Structural change in Minas Gerais and in Brazil between 2008 and 2019: an input-output analysis

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Abstract: This article investigates the drivers of structural change in Minas Gerais and Brazil between 2008 and 2019. The paper aims to address this question by employing a structural decomposition technique based on input-output models, applied to changes in value added. for both entities. Data were sourced from the Brazilian Institute of Geography and Statistics (IBGE) and the João Pinheiro Foundation (FJP). The research is novel in two aspects: it unveils the drivers of the structural change in a phase marked by deepened deindustrialization in Brazil; it compares structural changes between a national entity and a regional one, which is regarded as a microcosm of the former.

Keywords: structural decomposition technique; value added; Brazil; Minas Gerais; input-output models

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1. Introduction

Structural change is regarded as a driving force for economic growth. Transitioning from less productive economic activities to more productive ones fosters overall productivity and economic growth. Additionally, this creates better job opportunities, contributing to enhanced household well-being.

The forces underlying structural changes encompass both supply-side and demand-side drivers. Technological innovation varies across sectors, altering the sectoral value-added composition. Additionally, changes in demand preferences and relative prices modify the demand pattern. Together, these factors drive structural change.

As households become wealthier, they consume relatively more non-tradable services than tradable commodities. Consequently, the share of the service sector in the economy tends to grow larger than the industrial sector, leading to expected deindustrialization. Nevertheless, even countries with lower GDP *per capita* are experiencing this trend, known as premature deindustrialization. This phenomenon reflects a shrinking industrial sector, despite its higher productivity, and a growing services sector with low productivity.

These highly productive industries absorb only a small fraction of the workforce, causing many workers to move to the less productive service sector. This is allegedly why middle-income countries may experience premature deindustrialization. Countries where exports are concentrated in minerals and natural resources, and where the currency is overvalued, are more prone to follow this path. The former includes industries that do not generate much employment, while the latter acts as a tax on the tradable sector.

The Brazilian economy is a good example of this situation. The country's exports are concentrated in minerals and natural resources, and an overvalued currency may have helped buffer inflation pressures. However, these may not be the only underlying factors. Brazil began to deindustrialize as early as 1980. Morceiro and Guilhoto (2023) identified two periods of significant deindustrialization: between 1981 and 1999, coinciding with the removal of trade barriers; and from 2009 onwards, following the global financial crisis.

This study aims to analyze the driving forces behind deindustrialization in the second span of time. It expands the analysis to Minas Gerais, one of the main economic regions of Brazil, often regarded as a microcosm of the Brazilian economy. This state comprises wealthy cities in the South and poorer ones in the North, resulting in regional socioeconomic indicators that are similar to national ones. Therefore, the study will assess whether the regional economy mirrors the national economy in this regard. If it does, Minas Gerais could serve as a valuable testing ground for public policies that could then be expanded nationally.

The methodology involves structural decomposition analysis using input-output models. This technique allows for decomposing changes in value added into three components: variation in the value-added coefficient, which may represent productivity gains or losses; technological change, indicating whether the industry has become more or less important as an input supplier; and final demand effects, including household consumption and exports. This approach will help identify the main factors driving the deindustrialization trend in both Brazil and Minas Gerais.

This study will employ national data from the resources and uses tables published by the Brazilian Institute of Geography and Statistics (IBGE) and regional input-output matrices data from the João Pinheiro Foundation (FJP). The analysis will cover the period between 2008 and 2019.

The article is organized as follows: Section 2 reviews the structural change literature, emphasizing the most recent papers; Section 3 presents an overview of the economies of Minas Gerais and Brazil between 2008 and 2019, highlighting their sectoral composition; Section 4 explains the methodology; and Section 5 discusses the results. Finally, concluding remarks are provided.

2. Literature Review

Structural change is widely acknowledged as the pivotal force driving economic growth (Foster-McGregor et al., 2021; Rodrik, Sepúlveda and McMillan, 2016; McMillan, Rodrik and Verduzco-Gallo, 2014; Lewis, 1954). This entails transitioning from less productive to more productive sectors, thereby fostering economic growth. This is particularly relevant for developing economies where there are large different productivity gaps between different economic activities.

One of the key questions lies in understanding the driving forces behind structural change. The literature emphasizes that the interaction between supply-side and demand-side factors is fundamental to this process. On the supply side, the impact of technological innovations varies across sectors, contributing to shifts in sectoral composition. On the demand side, factors such as relative prices, changing preferences, the desire for new goods, and increased saturation of existing ones foster it (Krüger, 2008; Kuznets, 1973).

