

Gazonato, Mariana Camarin; Oliveira, Maria Aparecida Silva

**Article**

## Productivity variation and its intersectoral spillovers: An analysis of Brazilian economy

EconomiA

**Provided in Cooperation with:**

The Brazilian Association of Postgraduate Programs in Economics (ANPEC), Rio de Janeiro

*Suggested Citation:* Gazonato, Mariana Camarin; Oliveira, Maria Aparecida Silva (2019) :  
Productivity variation and its intersectoral spillovers: An analysis of Brazilian economy,  
EconomiA, ISSN 1517-7580, Elsevier, Amsterdam, Vol. 20, Iss. 2, pp. 92-108,  
<https://doi.org/10.1016/j.econ.2019.05.001>

This Version is available at:

<https://hdl.handle.net/10419/266939>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



<https://creativecommons.org/licenses/by-nc-nd/4.0/>

# Productivity variation and its intersectoral spillovers: An analysis of Brazilian economy<sup>☆,☆☆</sup>

Mariana Camarin Gazonato, Maria Aparecida Silva Oliveira<sup>\*</sup>

*Universidade Federal de São Carlos, Centro de Ciências em Gestão e Tecnologia, Departamento de Economia, Rodovia João Leme dos Santos (SP-264), KM 110, Itinga, 13052-780, Sorocaba, SP, Brazil*

Received 24 February 2017; received in revised form 8 April 2019; accepted 27 May 2019

Available online 27 June 2019

## Abstract

The main purpose of this article is to analyze the capacity of Brazilian economy sectors to transfer their productivity gains over the productive chain from 2000 to 2009. Therefore, it has been used structural decomposition technique and a methodology that deals with the variation of labor productivity. The results of this article yield in the period under review are that the Services and not the Industry were the responsible for transmitting these increments of productivity. However, the power of transmission of productivity variation of the tertiary sector comes to be relatively low when compared to the ability of the Industry to transmit its productivity variations.

*JEL classifications:* C67; O14; O40

*Keywords:* Productivity gains; Power of transmission; Intersectoral spillovers; Service economy; Industrial economy

© 2019 The Authors. Production and hosting by Elsevier B.V. on behalf of National Association of Postgraduate Centers in Economics, ANPEC. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## 1. Introduction

Many scholars attribute to the Industry the fundamental role for the establishment of an economy-sustained growth.<sup>1</sup> Among the many reasons for justifying such importance as discussed by Baumol (1967), there is a fact that those sectors provide high levels and increments of productivity besides greater effects of backward and forward linkages. Together, those facts lead to a sprawl of the industrial productivity gains in relation to other economy sectors, which results in positive effects on the performance of the aggregate product. The interventions of other sectors in those aspects would be limited, once both the productivity growth and transmission through the productivity chain would tend to be lower.

Several attributes justify the importance of the industrial sector into the process of economic growth. Besides its high productivity gains and its strong intersectoral dynamics (SQUEFF, 2012), mentioned above, it is possible to highlight,

<sup>☆</sup> Article awarded with Honorable Mention at CNI Prize of Economics in 2016.

<sup>☆☆</sup> This work was supported by Coordination for the Improvement of Higher Level- or Education-Personnel (CAPES).

<sup>\*</sup> Corresponding author.

*E-mail address:* [aparecidaoliveira@ufscar.br](mailto:aparecidaoliveira@ufscar.br) (M.A. Silva Oliveira).

<sup>1</sup> Furtado (1961), Hirschman (1961), Kaldor (1957) and Presbich (1949) are examples of authors who study this approach.

for instance, the fact that, on average, the industry wages tend to be higher than those observed in other productive sectors. In the case of the Brazilian economy, deflated<sup>2</sup> data on the Annual Social Information Report (RAIS) from the Ministry of Labor and Employment (MTE) for the year of 2013 indicated an average real wage of the industrial sector in the order of R\$ 3021.00. The remuneration of Services, on the other hand, was R\$ 2339.00, i.e., about 77% of the value found in the Industry.

The average wage of the industrial sector also showed to be higher than those of Agricultural and Construction, which were R\$ 1265.00 and R\$ 1794.00, respectively. The only segment whose remuneration was closer to the industrial average was the Industrial Services of Public Utility, with an average real wage of R\$ 2946.00.<sup>3</sup> Based on [Oreiro and Feijó \(2010\)](#) and [Tregenna \(2009\)](#), [Wasques \(2011\)](#) also highlights the presence of static and dynamic economies of scale in Industry and the fact that the sector is the main responsible for generating technological changes in the economy.

The leading role of Industry in the process of economic growth is also presented in [Baumol \(1967\)](#). His argument of “cost disease” divides the activities of the economy into two distinct groups: the first is composed of those segments with continuous gains, in which innovation, capital accumulation and economies of scale are present, e.g., manufacturing activities; the second allows only sporadic increases in its productivity, given its labor-intensive character, based on interpersonal relationships. Most Services are included in this last description and according to the author; the increase of participation of this sector in the economy would restrict the product growth, since an increasing share of the resources would be allocated in technologically stagnant segments and with limited evolution of the productivity ([Costa Jr. and Teixeira, 2010](#)).

In this context, the performance of the sectors of the Brazilian economy over the last decades would be a worrying fact, considering there has been a tendency to increase the participation of the Brazilian Services Gross Domestic Product (GDP) since the mid-1980s, concomitantly with a decrease of the Industry’s participation ([IBGE, 2015a,b,c](#)). In particular, between 1986 and 2013, the share of the tertiary sector increased from 45% to 70% of GDP, while that one of the industrial sector retracted from 44% to 25% ([IBGE, 2015a,b,c](#)). [Nakabashi et al. \(2010\)](#) claim that the weak Brazilian economic performance as of 1985 would be linked to this deceleration of its industrial growth.

Observing carefully, from a disaggregated perspective of the sectors, the perception of the increasing of participation of Services in GDP represents an obstacle to economic growth. This is due to the coexistence within the Services sector of dynamic, highly productive segments with those ones of low productivity.

In the first set of activities, certain business services are included, which, according to [Galinari and Teixeira Júnior \(2014, p. 235\)](#) "have been recognized by the international literature as catalysts for innovation, value added and productivity of other firms, and therefore, as likely alternative objects of policies to promote competitiveness." [Galinari and Teixeira Júnior \(2014\)](#) still affirm these are extremely dynamic segments, producers of complex goods and employers of skilled labor. Information, research and development and technical-professional services are included in this group. The characteristics of this type of service, known as Knowledge-Intensive Business Services (KIBS), similar to those attributed to the industrial sector, lead to the conclusion that the increase of its participation in the aggregate product can stimulate a country’s economic growth process, rather than restricting it. This was detected, for instance, in the study of [Greenhalgh and Gregory \(2000\)](#) regarding the changes in the role of the Services sector in the United Kingdom between 1979 and 1990.

Hence, the understanding of the diversity of segments existing within Services is a fundamental part of any analysis of the sector. Disregarding this heterogeneity can lead to the construction of a reductionist view of Services, characterized by the idea that all tertiary activities present low-skilled jobs, low tendency to innovate, and low productivity gains ([Galinari and Teixeira Junior, 2014](#)).

Considering the above, the main purpose of this article is to analyze the capacity of the sectors of Brazilian economy to sprawl their productivity gains over the productive chain, from 2000 to 2009. The intention is to verify whether Industry tends to present greater productivity increases and chain relationships with the other segments of the economy, especially when compared to Services. Therefore, the present study tries to contribute to the existing debate

<sup>2</sup> Deflated data by the Broad National Consumer Price Index (IPCA) of the Brazilian Institute of Geography and Statistics (IBGE), based on December 2013.

<sup>3</sup> For the aggregation of the Sections of the National Classification of Economic Activities ([CNAE, 2015](#)) 2.0 present in [RAIS \(2015\)](#) in these five large sectors, Agriculture was considered the Section A, Industry the section B and C, Utility the sections D and E, Construction the section F, and Services the sections G to T.

in Brazil, dealing with an aspect yet poorly examined in the literature: the intersectoral transmission of productivity gains.

