Structural change and sources of labor demand expansion in Brazil*

Mudança estrutural e fontes de expansão da demanda por trabalho no Brasil

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Abstract: This article investigates the changes in the use of labor in Brazil between 2000 and 2019 using structural decomposition analysis. We decomposed the sources of employment expansion into alterations in labor input coefficients, technology, and final demand. We found a negative relationship between the labor input coefficient and the final demand effect. The latter was pivotal in stimulating employment. Key sectors are the ones that can simultaneously raise productivity and employment. Our results highlight that extractive industries, manufacturing, and communications as critical sectors which stimulated the economy with efficiency and equity during period.

Keywords: Employment. Key sectors. Structural Decomposition Analysis.

Resumo: Este artigo investiga as mudanças no uso do trabalho no Brasil entre 2000 e 2019, aplicando análise de decomposição estrutural. Decompomos as fontes de expansão do emprego em alterações nos coeficientes de insumos trabalho, tecnologia e demanda final. Encontramos uma relação negativa entre o coeficiente de insumo trabalho e o efeito demanda final. Este último foi fundamental para estimular o emprego. Setores-chave são os que podem simultaneamente aumentar a produtividade e o emprego. Nossos resultados destacaram as indústrias extrativas, a manufatura e as comunicações como setores centrais que estimularam a economia com eficiência e equidade no período.

Palavras-chave: Emprego. Setores-chave. Análise de decomposição estrutural.

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1. Introdução

One of the most important questions in development economics concerns the role of sectors in output and labor demand expansion. Both neoclassical and structuralists look, at least partially, at sectors' input-output linkages and propagation length to assess sectors' importance (Aroche-Reyes; Muñiz, 2018; Morrone, 2021). However, only focusing on sectors' links and propagation length might limit the analysis, especially in surplus-labor economies with high inequality (Aroche-Reyes; Muñiz, 2018). In this context, a more reasonable indicator to evaluate the relevance of a given sector would be to gauge its capacity to boost output and employment efficiently.

In this paper, we aim to fill a significant gap in the current state of research. Building on the framework of Berni (2006), we identify critical sectors as those that exhibit sustained growth in labor demand and input productivity while also increasing final demand and employment levels. These sectors play a central role in stimulating economic output and employment, particularly in the context of improving socio-economic conditions, especially for marginalized populations. Our study aims to identify and analyze these sectors. This is a crucial aspect that has been overlooked in the economic analysis of Brazil, especially with regard to the dynamic interplay between labor productivity and employment trends.

To achieve our research objectives, we undertake a thorough examination of the patterns of labor input in the different sectors in Brazil from 2000 to 2019 and its sub-periods, using the robust Input-Output Structural Decomposition Analysis (SDA). The SDA approach, as underscored by Yang and Lahr (2010) and Schuschny (2005), allows us to study supply and demand factors together, providing a nuanced understanding of sectoral dynamics. Our study addresses two primary questions: How has the utilization of labor evolved from 2000 to 2019, and which sectors have shown increasing productivity alongside rising employment and final demand levels during this period?

For our analysis, we use four official Input-Output (I-O) tables from 2000 to 2015 and estimate an I-O table for 2019, which allows us to assess the significance of twelve critical sectors in the Brazilian economy. These I-O tables, which are available every five years, are crucial markers of economic policy change. We decompose sectorial employment changes into contributions from alterations in labor input coefficients (indicating changes in labor productivity), technological advancements (reflecting changes in input productivities), and final demand dynamics.

While there are recent studies that apply the SDA approach to decompose employment changes in Brazil (Sesso *et al*., 2010; Souza *et al*., 2016; Perobelli *et al*., 2016; Sousa-Filho *et al*., 2021; Acypreste, 2022), our paper advances existing literature on two fronts. First, we extend the analysis to a more recent period, 2019. Second, we introduce an innovative interpretation of the results inspired by Berni (2006). We emphasize the contributions of labor input coefficients, technology, and demand and also shed light on identifying key sectors driving rising employment alongside productivity gains. As the example of Brazil shows, this approach is crucial for capturing structural changes and economic performance in labor-surplus economies characterized by high-income inequality.

Over the last four decades, Brazil has undergone a significant structural transformation known as deindustrialization, characterized by a diminishing role of industry in value creation and employment. This transformation reflects changes in the sectoral configuration that can act as barriers constraints or catalysts for economic expansion (Rada, 2021; Ocampo *et al*., 2009). Recognizing the reciprocal relationship between structural change and economic expansion is essential, and the SDA procedure offers insights into this dynamic.

The article is structured as follows: Section 2 provides a brief outlook on the role of sectors in economies. Section 3 provides a Brazilian background, showing some statistics on output and employment. Section 4 gives a concise empirical background on SDA as applied to Brazil. Section 5 outlines our methodology and data sources. In Section 6, we present an overview of Brazilian economic performance, focusing on output and employment expansions, and share our results. Finally, in section 7, we discuss the practical implications of our research for policymakers, highlighting the sectors that are drive employment growth and economic expansion.

2. The role of sectors, structural change and economic expansion

Structural change and its relationship to economic growth is a central topic in economics. Economic growth fosters structural transformation, which in turn influences the trajectory of expansion or stagnation in an economy (Rada, 2021).

Recently, the mainstream has also incorporated the effect of different sectors in the process of productive expansion. In this context, studies discussing the theme of structural change are important, addressing deindustrialization, the increase in the service sector, the shifts in labor demand and particularly, the financialization of contemporary economies. In this sense, each sector has specific roles to foster aggregate output and labor demand.

Agriculture, industry, and services are the pillars of economic development. Agriculture plays a pivotal role. It not only stimulates demand, fostering economies of scale for domestic industry, but also serves as a major source of foreign exchange in developing countries through exports. This foreign exchange is crucial for importing machinery, a key component of industrialization. Moreover, agriculture acts as a labor buffer, boosting employment during economic downturns and reducing it during periods of growth. A robust agricultural sector, providing low-cost food, is a prerequisite for rapid industrialization. Without it, the industrialization process may stumble (Lewis, 1954). Lewis (1954) argues that development hinges on increased agricultural productivity, positioning the agricultural sector as both functional and passive in the development process.