According to Palma (2019), in the 1980s, the main hypotheses to explain deindustrialization were: (i) the growing use of services by the manufacturing sector; (ii) the reduction of the income elasticity of demand for manufactured goods; (iii) the rapid growth of productivity in the sector; and (iv) the new international division of labor, including outsourcing. The available evidence for industrialized countries during this decade suggests that factors (i) and (iv) may have influenced deindustrialization, whereas factors (ii) and (iii) did not. In particular, in the European Union, deindustrialization was driven by a deceleration in the growth of manufactured production, as its productivity increased more slowly than its growth from 1970 onwards.

McMillan, Rodrik and Verduzco-Gallo (2014) identify three factors that can lead the structural change to the right direction, contributing to overall productivity growth: (i) exports not concentrated in mineral and natural resources, since these economic activities do not generate much employment and cannot absorb the surplus labor from the agriculture; (ii) the maintenance of a competitive real exchange rate, which acts as a subsidy on tradable industries; and (iii) flexible labor markets, which facilitate the transference of labor between sectors.

Additionally, the structural transformation challenge requires a set of policies to promote the most dynamic sector, not only based on investing in education and enhancing institutional capabilities. Rodrik and Stiglitz (p.3, 2024) argue that:

> "The supply of human capital and good institutions yields little growth without simultaneous changes on the demand side of the economy, which typically come from the promotion of new, modern economic activities, and the structure of production, which come from the industrial policies…"

Palma (2019) claims that the shift in the ideological paradigm had a major influence on deindustrialization in the European Union. The replacement of the Keynesian view with the monetarist one negatively impacted economic growth. For instance, in the United Kingdom, this shift led to increased unemployment and decreased investment in manufacturing. From a theoretical perspective, it is important to note that mainstream growth theories are indifferent to sectoral composition, but in a Keynesian approach, sectoral composition does matter.

In this framework, an important issue is to identify which sectors hold the potential to spur such economic progress. Historical and new evidences underscore a robust correlation between the manufactured sector growth and economic growth (Lautier, 2024; Amsdem, 2001), attributed to the intrinsic characteristics of the manufacturing sector (Kaldor, 1967, 1966).

Notable among these characteristics are dynamic increasing returns to scale, technological externalities, and linkage effects.

In the postwar era, import-substitution industrialization was the main strategy in Latin America countries; East-Asia countries adopt the export-oriented industrialization strategy, which proved more sustainable. In the new paradigm of hyper-globalization, the participation in global value chains (GVCs) has emerged as a central strategy for fostering economic growth. However, this shift has brought about a dual consequence. While the technological advancements favoring skills and capital have augmented labor productivity within manufacturing sectors of advanced economies, they have simultaneously eroded the comparative advantage of low-income regions in labor-intensive economic activities. Consequently, the sector became an 'enclave' in these countries, characterized by high productivity yet employing only a fraction of available labor (Rodrik and Stiglitz, 2024).

More importantly, there was a significant shift in economic policy in Latin American countries. The import-substitution industrialization strategy was replaced by trade and financial liberalization. Additionally, the region is rich in natural resources, and when commodity prices rise, these countries can finance their imports. Consequently, deindustrialization advanced further as countries specialized in their comparative advantages (Palma, 2008).

As a result, they underwent a phenomenon known as 'premature deindustrialization' (Rodrik, 2016), meaning (i) it happened much earlier than historical norms, and (ii) it began at significantly lower levels of GDP *per capita* compared to early industrializers (less than US$ 20,000 in 2016 PPP)[1]. It is noteworthy that manufacturing sub-sectors are expected to reach their peak in GDP at different income *per capita* levels, corresponding to various stages of development. At lower income levels, expenditures are directed towards essential goods such as food and clothing, whereas at higher income levels, there is a shift towards more income-elastic products, including those from industries intensive in technology and knowledge. In this regard, countries successful in innovation may experience significant growth rates in these manufacturing sub-sectors during the final stage of deindustrialization (Haraguchi, 2015).

In Brazil, the industrial sector began to contract as early as 1980, starting from a low level of *per capita* income (US$ 10,800 in 2016 PPP). Over the subsequent decades, the manufacturing value added, as a percentage of GDP at current basic prices, witnessed a significant decline from 24.5% to 11.3% by 2018. There were two periods of significant deindustrialization: the first between 1981 and 1999, coinciding with the removal of trade barriers, and the second from 2009 onwards, triggered by the subprime crisis (Morceiro and Guilhoto, 2023). Between 2014 and 2016, one of the most severe economic downturns occurred in Brazil, resulting in a cumulative GDP decrease of over 6%. In addition to the political and institutional crises, the downturn was exacerbated by declining commodity prices and reduced investments in infrastructure and housing (Magacho and Rocha, 2022).

