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Regional and sectoral performance of Brazilian labour productivity in the period 2004-2014

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Abstract

This study aimed to analyze the behaviour of Brazilian labour productivity (2004-2014) and its impact on growth, seeking which regions and sectors contributed most to the low aggregate productivity. The trend of productivity growth is positive, and the worked hour had a smaller growth than the per person employed, indicating an increase in the workday. The results indicate that there was a growth in agricultural productivity, a fall in industry, and stagnation in services. The regions with the best performance were the North, Northeast and Center-West. The sectoral productivity performance in the country was found to be mainly due to intrasectoral productivity, so the low growth was due to the lack of growth within sectors, except in the North, where structural change significantly contributed to the good regional performance. Yet the econometric estimates showed that only in services the elasticity of productivity was higher than that of physical capital.

Key-words: Economic Growth; Sectoral and Regional Heterogeneity; Structural Change; Intrasectoral Productivity

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JEL Code: E24. J24

Desempenho setorial e regional da produtividade da força de trabalho brasileira no período 2004-2014

Resumo

Esse estudo buscou analisar o comportamento da produtividade do trabalho brasileira (2004-2014) e o seu impacto no crescimento, buscando quais regiões e setores contribuíram mais para a baixa produtividade agregada. A tendência do crescimento da produtividade é positiva, e as horas trabalhadas tiveram um crescimento menor do que o por pessoa empregada, indicando um aumento na jornada de trabalho. Os resultados indicam que houve um crescimento na produtividade agropecuária, queda na indústria e estagnação nos serviços. As regiões com melhor desempenho no país foram Norte, Nordeste e Centro-Oeste. O desempenho da produtividade setorial no país se deveu principalmente à produtividade intrassetorial, então o baixo crescimento se deveu à falta de crescimento dentro dos setores, exceto no Norte, onde a mudança estrutural contribuiu significativamente para o bom desempenho regional. Já as estimativas econométricas mostraram que somente nos serviços a elasticidade da produtividade é maior do que a do capital físico.

Palavra-chave : Crescimento Econômico. Heterogeneidade Setorial e Regional. Mudança Estrutural. Produtividade Intrassetorial.

JEL Classificação: E24. J24

Introduction

Productivity is a relevant theme for Brazil, given the scenario of economic growth. The interest in productivity as a factor of economic growth was due because, according to De Negri, and Cavalcante (2014), investment incentives did not have sufficient impacts to stimulate the Brazilian economy in the long run, given its resilience, and also the industry, which is the engine of the economy from the perspective of Kaldor (1966), has lost ground in the composition of GDP for services. However, as stated by Squeff, and De Negri (2014), Brazilian production efficiency has performed poorly since the 1980s, with slight growth in the early 2000s.

The importance of the relationship between labour productivity and production growth stems from the Kaldor-Verdoorn law, according to Marinho et al. (2002), which states that there is an empirical relationship between the two growth rates so that when there is productivity growth, there is a tendency for production growth to follow labour productivity growth. Thus, an improvement in production growth in the industry tends to improve industry labour productivity growth, and this fact has a multiplier character in other sectors, increasing labour productivity in the economy as a whole.

In the national empirical literature about the importance of labour for economic growth, some studies focus on labour productivity for the country [BONELLI; VELOSO, 2012; BONELLI; BACHA, 2013; CAVALCANT; DE NEGRI, 2014]. Some studies seek to analyze regional differences in labour productivity [MATTEO, 2015; NOGUEIRA et al., 2014]. In addition, sectoral analysis is also an area of interest [BONELLI, 2014; GALEANO; WANDERLEY, 2013; FOCHEZATTO; STULP, 2007; VELOSO et al., 2015]. In turn, Bonelli (2014) stated that the tendency is for the population to start decreasing by the year 2048 and that, to sustain long-run growth, the economy must be supported by growth in labour productivity, as the labour force will no longer provide the necessary growth.

In this context, this study aims to verify the performance of Brazilian productivity, its causes and its impact on economic growth, from 2004 to 2014. The contribution of the study derives from the analysis of these methodologies in a disaggregated way, analyzing the productivity by sector (agriculture, industry and services) and regions (North, Northeast, Southeast, South and Center-West) in the country. The purpose of the analysis is to verify which regions and sectors were responsible for the major contribution to the low aggregate performance.

Complementarily, two more growth decompositions were performed. The first decomposition of economic growth was between labour productivity and labour-related variables, the second was a decomposition of labour productivity between structural change and intrasectoral productivity. In the first decomposition, it was found that the increase in economic growth in the early 2000s was mainly due to the incorporation of labour into production, and in this time the country reached levels close to full employment, as argued by De Negri, and Cavalcante (2014). In turn, the second decomposition made it possible to verify whether the migration of labour from agriculture to industry and services had an impact on labour productivity growth, as well as the labour productivity of the sectors themselves. Finally, a fixed-effect panel data estimation was performed using Nelson's (1987) sectoral competition model, which showed that labour productivity, as well as physical capital stock, contribute positively to all sectors of the economy in the world. However, the elasticity of labour productivity varies depending on the sector analyzed.

This study is divided into three sections, besides this introduction and the final considerations. In the first section, there was a theoretical discussion about the relationship between labour productivity and economic growth, as well as the evidence on productivity behaviour in Brazil, highlighting a more disaggregated analysis. In section two we describe the methodology for estimating labour productivity, productivity decompositions and econometric estimation, which first addresses the challenges in calculating productivity. Subsequently, the estimates of labour productivity, as well as their decompositions, are presented and discussed.

Theoretical and empirical review

Labour productivity can be related to economic growth through Kaldor's second law or Kaldor-Verdoorn[3] law, according to Thirwall (1983). Under this law, the

[3] Verdoorn, and Kaldor, in separate studies, have established the theory for the empirical relationship between production growth and labour productivity. Thus, when labour productivity increases, there is a tendency for production to increase as well, becoming known as the Kaldor-Verdoorn law.

faster the rate of labour productivity growth, the faster the rate of output of the manufacturing industry would be, due to the existence of economies of scale and rising returns. Returns to scale were a macroeconomic phenomenon related to the interaction between the elasticity of demand and the supply of manufacturing goods. Besides, this interaction would be responsible for the positive relationship between productivity and product in manufacturing.

Kaldor (1966) studied the reasons why the UK growth rate was low in the first half of the twentieth century. According to the author, the economic growth rate would be associated with the growth rate of the manufacturing sector at an intermediate stage of economic development. At this stage, the economy would shift from immature to mature, and for the author, the low economic growth in the UK was because the maturity stage was reached earlier than in other countries, and therefore its potential for rapid growth was eroded before high levels of productivity were achieved. Thus, the United Kingdom suffered from premature maturity.

In addition, the higher the growth rate of manufacturing industry output, the greater the transfer of labour from other sectors with diminishing returns to this industry, inducing productivity growth in other sectors of the economy. Therefore, the higher the rate of output growth in the manufacturing industry, the higher the rate of productivity growth in the economy as a whole, known as Kaldor's third law, according to Thirwall (1983). As labour transfer from sectors with diminishing returns increased, or when output began to depend on employment in all sectors of the economy, manufacturing-induced overall productivity growth would tend to slow, along with the corresponding output growth rate.