According to Kaldor (1968), industry, especially manufacturing, is the driving force behind economic growth. His growth laws (Thirlwall, 1983) shed light on the dynamics of economic expansion. His first law establishes a strong positive relationship between the growth of manufacturing production and Gross National Product (GNP). Feijó and Carvalho (2002) underline the importance of sectoral weight and growth rate in driving GDP growth. Kaldor's second law links industrial labor productivity growth with production growth, attributing endogenous productivity growth to demand-driven production expansion.

Kaldor's third law reveals a positive correlation between productivity growth, industrial employment, and manufacturing production. Mamgain (1999) highlights the circular causation wherein industrial output growth drives industrial productivity, leading to increased non-industrial productivity and overall economic growth. In summary, Kaldor (1975) underscores the importance of domestic and external demand for manufacturing in sustaining productivity growth, positioning the industrial sector as pivotal for sustainable development.

More recently, the services sector has emerged as a potential catalyst for growth. Dasgupta and Singh (2005) suggest that services can foster robust economic expansion, and open new avenues for development.

There are two interpretations of the role of services in development. According to one view, services are complementary to manufacturing and subordinate to its growth, as Kaldor (1968) and Chang (2011) suggested. The second view, the hand, assumes that services can lead to economic development by substituting for manufacturing (Dasgupta; Singh, 2005). This argument supports the experience of Indian growth.

In conclusion, service activities can be contributed actively or passively to economic growth. The distinction between high-tech, highly productive services and low-productivity services prevalent in middle-income countries is crucial for understanding their contribution to economic activity expansion.

3. The Brazilian economic context

3.1 Economic background

After the unravelling of the external debt crisis of the 1990s, the Brazilian economy grew relatively fast during the 2000s. However, growth rates declined after another economic crisis, this being the world slump beginning in 2008.

The rise of the international economy in the 2000s, influenced by China and India's robust output growth rates, stimulated the Brazilian economy (Marquetti *et al*., 2020; Morrone, 2021). Brazil benefited from increasing exports and booming commodity prices in the early 2000s, led by agriculture (crops and livestock) and extractive industries (oil and iron ore). Cunha *et al*. (2013), Cooney (2016, 2021), among others, refer to a return to a primary-exporting economy.

Between 2002 and 2007, commodity prices grew 135% (Marquetti *et al*., 2020). As a result, Brazil became less prone to external crises and received a considerable inflow of foreign investment. When the great recession of 2008 hit, Brazil had international reserves and hence space to use countercyclical policies. One of the central government reactions to this crisis was implementing tax cuts on industrialized goods which galvanized economic activity in the short-medium term (Borghi, 2017).

A central characteristic of Brazil's achievements was the expansion of the domestic market due to three measures. Firstly, the government introduced a conditional cash transfer program (In Portuguese, Bolsa Família) and increased the minimum wage to boost consumption and thus economic output. Secondly, the State-owned banks' credit supply was expanded, increasing the credit-to-GDP ratio. The government also promoted an institutional change in credit markets through a new credit line offered to households with automatic repayments from the paycheck (Martins and Rugitsky 2021). Thirdly, the government introduced a Growth Acceleration Plan (PAC, Portuguese acronym) to promote public investments in infrastructure. Because of these policies, employment increased markedly, and there was a decline in poverty (Singer, 2012, 2018). The rise in the minimum wage and the formalization of the economy stimulated a cumulative causation process based on structural change toward services and commodities (Loureiro, 2019).

Despite the economic growth achieved in the 2000s, the exchange rate overvaluation damaged Brazil's international manufacturing competitiveness (Carvalho, 2018). To counteract the economic slowdown, the government introduced tax cuts for selected sectors and promoted capital centralization to increase the size of domestic companies. It also tried to sustain the investment level, providing subsidized interest rates via state-owned banks. This economic model started to show its limits in the 2010s, and a political and economic crisis emerged after 2014. The Gross Domestic Product (GDP) growth rate declined from 4.6% in 2011 to 2.3% in 2014 (Filgueiras, 2017). The economic slowdown, followed by soaring unemployment rates in conjunction with widespread public upheaval, contributed to the impeachment of President Dilma Roussef. The Gross Domestic Product dropped from 4.6% in 2011 to 2.3% in 2014 (Filgueiras, 2017; Morrone, 2021). High private health and education prices, together with the deterioration in the provision of public goods, further fueled the crisis (Singer, 2012, 2018; Carvalho, 2018; Pinheiro-Machado, 2019).

Between 2015 and 2019, the Brazilian economy performed poorly. The neoliberal agenda was further intensified with the new Temer government and later with Bolsonaro's presidency.

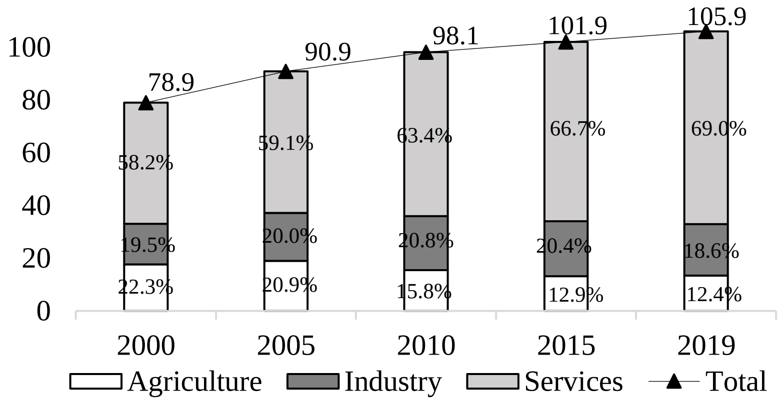
3.2 Employment and output in Brazil, 2000-2019

Figure 1 displays Brazil's aggregate and sectorial employment and value-added statistics. It shows that total employment grew 34.2% in the 2000-2019 period. Panel A of Figure 1 reveals that aggregate employment grew faster in the 2000-2005 timeframe. It grew 15.21% between 2000 and 2005. After that, employment grew at a diminishing 7.8% between 2005 and 2010, 3.9% from 2010 to 2015, and 4.0% between 2015 and 2019. The decline in employment growth rates between 2005 and 2010 might be related to the Great Recession of 2008.