The subsectoral trend revealed that even technology and knowledge-intensive sectors, like machinery and equipment, have begun to deindustrialize, despite Brazil's *per capita* income being at an intermediate stage of development (ranging from US$ 8,000 to US$ 18,500 in 2016 PPP). Others, such as pharmaceuticals, computers, and electronics, have not followed a robust industrialization trajectory. Hence, Brazilian deindustrialization can be categorized as premature and undesirable, and industrial policies could promote technology-intensive subsectors (Morceiro and Guilhoto, 2023).

[1] Lautier (2024) claims that this assertion is not necessarily accurate, as other factors contribute to this outcome, including the emergence of China in the manufacturing sector, its demand shock for primary products, and the ‘servicification’ of manufacturing (Baldwin, 2016). These findings may suggest that ‘premature deindustrialization’ thesis reflects the period (1990 to 2010) examined by Rodrik (2016).

However, it is important to note that regional trends may not always align with national ones. It's possible for certain regions to undergo industrialization while others experience deindustrialization. For instance, in Brazil, more than 60% of industrial production is concentrated in the Southeast region. According to Monteiro and Lima (2017), until 2010, there were signs of deindustrialization evident in both the Southeast and Northeast, while the North and the Midwest regions experienced the opposite trajectory. In the South, although the share of value-added in the manufacturing sector decreased, employment rates rose.

Examining a more recent timeframe from 2007 to 2017, Ribeiro et al. (2021) underscore that all regions experienced a rise in the service sector's share and a downward trajectory in the manufacturing industry's share. Notably, the Southeast region suffered the most significant decline. Thus, there is an ongoing process of deconcentration, albeit the region still commands approximately 55% of the value added of the sector and harbors the most knowledge-intensive industries.

The Southeast region of Brazil encompasses the primary states of São Paulo, Rio de Janeiro, and Minas Gerais. Collectively, they contribute to over 50% of the Brazilian GDP. However, within this region, the trajectory of deindustrialization has not been uniform. Pereira and Cario (2018) highlight that from 2008 to 2013, São Paulo experienced a more pronounced deindustrialization trend, despite witnessing a rise in the concentration of high-tech industries within the state. A similar phenomenon to a lesser extent was observed in Minas Gerais.

3. An Overview of the Economy of Minas Gerais and Brazil: 2008-2019

Minas Gerais, along with other states in the Southeast of Brazil, constitutes one of the country's primary economic regions. In 2019, it accounted for the third-largest share of Brazilian GDP (8.8%), following São Paulo (33.5%) and Rio de Janeiro (12.2%). In 2008, the respective shares of each state were 9%, 31.8%, and 10.6%. From 2008 to 2019, Minas Gerais' share of the GDP averaged 8.9%, São Paulo's 32.6%, and Rio de Janeiro's 11.3% (IBGE, 2024).

However, despite its significant contribution to the national economy, Minas Gerais' Human Development Index (HDI) is similar to that of Brazil, standing at 0,73 in 2010 (compared to Brazil's 0,72). The GDP *per capita* only ranked 10th in 2019. It amounted to R$ 30,8 thousand Reais, equivalent to 87.6% of the Brazilian average GDP *per capita*, far below the average of some states in the South and Southeast. In 2008, Minas Gerais held a slightly better position, ranking 9th and accounting for 89% of the Brazilian average.

In terms of US dollars adjusted for purchasing power parity (PPP), the GDP *per capita* in this period was about US$ 12,000 (2016 PPP) in Minas Gerais and US$ 14,000 (2016 PPP) in Brazil[2], indicating that both were at an intermediate stage of development. Throughout the period, there was not much change, with the highest levels reached in 2012 (US$ 13,516) in Minas Gerais and in 2013 (US$ 15,670) in Brazil, before the economic crisis. However, in Brazil, the annualized real minimum wage (adjusted for 2016 constant US$ PPP) varied from US$ 3,800 in 2008 to US$ 5,000 in 2019. In the latter year, 57.5% of households in Brazil and Minas Gerais (IBGE, 2024) earned at most one minimum wage *per capita*. Considering this, one could argue that to a certain extent, both could be classified as being at a low stage of development (less than US$ 8,000 2016 PPP).

Since household income changed only slightly during the period, it is unlikely that changes in consumption patterns have driven the structural change. At a low stage of development, expenditures are primarily directed towards basic needs, including food and clothing. Therefore, these industries are expected to continue playing an important role in manufacturing (Haraguchi, 2015).

[2] To convert to PPP, we used the PPP conversion factor available from the OCDE (2024). We chose the year 2016 to maintain consistency with the unit mentioned in the literature review.

