA		-	+	+	-	-		-
SE	MG	+		+	+		+		
	ES	+	+	+		+	+	+	
	RJ	+	+	+	+		-	+	-
	SP	+		+	+	+	+	+	+
S	PR	+	-	+	+			+	+
	SC	+		+	+	+		+	+
	RS	+	-	+	+	+		+	+
CW	MS	+	+	-	-		+	-	
	MT	+	+		-	+	+		
	GO	+	+	+	+		+		
	DF	+	+	+	+	+		+	+

As mentioned before, the results in TFP levels replicate the regional inequality levels observed in the country in many aspects, as GDP per capita, poverty, education, etc. Changing this situation requires that low-performing regions improve at a faster rate than high-performing regions. In order to check if there are any signs of that being happening, we have correlated the average levels of TFP in each state with the estimated TFP growth rates, as presented in Figure 5.

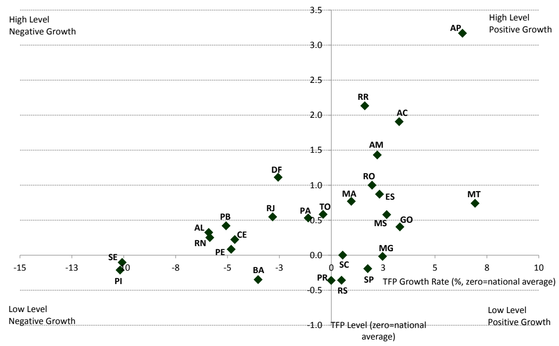
Considering the aggregate TFP, it is clear that states with high average levels are the ones with the best growth performances. The lower-left quadrant contains all states in the northeast region, with low levels and low growth rates. Thus, for production in general, the TFP trends do not show any sign of important changes in regional competitiveness in the country. The sectoral results replicate this situation in general, but they are more heterogeneous. In agriculture, several states present high TFP level and low growth rates. On the other hand, although São Paulo and Rio Grande do Sul present low TFP levels, they show high growth rates (especially São Paulo, probably due to sugarcane production). For manufacturing, all promising states (low levels and high growth rates) are from the North region. The service sector has the most homogeneous TFP growth rates among states, with the majority belonging to the worst quadrant (low levels and low growth rates). Only four states belong always to the same quadrant, independently of which sector is considered: Piauí and Sergipe have low TFP levels and low growth rates; Pernambuco shows always high TFP levels and negative growth rates; Goiás has high TFP levels and positive TFP growth rates.

Figure 5. Regional Productivity Levels and Growth Rates

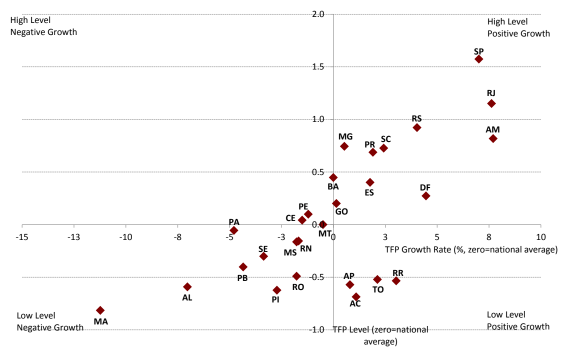
All Sectors



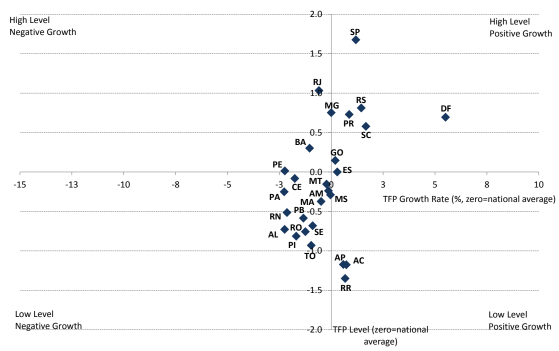
Agriculture



Manufacturing



Services



5. Conclusions

We have tackled the question of regional inequalities in Brazil from the fundamental point of view of the evolution of regional competitiveness. We have estimated TFP levels and TFP growth for the states in recent years, in order to gather information on their relative positions and their evolution of productivity, as a sign of potential future competitiveness. The results show that TFP has not grown at the national level in the period 1995-2009, although agriculture presented a positive performance, followed by manufacturing, with a pale positive growth. The tertiary sector, with around two-thirds of national GDP, presented a decrease in productivity, leading the overall result of no-growth.