In this sense came the idea that more developed countries with fewer people in agriculture would have a fall in production growth, known as the process of structural change, according to Baumol (1967), being a process of migrating labour from agriculture for industry and services. That is, as countries develop, the labour force that would be employed in agriculture would be replaced by physical capital and would be absorbed by the industrial sector, which would cause productivity gains in both sectors. After this, as countries became more and more developed, a stage would come when the industrial labour force would migrate to the services sector, characterizing a new process of structural change.

In the empirical literature, there are some studies on labour productivity in Brazil. Bonelli and Veloso (2012) found that the average growth rate of labour productivity was 1.2% per year between 1995 and 2009. Bonelli and Bacha (2013) found lower average growth values in the periods from 1993 to 1999, 0.36% per year, and from 2000 to 2009, 0.67% per year, respectively. Cavalcante, and De Negri (2014), analyzed the periods from 1992 to 2001 and 2001 to 2009, estimated average growth rates of 1.09% per year and 1.17% per year, respectively, closer to those obtained by Bonelli, and Veloso (2012). Analyzing labour productivity in the services sector, Bonelli (2014) observed that it was higher than the aggregate productivity of the Brazilian economy and that it grew slower than in the agricultural sector.

Some studies focus on the regional analysis of labour productivity, such as Matteo (2015) who studied the regions of Brazil, considering the agricultural, industrial, construction, trade and services sectors, from 1996 to 2008. Contrary to Ellery Jr's (2014) suggestion, the value-added of production was used as a product measure. Among his conclusions, he stated that labour productivity was higher in industry and lower in agriculture. Comparing the Center-West and Northeast, confirmed that the

productivity of the former was 6.5 times higher than the second in the period, which was corroborated by the fact that the Center-West has extensive cattle farming and Northeast family farming, as evidenced by Nogueira et al. (2014). Still considering the labour productivity of agriculture, the study also observed that the productivity of the Northeast was close to half of the Brazilian one. Besides the productive efficiency of agriculture, the productivity of the services sector was also low, being approximately 1/3 of the Southeast. The author concluded that, by maintaining inequality in labour productivity throughout the period, there was regional heterogeneity in the country. According to the study, this was caused by the productive structure and some regions having more capital included in the production than others.

Galeano and Wanderley (2013) studied the productivity in the industry considering the sectors according to their technological intensity and in a regional disaggregation, and concluded that sectors that had high technological intensity had higher productivity, however, this high productive efficiency was not able to compensate for the low productivity of other sectors with low technological intensity. The same occurred between regions, the decrease in labour productivity in the Southeast region was not absorbed by growth in other regions, which implied national stagnation in terms of labour productivity in the industry. However, they also state that by disaggregating the Southeast region into states, the decrease in labour productivity was only observed in the state of São Paulo. Analyzing the year 2007, the authors concluded that the industrial labour productivity in the South, Center-West and Northeast regions was below the national average and that the Southeast region was above average, but with decreases concerning the previous years. They also stated that the North was the region with the highest labour productivity.

Still considering the sectoral and regional disaggregation, Fochezatto, and Stulp (2007) studied the performance of labour productivity during the 1990s. This study differed from the others in some respects. The authors estimated a distribution function with four productivity classes for the beginning and end of the decade. After this, they estimated a transition matrix to verify the likelihood of change in productivity classes. Altogether they considered eight sectors, in which three converged to the highest productivity class, showing an increase in the performance of the Southeast, South and Center-West states. The authors stated that in the agriculture sector there was a convergence for the lower productivity class, but with good performance for the South and Center-West. They also noted that it was in the services sector that convergence to the highest productivity class occurred.

In Brazil, however, disaggregating into sectors, Veloso et al. (2015) studied labour productivity considering both formal and informal workers. They analyzed the period from 1995 to 2013, concluding that there was a drop in industry productivity, -0.4%, and that agriculture was the fastest-growing sector, 6.3%. They also concluded that the services sector had a short increase in production efficiency in the period, 0.7%, but for the economy, this growth was 1.3. Thus, the productivity growth in agriculture, fall in industry and practically zero growth in services influenced the aggregate, which corroborated the sectoral performance that De Negri and Cavalcante (2014) described for the national scenario.

Considering the importance of structural change for productivity analysis, Bonelli (2014) showed that there was still scope for structural change to have positive effects on productivity performance and that intrasectoral productivity growth had a greater effect. Squeff and De Negri (2014) also concluded that intrasectoral growth

had a greater effect on productivity than structural change. Despite the similar conclusions, these two studies started from different methodologies, while the second one decomposed the productivity between the structural, intrasectoral, price and interaction components, the first only decomposed into the structural and intrasectoral components[4]. The first author also showed that, in addition to these factors, growth in the services sector was responsible for changing the structure of the economy and also played a relevant role in productivity behaviour, as the highest concentration with low productivity was in the services sector.

In the 2000s, economic growth returned, but the financial crisis of 2008 affected GDP growth in 2009. However, the country started to grow again from 2010, and the average growth in the 2000s was 2.86% per year, higher than in the 1980s and 1990s. From 2010 to 2014, this increase was negligible, so during these five years, the average growth was 1.67% per year. In the 2000s there was also a growth in the number of people employed, 2.07% per year, being higher than in the previous decade. This growth corroborated the fact that GDP growth at the beginning of the decade was mainly supplied by the increase in the labour force, as stated by De Negri, and Cavalcante (2014). Thus, there was also a slight stagnation between 2008 and 2009, according to the GDP performance. Between 2010 and 2014, the growth was lower than the previous decade, averaging 0.99% per year, but exceeding the rates observed in the 1990s.

Regarding the number of average hours worked in the economy, according to data from PWT (2017), there has been a trend since 1970. Only in the 1950s and 1960s were registered positive growths averaging 0.40% per year and 0.05% per year respectively. From 1970 onwards negative growth was observed, the largest occurring in the 1970s, with -0.70% per year average. In the following decade, the fall was 0.50% per year. It is important to highlight that with the implementation of the 1988's Constitution, the workday was reduced from 48 hours per week to 44 hours, so part of the reduction from the late 1980s was due to this fact, as Barbosa-Filho, and Pessôa (2014) stated. The fall in a workday in the 1990s was 0.15% per year, lower than in previous periods, while in the 2000s there was also a fall, 0.54% per year, is higher than in the previous decade, which remained from 2010 until 2014, with an average fall of 0.20% per year.

Therefore, as identified by the empirical literature, the growth of Brazilian labour productivity has been practically stagnant in recent decades. Taking into account the disaggregated productivity in regions, it is confirmed that the productivity reached a higher level in the Center-West and Southeast regions, however, considering its growth, the Northeast region stands out. Moreover, sectoral productivity growth is higher in agriculture, despite being the sector with the lowest level of labour productivity.

[4] Bonelli (2014) analyzes the period from 1995 to 2012, while Squeff, and De Negri (2014) study the period from 2001 to 2012.