The analysis of such information will allow the verification whether the productivity of the activities present in Industry is, in fact, the greatest among all the sectors and if the industrial sector is one whose productivity gains are widely spread among the other segments of the economy. It is important to emphasize that, although many papers about economic growth analyze the productivity of the sectors, few of them focus on the issue of intersectoral linkages as described by [Hirschman \(1961\)](#). Although there is literature on productivity sprawl and/or productivity gains among sectors as a determining factor in the process of economic growth, it is still limited. In the case of the Brazilian economy studies, we may highlight the work of [Costa Jr. and Teixeira \(2010\)](#) on the intersectoral spillovers of productivity from 1990 to 2003. In accordance with the first work and different from the second one, this article will consider the measure of productivity derived from the work used in the production of the inputs utilized by a sector and throughout the national productive chain, besides that one obtained with the work employed directly in it. Additionally, it has been proposed a measure of transmission power of the productivity generated in one sector for the rest of the economy through the intersectoral purchase relationships of inputs.

Among the main results, it has been mentioned the heterogeneity of productivity levels in both services and industrial sector. In general, it was observed productivity losses in the allied industry, as well as the high capacity to transmit them to other sectors of the economy, while services presented gains of productivity but with low capacity of transmission.

In addition to this introduction, the article consists of three more sections. In Section 2, the database used and the classification of the sectors are presented. In addition, a general exposition of the input–output model, the structural decomposition analysis, and the methods of [Greenhalgh and Gregory \(2000\)](#) were used, which served as a fundamental basis for achieving the objective of this study. Section 3 contains the results of the estimated model and their analysis. Finally, in Section 4 are presented the final remarks of the article.

## 2. Methodology

### 2.1. Database and classification of the Sectors

In order to achieve the proposed objective, it has been collected database from the input–output matrices of Brazilian references from 2000 to 2009, composed by 56 sectors and 110 products. Those matrices, available from the University of São Paulo Regional and Urban Economics Lab ([NEREUS, 2015](#)), were estimated by [Guilhoto and Sesso Filho \(2005, 2010\)](#) based on IBGE National Accounts System (SCN), published from 2009 to 2011.

According to [Miller and Blair \(2009\)](#), when the data of input–output matrices from different years are compared, it is necessary to distinguish the price changes from those attributed to other types of sources. Regarding this, it is necessary to convert the current values of the tables to constant values of a particular base year. This procedure allows analyzing the real changes that occurred during the studied period. In the present study, the method used to perform the deflation is present in [Miller and Blair \(2009\)](#), and it is named *double deflation*. The base year was 2009 for all values to be expressed in prices of the most recent year of the analysis.

In terms of classifications of the sectors, the typology used to divide the sectors of industry was proposed by [OCDE \(2004\)](#), whose fundamental basis is the taxonomy developed by [Pavitt \(1984\)](#). In relation to Services segments, the classification used was the one described by [Browning and Singelmann \(1978\)](#).

Therefore, the 56 sectors of the Brazilian input–output matrix were classified as presented in [Table 1](#).

### 2.2. Input–output and structural decomposition analysis

The method used in this study is based on input–output analysis. Leontief input–output matrix corresponds to a model in which the activities of the economy are separated into productive sectors, so that the data in the matrix are the flows of the products that range between these segments, measured in monetary terms for a particular period. One of the main information supplied by the input–output matrix/source are the monetary values of the transactions done between two sectors (from each sector  $i$  to each sector  $j$ ), which are generally referred as  $z_{ij}$ . There are also those assets that are demanded to be used as assets and not as inputs of some productivity process. This is called final demand ([Miller and Blair, 2009](#)). Next, we present some fundamental relations of the models based on the studies of [Miller and Blair \(2009\)](#). Assuming the presence of  $n$  sectors of economy, and being  $x_i$  the total production of the sector  $i$ , and

Table 1  
Classification of the economy sector.

| Classification                          | Sectors   |
|---|---|
| Agriculture and livestock               | Agriculture, forestry and forestry exploitation; livestock and fishing  |
| Construction                            | Construction  |
| Utility                                 | Electricity and gas, water, sewage and urban cleaning   |
| Sciences-based industry                 | Office machines and computer; Pharmaceutical products   |
| Differentiated industry                 | Medical, optical and measurement equipment/instruments; household appliances; machines and equipment, including maintenance and repairs; machines, electrical appliances and materials; electronic material and communications equipment  |
| Intensive industry in scale             | Rubber and plastic materials; Automobiles, vans and commercial vehicles; trucks and buses; agricultural pesticides; manufacture of steel and its derivatives; manufacture of resins and elastomers; newspapers, magazines, records; other equipment of transportation; parts and accessories for motor vehicles; perfumery, hygiene and cleanliness; diverse chemical products and preparations; chemical products; paints, varnishes, enamels and lacquers |
| Intensive industry in natural resources | Alcohol; foods and drinks; cellulose and paper products; cement; metallurgy of nonferrous metals; iron ore; other products from mining industry; other non-metallic mineral products; petroleum and natural gas; wood products - including furniture; tobacco products; petroleum refining and coke   |
| Intensive industry in labor             | Leather and shoe artifacts; clothing articles and accessories; diverse furniture and industrial products; metal products - exclusive machines and equipment; textiles   |
| Distributive services                   | Trade; transport, storage and mail  |
| Personal services                       | Maintenance and repair services; accommodation and food services; services provided to families and associations; household chores  |
| Productive services                     | Financial intermediation and insurance; information service; real estate and rent services; business service to companies   |
| Social services                         | Public administration and social security; commercial education; public education; commercial health; public health   |

Source: Authors.

$f_i$  the total final demand of the product of the sector  $i$ , it is possible to write an equation to illustrate the way that each sector  $i$  distributes its production between the other sectors and to the final demand, such as:

$$x_i = z_{i1} + \dots + z_{ij} + \dots + z_{in} + f_i = \sum_{j=1}^n z_{ij} + f_i \tag{1}$$

Generalizing for the  $n$  sectors, we have:

$$\begin{aligned} x_1 &= z_{11} + \dots + z_{1j} + \dots + z_{1n} + f_1 \\ &\vdots \\ x_i &= z_{i1} + \dots + z_{ij} + \dots + z_{in} + f_i \\ &\vdots \\ x_n &= z_{n1} + \dots + z_{nj} + \dots + z_{nn} + f_n \end{aligned} \tag{2}$$

From  $z_{ij}$  and  $x_j$ , it is possible to calculate the technical coefficients of production,  $a_{ij}$ , which indicate how much the sector  $j$  purchases from the sector  $i$ , given the total production of the sector  $j$ , represented by  $x_j$ , such as:

$$a_{ij} = \frac{z_{ij}}{x_j} \tag{3}$$

Assuming a set of fixed technical coefficients and replacing each  $z_{ij}$  for  $a_{ij}x_j$  in the expression presented in (2), it is possible to obtain the following solution<sup>4</sup> :

$$x = (I - A)^{-1} f \tag{4}$$

<sup>4</sup> For further information about the input–output analysis, see [Miller and Blair \(2009\)](#).

where  $(I - A)^{-1} = B$  is known as Leontief inverse. Such matrix is composed of intersectoral technical coefficients  $b_{ij}$ , each of them representing the direct and indirect requirements of inputs of the sector  $i$  necessary for the production of one final demand of the sector  $j$  (Miller and Blair, 2009).

More specifically, the methodology employed in this study to identify the intersectoral transmission of the productivity gains is based on the structural decomposition, which allows disaggregating the changes in one aspect of an economy among the contributions made by its various components (Miller and Blair, 2009). Thus, assuming there are input–output matrices available for distinct periods (0 and 1), the production variance can be represented based on the Eq. (4), as follows:

$$\Delta x = x^1 - x^0 = B^1 f^1 - B^0 f^0 \quad (5)$$

There are several ways of expanding and rearranging the terms presented in (5) in order to identify how much the production changes can be attributed to each of the components.<sup>5</sup> However, based on Dietzembacher and LOS (1998), the most appropriate approach in the case of decompositions with two determinants is the one that each of these determinants is weighted by the average value of the other, such as<sup>6</sup> :

$$\Delta x = \left(\frac{1}{2}\right) (\Delta B) (f^0 + f^1) + \left(\frac{1}{2}\right) (B^0 + B^1) (\Delta f) \quad (6)$$

The first term on the right side of the Eq. (6) measures the variation of the total production of a sector that is due to changes in direct and indirect relations of purchase and sale of inputs, while the second term measures the variation due to the change in final demand.