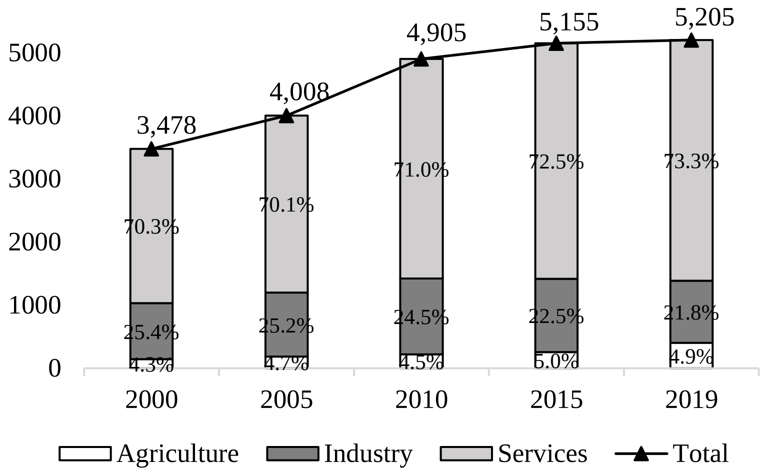
Panel A reveals that agriculture's share declined from 22.3% in 2000 to 12.9% in 2015, while services' share increased from 58.2% to 66.7%. A further decline was to 12.4% was found between 2015 and 2019. The percentage of industrial employment from the total remained relatively stable at around one fifth from 2000 to 2015, but declined to 18.6% when we look at the 2015-2019 period. The economic and political crisis of 2015 played a role in the results.

Figure 1 – Employment and value-added in Brazil and its sectorial shares (2000-2019)

Panel A – Employment (millions of workers) and sectorial shares (%)



Panel B – Value Added (Billions of Reals) and sectorial shares (%)



Note: Constant prices of 2015.
Source: Authors' elaboration based on IBGE (2022).

The employment expansion was driven by services, which increased its share in the total economy from 58.2% in 2000 to 69% in 2019. After 2015, the share of industry shrank. Moreover, agriculture fell consistently throughout the 2000-2019 period, a sign of the so-called conservative modernization (Canuto, 2004): modern technologies in crop production and extensive cattle raising.

Panel B of Figure 1 shows the total and sectorial value-added in the 2000-2019 period, measured at constant prices of 2015. The economy grew substantially in this period. This growth was sandwiched mainly in the 2005-2010 timeframe, as can be detected by the steeper-sloped line, showing an expansion of 22.4%. This performance was associated with the commodity prices cycle, rises in minimum wages, and progressive policies. Carvalho (2018) calls this period the Mild Miracle (In Portuguese, Milagrinho) concerning the robust Brazilian growth of the 1968-1973 years. After that, the value-added only expanded by 5.1%. Panel B exhibits a slight inflection in the value-added between 2010 and 2015. From 2015 to 2019, the Brazilian economy stagnated.

At the sectorial level, services' share expanded in value-added, moving from 71.0% in 2010 to 73.3% in 2019. Services' value-added rose considerably, leading to a rise in the importance of services in the economy. Agriculture's value-added was relatively stable, while the industry share in the total economy slightly declined between 2000 and 2019. This decline started after 2010.

These associated movements were observed in the growth of labor productivity. Table 1 reports some statistics for Brazil between 2000 and 2019. Here, labor productivity was calculated as sectorial value-added divided by sectorial employment (or labor occupied). The data is sourced from IBGE's (2022) official Input-Output (I-O) tables and Supply and Use tables. According to Sesso *et al*. (2010) and Sousa-Filho *et al*. (2021), the sectorial implicit deflators from the Make and Use table were applied to compute the gross product value at prices for the year 2015.

Between 2000 and 2015, productivity grew modestly. After 2015, labor productivity declined. Table 1 exhibits the labor productivity results. This increase is concentrated in the 2005-2010 subperiod. Agriculture presented sustainable productivity growth up to 2015; then it reduced between 2015 and 2019. Industry and services showed higher numbers in the 2005-2010 timeframe. An expansion in the industry also marked the 2015-2019 period. There was a decline in productivity for service sectors in the other subperiods.

Since the industrial performance relied on the rise of extractive activities (oil, iron, among others), it is essential to disaggregate our data. In the following sections, we present the methodology, dataset and explore the results for the disaggregated I-O tables.

Table 1 – Brazilian statistics (2000-2019)

Labor productivity (Chain index)	**2000**	**2005**	**2010**	**2015**	**2019**
Agriculture	100	117.78	143.91	138.84	97.87
Industry	100	96.79	106.05	94.64	103.27
Services	100	98.25	107.01	98.16	95.02
Total	**100**	**100.11**	**113.38**	**101.15**	**97.11**

Source: authors' elaboration.
Note: Labor productivity was computed as sectorial value-added divided by sectorial employment (or labor occupied). The data comes from the official I-O tables and Supply and Use tables from IBGE (2022). Following

> Sesso *et al*. (2010) and Sousa-Filho *et al*. (2021), the sectorial implicit deflators from the Make and Use table were employed to estimate the gross product value at prices for the year 2015.

4. Empirical Background

Other studies broadly apply the SDA approach internationally and to Brazil. The number of studies somewhat decreases when we look exclusively at employment decompositions. Kupfer and Freitas (2004) decomposed employment changes in Brazil from 1990 to 2001. They found that both domestic and external demand drove employment expansion. Conversely, imports and technological change contributed negatively to employment growth.

Berni (2006) employed the SDA method to investigate the pattern of labor use in different sectors for Brazil between 1949 and 2010. He estimated the I-O table for the year 2010 using the Delphi method. The objective was to detect which sectors were "virtuous", which presented rising productivity and employment in the period. His findings underscore the centrality of manufacturing of capital goods and services as the unique "virtuous" sectors in the whole period.