As outlined by McMillan, Rodrik and Verduzco-Gallo (2014), the composition of exports can also contribute to the structural change. Minas Gerais and Brazil's exports are heavily concentrated in commodities with low added value. In 2008, iron ore exports represented 29.6%, and coffee exports accounted for 12.4%, together making up 42.1% of total exports of Minas Gerais. While soybean exports contributed to the growth of commodity exports, reaching 51.1% of the total in 2019, the share of manufactured product exports decreased. For instance, exports of iron and steel declined from 25.3% to 17.9% (-7.9 percentage points - p.p.), and automobile manufacturing exports fell from 7.6% to 2.3% (-5.3 p.p.). Brazil's exports followed the same trend: the combined share of oil, iron ore, and soybeans increased from 24.8% to 37.5% (+12.6 p.p.), while the combined share of iron and steel, industrial machinery, automobile, and aircraft manufacturing decreased from 26.9% to 17.9% (-9 p.p.) (MDIC, 2024).

It is worth noting that Minas Gerais is one of Brazil's main exporters. In 2008, its share of Brazilian exports was 12.5%, the second-highest percentage after São Paulo, which accounted for 29.2% of Brazilian exports. In 2019, with the increase in oil exports, Rio de Janeiro reached the second position with 12.5% of exports, while São Paulo maintained the lead with 22%, and Minas Gerais fell to third place with 11.4%. From 2008 to 2019, São Paulo's exports averaged 24.6% of the total, Minas Gerais' 13%, and Rio de Janeiro's 9.6% (MDIC, 2024).

Therefore, considering the composition of Brazilian and Minas Gerais' exports during this period, it is possible that it contributed to the deindustrialization process. Since these economic activities generally do not generate much labor, displaced workers may have moved to the service sector, particularly to less productive ones. This outcome is consistent with an increase in the service sector and a decrease in the industrial sector.

Throughout the period from 2008 to 2019, the economic structure of Minas Gerais and Brazil, in terms of value added, exhibited some similarities (Table 1).

Table 1: Value Added Percentage by Economic Activity - Minas Gerais and Brazil - 2008/2019 and Percentage Change 2019/2008 (%) – constant prices[1]

Value Added	Minas Gerais		Brazil		Minas Gerais	Brazil
	2008	2019	2008	2019	Percentage change[2] 2019/2018 (p.p.)	
Agriculture, forestry, farming and fishing	**7,3**	**4,6**	**4,1**	**4,9**	**-2,7**	**0,8**
Agriculture and forestry	4,6	3,3	2,7	3,5	-1,4	0,8
Farming and fishing	2,7	1,4	1,3	1,4	-1,3	0,0
Industry	**33,6**	**27,1**	**26,6**	**21,8**	**-6,5**	**-4,8**
Mining and quarrying	7,1	4,5	3,0	2,9	-2,6	-0,2
Manufacturing	18,0	14,4	17,1	12,0	-3,5	-5,1
Electricity, gas and water supply; sewerage, waste managment and remediation activities	4,2	3,3	2,8	3,0	-0,9	0,2
Construction	4,2	4,8	3,6	3,9	0,6	0,3
Services	**59,1**	**68,3**	**69,3**	**73,3**	**9,1**	**4,0**
Wholesale and retail trade; repair of motor vehicles and motorcycles	12,6	12,3	13,9	12,9	-0,3	-0,9
Transportation and storage services	5,4	4,6	4,2	4,5	-0,8	0,3
Accomodation and food services	1,9	2,2	2,4	2,5	0,4	0,1
Information and communication services	1,3	2,2	2,0	3,4	0,9	1,4
Financial and insurance services	4,3	4,6	6,3	7,2	0,3	1,0

Value Added	Minas Gerais		Brazil		Minas Gerais	Brazil
	2008	2019	2008	2019	Percentage change[2] 2019/2018 (p.p.)	
Real state services	7,8	10,2	8,1	9,7	2,4	1,6
Services provided to companies	3,7	7,8	5,9	6,7	4,1	0,8
Public administration, public education and health services, defense and compulsory social security services	14,8	16,9	17,9	17,4	2,1	-0,5
Private education and healthy services	3,3	2,0	3,0	3,2	-1,4	0,2
Arts, enterteinament and recreation; other services	2,8	4,2	4,5	4,5	1,4	0,0
Domestic services	1,3	1,4	1,2	1,2	0,1	0,0
Total	**100,0**	**100,0**	**100,0**	**100,0**		

Source: FJP and IBGE.
[1] The deflation method used was the double deflation method, as presented in the following section.
[2] The differences between the percentage change and the actual numbers are due to rounding.

The share of agriculture, forestry, farming, and fishing accounted for 4.6% in Minas Gerais and 4.9% in Brazil in 2019. The 2.7 p.p. decrease in Minas Gerais compared to 2008 was caused by the decline in coffee production. Coffee is the main crop in the state, while in Brazil, soybeans are more representative. Coffe production in Minas Gerais follows a biannual productivity pattern, with higher yields in even years.