Once this approach is widely used in the literature that deals with the production and employment decomposition, as in Araújo Júnior and Tavares (2011), it has been chosen to be employed in this academic study, over the decomposition presented in Greenhalgh and Gregory (2000).<sup>7</sup> Consequently, it can be said that the present work, adapts the method proposed by Greenhalgh and Gregory (2000), using the decomposition proposed by Dietzembacher and LOS (1998).

### 2.2.1. Direct and total intensity of labor in sectoral production

Once a brief overview of the operation of the input–output model as well as the structural decomposition analysis were presented, it is presented the method of Greenhalgh and Gregory (2000) method, which served as a fundamental basis to achieve the objectives of this work. This method allows us to verify the productivity gains and their spillovers among the sectors of the economy, resulting from inter-industrial purchase and sale. According to Greenhalgh e Gregory (2000, p. 59), “This disaggregated perspective recognizes not only that labor productivity growth proceeds at varying rates in different sectors but that its transmission across sectors is an intrinsic part of the growth process”. According to the authors, in the input–output model, the total labor required in the economy can be expressed by:

$$L = \hat{l}x = \hat{l}(I - A)^{-1} f \quad (7)$$

<sup>5</sup> For further information, see Miller and Blair (2009).

<sup>6</sup> For further information, see Miller and Blair (2009).

<sup>7</sup> For further information, see Greenhalgh and Gregory (2000, pp. 61–64).

where  $L$  is the total labor,  $x$  and  $f$  are the column vectors of gross production and final demand for the product of each sector,  $(I - A)^{-1}$  is Leontief inverse, and  $l$  is the vector of labor required for each unit of gross sectoral production, known as the direct labor coefficient, its inverse corresponding to labor productivity.<sup>8 9</sup>

Once the part of the sectoral production, and indirectly of the labor, is sold to other sectors, it is defined the concept of the coefficient of the total labor or the intensity of the labor  $\lambda$ , as all the employment generated in the economy per unit of final sectoral demand, such as:

$$\hat{\lambda} = \hat{l}(I - A)^{-1} \quad (8)$$

where  $\ell$  corresponds to the inverse of direct labor productivity within each sector and  $(I - A)^{-1}$  corresponds to the inter-industry transmission of the production. Thus, changes in the labor intensity may come either from the variations in the directly employed labor, or from the changes in inter-industry purchases. Thus, we obtain two ways of measuring labor productivity in a productive sector. The first one considers the labor productivity employed in the sector and the other considers the labor productivity employed in the production of the inputs used by the sector and by the other sectors that are upstream of it in the productive chain. It is believed that the most appropriate way to measure productivity is to consider the two measures together, as presented in the last equation, since it represents the different sources of productivity that a sector can present.

Applying the decomposition terminology suggested by [Dietzembacher and LOS \(1998\)](#) in Eq. (8), we obtain:

$$\Delta\lambda = \left(\frac{1}{2}\right) \Delta l (B^0 + B^1) + \left(\frac{1}{2}\right) (l^0 + l^1) \Delta B \quad (9)$$

where, as in the Section 2.2,  $B$  corresponds to Leontief inverse matrix. The first component on the right side of the expression (9) will be denominated as Effect of Direct Coefficient of Labor and represents the part of the variation of the labor intensity in each sector, which is due to the amount of work employed in it to obtain a production unit. The second component known as Effect of Inter-industry Purchases represents how much of the variation in the labor intensity that is due to the purchases of inputs made by the sector.

We verify that, from the identity (8), it is possible to rewrite the total labor described in (7) as follows:

$$L = \lambda f \quad (10)$$

Expanding this expression to the labor vector used among the sectors, we obtain:

$$\hat{\lambda} f = \hat{l}(I - A)^{-1} f \quad (11)$$

Thus, while the Eq. (8) provides the employment generated in the economy to produce a unit of sector final demand, the expression (11), when dimensioning this employment by the final level of demand of each sector, assesses the total level of employment generated in the economy.

The differentiation of the Eq. (11) contains two components: a difference term in  $\hat{\lambda}$  and another in  $f$ . Applying the principle suggested by [Dietzembacher and LOS \(1998\)](#), this difference can be written as:

$$\Delta L = \left(\frac{1}{2}\right) \Delta\hat{\lambda}(f^0 + f^1) + \left(\frac{1}{2}\right) (\hat{\lambda}^0 + \hat{\lambda}^1) \Delta f \quad (12)$$

<sup>8</sup> Once (VA) is the main added value in the difference among the gross value of production (VBP) and the intermediary consumption (CI), the productivity of labor, measured by the ratio between VA and the number of the employed workers, is equal to VBP by employed worker minus CI by employed worker. Thus, we can say that the concept of labor productivity defined by the input–output methodology of the present study corresponds to a proxy of this variable, as it refers only to the gross sectoral production divided by the labor employed, that is, to the first component of the difference described. It is important to point out, however, that the values calculated of the proxy and the original variable were very similar. In 2000, the correlation between these values was 0.988, and in 2009, it was 0.983. In terms of the macro-sectors, this measure, in 2000, was 0.999 for Agriculture, 0.868 for Industry and 0.941 for Services. In 2009, these values were 0.999, 0.978, and 0.970, respectively. That is, the proxy seems to be a good indicator of the behavior of labor productivity. We should also highlight that other studies made similar procedures, by using the ratio between VBP and the personnel employed as labor productivity proxy. These are the studies of [Barbosa Filho \(2001\)](#) and [Costa Jr. and Teixeira \(2010\)](#).

<sup>9</sup> [Greenhalgh and Gregory \(2000\)](#) used as a measure of the direct labor coefficient the ratio between the labor remuneration and the personnel employed.



Once this study treats productivity gains, variations in the levels of final demand are not considered, so that only the first part of the right side of the Eq. (12) is used:

$$\Delta L = \left(\frac{1}{2}\right) \Delta \lambda (f^0 + f^1) \quad (13)$$

Therefore, it has been concluded when disregarding alterations in the aforementioned variable, the differentiation of the Eq. (11) represents the variable in the levels of labor intensity, weighted by the mean value of the final demand. Based in (8) and in the decomposition term of Dietzembacher and LOS (1998) in (13), it is possible to differentiate the contribution of each component of the intensity of labor in this variation, such as:

$$\Delta \lambda \hat{f} = \left(\frac{1}{2}\right) \Delta l (B^0 + B^1) \hat{f} + \left(\frac{1}{2}\right) (l^0 + l^1) \Delta B \hat{f} \quad (14)$$

where  $\hat{f}$  corresponds to the diagonal matrix of the average of the final demand in the periods 0 and 1.

The interpretation of the components of the Eq. (14) is similar to the interpretation of the expression (9): the first term on the right side represents how much of the productivity gains can be attributed to the economy of the use of the labor factor directly employed in the production of the sectors, while the second one evaluates, in this process, the contribution of the changes in intersectoral purchases. The advantage of this analysis adjusted by the average final demand is that it measures the impact of the size of the different sectors. Thus, a sector whose productivity gains were extremely high, but whose average final demand is small, can impact the economy less than a segment with lower productivity gains, but with more expressive average levels of final demand.