Sesso *et al*. (2010) investigated the changes in the sectorial employment in Brazil in the 1991-2003 period, a context wherein the Brazilian economy was more externally open to other economies. Indexes of structural change for employment, gross output and value-added were also computed. Their results show the displacement of jobs from agriculture and industry to services, especially trade activities. These changes were driven mainly by final demand and labor intensity.

Souza *et al*. (2016) used the SDA method to assess changes in the service sector and compared the experiences of the United States and Brazil. They found that household consumption fostered service expansion in both countries. Productivity expanded rapidly in some service activities in Brazil.

Perobelli *et al*. (2016) applied the SDA method to decompose employment growth in Brazil between 1990 and 2005. They divided the working population into different educational levels. One of the significant results found from this study was the role of demand in boosting jobs at most educational levels and the negative effect of productivity on employment growth.

Sousa-Filho *et al*. (2021) applied the SDA method to investigate the structural change in Brazil from 1990 to 2015. Their focus was on gross output decomposition. According to them, a significant structural change was absent in Brazil since most of the changes in gross output are explained by demand. They found a negative relationship between the technology and demand effects. Furthermore, it was found that manufacturing was the main activity to foster structural change in production.

Finally, Acypreste (2022) applied a disaggregated SDA analysis to Brazil in the period 2000-2015. He found that all sectors were job generators, except agriculture. Moreover, the expansion of demand compensated for the technological effect during this period.

5. Methodology and data

In the input-output framework, structural change emerges when sectors alter their inter-sectorial and intra-sectorial transactions (Hirschman, 1958; Syrquin, 1988). It provokes changes in the density of I-O tables. Scholars worldwide are dealing with constructing equations that can assess structural change by decomposing economic variables. In this section, we introduce the methodology and the data set. Initially, we describe the structural decomposition analysis (SDA) to evaluate the changes in the use of labor in Brazil. Then we describe the dataset.

5.1 Method

The decompositions of the changes in sectorial employment are carried out using the SDA approach. The changes in employment can be split into changes in labor input coefficients, technology, and final demand. This subsection draws on Miller and Blair (2009).

Since changes in employment are linked to changes in gross output, let's first look at how to separate changes in the latter. The vector of changes in gross output can be presented as follows:

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

where x^t is the gross output in year t, L^t is the nxn Leontief matrix for year t, and f^t stands for the column vector of final demand (nx1). Hereafter, superscripts denote time indicators.

If the effect of price changes was removed (for example, through a double-deflation procedure applied on the dataset), we can proceed to the decomposition process . One way to separate the changes in gross output between two periods is to use year-1 values for L and year-0 values for f. Substituting L^0 with $(L^1-\Delta L)$ and f^1 with $(f^0+\Delta f)$, we get as a result:

$$\Delta x=L^1 (f^0+\Delta f)-(L^1-\Delta L) f^0=L^1 (\Delta f)+(\Delta L) f^0 \qquad (2)$$

Equation 2 shows gross output changes decomposed into two components: a part denoted by changes in final demand, Δf, and a second component related to changes in technology, ΔL, measured as changes in the Leontief production function. The first component is weighted by year-1 technology, L^1; while the second is weighted by year-0 final demand, f^0. Note a substantial quality gain when moving from equation 1 to equation 2. In the former, the gross output variation between periods 0 and 1 is obtained as a simple subtraction of these polarized years. In contrast, the latter puts side by side the variations of ΔL and Δf.

A similar way to break up the changes in gross output is to reverse the weights used in equation 2. In this case, we use values of year-0 for L and year-1 for f. To proceed in this fashion, we should replace L^1 with $(L^0+\Delta L)$ and f^0 with $(f^1-\Delta f)$, yielding :

$$\Delta x=(L^0+\Delta L)f^1-L^0 (f^1-\Delta f)=L^0 (\Delta f)+(\Delta L) f^1 \qquad (3)$$

Adding equations 2 and 3, we obtain the following expression:

$$2\Delta x=L^1 (\Delta f)+(\Delta L) f^0+L^0 (\Delta f)+(\Delta L) f^1 \qquad (4)$$

Rearranging terms leads to:

$$\Delta x=(1/2)(\Delta L)(f^1+f^0)+(1/2)(L^1+L^0)(\Delta f) \qquad (5)$$

The first element is the technology effect, and the second term stands for the final demand effect. These two terms represent the contributions of technological changes and final demand to output variation. A positive sign for the technological effect indicates high sectorial integration - and use of domestic inputs. In contrast, a negative sign for this component reflects rising input productivity, which implies greater production efficiency (Aroche-Reyes, 1996; Guilhoto, 2004). To find economy-wide effects, it is necessary to premultiply both terms of equation 5 by a column vector of 1's.

The additive decomposition of gross output involves two terms, L and f. To separate the changes in employment, we have to add another element, namely the labor input coefficients, $\hat{e}^t$. In the input-output system, the employment level is determined by three elements, $\varepsilon^t= \hat{e}^t L^t f^t$. The expression below represents the changes in employment, $\Delta\varepsilon$.

$$\Delta\varepsilon=\varepsilon^1-\varepsilon^0=\hat{e}^1 x^1-\hat{e}^0 x^0=\hat{e}^1 L^1 f^1 - \hat{e}^0 L^0 f^0 \qquad (6)$$

The additive decomposition for more than two terms works as an analogous extension for the case of the two terms explained above. Substituting $\hat{e}^1=\hat{e}^0+\Delta\hat{e}$, $L^1=L^0+\Delta L$, and $f^1=f^0+\Delta f$ in equation 6, and rearranging its terms, we can rewrite the above equation as follows

$$\Delta\varepsilon=(\Delta\hat{e}) L^0 f^0+\hat{e}^1 (\Delta L) f^0+\hat{e}^1 L^1 (\Delta f) \qquad (7)$$