Methodology

Database

The purpose of this study is to calculate the Brazilian labour productivity and analyze its performance from 2004 to 2014. Additionally, two disaggregations were estimated, considering the three sectors of the economy, agriculture, industry and services, and also by regions, North, Northeast, Southeast, South and Center-West. Productivity has been a recurrent theme in economics and especially in Brazil, due to its low growth, according to De Negri, and Cavalcante (2014). The calculation of labour productivity (LP), however, has measurement issues, as stated by Messa (2014), which lies in deciding which production unit measure to use, whether total production or value-added, whether the measure used would be physical production or monetary indicator, as the latter could show variations that would not be of efficiency.

It is also necessary to decide on the use of the employed population or the number of hours worked as a unit of labour. Messa (2014) stated that the calculation using these two labour measures had differences, mainly in Brazil, due to the change in the workload that occurred in the 1980s, with the promulgation of the 1988's Constitution. Therefore, if productivity were calculated based only on the employed population, it would be possible to conclude that there was a decrease in labour productivity, when in fact what happened was that the hours worked decreased, causing a higher ratio between production and labour.

For Barbosa-Filho, and Pessôa (2014), there would be no problems as to which labour measure to use as long as the economy was stable[5] in terms of labour, but when it varied, labour productivity would also suffer from these variations and in this case, the calculation using the average amount of hours worked would be more accurate than by the employed population. However, as described by De Negri, and Cavalcante (2014), these measures are not always available, so hours worked are more often used in short-run analysis and employed people in long-run analysis.

Thus, the variables used to measure labour productivity were obtained from different sources, covering the period from 2004 to 2014. The deflator was obtained from IPEADATA (2017), with the base year being considered 2010. For production, it was considered the gross value of production of the production account by economic activity of the IBGE's Regional Accounts (2017). To measure the employed population and the number of hours worked annually, the PNAD's microdata (2017) was used, considering the federation units, the grouping of activities of labour, age of the resident, occupation situation, person's weight and several hours usually worked.

To perform the econometric estimation it was necessary to calculate the fixed capital stock, and for this, the population was used to calculate the population growth rate; US[6] production, implicit deflator and hours worked were required to estimate the rate of technical progress or frontier of technological progress. The investment, depreciation, and US[7] residential and nonresidential net capital were used in the calculation of the depreciation rate, these rates, together with gross fixed capital

[5] The workday is not changing in relation to the number of employed people.

[6] The US labour productivity growth rate was considered as the technological frontier for Gomes et al. (2003). Being that, it was defined as the highest level possible to be reached in a trajectory.

[7] The depreciation rate was calculated based on the US National Accounts because of the reliability of their data, according to Gomes et al. (2003).

formation, implicit deflator, regional output, and domestic output were fundamental to the calculation methodology. These data were collected from the Regional Accounts (IBGE), the National Accounts System (IBGE) and the Bureau of Economic Analysis (BEA).

Methods

Initially, it is necessary to decide on the unit of measure that would be considered to indicate aggregate production. Since productivity was calculated by region and sector, being a more disaggregated measure, it was preferable to use the gross value of production to prevent bias in estimation, according to Ellery Jr. (2014). The real production was obtained using the implicit GDP deflator based on 2010, and the value of the sector production was given by the sum of activities belonging to the sector.

The labour measure used in the estimation was based on the methodology of Barbosa-Filho, and Pessôa (2014):

$$L_{i.j} = \sum_{\substack{i=1 \\ j=1}}^{N} w_{i,j} WH_{i,j} \quad (1)$$

$L_{i,j}$, is the average amount of hours worked of all workers in the month, $WH_{i,j}$, is the average amount of hours worked per worker and $w_{i,j}$ is the weight of the person in the sample. Indexes *i* and *j* correspond to sectors and regions, respectively. The average number of hours worked per week was then multiplied by the number of weeks of the year to obtain the average number of hours worked per year by all workers. The employed population *(EP)*, economically active population *(EAP)* and working-age population *(WAP)* were estimated considering people over 10 years, according to the Instituto Brasileiro de Geografia e Estatística (IBGE, 2017). Also, this age range was considered to estimate the total average hours worked. And for 2010, a linear interpolation was used to obtain the data.

Labour productivity *(LP)* was obtained from the ratio between production *(Y)* and total hours worked *(L),* as well as the ratio between *(Y)* and employed population *(EP),* based on Barbosa-Filho, and Pessôa (2014), in order to verify possible differences in *LP* performance due to different labour measures, i.e.:

$$LPHW_{t,i,j} = \frac{Y_{t,i,j}}{L_{t,i,j}} \quad (2)$$

And,

$$LPPE_{t,i,j} = \frac{Y_{t,i,j}}{EP_{t,i,j}} \quad (3)$$

LPHW is the productivity per hour worked and *LPPE* is the productivity of the *n-th* employed person.

In turn, the growth decomposition was also performed to measure how much labour productivity measured by the number of average hours worked and employed population contributed to aggregate production, following Barbosa-Filho, and Pessôa (2014), through the equations:

$$\frac{1}{N}\ln\left(\frac{Y_{t+N}}{Y_t}\right) = \frac{1}{N}\ln\left(\frac{LPHW_{t+N}}{LPHW_t}\right) + \frac{1}{N}\ln\left(\frac{WD_{t+N}}{WD_t}\right) + \frac{1}{N}\ln\left(\frac{EP_{t+N}}{EP_t}\right) \quad (4)$$

And,

$$\frac{1}{N}\ln\left(\frac{Y_{t+N}}{Y_t}\right)=\frac{1}{N}\ln\left(\frac{LPPE_{t+N}}{LPPE_t}\right)+\frac{1}{N}\ln\left(\frac{EP_{t+N}}{EP_t}\right) \quad (5)$$

Where *WD* is the workday or the ratio between total hours worked and employed people, with *N = 1, ..., 11*, the number of observations or number of years. Besides this, Bonelli (2014) presented another growth decomposition that allowed us to verify the importance of the occupation, activity and participation rate for the economy, besides productivity.

$$\frac{1}{N}\ln\left(\frac{Y_{t+N}}{Y_t}\right)=\frac{1}{N}\ln\left(\frac{LPPE_{t+N}}{LPPE_t}\right)+\frac{1}{N}\ln\left(\frac{OR_{t+N}}{OR_t}\right)+\frac{1}{N}\ln\left(\frac{AR_{t+N}}{AR_t}\right)+\frac{1}{N}\ln\left(\frac{WAP_{t+N}}{WAP_t}\right) \quad (6)$$

Where *OR* is the occupancy rate, i.e., the ratio of employed people *(EP)* to economically active people *(EAP)*, *AR* is the activity rate, being the ratio of economically active people to the working-age population *(WAP),* and the last term represents the rate of participation in the economy. This decomposition was derived from the following identity:

$$GDP=\frac{GDP}{EP}+\frac{EP}{EAP}+\frac{EAP}{WAP}+WAP \quad (7)$$

Thus, economic growth depends on productivity, occupancy rate, activity rate and participation rate, which represents a measure of the decomposition of supply-side growth.