### 2.2.2. Transmission of productivity gains

Greenhalgh and Gregory (2000) propose a distinction among the productivity gains resulting from the decision made inside the sector itself and those gains originated from sectors from which the inputs were purchased. The first relation is named “Own Effects”, and the second, characterized by the intersectoral transmission of productivity gains, “Input Effects”. To examine the contribution of these impacts, it is necessary to accomplish the decomposition of the Eq. (14). Thus, given that:

$$B = (I - A)^{-1} = I + A + A^2 + A^3 + \dots = I + A + \tilde{A} \quad (15)$$

Note that  $A = \hat{A} + (A - \hat{A})$ , where  $\hat{A}$  is a matrix with the main diagonal of A and the other elements equals to zero, the expression (14) can be expressed as:

$$\begin{aligned} \Delta \lambda \hat{f} &= \left(\frac{1}{2}\right) \Delta l \left[ (I + A^0 + \tilde{A}^0) + (I + A^1 + \tilde{A}^1) \right] \hat{f} + \left(\frac{1}{2}\right) [l^0 + l^1] (\Delta A + \Delta \tilde{A}) \hat{f} \\ &= \frac{1}{2} \{ \Delta l \left[ (I + \hat{A}^0) + (I + \hat{A}^1) \right] \hat{f} + [l^0 + l^1] \Delta A \hat{f} + \Delta l \left[ (A^0 - \hat{A}^0 + \tilde{A}^0) + (A^1 - \hat{A}^1 + \tilde{A}^1) \right] \hat{f} \\ &\quad + [l^0 + l^1] \Delta \tilde{A} \hat{f} \} \quad (16) \end{aligned}$$

Combining the first and the second pairs of terms, it will be possible to rewrite (16) as follows:

$$\Delta \lambda \hat{f} = \Delta \lambda_p \hat{f} + \Delta \lambda_i \hat{f} \quad (17)$$

where:

$$\Delta \lambda_p \hat{f} = \frac{1}{2} \{ \Delta l \left[ (I + \hat{A}^0) + (I + \hat{A}^1) \right] \hat{f} [l^0 + l^1] \Delta A \hat{f} \} \quad (18)$$

$$\Delta \lambda_i \hat{f} = \frac{1}{2} \left\{ \Delta l \left[ (A^0 - \hat{A}^0 + \tilde{A}^0) + (A^1 - \hat{A}^1 + \tilde{A}^1) \right] \hat{f} + [l^0 + l^1] \Delta \tilde{A} \hat{f} \right\} \quad (19)$$

The Eq. (18) measures the Own Effects (OE) and the Eq. (19), the Input Effects (IE).

The Own Effects ( $\Delta \lambda_p \hat{f}$ ) include variations of the labor employed ( $\Delta l$ ) directly in the production of the sector itself ( $I + \hat{A}^t$ ), in addition to variations in the amount of labor that occurs when there is a change in the number



of intermediate inputs used in the productive process of the same sector ( $\Delta A$ ). These elements are associated with decisions concerning the organization of production, the input proportion, as well as intermediate purchases that are under the direct control of the firms. On the other hand, the input effects called  $(\Delta\lambda; \hat{f})$  correspond to changes in the amount of labor involved in the production of inputs by the supplier ( $A^t - \hat{A}^t$ ), besides labor changes involved in even more distant links in the supply chain, captured by the matrix  $\hat{A}^t$ . These effects also include changes in the proportion of intermediate inputs ( $\Delta\hat{A}$ ) of all suppliers involved in a given supply chain, i.e., it considers changes in the proportion of intermediate inputs used by the suppliers of the suppliers of a given sector, as well as by the suppliers of these first suppliers and so on (Greenhalgh and Gregory, 2000). The spillovers in productivity gains will be assessed through these input effects.

Thus, the first component on the right side of Eq. (18) will be denominated as Effect of Own Direct Coefficient of Labor (Own DCL), and the second as Effect of Direct Inter-industry Purchases (Direct IP). Regarding the expression (19), the first term will be classified as Effect of Direct Coefficient of Labor of the Suppliers (Suppliers DCL), and the second as Effect of Inter-industry Purchases of the Suppliers (IP Suppliers).

Finally, Greenhalgh and Gregory (2000) indicate a way to assess the transmission of productivity gains contrary to what has been employed, that is, analyzing the forward effects in the supply chain, of the industry that originated the variations in productivity for those who bought its products. Thus, analyzing the Eq. (19) from the perspective of whom sells the inputs and not from those who buy them, we have the following equation:

$$\Delta\hat{\lambda}_f f = \frac{1}{2} \left\{ \Delta\hat{\lambda} \left[ (A^0 - \hat{A}^0 + \tilde{A}^0) + (A^1 - \hat{A}^1 + \tilde{A}^1) \right] f + [\hat{l}^0 + \hat{l}^1] \Delta\tilde{A} f \right\} \quad (20)$$

The expression above evaluates the economy in the use of the labor factor each time the sector sells its product for intermediate use and for final demand. The first term on the right side of the equation represents the productivity gains transmitted forward or Own Forward Effects (OFE), i.e., it corresponds to the increments that are originated from the economy in the use of the labor factor occurring within the industry itself.

The second term, on the other hand, indicates the ability of the industry to transmit productivity gains that are originated in other sectors. In the present study, we opted to analyze only the first component of this equation, that is, the productivity gains transmitted forward which were originated in the industry itself. In order to assess the intensity of these spillovers along the production chain, their transmission powers will be calculated, i.e., how much profit or productivity losses related to changes in the labor employed directly in its own production sector were transmitted forward. The transmission power of each sector will be obtained as follows:

$$TP = \frac{OFE}{OwnDCL} \quad (21)$$

In which *OFE* corresponds to Own Forward Effect transmitted from the sector  $j$  to all the economy sectors and *Own DCL* represents the Effect of Own Direct Coefficient of Labor, i.e., the productivity gains originated from the economy in the use of labor factor occurring in the industry itself. From this ratio, it is verified how much of the variations of productivity generated within a sector are transferred along the productive chain by the sale of the inputs. It should be emphasized that the authors of the present study have proposed this indicator of transmission power.

### 3. Results

#### 3.1. Direct productivity levels and total labor in sectoral production

As presented in Section 2.2.1, the concept of labor productivity will be analyzed from two different perspectives. In the first one, the focus will be on the sector where the goods are produced, i.e., the concept will evaluate the total labor required for each Million Reais produced considering only the workers of that particular sector. In the second approach, the work demanded in all lines of business to generate one Million Reais of sectoral production will be considered (Greenhalgh and Gregory, 2000). Table 2 presents the sectoral information regarding the first perspective:

The data related to the direct coefficient of labor reveal that the Utility was the most productive segment in the two years analyzed. Costa Jr. and Teixeira (2010) had already found similar result in a 1990–2003 study, in which Utility was the sector with the highest direct labor productivity. One of the main justification for this result would be the expressive productivity gains obtained by this segment in the 1990s. In a study about labor productivity in Brazil

Table 2  
Direct coefficient of labor of the sectors of the Brazilian economy in 2000 and 2009.

| Sectors                                 | 2000  | 2009  |
|---|-------|-------|
| Agriculture and livestock               | 87,06 | 60,69 |
| Construction                            | 22,11 | 24,13 |
| Utility                                 | 2,53  | 2,42  |
| Sciences-based industry                 | 2,83  | 2,85  |
| Differentiated industry                 | 4,36  | 5,78  |
| Intensive industry in scale             | 3,09  | 3,51  |
| Intensive industry in natural resources | 4,65  | 5,16  |
| Intensive industry in labor             | 19,24 | 23,76 |
| Distributive services                   | 26,73 | 26,03 |
| Personal services                       | 57,86 | 54,11 |
| Productive services                     | 8,97  | 8,70  |
| Social services                         | 16,06 | 16,75 |
| Industry                                | 6,18  | 6,88  |
| Services                                | 21,45 | 20,53 |
| Total                                   | 18,39 | 17,63 |

Source: Elaboration from the input–output tables estimated by NEREUS (2015) based on the System of National Accounts (IBGE, 2009, 2011).

and its progress between 1990 and 2000, Bonelli (2015) classified Utility as “high productivity growth sector”, once its rate productivity growth was 9.5% a year, the third highest value among the 42 sectors analyzed. According to the author, a probable cause of this result would be the privatizations of assets of the sector occurred in the period.

Industry activities are claimed to have high levels of productivity, what has been reinforced under this perspective. Except for Intensive Industry in Labor, all other segments of the sector report low direct coefficient of labor compared to the rest of the economy. In this context, Sciences-based Industry stands out, as the industrial sector, which needed less direct personnel employed to generate one Million Reais of gross sectoral production.

The reduced productivity levels for Intensive Industry in Labor, on the other hand, are probably a consequence of the fact that this sector has low technological content and low capital-labor ratio. Thus, to generate almost one Million Reais in 2009, this segment needed approximately 24 directly employed workers, almost eight times higher than the number found for sciences-based activities. This difference in productivity can also be an indicator that intra-sectoral heterogeneity is not only present in Services, but also within the Industry itself.