Alternatively, employing other substitutions into equation 6 and further rearranging terms, we find the following expression with different weights:

$$\Delta\varepsilon=(\Delta\hat{e}) L^1 f^1+\hat{e}^0 (\Delta L) f^1+\hat{e}^0 L^0 (\Delta f) \qquad (8)$$

Applying the same procedure as in the case of decomposition for two terms, that is, averaging and adding equations 7 and 8, we arrive at

$$\Delta\varepsilon=(1/2)(\Delta\hat{e})\,(L^0 f^0+L^1 f^1)+(1/2)[\hat{e}^0(\Delta L)f^1+\hat{e}^1(\Delta L)f^0]+(1/2)(\hat{e}^0 L^0+\hat{e}^1 L^1)(\Delta f) \qquad (9)$$

Equation 9 presents the sources of employment change. The first component of equation 9 is known as the labor input coefficient effect. This measure is determined by the ratio between the number of occupations in the sector and its gross value of production. It reflects the sectorial labor-output structure, reflecting the inverse of the labor productivity. A positive sign for the labor input coefficient effect denotes lower labor productivity, while a negative sign indicates higher labor productivity. The second term stands for the effect of technological change, and the last term describes the contributions of final demand changes. In this sense, equation 9 breaks up the sources of employment growth into changes in labor input coefficients, technology, and final demand. For further details on SDA, see Dietzenbacher and Los (1998), Berni (2006) and Miller and Blair (2009).

5.2 Data

The data set used in this paper comes from the Brazilian Statistical Office (IBGE, 2022). We used the official Brazilian input-output tables (direct pooling tables) for 2000, 2005, 2010, and 2015. The most up-to-date I-O tables available were employed in our study. Moreover, we estimated the 2019 I-O table from the Supply and Use tables, employing Guilhoto and Sesso (2005) 's method. These tables provide data on sectorial employment, gross output, value-added, final demand, and intermediate purchases. (The data on employment can also be found in the Make and Use table). We used the statistics on people occupied in production (In Portuguese, pessoal ocupado) as a proxy for employment. Following Momigliano and Siniscalco (1986) and Sousa Filho, Santos and Ribeiro (2021), we considered the capital stock as given in our short/medium-term analysis. The survey-based I-O tables for Brazil comprise 12 sectors: agriculture (1), extractive industries (2), manufacturing industries (3), industrial utilities (4), construction (5), trade (6), transport (7), communications (8), financial services (9), real estate (10), other services (11), and public administration (12). From the Make and Use tables, the implicit deflators from IBGE (2022) were employed to gauge the I-O tables at prices for 2015. A similar procedure was adopted by Sesso *et al*. (2010). Here, the sectorial aggregation of the I-O tables follows the Brazilian Statistical Office (In Portuguese acronym IBGE) classification.

The Brazilian Statistical Office changed the methodology to estimate the I-O tables in 2010. The table for 2005 (reference 2000) uses the System of National Accounts of 1993, while the I-O tables for 2010 and 2015 (reference 2010) employ the System of National Accounts of 2008 (Sousa-Filho; Santos; Ribeiro, 2021). As a result, it becomes difficult to compare the official I-O tables for 2005, 2010, 2015 and 2019.

There are two ways to somewhat avoid this shortcoming. First, the two official matrices can be compared at a highly aggregated level, as suggested by Sousa-Filho, Santos, and Ribeiro (2021). This procedure would arguably reduce the bias presented in comparing tables constructed from different methods. A drawback in using this procedure would be studying structurally heterogeneous activities.

Second, we can analyse disaggregated I-O tables estimated from the retropolated Resource and Use Tables (IBGE, 2022), using the technique of Guilhoto and Sesso (2005). This method would allow for comparing the estimated matrices. Nonetheless, estimated I-O tables are biased because the import and tax matrices are calculated (Martinez, 2016).

Following Berni (2006) and Sousa-Filho, Santos, and Ribeiro (2021), we opted for the first procedure in our study since it has the benefit of providing a more extended period of analysis and it can reduce the problems related to comparions of tables with different methologies. Highly aggregated I-O tables generate another bias because different technologies are placed in only one given sector. This is a shortcoming of our study. Another drawback refers to the linear feature of the SDA method. We computed 4 subperiods (2000-2005, 2005-2010, 2010-2015, and 2015-2019) to circumvent this limitation. However, the bias produced by different methodologies might somewhat persist, and the results should be taken with a grain of salt.

Another possible drawback is to compare the official IO tables (2000, 2005 and 2010) with a estimated one (2019), the latter based on Make and Use tables. Although compare official tables with estimated ones might be problematic, Guilhoto and Sesso (2005) demonstrated that their estimation method yields output multiplier results similar to those found in official tables. Moreover, to avoid this potential problem, we compared the properties of the official and estimated tables for the year 2010. Here, we used highly disagregated tables, each comprising 67 sectors. For the sake of consistency and in accordance with Lahr and Dietzenbacher (2001) and Morrone (2021), we estimated an Input-Output (IO) table for the year 2010 and conducted a comparison with the official IO table for the same year. Our analysis revealed that the average technical coefficients in the official table did not exhibit any statistically significant differences when compared to those in our estimated table. In other words, there was no statistically significant differences between the coefficient averages in our estimations and those in the official IO table. In this sense, we opted to include the table for the year 2019 in our analysis. The results should be interpreted with caution.

After the computation of the I-O tables at constant 2015 prices, the structural decomposition analysis (SDA) was applied. As already, we break up employment changes regarding contributions from the labor input coefficient effect, technology effect, and final demand effect. According to Dietzenbacher and Los (1998), there are several decomposition techniques, and presently, no superior SDA is available. According to them, the results from averaging equations 7 and 8 are similar to those in averaging several types of alternative decompositions. These I-O tables display vital information to evaluate the changes in the Brazilian economy and detect key sectors regarding rising productivity and employment.

6. SDA Results

Despite falling behind with developed countries in terms of per capita income and production structure, Brazil presented lower shares of agriculture and industry and service expansion. Table 2 shows employment growth rates from 2000 to 2019 and its subperiods. It reveals 29.1% (1.7% per year) growth in the first 15 years, a modest performance when population growth and the high number of precarious jobs are considered (Morrone, 2021). Critical sectors in terms of value-added and employment such as construction (62.1%), trade (51.8%) and other services (54.2%) were able to offset the negative growth of 25.4% in agriculture.