The estimated productivity levels indicate that the most productive states are in the richer part of the country, although some exceptions appear in the center-west, mostly related to agriculture, and in the north, associated with the free-trade zone in Manaus and the mining industry in the state of Pará. The estimated growth rates of TFP present a pessimistic scenario, for the low-level states tend to present below-average growth. As a result, no signs of convergence of productivity levels were found. On the contrary, signs are of divergence, which points to an even more concentrated regional distribution of economic activities in the country in the future.

The exceptional cases of success outside the traditional economic center of the country are in a way related to government initiatives. These are the cases of the free-trade zone in the north, the petrochemical complex in Bahia, the oil-related activities in Sergipe, but the most impressive case is the performance of the agricultural states of the center-west. The technological development led by Embrapa, the government-owned research institution in agriculture, has created the conditions for states in that region to go from a low-productivity agriculture to a state-of-the-art and highly competitive modern activity, competitive at the international level. More recently, social programs targeting poor families have created a growing demand for wage goods in poor areas, leading to some movement of part of the production of this sort of goods in the vicinity of the new consumption centers. But this effect does not appear in the TFP estimates so far.

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Appendix

A. States and Regions

North (N)	Northeast (NE)	Southeast (SE)	South (S)	Center-West (CW)
RO – Rondônia	MA – Maranhão	MG – Minas Gerais	PR – Paraná	MS – Mato Grosso do Sul
AC – Acre	PI – Piauí	ES – Espírito Santo	SC – Santa Catarina	MT – Mato Grosso
AM- Amazonas	CE – Ceará	RJ – Rio de Janeiro	RS – Rio Grande do Sul	GO – Goiás
RR – Roraima	RN – Rio Grande do Norte	SP – São Paulo		DF – Distrito Federal
PA – Pará	PB – Paraíba			
AP – Amapá	PE – Pernambuco			
TO - Tocantins	AL – Alagoas			
	SE – Sergipe			
	BA - Bahia			

B. Table 1: Descriptive Statistics

	Annual Average	Std. Dev.	Minimum	Maximum
Agriculture				
AV	5,132.4	5,526.0	121.0 (RR, 95)	24,827.3 (MG, 08)
L	616.9	566.4	3.1 (AP, 00)	2,551.1 (BA, 05)
K	30,165.1	46,127.4	70.2 (AP, 09)	170,932.2 (RS, 09)
Industry				
AV	20,536.7	40,620.7	195.0 (TO, 95)	248,339.6 (SP, 08)
L	550.5	861.6	11.1 (AP, 01)	4,980.5 (SP, 08)
K	5,223.8	9,338.0	7.8 (RR, 95)	5,5329.1 (SP, 08)
Services				
AV	43,324.5	85,509.3	907.0 (RR, 95)	548,759.3 (SP, 08)
L	1,569.6	2,162.9	54.5 (AP, 95)	13,390.4 (SP, 09)
K	1,741.7	3,203.4	32.1 (RR, 95)	20,130.9 (SP, 09)

The text in parentheses identifies the state and year of minimum and maximum values

C. Regression Results from Section 4

National Production Functions Results

	Model 1		Model 2		Model 3	
	Coeff.	T-stat	Coeff.	T-stat	Coeff.	T-stat
log(L)	0.4568	19.3	0.4508	19.39	0.4484	19.32
log(K)	0.2864	19.82	0.3798	23.46	0.3799	24.42
ds2*log(K)	0.2113	40.82	0.0417	2.5	0.0423	2.58
ds3*log(K)	0.3118	34.43	0.2803	16.42	0.2943	17.94
Trend	0.0028	1.04	0.0028	1.11	0.0209	4.37
ds2			1.4623	10.24	1.5747	10.6
ds3			0.4575	3.46	0.689	5.22
ts2					-0.0147	-2.1
ts3					-0.0401	-7.57
Constant	2.6668	41.05	1.828	13.84	1.6967	12.77
R^2	0.9343		0.9429		0.9449	
F	3303.9		5235.8		5250.6	