Regarding the tertiary sector, it has been verified that the majority of segments had relatively small levels of labor productivity. Exception for Productive Services, whose direct coefficient of labor levels were the ones closest to the Industry.

The productivity levels of Industry were higher than those ones of Services under the aggregated view of the sectors. This difference, however, was lower in 2009 than in 2000. This is because the data analyses emphasized that the period in question was characterized by productivity losses in all Industry segments and by gains in most of Services segments. The only segment within the tertiary sector that became less productive was Social Services. It is important to highlight that productivity losses in the industrial sector over the 2000s had already been detected by Galeano and Feijó (2013). These losses would be indicative of macroeconomic transformations occurred in Brazil in the 1990s did not generate lasting impacts on the productivity of the country’s industry. Regarding other sectors, there are significant productivity gains in Agriculture and livestock, moderate gains in Utility, and losses in Construction. Corroborating, Maia and Menezes (2014) showed that the variations in the productivity of Mining, Industry and ISPU and Construction contributed negatively to the growth of the Brazilian economy between 1981 and 2009, while this variation in Agriculture and livestock and services like Transportation, Wholesale, Retail, Restaurants and Hotels contributed positively. The authors emphasize that these last two services are segments of low technology and productivity and increasing their participation in growth may denote growing difficulties for Brazil to maintain long-term sustainable economic development.

In relation to the agricultural sector, Cruz et al. (2012) address the causes of its significant performance from 2000 to 2009, the higher qualification of the sector’s workforce, combined with a process of increasing mechanization of its activities. Additionally, according to Gasques et al. (2008), the increased productivity resulting from the research investments stood out, accomplished by the Brazilian Agricultural Research Corporation (EMBRAPA).

Table 3  
Coefficient of total labor of the sectors of Brazilian economy in 2000 and 2009.

| Sectors                                 | 2000   | 2009  |
|---|--------|-------|
| Agriculture and livestock               | 103,51 | 74,24 |
| Construction                            | 36,06  | 36,15 |
| Utility                                 | 8,95   | 9,11  |
| Sciences-based industry                 | 15,66  | 13,58 |
| Differentiated industry                 | 17,85  | 18,80 |
| Intensive industry in scale             | 16,56  | 16,91 |
| Intensive industry in natural resources | 33,64  | 31,41 |
| Intensive industry in labor             | 34,15  | 38,53 |
| Distributive services                   | 34,77  | 34,39 |
| Personal services                       | 72,06  | 64,69 |
| Productive services                     | 15,82  | 14,41 |
| Social services                         | 22,90  | 23,66 |
| Industry                                | 27,20  | 26,81 |
| Services                                | 30,47  | 29,11 |
| Total                                   | 31,74  | 30,10 |

Source: Elaboration from the input–output tables estimated by NEREUS (2015) based on the System of National Accounts (IBGE, 2009, 2011).

The productivity results presented so far correspond only to workers employed in the sector where the goods or services are located. However, once inputs are demanded in the sector production and, indirectly, workers in other segments of the economy are demanded as well, the consideration of these links in the measurement of the levels of productivity of the sectors is necessary for a more complete analysis of the subject. Concerning this, the measures of labor productivity are explained in Table 3, considering the labor demanded, in other words, upstream supply chain, in all lines of business to generate one Million Reais of the sectoral production:

The information in Table 3 relates that this second approach to productivity measurement generates some results different from those found under the first perspective. Thus, the tendency for Industry segments to have higher productivity levels than Service is not observed. Productive Services, for instance, present superior productivity from all industrial segments, except for Sciences-based Industry, and correspond to the third most productive segment of the Brazilian economy in the two years analyzed. Concomitant with these significant values of Productive Services there are Personal Services, a segment with the second worst performance among all analyzed sectors.

In relation to the industrial segments, data indicate high levels of productivity in Sciences-based Industry and in Intensive Industry in Scale. Intensive Industry in Natural Resources and in Labor, on the other hand, were those with the highest values of the total labor coefficients. Like the case of direct labor productivity, among all segments, the most and least productive sectors were Utility, and Agriculture and livestock, respectively.

The comparison among the total labor coefficients in the two years considered allows verifying that the segments with gains of productivity in the period were the Agriculture and livestock, Intensive Industry in Natural Resources, Sciences-based Industry and Distributive Services, Personal Services and Productive Industry. The other segments were less productive. The decomposition of these productivity gains and losses will be described in the following subsection.

### 3.2. Transmission of productivity gains among sectors of the Brazilian economy from 2000 to 2009

As previously discussed, the gains or losses in productivity earned by a determined segment end up sprawling to other sectors of the economy through the purchase and sale input process. Thus, the results of (18) and (19) are presented below, which allow differentiating the increases or losses of productivity originated from the sector itself and how much originated from the other segments:

According to Tables 4 and 5, in the period of 2000–2009 the total gains of productivity in the sectors generated an economy of the use of the labor factor of about 4.4 m jobs. From this total, around 2.5 m originated from Agriculture, 1.8 m from Services and 98,000 from Industry.

The database presented reveal the importance of Own Effects in the segments of the tertiary sector with productivity gains in the period. In the case of Personal Services, the economy use of the labor factor resulting of such effects

Table 4  
Productivity gains from 2000 to 2009 (in labor positions) – Own Effects (OE).

| Sectors                                 | Effects    |            |            |           |
|---|------------|------------|------------|-----------|
|   | Total      | OE         | Own DCL    | Direct IP |
| Agriculture and livestock               | –2,573.468 | –2,536.734 | –2,507.785 | –28.949   |
| Construction                            | 20.676     | 306.957    | 465.836    | –158.879  |
| Utility                                 | 8.196      | –1.914     | –7.123     | 5.209     |
| Sciences-based industry                 | –82.071    | –33.912    | 723        | –34.635   |
| Differentiated industry                 | 107.134    | 175.671    | 178.630    | –2.959    |
| Intensive industry in scale             | 65.081     | 182.813    | 96.793     | 86.020    |
| Intensive industry in natural resources | –752.669   | 921.405    | 211.953    | 709.452   |
| Intensive industry in labor             | 565.171    | 720.358    | 668.216    | 52.142    |
| Distributive services                   | –134.778   | –189.220   | –274.030   | 84.810    |
| Personal services                       | –1,681.310 | –1,187.864 | –870.290   | –317.574  |
| Productive services                     | –530.685   | –304.239   | –120.689   | –183.550  |
| Social services                         | 548.144    | 746.485    | 497.299    | 249.186   |
| Industry                                | –97.354    | 1,966.337  | 1,156.316  | 810.021   |
| Services                                | –1,798.629 | –934.837   | –767.710   | –167.127  |
| Total                                   | –4,440.580 | –1,200.191 | –1,660.466 | 460.275   |

Source: Elaboration from the input–output tables estimated by NEREUS (2015) based on the System of National Accounts (IBGE, 2009, 2011).

\*DCL corresponds to direct coefficient of labor and IP to inter-industry purchases.

Table 5  
Productivity gains from 2000 to 2009 (in labor positions) – Input Effects (IE).

| Sectors                                 | Effects    |            |               |              |
|---|------------|------------|---------------|--------------|
|   | Total      | IE         | Suppliers DCL | IP suppliers |
| Agriculture and livestock               | –2,573.468 | –36.733    | –81.238       | 44.505       |
| Construction                            | 20.676     | –286.281   | –218.077      | –68.204      |
| Utility                                 | 8.196      | 10.109     | –21.448       | 31.557       |
| Sciences-based industry                 | –82.071    | –48.159    | –14.155       | –34.004      |
| Differentiated industry                 | 107.134    | –68.538    | –53.160       | –15.378      |
| Intensive industry in scale             | 65.081     | –117.733   | –148.804      | 31.071       |
| Intensive industry in labor             | 565.171    | –155.187   | –133.318      | –21.869      |
| Intensive industry in natural resources | –752.669   | –1,674.075 | –2,131.985    | 457.910      |
| Distributive services                   | –134.778   | 54.442     | –167.328      | 221.770      |
| Personal services                       | –1,681.310 | –493.447   | –272.374      | –221.073     |
| Productive services                     | –530.685   | –226.447   | –56.763       | –169.684     |
| Social services                         | 548.144    | –198.341   | –219.982      | 21.641       |
| Industry                                | –97.354    | –2,063.691 | –2,481.422    | 417.731      |
| Services                                | –1,798.629 | –863.793   | –716.447      | –147.346     |
| Total                                   | –4,440.580 | –3,240.389 | –3,518.632    | 278.243      |

Source: Elaboration from the input–output tables estimated by NEREUS (2015) based on the System of National Accounts (IBGE, 2009, 2011).