In turn, a sectoral decomposition was also obtained, which allowed us to analyze the reason for the variation in productivity in the period, whether due to structural change or due to growth in intrasectoral productivity. According to Bonelli (2014), this decomposition was obtained considering the productivity variation:

$$\Delta P=P_t-P_0=\Sigma[P_{i,t}.(A_{i,t}-A_{i,0})]+\Sigma[A_{i,0}.(P_{i,t}-P_{i,0})] \quad (8)$$

Or,

$$\Delta P=P_t-P_o=\Sigma[P_{i,0}.(A_{i,t}-A_{i,0})]+\Sigma[A_{i,t}.(P_{i,t}-P_{i,0})] \quad (9)$$

Where $A_{i,t}$ and $A_{i,0}$ are the relative shares of each sector in total occupations in the final and initial year, and $P_{i,t}$ and $P_{i,0}$ are the labour productivity for each sector. The first term on the right side of the equation represents the variation caused by structural change, while the second term corresponds to the variation caused by variation in intrasectoral productivity. It is noteworthy that the two decompositions have a different base year, but the final result is the same, so the result for each term would be an average between the results of the two decompositions.

Finally, the sectoral competition model of Nelson (1987) was estimated to verify the importance of labour productivity and fixed capital stock for production in regions and sectors. The model used was as follows:

$$Y_{i,j}=A_{i.j}K_{i.j} \quad (10)$$

Where $Y_{i,j}$ is production in sector *i* and region *j*, $A_{i,j}$ is labour productivity in sector *i* and region *j* and $K_{i,j}$ is the fixed capital stock in sector *i* and region *j*. So that the econometric estimation could be performed the model was linearized:

$$\ln Y_{i.j}=\beta_1+\beta_2\ln A_{i.j}+\beta_3\ln K_{i.j}+\mu \quad (11)$$

To estimate the model, we used the panel data methodology, and the Hausman test indicated the use of fixed effects panel data. To this end, the fixed capital stock was constructed using the perpetual inventory methodology, in which:

$$K_{t+1}=(1-\delta)K_t+I_t \quad (12)$$

Where K_{t+1} and K_t are the aggregate capital stock in the period *t+1* and *t*, *It* is the gross annual investment and δ is the depreciation rate of the annual fixed capital stock. To estimate the series it was necessary an initial value of the fixed capital stock and also the depreciation rate. Following Gomes et al. (2003), the initial stock was obtained by:

$$K_0 = \frac{I_0}{(1+g)(1+n)-(1-\delta)} \tag{13}$$

With K_0 being the initial capital stock, I_0 being the initial investment, *g* is the annual technical progress rate and *n* is the annual population growth rate. According to Gomes et al. (2003), the initial investment was obtained by the average of the investment of the first five years of the period. All data were deflated by the implicit GDP deflator based on the year 2010 and the activities were aggregated according to the respective sectors to which they belonged. The rate of technical progress was considered to be the annual US labour productivity growth rate. And the depreciation was calculated by following the equation:

$$\delta = 1 - \frac{K_{t+1} - I_t}{K_t} \tag{14}$$

The depreciation used was calculated considering US data, as suggested by Gomes et al. (2003), given the reliability of the data. After estimating the national fixed capital stock, it was possible to use the methodology of Garafolo, and Yamarik (2002) to estimate the stock of the regions:

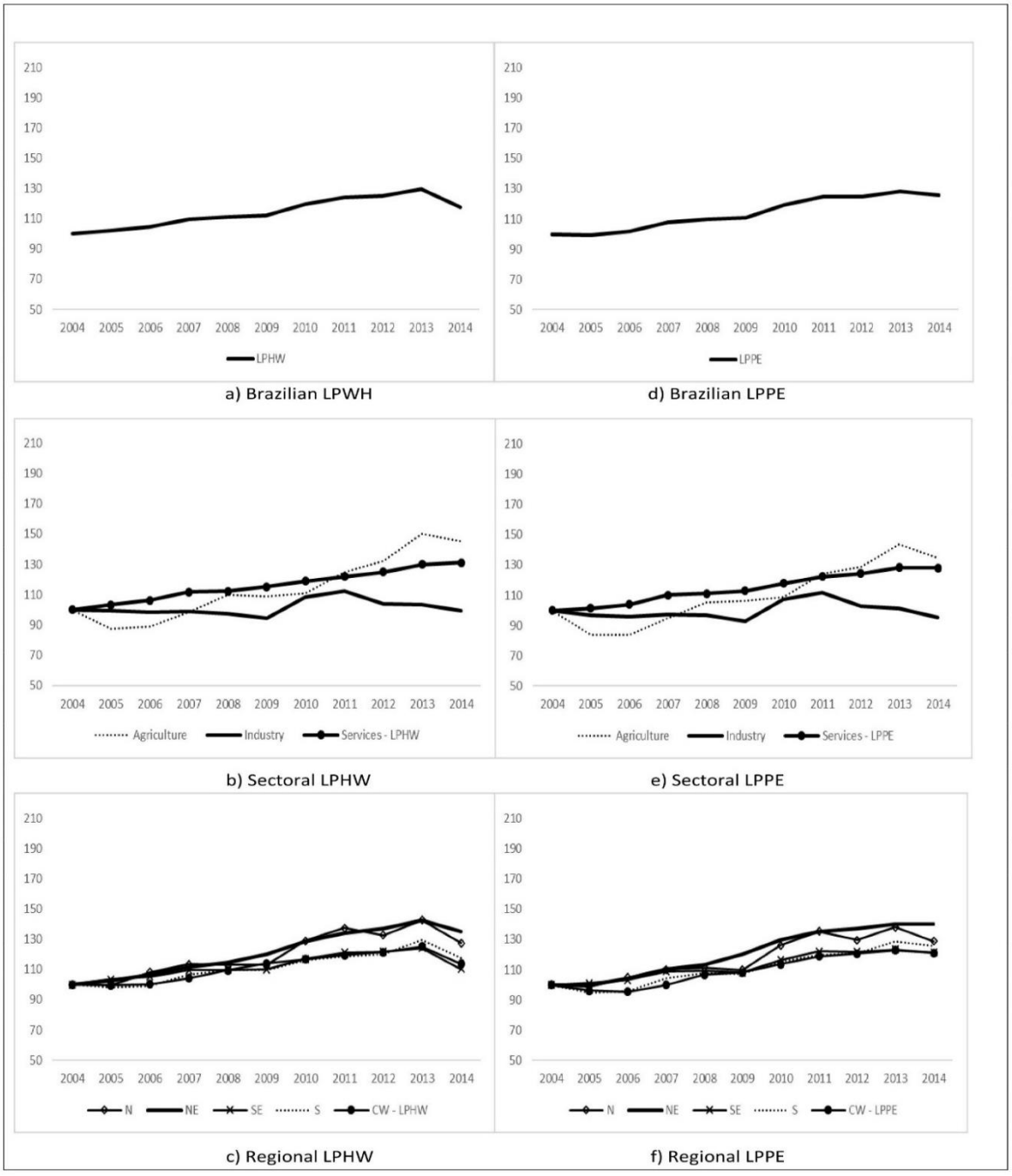
$$k_{t,i,j} = \left[\frac{y_{t,i,j}}{Y_{t,i}}\right] K_{t,i,j} \tag{15}$$

With $k_{t,i,j}$ being the fixed capital stock by region and $y_{t,i,j}$ the product by region. While $Y_{t,i}$ and $K_{t,i,j}$ are national production and fixed capital stock.