In the industrial sector, mining holds more significance in Minas Gerais, and it does not include oil extraction; whereas in Brazil, mining and oil and gas extraction have a similar percentage. In manufacturing, iron and steel mills and products made from purchased steel are more prominent in Minas Gerais than in Brazil. Conversely, industries such as coke and petroleum refining, and the production of chemicals and chemical products, are more notable in Brazil (Table 2).

In the services sector, in 2019, public administration, public education, and health services accounted for roughly 17% of the total in both Minas Gerais and Brazil. Among private services, there was also a similar share regionally and nationally, except for financial and insurance services, which have a larger share in Brazil.

Between 2008 and 2019, there was a significant structural change both nationally and regionally. The industrial sector shrank by 4,8 p.p. in Brazil and by 6,5 p.p. in Minas Gerais, while the service sector grew by 4 p.p. and 9,1 p.p. respectively. The decrease in mining and quarrying in Minas Gerais was caused by the negative economic impacts of the dam collapse in Brumadinho, which resulted in the loss of 272 lives. Following the disaster, many operations involving iron ore extraction were halted.

The manufacturing industry was particularly affected, declining by 3,5 p.p. in Minas Gerais and 5,1 p.p. in Brazil. This notable decline in manufacturing occurred following one of the main economic crisis in Brazil and deepened the ongoing deindustrialization process. However, this phenomenon was not uniform across industries between 2008 and 2019 (Table 2). On one hand, in Minas Gerais, machinery and equipment; repair and installation services of machinery and equipment (+5,5 p.p), fabricated metals products, except machinery and equipment (+2,7 p.p), leather and related products (+2 p.p.), basic pharmaceutical products and pharmaceutical preparations (+1,9 p.p), wood and products of wood; furniture; and other manufactured goods (+1,6 p.p.) expanded their share. In Brazil, the growth in the share of basic pharmaceutical products and pharmaceutical preparations (+1,6 p.p.) stand out, followed by biofuels (+1,3 p.p.). On the other hand, food and beverages (-5,1 p.p.), computer, electronic and optical products; electrical equipment (-4,1 p.p.), other transport equipment (-2 p.p.), textiles and wearing apparel (-1,7 p.p.) and rubber and plastic products (-1,3 p.p.) reduced their share in Minas Gerais. In Brazil, apart from computer, electronic and optical products; electrical equipment (+1,1 p.p.), a similar trend unfolded, albeit with less intensity overall.

Table 2: Value Added Percentage by Manufacturing Industries – 2008 e 2019 and Percentage Change 2019/2008 – Minas Gerais and Brazil (%) – constant prices[1]

Manufacturing Activities	**Technological Intensity**	**Minas Gerais**		**Brasil**		**Minas Gerais**	**Brazil**
		2008	**2019**	**2008**	**2019**	**Percentage change[2] 2019/2008 (p.p.)**	
Food and beverages	medium-low	24,8	19,6	21,4	18,0	-5,1	-3,4
Tobacco	medium-low	1,4	0,8	0,4	0,5	-0,6	0,1
Textiles and wearing apparel	medium-low	3,3	1,6	2,9	2,2	-1,7	-0,7
Leather and related products	medium-low	2,7	4,7	4,6	5,6	2,0	1,1
Paper and paper products	medium-low	2,7	2,4	3,0	4,1	-0,4	1,1
Printing and recording services	medium-low	0,8	0,7	1,0	1,1	-0,1	0,1
Coke and refined petroleum	medium-low	5,0	5,4	8,3	7,3	0,4	-1,1
Biofuels	medium-low	0,6	1,8	0,6	1,9	1,2	1,3
Chemical and chemical products	medium-high	4,7	4,1	5,9	6,1	-0,6	0,2
Soap and cleaning compund manufacturing, toilet preparation, other chemical manufacturing	medium-high	0,7	0,7	1,5	1,7	0,0	0,2
Basic pharmaceutical products and pharmaceutical preparations	high	0,5	2,4	3,1	4,7	1,9	1,6
Rubber and plastic products	medium	2,8	1,6	4,7	4,0	-1,3	-0,7
Other non-metallic mineral products	medium	2,9	3,1	2,6	3,2	0,1	0,7
Iron and steel mills and manufactured from purchased steel	medium	15,3	15,7	3,6	3,1	0,4	-0,5
Nonferrous metal production and processing and foundries	medium	3,9	4,5	2,1	2,0	0,6	-0,1
Fabricated metals products, except machinery and equipment	medium-low/medium-high	2,9	5,6	4,4	5,1	2,7	0,7
Computer, eletronic and optical products; eletrical equipment	medium-high/high	6,6	2,4	5,5	6,6	-4,1	1,1
Machinery and equipment; Repair and installation services of machinery and equipment	medium/medium-high	5,2	10,7	8,6	9,5	5,5	0,9
Motor vehicles, trailers and semi-trailers	medium-high	3,0	2,5	3,9	3,1	-0,5	-0,8
Other transport equipment	medium/medium-high/high	7,7	5,7	7,5	5,4	-2,0	-2,1
Wood and products of wood; furniture; and other manufactured goods	medium-low/medium/medium-high	2,6	4,2	4,4	4,8	1,6	0,4
Total		**100**	**100**	**100**	**100**	**-**	**-**