\*DCL corresponds to direct coefficient of labor and IP to inter-industrial purchases.

was approximately 1.19 m, which represents more than 70% of their total productivity gains in the mentioned period. In relation to Productive Services, this contribution was 304,000 workplaces, about 57% of the total increase in this segment.

Whether for Personal Services and Productive Services, both components of Own Effects played to generate productivity gains, the same did not occur in Distributive Services. Analyzing the direct coefficient of labor of the latter, it can be observed a productivity gain with the reduction of 274,000 workstations, while the changes in the purchase of inputs resulted in productivity losses estimated at 85,000 workers.

Although this second component offset in parts the gains obtained by the first, it is verified that the Own Effects were the main responsible for Distributive Services to be more productive at the end of the analyzed period

Table 6  
Transmission of own productivity gains from 2000 to 2009 (in workstations) –Own Forward Effects (OFE).

| Sectors                                 | OFE        |
|---|------------|
| Agriculture and livestock               | –3.790.618 |
| Construction                            | 66.684     |
| Utility                                 | –10.224    |
| Sciences-based industry                 | 194        |
| Differentiated industry                 | 76.541     |
| Intensive industry in scale             | 113.316    |
| Intensive industry in natural resources | 171.606    |
| Intensive industry in labor             | 330.634    |
| Distributive services                   | –199.446   |
| Personal services                       | –183.200   |
| Productive services                     | –104.370   |
| Social services                         | 10.252     |
| Industry                                | 692.290    |
| Services                                | –476.764   |
| Total                                   | –3.518.632 |

Source: Elaboration from the input–output tables estimated by NEREUS (2015) based on the System of National Accounts (IBGE, 2009, 2011).

Agriculture and livestock was another segment in which these effects were present with great intensity. Particularly, it is possible to verify the expressive relevance of the labor-related component directly employed in the sector, since it was responsible for 97% of the productivity gains of the period. Thus, among 2000 and 2009, only this fact promoted labor input of 2.5 m workers.

The presence of these effects as enhancement of increases of productivity was much less recurrent in Industry. The information in Table 4 indicates that the term related to the direct coefficient of labor did not make any of the industrial segments more productive. On the contrary, it played to cause productivity losses. The component of inter-industry purchases, on the other hand, generated earnings only in Sciences-based Industry and Differentiated Industry. In other cases, it also collaborated to make the segments less productive in the period.

The database in Table 5 expose that the productivity increases found in the sector originated, mostly, from the input effects. It is possible to identify the importance of these effects in the only two industrial segments that reported the total productivity increases in the period. In the case of Sciences-based Industry, about 60% of the total gains are related to these intersectoral spillovers, which represented an economy of approximately 50,000 jobs. In relation to Intensive Industry in Natural Resources, it has been noted that its productivity gains originated exclusively from its input suppliers.

The results described above allow detecting the fundamental difference between Services and Industry segments that presented the total productivity gains. Regarding the former, those gains originated internally, while the latter, the gains are more associated with the process of sprawling of the productivity gains among the segments.

Although this information already presents an indication of productivity gains spillovers, it does not show how much each particular sector transmitted forward such increases, through the sale of its product for intermediary use or final demand. Therefore, the results of the first component of the right side of Eq. (20) are reported in Table 6, which evaluate the spillovers from this perspective. In addition, Table 7 presents the power of transmission of each of the twelve analyzed segments.

The first component on the right side of Eq. (20) represents the productivity gains transmitted forward which originated from the economy of labor factor used in the own sector. According to the database in Table 2, the segments in which these increases were seen were Agriculture and livestock, Utility and in Distribution, Personal and Productive Services, while it has been observed losses in the others. Therefore, these were the only sectors capable of transferring gains in productivity. In such context, it is fundamental to evaluate the magnitude with which these sprawl occurred, i.e., since one segment achieved gains in productivity, through reductions in the direct coefficient of labor, it has been questioned how much of these increases were transmitted forward, through the input sale.

Among the sectors that presented gains, the database in Table 7 reveals a high power of transmission of Agriculture and livestock and Utility. It is verified that these segments transmitted a higher number of gains than their own direct

Table 7  
Transmission Power from 2000 to 2009.

|   | Transmission power |
|---|--------------------|
| Agriculture and livestock                         | 151%               |
| Construction                                      | 14%                |
| Utility   | 144%               |
| Sciences-based industry                           | 27%                |
| Differentiated industry                           | 43%                |
| Intensive industry in scale                       | 117%               |
| Intensive industry in natural resources           | 81%                |
| Intensive industry in labor                       | 49%                |
| Distributive services                             | 73%                |
| Personal services                                 | 21%                |
| Productive services                               | 86%                |
| Social services                                   | 2%                 |
| Industry  | 60%                |
| Services (Transmission Power Gains) <sup>a</sup>  | 38%                |
| Services (Transmission Power Losses) <sup>a</sup> | 2%                 |
| Total (Transmission Power Gains) <sup>a</sup>     | 113%               |
| Total (Transmission Power Losses) <sup>a</sup>    | 36%                |

Source: Own elaboration from the input–output tables estimated by NEREUS (2015) based on the System of National Accounts (IBGE, 2009, 2011).  
<sup>a</sup> Once in Services there are segments that have obtained gains and another one that has obtained loss, the transmission power of the sector cannot be aggregated into a single indicator. Thus, the category “Services (Transmission Power Gains)” involves Distributive, Personal and Productive Services, while the group “Services (Transmission Power Losses)” comprises only Social Services. The same reasoning is applicable in the “Total” aggregation.

productivity increases, since their transmission powers were greater than 100%. These results are extremely relevant, especially in the case of Agriculture and livestock, since it is the sector with the highest productivity gains in the analyzed period.

Although in smaller magnitude, certain segments of Services sector also exhibited a high capacity to transfer its gains. Productive Services, for instance, transmitted 86% of their productivity increases forward, while Distribution Services, 73%. On the other hand, there is the case of Personal Services, which forwarded only 21% of their productivity gains. Hence, it can be observed that the second largest sector of the country’s economy in terms of such increases in the period presented small capacity in transferring them to the other sectors of the productive chain. Therefore, despite showing direct productivity gains estimated at about 870,000 jobs, only 183,000 were transmitted forward. Regarding the performance of Social Services, it has been observed that although the sector presented productivity losses from 2000 to 2009, those ones were lightly transmitted along the distribution chain.

The capacity of the segments of Industry to transfer forward their losses of productivity was very heterogeneous. The transmission power of Intensive Industry in Scale, for instance, was 117%, while in Sciences-based Industry, 27%. In relation to the Intensive Industry in Labor, characterized as the segment of the economy with the greatest direct losses of productivity, it was seen a transmission power of around 50%. Regarding the large sectors, it has been observed that 60% of the productivity losses of Industry were transmitted forward, a value that represents approximately 692,000 workplaces.

Considering only those segments of Services that achieved gains (i.e., all of them but Social Services), there is a transmission power of the tertiary sector of 38%, which represents an economy of around 487,000 workstations. Hence, it has been concluded that, on the average, the capacity of Industry to transfer its productivity losses showed to be larger than the capacity of Services to transmit their gains in about 205,000 jobs. Therefore, the sprawl of productivity increases in the latter is more than offset by the sprawl of the industrial sector losses. The fact that the productivity gains have higher transmission power than the losses is mainly due to the high capacity of Agriculture and livestock to spread its increases, given that, it was an important supplier in the economy and presented significant productivity gains in the period.