Evolution, disaggregation and labour productivity decomposition

The evolution of labour productivity per hour worked and employed people in Brazil, in the sectors and regions can be observed in Figure 1. Initially, both measures follow the same trend. Thus, it is noticeable that for the Brazilian labour productivity in 2008 there was a fall, but there is a recovery from 2009. However, there was also a decrease from 2013 to 2014. It is verified that productivity per hour worked fell more than productivity per person employed, indicating that there was a fall in the workday. The average percentage variation was 0.78% per year for LPHW and 1.54% per year for LPPE.

Figure 1 – Brazilian Productivity Indexes, Sectoral and Regional, 2004-2014 *(2004=100)*



Source: Own elaboration based on data from IBGE, IPEADATA, PNAD (2017).
LPHW= labour productivity per hour worked, and LPPE= labour productivity per person employed.
N= North, NE= Northeast, SE= Southeast, S= South e CW= Center-West.

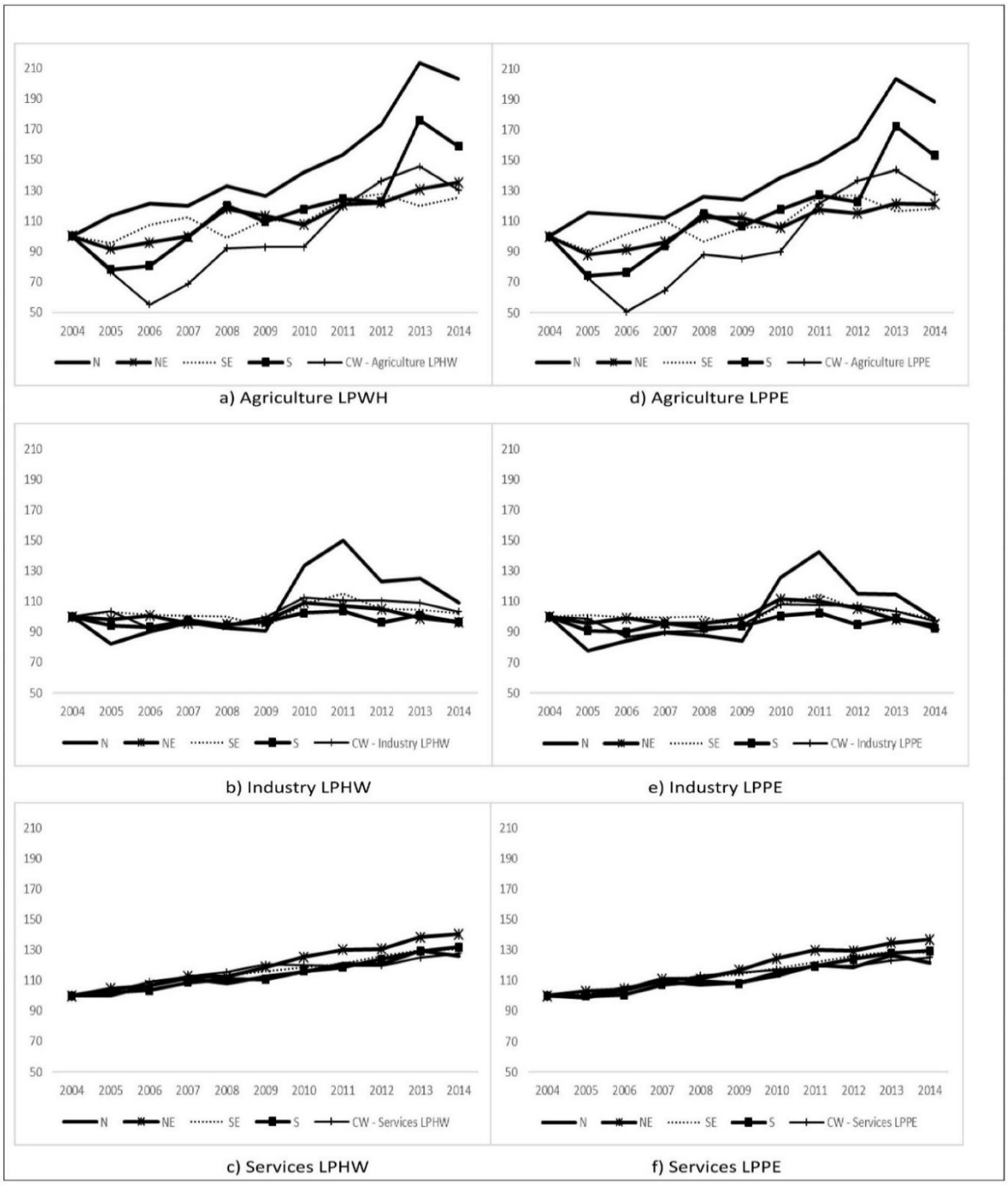
Regarding sectoral productivity, there is a similar behaviour for both measures. We highlight the positive results of agriculture, since 2010. The sector showed negative variations until the year 2006, followed by a positive variation until the year of the crisis, with recovery only from the year 2010. The average percentage variation in LPHW in the sector was 4.62% per year and 3.55% per year in LPPE, this greater variation in productivity per hour worked indicated that there was a drop in workday in the sector

during the period. In the services sector, there is a constant trend of variation in the period, with an average of 2.43% per year for LPHW, and 2.13% per year for LPPE. It is interesting to note that there was no decrease in the sector's productivity after 2008, differing from the other two sectors. Unlike services and agriculture, the industry presented negative average percentage variation in the period, -0.37% per year for LPHW, and, -0.74% per year for LPPE. Until 2007, the sector remained practically unchanged, but from 2008 onwards it started to fall, with a slight recovery until 2011, followed by a fall again. These results are related to those found by Menezes-Filho et al. (2014) regarding the industry, when studying the period 1965-1980 found that it was from this moment on that industrial productivity started falling behaviour and agricultural productivity started to have higher growth. However, unlike the authors' conclusions, which stated that the productivity of industry and services were similar, in this study it was found that the behaviour of the sectors was different, considering the period from 2004 to 2014.

Regarding regional labour productivity, the largest percentage variation in productivity per hour worked occurred in the Northeast, with 2.68% per year, followed by the North, with 1.65% per year, Center-West, 1.05 % per year, South, 0.77% per year, and the Southeast with the lowest average percentage variation of the period, 0.04% per year, i.e., practically unchanged. While about LPPE variation, again the region that obtained the highest percentage value was the Northeast, 3.14% per year, however, the result was lower in LPHW, indicating an increase in a workday in the region. However, about LPPE, the Center-West region was 1.78% per year, which suggests an increase in the workday. Subsequently, there is the region North, with an average variation of 1.77% per year, South with 1.50% per year, and Southeast with 1.04% per year. Thus, these results suggest that there was an increase in a workday in all regions, given that the percentage variation in LPHW was lower than the LPPE. This was particularly noticeable for the Northeast region in Figures 1c and 1f, where from 2013 to 2014 there was a slight positive variation in LPPE while in LPHW the variation was negative. In 2008, with the exception of the Center-West in LPHW, all regions had a fall in labour productivity in the subsequent year. These results regarding agriculture contrasted with those obtained by Matteo (2015), because the author found that the productivity of the Center-West was higher than that of the Northeast, considering that the former is characterized by extensive cattle ranching and the latter by family farming. The results obtained in this study, considering the percentage variation in productivity, showed that the Northeast has greater percentage variation in agriculture when compared to the Center-West.