From 2015 to 2019, employment expanded 4%. Most sectors presented positive growth rates, except extractive industries and construction. These two activities declined substantially between 2015 and 2019.

Table 2 – Total employment growth (%)

Sectors	2000-2019	2000-2005	2005-2010	2010-2015	2015-2019
Agriculture	-25.1	7.8	-18.4	-15.1	0.4
Extractive industries	-7.0	16.9	-3.2	7.7	-23.7
Manufacturing	15.8	23.0	-0.6	-3.4	-1.94
Industrial utilities	118.5	8.8	87.7	-3.1	10.4
Construction	45.3	10.2	33.6	10.1	-10.35
Trade	52.4	19.0	20.4	6.0	0.4
Transport	63.8	17.4	10.5	12.7	12.0
Communications	10.9	24.0	-26.0	17.1	3.3
Financial services	67.2	9.3	17.5	11.0	17.2
Real estate	-12.5	3.9	-39.5	21.1	14.9
Other services	74.2	16.1	19.0	11.6	12.9
Public administration	41.9	16.0	13.2	6.1	1.9
Total	**34.2**	**15.1**	**7.9**	**3.9**	**4.0**

Source: authors' computations.

A glance at the three first subperiods shows a steady loss of dynamism, culminating with a growth of 3.9% between 2010 and 2015. The employment variation in agriculture, though negative on average, grew 7.8% in the first subperiod, followed by a fall in the two subsequent ones. Alongside agriculture, the only sector with negative growth in the whole period was real estate (-23.8%), presenting a rate of -39.5% between 2005 and 2010. From 2000 to 2005, it showed positive growth rates. Manufacturing and communications were the leaders in this period, accompanied by trade and transport. There was a slight decline in manufacturing (-0.6%) in the 2005-2010 timeframe, repeated in the last subperiod (-3.4%). Agriculture, communications and real estate employment dropped substantially, while industrial utilities and construction grew 87.7% and 33.6%, respectively. In the 2010-2015 subperiod, no sector overtook the overall growth rate of 29.1%. Although small in value, FIESP (2019) suggested a process of deindustrialization in Brazil. The deindustrialization hypothesis was reinforced by the decline in manufacturing jobs from 2015 to 2019.

Having stressed the evolution of employment by sector, we turn to the analysis of Table 3. Changes in employment were split into three components: labor input coefficient effect, technology effect, and final demand effect. The

41.6% increase in aggregate employment represents a rise of 55 million jobs between 2000 and 2019. The labor input coefficient effect presented a positive sign. It indicates no labor productivity gains, disregarding the other effects, which caused a rise of 10 million jobs. The positive technology effect contributed to an increase of 16.3 million jobs. In other words, input productivity dropped over time, pointing to a rise in sectorial integration and use of intermediates. The final demand effect was important in explaining the aggregate employment expansion. Most sectors showed some employment expansion in the period. In line with Sesso *et al*. (2010) and Perobelli *et al*. (2016), the final demand effect was the major force in boosting employment. In the entire period, the labor input and technology effects were usually positive (reinforcing the final demand effect) but relatively small.

Table 3 – Sectorial employment in Brazil and its decomposition in labor productivity, input productivity and final demand (1,000 workers)

Sectors	2000	Labor input Coeff.	Tech. effect	Final demand effect	2019
Agriculture	17,610	-11,751	-2,960	10,289	13,187
Industry	15,401	796	-2,966	6,475	19,707
Extractive industries	235	-306	2	287	219
Manufacturing	9,493	325	-3,299	4,475	10,995
Industrial utilities	342	246	-15	174	747
Construction	5,329	531	345	1,538	7,745
Market services	37,943	9,492	12,607	1,680	61,724
Trade	12,435	3,365	8,672	-5,515	18,959
Transport	3,229	1,196	403	460	5,289
Communications	1,256	-1,050	13	1,174	1,394
Financial services	841	241	3	321	1,406
Real estate	547	-377	47	261	479
Other services	19,633	6,117	3,467	4,978	34,195
Public administration	8,015	1,213	34	2,112	11,375
Total	**132,317**	**10,040**	**16,353**	**28,715**	**187,427**

Source: authors' calculations.

Examining the sectorial components of Table 3, we found that most of the activities presented positive signs for technology effect; input productivities declined during the entire period. Within the industry, extractive industries and construction exhibited positive numbers. Manufacturing' performance drove the negative technology effect found in industry. Market services presented a positive technological effect. We found positive and robust numbers for the final demand effect, except for trade.

The results suggest that the effect of final demand drove the increase in jobs, which ultimately reflected the size of value-added. As before, these sectorial shifts affected the aggregate economic performance. The numbers for 2019, when compared with those of 2000, highlight the tertiarization of the economy. The economy created 55 million jobs, mostly in market services.

In the following three tables further decompose the effects presented in Table 3 into different subperiods. Starting with the labor input coefficient effect, the first aspect to be underscored concerns agriculture, which showed negative numbers from 2000 to 2015. Agriculture recovered in the last period, 2015-2019, showing somewhat positive numbers. As mentioned before, the labor input coefficient effect is the inverse of labor productivity. Agriculture improved labor productivity, with the most significant numbers in Table 4. This sector experienced radical transformations throughout the 19 years. Substantial effects were found for other services and construction in the 2000-2005 and 2005-2010 subperiods. Overall, manufacturing evolved hand in hand with trade, except for the 2015-2019 subperiod.