Regional TFP Level Estimates

		General		Agriculture		Manufacturing		Services	
		Coeff.	T-stat	Coeff.	T-stat	Coeff.	T-stat	Coeff.	T-stat
	log(L)	0.598	23.18	0.720	17.47	0.340	13.76	0.465	19.08
	log(K)	0.179	12.26	0.578	4.86	0.438	28.06	0.371	23.09
	ds2*log(K)	0.186	29.57	-0.318	-2.58	-0.163	-2.12	0.041	2.47
	ds3*log(K)	0.283	28.92	-0.134	-1.06	0.328	21.02	-0.264	-3.87
	trend	0.010	2.67	0.016	6.15	0.021	4.35	0.021	4.29
	ds2			5.143	3.81	2.942	5.85	1.571	10.33
	ds3			4.256	3.16	0.711	5.87	4.220	9.27
	ts2	0.007	1.42	-0.011	-2.11	-0.004	-0.63	-0.015	-2.09
	ts3	-0.025	-5.49	-0.034	-8.70	-0.041	-7.72	-0.012	-2.03
N	RO			0.999	3.09	-0.491	-3.86	-0.757	-8.73
	AC	0.113	2.38	1.906	3.29	-0.687	-2.39	-1.177	-7.19
	AM	0.252	2.97	1.431	2.59	0.818	19.80	-0.239	-4.81
	RR	0.173	2.52	2.133	3.27	-0.534	-1.62	-1.350	-7.17
	PA	-0.179	-3.19	0.531	1.90	-0.055	-0.31	-0.252	-7.63
	AP	0.263	3.71	3.169	3.98	-0.571	-2.29	-1.172	-7.16
	TO	0.014	0.24	0.582	2.37	-0.522	-2.79	-0.931	-8.21
NE	MA	-0.310	-3.82	0.769	2.51	-0.816	-5.01	-0.374	-7.27
	PI	-0.533	-8.28	-0.213	-0.60	-0.624	-4.71	-0.814	-9.28
	CE	-0.241	-4.48	0.223	0.72	0.043	0.60	-0.082	-2.46
	RN	-0.286	-4.72	0.251	0.71	-0.156	-4.09	-0.514	-9.35
	PB	-0.339	-7.56	0.420	1.10	-0.403	-11.37	-0.585	-8.81
	PE	-0.275	-4.91	0.084	0.28	0.098	1.21	0.013	0.31
	AL	-0.424	-9.52	0.325	0.91	-0.592	-8.10	-0.728	-10.20
	SE	-0.423	-5.33	-0.104	-0.28	-0.301	-6.84	-0.681	-7.78
	BA	-0.086	-1.37	-0.350	-2.79	0.448	2.51	0.301	4.81
SE	MG	0.216	2.59	-0.018	-0.26	0.744	2.87	0.752	7.40
	ES	0.253	4.90	0.870	3.92	0.401	3.46		
	RJ	0.190	2.50	0.546	2.06	1.151	6.11	1.031	7.36
	SP	0.463	5.19	-0.193	-1.67	1.573	5.12	1.676	8.40
S	PR	0.224	3.33	-0.361	-3.75	0.687	3.95	0.729	8.72
	SC	0.319	5.50			0.727	4.58	0.578	10.74
	RS	0.351	5.23	-0.359	-3.04	0.922	5.23	0.811	9.32
CW	MS	0.176	3.06	0.579	5.99	-0.164	-3.60	-0.291	-6.33
	MT	0.299	4.13	0.740	6.96			-0.154	-3.88
	GO	0.193	3.02	0.403	5.16	0.200	2.50	0.146	4.01
	DF	0.311	4.11	1.113	2.54	0.273	3.84	0.694	18.06
	Constant	2.710	21.92	-2.209	-1.63	1.809	14.77	1.680	12.22
	R^2	0.9631		0.9672		0.9684		0.9490	
	F	1747.31***		1899.02***		5774.41***		7051.19***	