The evolution of sectoral labour productivity by region, per hour, worked and per person employed, from 2004 to 2014, can be seen in Figure 2. It is noted that the sector that obtained the highest percentage variation in labour productivity was agriculture, both in LPHW, and LPPE. In all regions, the percentage change in productivity per hour worked was greater than the productivity per person employed, indicating that there was a reduction in a workday in the sector.

Figure 2 – Sectoral Productivity Indexes, Brazilian Regions, 2004-2014 (2004=100)



Source: Own elaboration based on data from IBGE, IPEADATA, PNAD (2017).
LPHW= labour productivity per hour worked, and LPPE= labour productivity per person employed.
N= North, NE= Northeast, SE= Southeast, S= South e CW= Center-West.

In Figure 2a as well as 2d it was possible to verify the differentiated performance of the North region, which had an average percentage variation of 8.91% per year at LPHW, and 7.54% per year at LPPE. Next, the region with the highest variation was the South. The Northeast presented a higher average percentage

variation in LPHW, and the Center-West showed positive variation in both productivities per hour worked and productivity per person employed. The region with the lowest percentage variation in the period was the Southeast.

In industry, labour productivity was relatively stable, as shown in Figures 2b and 2e. The exception was the Center-West region where LPHW varied positively by 0.59% per year. However, when the productivity per person employed was analyzed, the variation of all regions was negative, including the Center-West, with a negative variation of 0.03% per year, and the North, with a negative variation of 0.93% per year. The other regions had negative variations in both LPHW and LPPE. The South varied negatively by 0.55% per year at LPHW, and 0.91% per year at LPPE on average. The Northeast presented a negative variation of 0.48% per year at LPHW and 0.66% per year at LPPE. The Southeast presented lower negative variation, being 0.16% per year at LPHW, and 0.49% per year at LPPE.

Finally, in Figures 2c and 2f, it is possible to identify an increasing trend of the percentage variation in labour productivity in services in all regions. The largest average variation in the services sector occurred in the Northeast, 3.50% per year at LPHW, and 3.18% per year at LPPE. The South presented 2.47% per year variation at LPHW, and 2.24% per year at LPPE, the Southeast with 2.34% per year in LPHW, and 2.06% per year in LPPE, and the North exhibited 2.29% per year in productivity per hour worked and 1.85% per year in productivity per person employed. In terms of LPHW, the one with the lowest variation was the Center-West, with 2.22% per year and 1.97% per year at LPPE. However, the northern region showed the lowest variation in productivity per person employed.

In general, the sector that presented the highest percentage variation in all regions was agriculture, followed by services, and lastly, industry, which presented negative variation in all regions in productivity per person employed. In addition, considering that there was a greater percentage variation in LPHW in all sectors and regions compared to LPPE, it was possible to conclude that there was a reduction in a workday about the number of employed people. These results are consistent with the empirical evidence, suggesting that the sectoral analysis follows the trend previously observed.

The growth decomposition into factors related to labour productivity is presented in Table 1. The first four columns refer to the decomposition by productivity per hours worked and the last three columns refer to the decomposition by productivity per person employed. Considering the aggregate economy, production grew more in the Center-West and regarding LPHW we highlight the positive performance of the Northeast and North. About LPPE, the Northeast was also the fastest-growing region. It is interesting to highlight the difference in productivity growth per hour worked and per person employed in the aggregate, wherein the Southeast, South, Center-West and the Brazilian average, the growth of LPHW was lower than that of LPPE. This lower growth in productivity per hour worked indicated that there was a fall in a workday in the period. The difference between labour productivity growth rates possibly occurred due to the differentiated growth of the employed population in the regions.

In agriculture, as well as in production, the North stood out as the region with the highest growth, in productivity per hour worked, and the region also had the highest growth in production. Both the Southeast and the Center-West grew below the Brazilian average. Regarding workday, there was a decrease in all regions during the period. There was also a decrease in the occupied population in the sector, indicating

the process of structural change already observed previously. Regarding the productivity decomposition per person employed, the highest growth was also registered in the North. Therefore, it was concluded that the growth of agricultural production was the most positively influenced by labour productivity.

Regarding industry, productivity per hour worked only increased in the Center-West, 0.52% per year. In all other regions, there was a decrease, but when considering productivity per person employed, there was also a decrease in the Center-West, 0.03% per year. The fall in workday was also present in all regions in the industry sector. However, unlike agriculture, the number of employed people grew in the sector in all regions, with the highest growth occurring in the Center-West, 3.42% per year. Thus, it was possible to verify that in the industrial sector, only the employed population contributed positively to the production growth and the Center-West stood out as the only region where there was growth in LPHW.

Table 1 – Growth Decomposition by Sector and Region, Brazil, 2004-2014 (% per year)