Table 4 – The Labor input coefficient effect in Brazil (2000-2019) (1,000 workers

Sectors	2000-2005	2005-2010	2010-2015	2015-2019
Agriculture	-1,595.9	-6,245.5	-4,802.5	877.6
Industry	30.9	-1,584.3	825.2	1,735.6
Extractive industries	-48.4	-71.8	-13.7	-167.1
Manufacturing	822.5	-1,603.9	237.6	729.6
Industrial utilities	6.8	211.6	-110.5	114.2
Construction	-811.8	-120.1	711.8	1,058.9
Market services	-400.2	-3,804.6	1,118.9	12,767.1
Trade	876.0	-1,548.9	313.5	3,567.5
Transport	224.3	-458.4	111.4	1,296.9
Communications	-305.4	-698.5	-58.1	74.9
Financial services	12.1	-381.0	2.3	615.4
Real estate	-167.1	-292.2	17.4	85.9
Other services	-1,040.2	-425.5	732.3	7,126.5
Public administration	121.7	-417.1	-18.4	1,498.4
Total	**-1,905.3**	**-12,051.6**	**-2,876.8**	**16,878.8**

Source: authors' calculations.

Except for the positive numbers found for industrial utilities, the remaining 11 sectors showed an employment decline between 2005 and 2010. Industry and market services presented substantial increases in labor productivity, with trade slightly surpassing the industrial results. The 2010-2015 subperiod revealed a 2.9 million job decline triggered by labor productivity expansion. Agriculture was the primary source of labor productivity growth. Labor productivity in construction and other services declined in this period. For the 2015-2019 period, most sectors presented a decline in labor productivity, except extractive industries.

Observing the technology effect results in Table 5, we note its growth and posterior reduction. This is also revealed at the aggregate level of the four subperiods. Between 2000 and 2005, the technology effect was negative, suggesting a decline of 1.1 million workers due on average to more efficient use of inputs. Industry (-5.3 million jobs), trade (-0.74 million) and other services (-0.94 million) drove this result. The 2005-2010 timeframe showed a 3.4 million rise in jobs, explained by the lack of input productivity gains.

Conversely, agriculture increased its efficiency in the use of inputs between 2005 and 2010. The positive numbers for construction (0.42 million jobs), trade (1.4 million) and other services (3.7 million) point to inefficiency. These three sectors yielded 56.7% of total employment in 2015.

Table 5 – The Technology effect in Brazil (2000-2019) (1,000 workers)

Sectors	2000-2005	2005-2010	2010-2015	2015-2019
Agriculture	1,196.3	-2,197.0	351.2	-2,404.9
Industry	-527.3	17.0	-393.3	-2,071.5
Extractive industries	-2.9	-32.8	27.7	8.6
Manufacturing	-394.1	-331.2	-384.2	-2,214.5
Industrial utilities	8.2	-41.8	36.7	-17.1
Construction	-138.4	422.8	-73.5	151.5
Market services	-1,777.3	5,513.6	255.3	9,170.4
Trade	-743.8	1,360.9	87.8	8,199.1
Transport	-49.7	323.3	262.0	-68.0
Communications	-5.7	-59.2	27.3	32.7
Financial services	-53.3	161.0	23.3	-112.3
Real estate	10.5	12.9	-2.2	26.6
Other services	-935.3	3,714.7	-142.9	1,092.2
Public administration	-23.9	96.1	-7.9	-22.2
Total	**-1,132.2**	**3,429.7**	**205.3**	**4,671.8**

Source: authors' calculations.

Manufacturing presented robust input productivity gains in the 2010-2015 and 2015-2019 subperiods. This was also seen in the two previous subperiods. Between 2010 and 2015, 0.38 million jobs could have been released, more than doubling the result of other services. Inefficiency in using intermediary inputs was found in agriculture (0.35 million) and transport (0.26 million).

To conclude our decomposition analysis, we look at the effect of final demand in Table 6. This table reports positive numbers for all the sectors in the three subperiods from 2000 to 2015, except manufacturing. Agriculture provided a boost in employment when we isolate the final demand effect. This positive contribution to employment was found in the three subperiods, with 56.0% concentrated between 2005 and 2010. Despite presenting a negative variation in employment from 2000 to 2015, agriculture remained an important source for job creation between 2000 and 2005. In the 2010-2015 subperiod, agriculture and other services presented high numbers, while trade (3.2 million) took second place during the 2005-2010 subperiod. Both industry (-0.03 million jobs) and manufacturing (-0.24 million) showed negative results between 2010 and 2015.

From 2015 to 2019, only agriculture presented positive demand effects. The remaining three sectors presented negative numbers. In the aggregate economy, there was a destruction of 17 million jobs in this subperiod.

Table 6 – The Final demand effect in Brazil (2000-2019) (1,000 workers)

Sectors	2000-2005	2005-2010	2010-2015	2015-2019
Agriculture	1,769.3	4,942.9	2,108.0	1,577.7
Industry	3,351.3	3,787.8	-28.8	-774.8
Extractive industries	91.2	95.8	6.6	90.3
Manufacturing	1,751.7	1,866.4	-244.8	1,266.3
Industrial utilities	15.2	156.7	52.2	-26.6
Construction	1,493.2	1,668.9	157.1	-2,104.8
Market services	8,663.3	5,556.7	3,761.9	-17,044.9
Trade	2,232.1	3,200.2	660.1	-11,680.9
Transport	386.9	532.7	159.0	-660.7
Communications	612.6	352.3	227.8	-62.8
Financial services	119.8	381.3	93.1	-296.7
Real estate	177.8	54.8	57.5	-50.2
Other services	5,134.0	1,035.5	2,564.3	-4,293.5
Public administration	1,186.9	1,544.9	669.3	-1,267.8
Total	**14,970.8**	**15,832.3**	**6,510.4**	**-17,509.9**

Source: authors' calculations.

Focusing on the results of market services, we found a significant role for this sector, with 8.7 million jobs in the 2000-2015 period. Other services surged from 2000 to 2005, diminishing somewhat their performance during the next two subperiods. Public administration presented positive results in the first two subperiods (1.2 and 1.5 million jobs), falling to a more modest rise in the final period.

The final demand effect in agriculture (8.8 million jobs) is one of the highest among the 12 sectors. Its labor productivity however, increased considerably between 2000 and 2015. The decrease of 4.5 million in employment between 2000 and 2015 was explained by the contribution of labor and input productivities, offsetting the increase in the final demand effect. In the 2010-2015 subperiod, manufacturing presented negative results for the final demand effect.