Source: FJP, IBGE and OECD.
[1] The deflation method used was the double deflation method, as presented in the following section.
[2] The differences between the percentage change and the actual numbers are due to rounding.

Regarding technological intensity, it is worth noting that since many industries gather different kinds of commodities, they can be classified under different levels of technological intensity. Both in Minas Gerais and in Brazil, the main industry is food and beverage, comprising approximately 20% of the total and classified as medium-low technology. Summing up all the industries classified only as medium-low technology, they accounted for roughly 40% of the total. However, their share slightly decreased over this timeframe, following a decline in food and beverage manufacturing.

Considering industries classified only as medium-high and high technology, these accounted for approximately 20% in Brazil and 15% in Minas Gerais. In both regions, the chemical and chemical products sector, as well as the computer, electronic, and optical products sector; electrical equipment manufacturing stood out. In Minas Gerais, the share of these high-technology products decreased, reflecting a decline in their production. Conversely, in Brazil, the share of these higher technology products expanded. Lastly, it is worth noting that the basic pharmaceutical products and pharmaceutical industry increased its share in both entities. This is the only industry presented in Table 2 classified solely as high-tech.

4. Methodology

The input-output table is a central framework for analyzing productive structures. It encompasses supply and demand data by industries and product, allowing for the analysis of demand composition and value-added composition. Moreover, it enables the construction of the input-output model (IOM) developed by Leontief, which assumes that industries use inputs in fixed proportions. The Leontief system can be represented in matrix form:

$$Ax + f = x \tag{1}$$

where A is the technical coefficients matrix, which shows the amount of input required by industry j from indutry i to produce one unit of its final product, calculated by $a_{ij} = x_{ij}/x_j$. x is the vector of total output from industry i. The total output needed to meet the final demand is:

$$x = (I - A)^{-1} f \tag{2}$$

$$x = Lf \tag{3}$$

where $L = (I - A)^{-1}$ is the total requirements matrix, also known as Leontief matrix. The entries of this matrix represent the total production of industry i required to produce one unit of final demand of industry j.

When an economy has two or more sets of input-output data, structural decomposition analysis allows for the disaggregation of the total change in gross output into two parts: changes associated with technology and changes related to final demand over a given period.

Given two different years, using superscripts 0 to denote the beginning and 1 to denote the end, the gross output is found in an output-output system as:

$$x^1 = L^1 f^1 \text{ e } x^0 = L^0 f^0 \tag{4}$$

where f^t is the vector of final demand in year t, and $L^t = (I - A^t)^{-1}$. Then, the observed change in gross output over the period is calculated as:

$$\Delta x^1 = x^1 - x^0 = L^1 f^1 - L^0 f^0 \tag{5}$$

Initially, the total change in outputs between year 0 and year 1 can be decomposed into technological change [$L(\Delta L = L^1 - L^0)$] and changes in final demand [$f(\Delta f = f^1 - f^0)$][3]. Rearranging equation (5) and replacing L^0 by $(L^1 - \Delta L)$ and f^1 by $(f^0 + \Delta f)$ in (5) yelds:

$$\Delta x = L^1(f^0 + \Delta f) - (L^1 - \Delta L)f^0 = (\Delta L)f^0 + L^1(\Delta f) \qquad (6)$$

The first term on the right side of equation (6) quantifies changes in technology, weighted by the final demand of year 0, while the second term quantifies changes in final demand, weighted by the technology of year 1.

Alternatively, it is possible to rearrange this equation by replacing L^1 with $(L^0 + \Delta L)$ and f^0 with $(f^1 - \Delta f)$. Hence, equation (6) becomes

$$\Delta x = (L^0 + \Delta L)f^1 - L^0(f^1 - \Delta f) = (\Delta L)f^1 + L^0(\Delta f) \qquad (7)$$

In equation (7), changes in technology are weighted by the final demand of year 1, and changes in final demand are weighted by the technology of year 0.