Sector/Region	WORKDAY				EMPLOYED PEOPLE		
	GDP	LPHW	WD	EP	GDP	LPPE	EP
Aggregate							
Brazil	2.46	0.69 (27.9)	0.62 (25.1)	1.15 (46.8)	2.46	1.31 (53.1)	1.15 (46.8)
North	3.06	1.39 (45.4)	0.09 (2.9)	1.58 (51.5)	3.06	1.48 (48.4)	1.58 (51.5)
Northeast	3.32	2.16 (64.9)	0.33 (9.8)	0.84 (25.1)	3.32	2.49 (74.8)	0.84 (25.1)
Southeast	2.20	0.03 (1.5)	0.87 (39.6)	1.29 (58.7)	2.20	0.91 (41.2)	1.29 (58.7)
South	2.07	0.67 (32.6)	0.60 (28.8)	0.80 (38.5)	2.07	1.27 (61.4)	0.80 (38.5)
Center-West	3.38	0.91 (26.9)	0.58 (17.2)	1.89 (55.8)	3.38	1.49 (44.1)	1.89 (55.8)
Agriculture							
Brazil	0.72	3.45 (481.1)	-0.68 (-95.2)	-2.05 (-285.8)	0.72	2.77 (385.8)	-2.05 (-285.8)
North	3.75	5.79 (154.6)	-0.68 (-18.2)	-1.36 (-36.3)	3.75	5.11 (136.3)	-1.36 (-36.3)
Northeast	0.36	3.53 (981.3)	-1.00 (-278.1)	-2.17 (-603.1)	0.36	2.53 (703.1)	-2.17 (-603.1)
Southeast	0.28	2.30 (813.1)	-0.57 (-199.4)	-1.46 (-513.6)	0.28	1.74 (613.6)	-1.46 (-513.6)
South	0.13	3.64 (2775.7)	-0.33 (-252.4)	-3.18 (-2423.3)	0.13	3.31 (2523.3)	-3.18(-2423.3)
Center-West	1.25	2.90 (232.1)	-0.20 (-15.7)	-1.45 (-116.4)	1.25	2.70 (216.4)	-1.45 (-116.4)
Industry							
Brazil	1.27	-0.35 (-27.1)	-0.36 (-27.9)	1.98 (155.1)	1.27	-0.70 (-55.1)	1.98 (155.1)
North	2.01	0.01 (0.5)	-0.91 (-45.1)	2.91 (144.5)	2.01	-0.90 (-44.5)	2.91 (144.5)
Northeast	2.01	-0.45 (-22.5)	-0.17 (-8.6)	2.63 (131.2)	2.01	-0.63 (-31.2)	2.63 (131.2)
Southeast	0.90	-0.15 (-16.9)	-0.31 (-34.3)	1.37 (151.2)	0.90	-0.46 (-51.2)	1.37 (151.2)
South	1.09	-0.52 (-47.1)	-0.36 (-32.5)	1.97 (179.6)	1.09	-0.87 (-79.6)	1.97 (179.6)
Center-West	3.39	0.52 (15.3)	-0.55 (-16.2)	3.42 (100.8)	3.39	-0.03 (-0.8)	3.42 (100.8)
Services							
Brazil	3.63	1.97 (54.4)	-0.21 (-5.9)	1.87 (51.4)	3.63	1.76 (48.5)	1.87 (51.4)
North	4.06	1.88 (46.2)	-0.33 (-8.0)	2.51 (61.8)	4.06	1.55 (38.1)	2.51 (61.8)
Northeast	4.61	2.73 (59.3)	-0.22 (-4.7)	2.09 (45.4)	4.61	2.51 (54.5)	2.09 (45.4)
Southeast	3.38	1.91 (56.6)	-0.20 (-6.0)	1.67 (49.3)	3.38	1.71 (50.6)	1.67 (49.3)
South	3.45	2.01 (58.2)	-0.17 (-4.7)	1.61 (46.6)	3.45	1.84 (53.4)	1.61 (46.6)
Center-West	3.82	1.82 (47.7)	-0.18 (-4.8)	2.18 (57.0)	3.82	1.64 (42.9)	2.18 (57.0)

Source: own elaboration based on data from IBGE, PNAD, and IPEADATA (2017).
PS: between parenthesis are the percentual contributions of each input factor to economic growth, the ratio between the growth of the factor and production growth.

In the services sector, the North and Northeast had the highest growth, 4.06% per year, and 4.61% per year respectively. Regarding productivity per hour worked, all regions had growth, however, the highest growth occurred in the Northeast, 2.73% per year, while the Brazilian average was 1.97% per year. Besides the Northeast, only the South had growth above the Brazilian average, 2.01% per year. Considering

productivity per person employed, the highest growth also occurred in the Northeast, 2.51% per year, followed by the South, with 1.84% per year. Regarding workday, there was a decrease in all regions in the period, however, about employed people there was growth. This growth in employed people was highest in the North, 2.51% per year, followed by the Center-West, 2.18% per year, and Northeast, 2.09% per year.

Next, the growth decomposition of labour productivity for Brazil is performed, based on equation (7). This relationship is primordial given that in recent years there has been a drop in economic growth and even a decrease in some years. In the last decade, as indicated by De Negri, and Cavalcante (2014) and Bonelli (2014), Brazil has benefited from a demographic bonus to continue growing. Thus, in Brazil, even if productivity were low, there was a possibility of continuing to grow through the incorporation of more people into the labour market, either by reducing unemployment, increasing people entering the labour force, or even through the increasing working-age population. However, this scenario of high labour availability and production growth has recently changed, in which the country would be approaching the condition of full employment, in addition to the prediction that Brazilian demographics would decrease by 2048, as indicated by Bonelli (2014). Thus, for the country to continue sustained growth, it would be necessary for production to rely more on labour productivity. Therefore, it would be necessary for Brazilian labour productivity to improve.

In this context, it is interesting to verify the contribution of each share to economic growth in a more recent period, as shown in Table 2, whose first part presents the results of the growth decomposition for Brazil and the regions, following the methodology described in the equation (6). In this decomposition, production depends on labour productivity, occupancy rate, activity rate, and participation rate. The economic growth rate was positive in the period, as previously observed and the productivity growth rate was positive for all regions, also presenting positive percentage variation about production. The Northeast was the region with the largest variation in GDP, 71.17%, followed by the South, 55.29%. Regarding the occupancy rate, it was found that there was growth in all regions except the North, -0.03% per year.

Table 2 – Growth Decomposition from Production by Region and Brazil, 2004-2014 (% per year)

Region	Production	Labour Productivity	Occupation Rate	Activity Rate	Participation Rate
Brazil	2.46	1.13 (46.06)	0.16 (6.70)	-0.20 (-8.03)	1.36 (55.27)
North	3.06	1.40 (45.71)	-0.03 (-1.08)	-0.42 (-13.77)	2.12 (69.14)
Northeast	3.32	2.36 (71.17)	0.07 (2.22)	-0.45 (-13.68)	1.34 (40.29)
Southeast	2.20	0.66 (30.24)	0.27 (12.24)	0.06 (2.66)	1.20 (54.86)
South	2.07	1.14 (55.29)	0.14 (6.56)	-0.38 (-18.44)	1.17 (56.59)
Center-West	3.38	1.37 (40.58)	0.18 (5.29)	-0.13 (-3.90)	1.96 (58.04)

Therefore, these results indicate that the ratio between the employed and the economically active people contributed to the growth, however, it was found that this growth was low, and the fastest-growing region was the Southeast, 0.27% per year, and that this growth presented a variation of 12.24% per year about production growth. Regarding the activity rate, there was a decrease in all regions, with the Southeast as

an exception, 0.06% per year. So, there is evidence that this relationship no longer contributed positively to economic growth. The participation rate was the one that had the highest growth in the period, except in the Northeast, therefore, it was the ratio that contributed the most to the economic growth. With its highest growth in the North, 2.12% per year, and the lowest in the South, 1.17% per year.

Thus, it was possible to conclude that growth was influenced most by the increased participation rate, followed by labour productivity. Occupancy and activity rates no longer contributed much to growth, which is in line with Bonelli (2014), who stated that the country could not continue to rely on labour growth to generate long-run growth. During the period, as observed, the increase in the participation rate was the major contributor to economic growth, however, this behavior tends to change in the future, considering that the Brazilian population tends to fall. Thus, it was seen the importance that labour productivity growth has for long-run economic growth to be sustainable.

Considering that there was sectoral heterogeneity in Brazil and the regions, and also that there was a trend of migrating jobs from agriculture to industry and services, it is interesting to see how the growth of intrasectoral productivity has been decomposed. Table 3 shows the contribution of structural change and intrasectoral productivity to aggregate productivity. It is verified that the growth rate of structural change and intrasectoral productivity was positive for Brazil and all regions in the period. Only in the northern region was found that the percentage variation of structural change was greater than that of sectoral productivity, 57.36%, and 42.64%, respectively. Thus, the results obtained for the percentage variations in structural change and intrasectoral productivity plus the analysis of growth rates and percentage variations in productivity seen earlier indicate that, with the exception of the North, low labour productivity growth in both Brazil and the regions is mainly a reflection of the lack of productivity growth within sectors, this being stronger in industry. Therefore, it would be necessary to promote the efficiency of labour in production so that there was the growth of aggregate labour productivity and, from that could contribute to the growth and promotion of Brazilian production in the long run.