The last period, 2015-2019, was marked by economic stagnation. Most sectors exhibited negative final demand effects, except extractive industries and manufacturing.

Table 7 synthesizes our findings and answers the questions raised in section 1. It highlights the sectors that exhibited rising labor and input productivity in conjunction with final demand and employment expansion. We designed a scale of 1-4, attributing 1 to sectors that match one of these characteristics, 2 for two features, 3 for three characteristics and 4 for all of them. The most efficient sectors are the ones denoted by 4 on our scale.

Comparing the results of Tables 3 to 6, Table 7 shows 12 sectors with two subgroups: industry and market services and their corresponding results. As mentioned before, Table 3 shows the sources of employment expansion in terms of labor input coefficients (inverse of labor productivity), technology, and final demand. Our SDA estimations underline the findings of Table 3, where the gains in labor productivity and final demand effect were vital forces driving changes in employment. Similar results were found by Sesso *et al*. (2010) and Perobelli *et al*. (2016) for different periods, showing that this phenomenon is persistent in Brazil.

Table 7 reports that between 2000 and 2015, industry in general, the extractive industry, manufacturing, and the communications sectors presented rising labor and input productivities together with a positive effect on final demand effect and employment expansion. These are the key sectors in the entire timeframe. In the 2000-2005 subperiod, we note a structural shift towards market services. Within the industry, only extractive industries and construction were key sectors in this subperiod. In the 2005-2010 timeframe, we found no key sectors. From 2010 to 2015, only public administration was a key sector.

Table 7 – Periods of virtuosity in the use of labor and inputs (2000-2019)

Sectors	2000-2019	2000-2015	2000-2005	2005-2010	2010-2015	2015-2019
Agriculture	3	3	3	3	2	3
Industry	3	4	3	3	2	1
Extractive industries	2	4	4	3	3	2
Manufacturing	3	4	3	3	1	2
Industrial utilities	3	2	2	3	2	2
Construction	2	3	4	3	2	0
Market services	2	3	4	3	2	0
Trade	1	3	3	3	2	1
Transport	2	3	3	3	2	2
Communications	3	4	4	3	3	1
Financial services	2	3	3	3	2	2
Real estate	2	2	3	2	3	1
Other services	2	3	4	3	3	1
Public administration	2	3	3	3	4	2
Average of 12 sectors	2.2	3.1	3.3	2.8	2.4	1.6

Source: authors' calculations.

Table 7 gives some new information, showing an average decline from 3.3. to 2.8 when the first two subperiods are compared. The Mild Miracle achieved between 2005 and 2010 seems to have hinged on faulty lines since a qualitative improvement in the economy was lacking. This fact, in conjunction with the rising shares of output and employment in market services (segment with lower labor and input productivity levels), suggest that the economy did not recover from the 2008 great recession. In this sense, the Keynesian countercyclical policies were insufficient to reignite output and employment efficiently. At the same time, it is possible to stress the poor economic performance found in the 2010-2015 subperiod. Scoring lower (2.4) on our scale, Brazil was already embedded in its economic and political crisis. The economy slowed down well before the crisis struck Brazil in 2015. Together with a weak supply-side performance (insufficient gains in labor and input productivities), the structural shift towards services put Brazil on a clear route to a deep economic crisis after 2005. For the 2015-2019 period, we found an even stronger deterioration of the economic structure. It scored only 1.6 in our scale, with no key sector found.

7. Final remarks

In this article, structural decomposition analysis was applied to investigate the causes of changes in employment in Brazil between 2000 and 2019 and its four subperiods. This method allowed us to verify the importance of labor productivity, technology (input productivity) and final demand in explaining employment variations. We decomposed the aggregate and sectorial employment change from the I-O tables for 2000, 2005, 2010, 2015, and 2019. Applying this method, we selected the key sectors that presented rising labor and input productivities together with final demand and employment expansion.

Our decomposition estimations reinforced the importance of demand to spur employment growth. Following Sesso *et al*. (2010), Souza *et al*. (2010), Perobelli *et al*. (2016), Sousa-Filho *et al*. (2021), and Acypreste (2022), we found that the demand effect was the major force in triggering job creation. A positive relationship between the labor input coefficient effect and demand effect was also found, by the previous literature.

Furthermore, the results underlined the importance of industry, extractive industries, manufacturing, and communications between 2000 and 2015. From 2000 to 2005, we detected a rise in the significance of market services. However, the structural shift in employment creation towards market services was unfollowed by increasing numbers of key sectors in this segment in the 2005-2010 subperiod. The efficient use of inputs did not lead the economic expansion. The efficient use of economic resources did not follow the countercyclical policies implemented to fight the great recession of 2008. In the 2010-2015 period, due to the political and economic crisis of 2015, there was no market key sector. The economy stagnated from 2015 to 2019, following the unfolding consequences of the crises.

The results, therefore, indicate that the unsustainability of the growth process began after 2005. Afterwards, there was a decline in the number of key economic sectors. We argue that the growth in industries with low efficiency played a part in the crisis of 2015. The 2015-2019 subperiod was marked by an even stronger deterioration of the economy. In this sense, our results arguably serve as a guide for policymakers; moreover, with poor supply-side performance (labor and input productivities), public policy should target long-term investment in the infrastructure of energy, sewage, and urban waste collection of industrial utilities. In this vein and in line with Souza *et al*. (2016), investments in the transport sector should increase the transport networks. Following Bielschowsky (2012), it is central to reactivate traditional productive linkages in Brazil, mainly in infrastructure. The other services sector, encompassing health and education, should receive long-term government support to improve the labor force's quality, inducing new productivity gains and enhancing people's lives.

Despite the importance of these results, the paper presents a drawback since it considers sectorial fixed capital as a given in the analysis and focuses on a specific time frame (2000-2019), which is difficult to compare. Future research should include reliable estimates of sectorial capital stock in the decomposition analysis to allow for assessing the capital productivity ("capital deepening") effect on employment. Moreover, new official I-O tables should be included in the analysis.

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