Estimated Regional TFP Annual Growth Rates

		General		Agriculture		Manufacturing		Services	
		Coeff.	T-stat	Coeff.	T-stat	Coeff.	T-stat	Coeff.	T-stat
	log(L)	0.554	22.43	0.573	17.98	0.371	15.75	0.462	19.14
	log(K)	0.314	20.39	0.294	12.09	0.421	27.55	0.373	23.31
	ds2*log(K)	0.051	3.66	0.054	2.24	0.043	1.87	0.041	2.49
	ds3*log(K)	0.228	13.76	0.275	10.41	0.318	20.32	0.272	13.82
	trend	0.004	0.76	0.028	4.26	0.021	4.37	0.021	4.30
	ds2	1.310	10.65	1.374	6.12	1.616	8.97	1.572	10.36
	ds3	0.547	4.56	0.488	2.26	0.705	5.69	0.795	5.29
	ts2			-0.022	-2.76	-0.015	-1.95	-0.015	-2.09
	ts3			-0.047	-6.57	-0.041	-7.70	-0.037	-6.28
N	RO			0.020	2.42	-0.018	-2.29	-0.012	-2.97
N	AC	0.019	3.14	0.033	2.62	0.011	0.90	0.007	1.54
N	AM	0.038	4.73	0.022	1.91	0.077	8.58	-0.001	-0.37
N	RR	0.020	3.12	0.016	0.93	0.030	2.36	0.007	1.24
N	PA	-0.021	-3.74	-0.011	-1.11	-0.048	-7.61	-0.023	-5.54
N	AP	0.030	3.37	0.063	3.54	0.008	0.54	0.006	1.28
N	TO	0.003	0.42	-0.004	-0.51	0.021	2.10	-0.010	-2.41
NE	MA	-0.028	-2.86	0.010	1.07	-0.112	-9.68	-0.005	-1.39
NE	PI	-0.050	-6.85	-0.102	-9.02	-0.027	-3.10	-0.017	-3.97
NE	CE	-0.027	-4.96	-0.046	-5.12	-0.015	-3.60	-0.018	-5.74
NE	RN	-0.029	-4.83	-0.059	-4.29	-0.017	-3.31	-0.021	-6.62
NE	PB	-0.033	-6.53	-0.051	-5.45	-0.043	-7.72	-0.013	-3.69
NE	PE	-0.026	-4.68	-0.048	-4.59	-0.012	-3.51	-0.022	-6.03
NE	AL	-0.044	-8.12	-0.059	-6.34	-0.070	-10.84	-0.022	-4.67
NE	SE	-0.041	-5.54	-0.101	-7.29	-0.034	-6.10	-0.009	-2.49
NE	BA	-0.013	-2.17	-0.035	-4.69			-0.010	-3.60
SE	MG	0.010	1.55	0.025	3.75	0.005	1.75		
SE	ES	0.020	3.67	0.023	2.46	0.018	5.54	0.003	0.93
SE	RJ	0.015	1.67	-0.028	-3.32	0.076	14.05	-0.006	-2.27
SE	SP	0.032	4.37	0.018	2.29	0.070	9.03	0.012	4.62
S	PR	0.010	1.67			0.019	4.96	0.009	4.48
S	SC	0.017	2.97	0.006	0.93	0.024	4.77	0.017	4.84
S	RS	0.019	3.22	0.005	0.76	0.040	7.61	0.014	6.54
CW	MS	0.005	0.76	0.027	2.83	-0.018	-3.38	0.000	-0.09
CW	MT	0.023	2.58	0.069	8.92	-0.005	-0.91	-0.002	-0.58
CW	GO	0.011	1.70	0.033	4.25	0.001	0.38	0.002	0.79
CW	DF	0.027	3.67	-0.026	-1.64	0.045	5.32	0.055	8.56
	Constant	1.810	11.83	1.742	7.88	1.777	14.25	1.683	12.30
	R^2	0.9625		0.9625		0.9634		0.9476	
	F	1487.92***		1715.29***		2811.81***		9194.44***	