Table 3 – Growth Decomposition from Productivity by Region and Brazil, 2004-2014 (% per year**)**

Region	Structural Change	Intrasectoral Productivity	Total
Brazil	394.45 (43.37)	514.96 (56.63)	909.41
North	371.51 (57.36)	276.21 (42.64)	647.72
Northeast	387.34 (48.53)	410.86 (51.47)	798.20
Southeast	158.77 (18.69)	690.93 (81.31)	849.70
South	481.65 (48.71)	507.07 (51.29)	988.72
Center-West	156.67 (12.78)	1068.94 (87.22)	1225.61

Source: own elaboration based on data from IBGE, IPEADATA, and PNAD (2017).
PS: data in parenthesis refer to percentual variation from the items related to production.

Table 4 presents the estimation results from fixed-effects panel data for Nelson's (1987) sectoral competition model, encompassing the five regions of Brazil in its three sectors and the aggregate. The model allows us to verify the importance of both fixed capital stock and labour productivity for production. Among the results, it was possible to verify that both factors contribute positively to the increase of

production in all the analyzed sectors and also in the aggregate. However, it is noticeable the difference is attributed to the elasticities of the two variables depending on the sector. In the agricultural sector, it is found that the elasticity value of the fixed capital stock is higher than that of labour productivity, that is, increases in the fixed capital stock bring superior results for the increase of the sector's production. Therefore, considering that labour productivity brings inferior improvements, its improvement in agriculture is not encouraged.

The same is true of industry, despite being the sector with the highest labour productivity in the country. The share of elasticity of the fixed capital stock is higher than that of labour productivity, which may explain the fact that the sector output grows compared with the observed fall in its productivity.

Table 4 – Estimation in the Regions, Brazil, sectorial productivity, 2004-2014

Variables	Sector			
	Agriculture	Industry	Services	Aggregation
Constant	7.07**	8.95**	2.49	6.17***
LnK	0.62***	0.51***	0.32**	0.54***
LnA	0.23***	0.29**	1.47***	0.55***
R^2	0.87	0.98	0.67	0.90
Hausman Test	11.48	41.36	30.86	39.33
p-value	(0.0032)	(0.0000)	(0.0000)	(0.0000)
F Test	117.78	44.30	883.72	208.72
Prob>F	(0.0003)	(0.0019)	(0.0000)	(0.0000)
Observations	55	55	55	55

Source: own elaboration based on data from IBGE, PNAD, and BEA (2017). PS: *** represents significance at 1%, **, and significance at 5%. In the regression results, the terms between parenthesis represent tests significances.

Regarding the services sector, the scenario is reversed. It is found that the highest elasticity is in labour productivity and that it is even greater than unity. However, it is also characteristic of the services sector to be labour intensive and to have little fixed capital stock. It is also interesting to note that the sector had little growth in the period analyzed, despite having a larger share of GDP, and its productivity remained little changed in the period. Regarding total production, the elasticity of both the fixed capital stock and labour productivity is practically the same. This indicates that increases in both factors lead to possibly the same positive output. Therefore, when comparing the sectors, it appears that only in services the elasticity of labour productivity is higher than that of the fixed capital stock.

The results of the present study are in agreement with the literature, except for the industry growth for Veloso et al. (2015). When checking estimates and labour productivity growth in Brazil from 2004 to 2014, it was found that growth in the sectors followed a trend close to that stated by Squeff, and De Negri (2014), and Veloso et al. (2015), with growth in agriculture, fall in industry, and practically zero growth of services, causing low growth in the aggregate when considering labour productivity.

Considering labour productivity, the conclusions that in the Center-West agricultural productivity was higher than in the Northeast corroborated with the findings

of Matteo (2015), however, the percentage variation and growth in the Northeast was higher than that of the Center-West, when considering LPHW. However, the same could not be said about services productivity being a third lower in the Northeast when compared to Brazil. In the present research it was found that the productivity of services in the Northeast and Brazil followed the same growth trend, but with the Northeast always below. Therefore, it can be stated that labour productivity follows the performance observed in the literature, considering both an earlier period and other data sources, such as the studies by Squeff, and De Negri (2014), and Veloso et al. (2015), especially about the growing trend of the sectors and the regional and sectoral heterogeneity.

Final considerations

Thus, the objective of this study was to verify the performance of Brazilian labour productivity and its impact on economic growth, through its measurement, regional and sectoral disaggregation, as well as the decomposition of its growth and the use of its participation in the production of the sectors. Initially, it was found that both productivities per hour worked and per person employed showed the same trend, with growth in agriculture and services and decrease in industry. We highlight the decreases in labour productivity that occurred in 2008 and 2014, due to the unfavorable economic scenario, which was greater in the analysis per hour worked than per person employed, indicating that the adjustment occurred more in the occupation than in the workday, with reduced employment in the country.

In turn, the results of disaggregated productivity estimates point to the existence of sectoral and regional heterogeneity in the country. The sectoral analysis indicates that in agriculture, the highest productivity growth occurred in the North, the industry performed better in the Center-West, followed by the North, while services stand out in the Northeast. It should be noted that the regions with the highest rates of productivity growth in some sectors were the Center-West, Northeast, and North, with a more moderate performance in the Southeast (mainly in the industry) and the South.

The decomposition analysis suggests the continuity of the process of structural change in the Brazilian economy, with a decrease in the agricultural labour force and an increase in industry and services labour force. The decomposition of supply-side growth pointed out that the participation rate contributed the most to growth, except for the Northeast, followed by labour productivity. It was possible to verify that the activity rate no longer contributed positively to the growth, except for the Southeast, corroborating the difficulty of the country to continue growing based on the incorporation of the labour force. Therefore, we once again affirm the importance of improved productivity performance to sustain economic growth. Moreover, the results of the productivity decomposition also indicate that the largest share of the production efficiency growth, or its lack, resulted mainly from intrasectoral productivity, and the smallest part corresponded to structural change, except for the North, where structural change obtained the largest share of variations.

Thus, what could be concluded was that while productivity depends more on the process of structural change, there is higher growth, but when it becomes dependent on intrasectoral growth, it is costlier to sustain its growth. Therefore, these

results indicate that the favorable performance of productivity in the North is due to the even deeper structural changes in this region.

The results of the econometric estimates show that the elasticity of labour productivity is lower than that of the fixed capital stock in both agriculture and industry. Only in services, this fact is reversed, however, this fact is likely to occur due to the characteristic of the sector to be labour intensive. Moreover, when considering aggregate production, it was found that the elasticities of both factors are virtually the same, thus improvements in both factors have virtually the same effect in terms of increased production.

In conclusion, if productivity is to be better performed, it would be necessary to stimulate productivity, especially in industry and services, which showed a decline and stagnation, especially in the Southeast and South, where they showed lower growth. In addition, intrasectoral productivity would need to achieve long-run growth, as it accounted for more than half of productivity variations.

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