### 3.3. Result analysis

After exposing this information regarding productivity and the transmission of its gains or losses along the productive chain from 2000 to 2009, it is given an analysis of the results obtained. In terms of the Brazilian economic scenario, database from the IBGE (2015a,b,c) indicates that in the analyzed period the participation of Services in the Brazilian GDP increased from 64.73% to 67.54%. In addition to these values, a retraction tendency of Industry can be noticed, once its contribution to the GDP of the country fell from 21.51% in 2000 to 18.48% in 2009. These numbers of the Brazilian economy could compromise the country's economic growth, according to many scholars, such as Kaldor (1957) and Baumol (1967). Among the reasons to justify this fact are the low levels and productivity gains of Services, in addition to its reduced linking capacity with the other segments of the economy. Hence, it has been questioned whether the results described in Section 3.2 support these justifications or refute them.

Regarding the direct coefficient of labor, it has been verified that, in general, Industry is more productive than Services. The performance of Productive Services, however, is closer to the Industry average than to the Services one. It is still emphasized that the productivity levels of this segment are more than the double for Intensive Industry in Labor, i.e., low productivity rates are characteristics of some segments of the tertiary sector, such as Personal Services but not for all the Services sectors.

Under this first perspective, it has been verified that none of the industrial segments presented increases of productivity from 2000 to 2009. These results are in accordance with the estimates found by Miguez and Moraes (2014), which indicate that the majority of the Brazilian industrial segments lost relative productivity in relation to the border, i.e., compared with the economies used as reference of high productivity,<sup>10</sup> between 1995 and 2009. Regarding Transformation Industry, this distance practically doubled in the period, since in 2009 the estimates indicate that the border was 9 times more productive than the national industry, while in 2000, it was 4.9 times more productive (Miguez and Moraes, 2014).

Hence, despite the information indicates that the industrial segments constitute, in their majority, the sectors with the highest levels of direct productivity in the Brazilian economy, the data presented by Miguez and Moraes (2014) show that there are still margins for the productivity increases in the country's industry, capable of positively influencing the evolution of the Brazilian aggregate product.

Most of Services sectors, on the other hand, showed productivity gains. The increases were verified in two less productive segments of the sector in 2000, Distributive and Personal Services, and in Productive Services, a segment that has already presented a relatively high productivity at the beginning of the period. Therefore, the information related to the direct coefficient of labor does not confirm the hypothesis that Industry tends to present higher productivity gains than Services, given that, at least in the analyzed period, such increases occurred in the segments of the tertiary sector, but not in the industrial sector.

In relation to the second approach to the productivity, its levels of Industry and Services are very similar. Hence, the traditional view that Industry is more productive than Services, receives support only when the interdependence among the sectors is not considered, at least for the Brazilian case from 2000 to 2009. Under this second perspective, the fact that the productivity increases in the industrial sector originated mainly from the input effects, already provides evidence that the transmission of productivity gains in the analyzed period did not have the industrial sector segments as a fundamental source, as expected.

Own Forward Effects revealed that in the recent years of the Brazilian economy, Agriculture and livestock and Services were the main sectors to spread productivity increases along the production chain, to the detriment of the Industry. It has been questioned what are the consequences of this process. Although the majority of the segments of the tertiary sector achieved productivity gains in the period, on the average, the capacity of these sectors to transmit them forward was relatively low, about 38%. This is due to most of their productivity increases occurred in Personal Services, a segment with a low degree of linkage with others and whose goods mainly serve the individual consumer, not being directly involved in the production processes of the sectors. Hence, the gains of Personal Services had little impact on the efficiency of other segments of the Brazilian economy.

<sup>10</sup> In the study of Miguez and Moraes (2014), the economies used as reference for high productivity were Germany, for the years of 1995 and 2000, and the United States, for the years of 2005 and 2009.



Such result corroborates those found by Cruz et al. (2007). The authors affirm that within Services sector, there are those ones with high productivity, i.e., information and communication technology, which have great dynamic potential and effects of linkages with other sectors of the economy. However, there are also services with contrary characteristics, like Personal Services. Their results showed that, in the period from 1985 to 2005, the former lost participation in employment and in the product of Brazilian economy, while the latter increased participation in it. Those authors stated that those with low productivity have low potential to generate economic dynamism not acting as an alternative to the industrial sector like an engine of growth.

As previously discussed, productivity losses in the industrial sector were transmitted with a greater intensity than gains in Services, since the transmission power of Industry was approximately 60%. Along with this larger capacity, the losses of direct productivity of Industry were greater than the increases of Services, as shown in Table 4. Therefore, the spillovers of their productivity losses surpassed the gains of the tertiary sector in about 205,000 workstations. Hence, it has been understood that, if it were not for the excellent performance of the Agriculture and livestock, the total balance for the period 2000–2009 would be the forward transmission of productivity losses to the detriment of gains.

These results reinforce the hypothesis that Services have relative limitations to the linkages with the rest of the economy, especially when compared to Industry. The transmission power of the industrial sector is greater than that of the tertiary one, what allows verifying that if Industry had increased its productivity, instead of reducing it, this would have led to bigger gains for the other segments of the economy than the ones observed by the raising of Services productivity. The data estimated by Miguez and Moraes (2014) indicate that there are margins for these increases, once in 2009 none of the segments of Brazilian Industry was on the international border, formed by the economies used as reference of high productivity. Therefore, it is imperative to make investments in the sector involved in the improvement in the country's infrastructure up to promoting research and development in industrial companies.

In order the Services productivity gains have a stronger impact on the economy; it is essential that they occur in segments with dynamic links in the sectoral production processes. In this context, disaggregated information reveals that “Information Services” and “Business Services” are the two segments of the tertiary sector with the highest transmission power observed, of about 208% and 468%, respectively.<sup>11</sup> Cruz et al. (2007) as mentioned above showed the dynamic role of Information Services.

Therefore, the gains achieved by them would tend to spread more intensely along the production chain. It is important to emphasize that from 2000 to 2009, increases of this type were found in Information Services, but not in Business Services. Given the excellent capacity of the latter in establishing forward chain-linked relationships, it is essential that it becomes more productive and transmits these productivity increases to the other sectors. According to Silva et al. (2006), intensive Business Services in knowledge corroborate the innovations both in the own sector and in the industry. The authors claim the Services play an important role in the diffusion of innovation and productivity gains to other sectors, being fundamental in modern economies as the growing portion of the sector aims at the intermediate consumption. Hence, the present study also restates the importance of those KIBS for the Brazilian economy as some previous studies on the subject have identified them for other nations.

#### 4. Concluding remarks

The main objective of this study was to analyze the capacity of Brazilian economy sectors to sprawl their productivity gains or losses along the production chain between 2000 and 2009. Therefore, the methodology proposed by Greenhalgh and Gregory (2000) was used as a basis. Particularly this method has been adapted by the structural decomposition technique suggested by Dietzembacher and LOS (1998).

The verified estimates indicate that the direct productivity gains from 2000 to 2009 occurred in almost all Services segments, to the detriment of the industrial ones, in which the levels of direct coefficient of labor increased. On the other hand, the estimates show that the capacity of Services segments, which achieved gains of forward transmission, is, on average, less than the power of Industry to transfer its losses. However, it is important to note that this low capacity of sprawling is not characteristic of all Services segments. The subset of Productive Services formed by Information Services and Business Services, for instance, presented high capacity of forward sprawling.

<sup>11</sup> Due to the article format limitation, the disaggregated database of the 56 sectors of the input–output matrix were not presented in Table 6. To obtain this information, e-mail the authors.

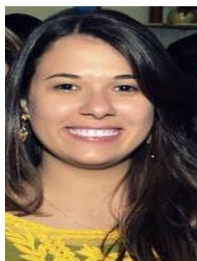
Therefore, in terms of the transmission of productivity gains, the Services field can only be considered a factor capable of restricting Brazil's economic growth if there are increases exclusively in segments with low transmission powers, in which the gains are little externalized. If, on the other hand, highly dynamic segments of the tertiary sector and with important links in sectoral supply chains become more productive, significant productivity gains will be transmitted, promoting positive effects on the country's economic efficiency.

Hence, it is possible to affirm that from 2000 to 2009 both Industry and Services presented restrictions regarding these intersectoral spillovers. In relation to the first sector, for transferring productivity losses, and to the second, because its ability to transmit gains is not large enough to offset the losses spread by the Industry. Therefore, the results of the present study show that in order the spillovers of productivity gains to act in a positive and significant way to impact the Brazilian aggregated product, it is fundamental that those increases occur again in the segments of Industry and are also present in high power transmission Services, such as KIBS.