A number of alternative expansions and rearrangements of equation (5) can be derived. Following Dietzenbacher and Los (1998), we will use the average of the results from (6) and (7). Therefore, by summing up these two equations, we have:

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

And so

$$\Delta x = \left(\frac{1}{2}\right)(\Delta L)(f^0 + f^1) + (\frac{1}{2})(L^0 + L^1)(\Delta f) \qquad ((8)$$

where $(\Delta L)(f^0 + f^1)$ = technological change and ($L^0 + L^1)(\Delta f)$ = final demand change.

Technological change is reflected in changes in the Leontief Matrix, as noted in equation (8). It demonstrates how the interlinkages between industries vary, indicating an increase or decrease in their connections. For instance, if an industry reduces its production due to technological change, it observes a negative value effect, indicating that the industry has become less important as an input supplier. This outcome may indicate a shift in production techniques within downstream industries, organizational changes, or the substitution of domestic inputs with imported ones. Therefore, technological changes reflect technical changes due to any of these underlying factors (Figueiredo and Oliveira, 2015; Rangel and Campanario, 2013; Messa, 2013; Holland and Cooke, 1992).

The final demand effect results from change in domestic demand, including household, nonprofit organizations, and government consumption, as well as investment, or from international and regional demand, such as international and interregional trade.

Structural change decomposition can also be applied to changes in the value added derived from technological or demand factors. To achieve this, we use the value-added coefficient, va_i^t, which represents the ratio between the value added and the production value from industry i in year t

$$va_i^t = \frac{v_i^t}{x_i^t} \qquad (9)$$

[3]Input-output tables should be deflated to remove price effects on gross output change. In this study, prices are held constant at 2019 levels.

where v_i^t is the value added from industry i in year t. Thereby, the vector of industry value added in year t is:

$$v_i^t = \widehat{va}^t x^t = \widehat{va}^t L^t f^t \qquad (10)$$

where the hat denotes a diagonal matrix.

The vector representing the change in value added between two years is:

$$\Delta v = v^1 - v^0 = \widehat{va}^1 L^1 f^1 - \widehat{va}^0 L^0 f^0 \qquad (11)$$

Similar to the gross output decomposition, the value-added decomposition is as follows:

$$\Delta v = \left(\frac{1}{2}\right)(\Delta\widehat{va})(L^1 f^1 + L^0 f^0) + \left(\frac{1}{2}\right)(\widehat{va}^0 \Delta L f^1 + \widehat{va}^1 \Delta L f^0) + \left(\frac{1}{2}\right)(\widehat{va}^0 L^0 + \widehat{va}^1 L^1)(\Delta f) \qquad (12)$$

The first term on the right side of equation (12) represents the variation in the value-added coefficient. The second term indicates the change in value added due to technological changes, while the third term reflects the effect of changes in final demand on value added.

This study will apply the structural decomposition of the value-added change using the input-output tables for Brazil and Minas Gerais in the years 2008 and 2019. The input-output matrices for Minas Gerais were published by the João Pinheiro Foundation (FJP, 2022; FJP, 2015). The input-output matrices for Brazil were calculated based on the Resources and Uses table from the Brazilian Institute of Geography and Statistics (IBGE). The estimation method followed the methodology of Guilhoto and Sesso (2005).

To achieve this task, it is necessary to match the input-output matrices from 2008 and 2019, as they aggregate their industries differently. Since the input-output matrices for Minas Gerais are less disaggregated than those for Brazil, we begin by aligning them before adjusting the Brazilian input-output matrices accordingly. Additionally, to eliminate the influence of price factors, we also need to deflate them.

The Minas Gerais' IOM from 2008 has 42 industries and was devised following the National Classification of Economic Activities (CNAE) 1.0 and the System of National Account (SNA) of 2000. In contrast, the Minas Gerais' IOM from 2019 has 57 industries and was devised in line with the CNAE 2.0 and the SNA 2010 guidelines. To match these data, we consider the modifications in CNAE and SNA as Passoni and Freitas (2020) did for Brazil. Nevertheless, we adapt it to consider specificities from Minas Gerais' productive structure. In general, this process results in fewer industries than the original input-output table. In this work, we consider 37 industries as presented in Table 3.

Table 3: Industries for Brazil and Minas Gerais

Code	**Industry**	**Code**	**Industry**
1	Agriculture and forestry	20	Computer, eletronic and optical products; eletrical equipment
2	Farming and fishing	21	Machinery and equipment; Repair and installation services of machinery and equipment
3	Mining and quarrying	22	Motor vehicles, trailers and semi-trailers