## References

- Araújo Júnior, I.T., Tavares, F.B., 2011. Mudanças estruturais no Nordeste entre 1997 e 2004: uma análise de insumo-produto. *Anais do XVI Encontro Regional de Economia – ANPEC/NE, Fortaleza*.
- Barbosa Filho, F.H., 2001. *Evolução Recente da Produtividade no Brasil e o Impacto de Tarifas e Importações*. 87f. Dissertação (Mestrado em Economia) – Escola de Pós-Graduação em Economia, Fundação Getúlio Vargas.
- Baumol, W.J., 1967. Macroeconomics of unbalanced growth: the anatomy of urban crisis. *Am. Econ. Rev.* 57, 415–426.
- Bonelli, R., 2015. *Labor Productivity in Brazil during the 1990s*. Discussion text 117. IPEA, Brasília.
- Browning, H.L., Singelmann, J., 1978. The transformation of the US Labour Force: the interaction of industry and occupation. *Polit. Soc.* 8, 481–509.
- CNAE, 2015. Classificação Nacional de Atividades Econômicas. <http://cnae.ibge.gov.br/classificacoes.html>.
- Costa Jr., L., Teixeira, J.R., 2010. Mudança estrutural e crescimento econômico no Brasil: uma análise do período 1990–2003 usando a noção de setor verticalmente integrado. *Revista Nova Economia* 20, 85–116.
- Cruz, A.I.G., Ambrozio, A.M.H., Puga, F.P., Souza, F.L., Nascimento, M.M., 2012. A economia brasileira: conquistas dos últimos dez anos e perspectivas para o futuro. *BNDES 60 anos: perspectivas setoriais*. Banco Nacional de Desenvolvimento Econômico e Social, Rio de Janeiro, pp. 12–41.
- Cruz, M.J.V., Nakabashi, L., Porcile, G., Scatolin, F.D., 2007. Uma análise do impacto da composição ocupacional sobre o crescimento da economia brasileira. *Rev. Econ.* 8 (4), 55–73.
- Dietzembacher, E., LOS, B., 1998. Structural decomposition techniques: sense and sensitive. *Econ. Syst. Res.* 10, 307–323.
- Furtado, C., 1961. *Desenvolvimento e subdesenvolvimento*. Fundo de Cultura, Rio de Janeiro.
- Galeano, E., Feijó, C., 2013. A estagnação da produtividade do trabalho na indústria brasileira nos anos 1996–2007: análise nacional, regional e setorial. *Nova Econ.* 23, 9–50.
- Galinari, R., Teixeira Junior, J.R., 2014. *Serviços: conhecimento, inovação e competitividade*. BNDES, Rio de Janeiro 39, 235–280.
- Gasques, J., Bastos, E., Bacchi, M., 2008. Produtividade e fontes de crescimento da agricultura brasileira. In: Negri, J.A., Kubota, L.C. (Eds.), *Políticas de incentivo à inovação tecnológica no Brasil*. IPEA, Brasília.
- Greenhalgh, C., Gregory, M., 2000. Labour productivity and product quality: their growth and inter-industry transmission in the UK 1979–1990. In: Barrel, R., Mason, G., O'Mahony, M. (Eds.), *Productivity, Innovation and Economic Performance*. Cambridge University Press, Cambridge, pp. 58–92.
- Guilhoto, J.J.M., Sesso Filho, U.A., 2005. Estimação da Matriz Insumo-Produto a Partir de Dados Preliminares das Contas Nacionais. *Econ. Apl.* 9, 277–299.
- Guilhoto, J.J.M., Sesso Filho, U.A., 2010. Estimação da Matriz Insumo-Produto Utilizando Dados Preliminares das Contas Nacionais: Aplicação e Análise de Indicadores Econômicos para o Brasil em 2005. *Economia e Tecnologia. UFPR/TECPAR* 23, 53–62.
- Hirschman, A.O., 1961. *Estratégia do desenvolvimento econômico*. Fundo de Cultura, Rio de Janeiro.
- IBGE, 2015. Instituto Brasileiro de Geografia e Estatística. Índice Nacional de Preços ao Consumidor Amplo (IPCA) <http://www.ibge.gov.br/home>.
- IBGE, 2015. Sistema de Contas Nacionais (2009, 2011). Instituto Brasileiro de Geografia e Estatística [http://www.ibge.gov.br/home/estatistica/pesquisas/pesquisa\\_resultados.php?id\\_pesquisa=48](http://www.ibge.gov.br/home/estatistica/pesquisas/pesquisa_resultados.php?id_pesquisa=48).
- IBGE, 2015. Sistema de Contas Nacionais Referência 2000. Instituto Brasileiro de Geografia e Estatística <http://www.ibge.gov.br/home>.
- Kaldor, N., 1957. A. Model of economic growth. *Econ. J.* 67, 591–624.
- Maia, A.G., Menezes, E., 2014. Economic growth, labor and productivity in Brazil and the United States: a comparative analysis. *Revista de Economia Política* 34 (2), 212–229.
- Miguez, T., Moraes, T., 2014. Produtividade do Trabalho e Mudança Estrutural: uma comparação internacional com base no World Input–Output Database (WIOD) 1995–2009. In: De Negri, F., Cavalcante, L.R. (Eds.), *Produtividade no Brasil: desempenho e determinantes*, 1. IPEA, Brasília, 445 f.
- Miller, R.E., Blair, P.D., 2009. *Input–output Analysis: Foundations and Extensions*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 464p.
- Nakabashi, L., Scatolin, F.D., Cruz, M.J.V., 2010. Impactos da Mudança Estrutural da Economia Brasileira sobre o seu Crescimento, 14. *Revista de Economia Contemporânea, Rio de Janeiro*, pp. 237–268.
- NEREUS, Dados e Programas 2015. Núcleo de Economia Regional e Urbana da Universidade de São Paulo. <http://www.usp.br/nereus/?fontes=dados-matrizes>.

- OCDE, 2004. Digital delivery of business services. In: Working Party on the Information Economy. Directorate for Science Technology and Industry.
- Oreiro, J.L., Feijó, C.A., 2010. Desindustrialização: conceituação, causas, efeitos e o caso brasileiro, 30. *Revista de Economia Política*, São Paulo, pp. 219–232.
- Pavitt, K., 1984. Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory, 13. *Research Policy*, Amsterdam, pp. 343–373.
- Presbich, R., 1949. El desarrollo económico de la América Latina y algunos de sus principales problemas. *Desarrollo Económico* 26, 1986.
- RAIS, 2015. *Relação Anual de Informações Sociais*. Ministério do Trabalho e Emprego, Brasília.
- Silva, A.M., De Negri, J.A., Kubota, L.C., 2006. Estrutura e dinâmica do setor de serviços no Brasil. In: *Estrutura e dinâmica da produtividade do setor de serviços no Brasil*. IPEA, Brasília, pp. 15–34.
- Squeff, G.C., 2012. *Desindustrialização: luzes e sombras no debate brasileiro*. Texto para Discussão 1747. IPEA, Brasília.
- Tregenna, F., 2009. *Characterizing deindustrialization: an analysis of changes in manufacturing employment and output internationally*. Cambridge J. Econ., 33.
- Wasques, R.N., 2011. O fenômeno da desindustrialização: uma análise do caso brasileiro na década de 2000. *Revista Economia Ensaios*, Uberlândia 26, 65–84.



**Mariana Camarin Gazonato** holds a degree in Economic Sciences from UFSCAR - Federal University of São Carlos and a Masters degree in Applied Economics also from UFSCAR - Federal University of São Carlos. She has experience in the areas of Economic Growth and Structural Change.



**Maria Aparecida Silva Oliveira** is an Associate Professor at UFSCar – Federal University of São Carlos. She holds a Doctorate in Applied Economics from UFV – Federal University of Viçosa. Professor Oliveira has been researching infrastructure and economic growth, analyzing the relationship among supply of electricity, communication and road and the GDP growth. She has been advising researches about economics structural change and multisectorial analyses recently. She has published papers in peer-reviewed journal and congresses, book chapters and has coauthored papers.