Code	Industry	Code	Industry
4	Food and beverages	23	Other transport equipment
5	Tobacco	24	Wood and products of wood; furniture; and other manufactured goods
6	Textiles and wearing apparel	25	Electricity, gas, water supply, sewerage and waste management
7	Leather and related products	26	Construction and construction works
8	Paper and paper products	27	Wholesale and retail trade; repair services of motor vehicles and motorcycles
9	Printing and recording services	28	Transportation and storage services
10	Coke and refined petroleum	29	Accomodation and food services
11	Biofuels	30	Information and communication services
12	Chemical and chemical products	31	Financial and insurance services
13	Soap and cleaning compund manufacturing, toilet preparation, other chemical manufacaturing	32	Real state services
14	Basic pharmaceutical products and pharmaceutical preparations	33	Services provided to companies
15	Rubber and plastic products	34	Public administration, public education and health services, defense and compulsory social security services
16	Other non-metallic mineral products	35	Private education and healthy services
17	Iron and steel mills and manufactured from purchased steel	36	Arts, enterteinament and recreation; other services
18	Nonferrous metal production and processing and foundries	37	Domestic services
19	Fabricated metals products, except machinery and equipment		

Source: Own elaboration.

For the Brazilian IOM, we used the retropolated input-output tables from 2008 and 2019 published by IBGE. Then, we match them to Minas Gerais' industries.

To remove price effects, we calculated price indexes based on the retropolated resources tables published by IBGE (Figueiredo and Oliveira, 2015). In the first step, we calculate the inflation rate for each industry using the supply table in current prices compared to the supply table in the previous year's prices. More specifically, we used the gross output in current prices compared to the gross output in the previous year's prices. Then, we calculate the price index for each industry (implicit price deflator).

The deflation method used was the double deflation method (Figueiredo and Oliveira, 2015; Messa, 2013; Miller and Blair, 2009). This method involves using the calculated price indexes to adjust both the intermediate demand and the final demand. Subsequently, the value added is determined as the difference between real gross output and real intermediate inputs.

5. Results and Discussion

From 2008 to 2019, the deindustrialization processes in Brazil and Minas Gerais deepened. However, the drivers of this phenomenon varied across industries. By applying structural decomposition analysis, we will disentangle these drivers into efficiency gains (losses), positive (negative) technological effects, and positive (negative) demand effects. Regarding the last driver, we will focus particularly on household consumption and exports. The former may indicate changes in preferences, while the latter may signal competitiveness strength (weakness).

According to the literature, the globalization of the production process contributes to enhanced productivity but also leads to increased fragmentation. In this context, efficiency gains may be offset by negative technological effects, as domestic production increasingly relies on imported commodity inputs. Meanwhile, changes in household consumption are not expected to be a major driver, assuming household income has not changed significantly. However, shifts in preferences might have played a role. Positive demand effects from international exports indicate gains in competitiveness, but if these are concentrated in primary and resource-based industries, they can undermine structural change towards more productive industries.

Table 4 presents the results for primary and resource-based industries in Brazil and Minas Gerais. While all industries in Brazil experienced an increase in value added, all industries in Minas Gerais saw a decrease.

Table 4: Change in the value added of primary and resource-based industries due to technological changes and changes in components of final demand - Brazil and Minas Gerais - 2008-2019 - (%).

Industry	Changes in value-added (R$ milhões)	Change attributed to (%):						
				Final demand effects				Total
		Value-added coefficient (efficiency)	Technological effects	Household consumption	Internacional exports	Interregional exports	Other demands	
Brazil								
Agriculture and forestry	68.765	9,5	5,0	23,2	73,3	-	-11,1	**100**
Farming and fishing	12.434	2,4	20,5	82,0	15,5	-	-20,3	**100**
Mining and quarrying	11.883	-233,3	-30,1	87,5	294,0	-	-18,1	**100**
Total	**93.083**	**-22,4**	**2,6**	**39,3**	**93,8**	**-**	**-13,2**	**100**
Minas Gerais								
Agriculture and forestry	-6.287	131,7	63,1	2,2	-86,8	-61,6	51,4	**100**
Farming and fishing	-6.575	88,4	-13,1	-0,5	-2,9	17,5	10,7	**100**
Mining and quarrying	-12.326	69,6	8,0	-1,3	22,8	5,4	-4,6	**100**
Total	**-25.188**	**90**	**16**	**-0,2**	**-11,3**	**-8,2**	**13,4**	**100**

Source: Own elaboration.

* The grey shaded lines indicate that the value-added change was negative; thus, a negative change attributed to any factor means that it mitigated the negative value-added change.

In Brazil, international exports were the main driver of the increase in value added across most industries, except for farming and fishing. In this industry, household consumption contributed to an 82% increase in value added, possibly indicating a growing preference for meat. This seems to be true at least for poultry, which is cheaper, but not for beef (Hotzel and Vandresen, 2022). In the mining and quarrying industry, the negative impact from efficiency losses almost offset the gains from international exports. This result may reflect the effects of the mining dam collapse in Brumadinho, Minas Gerais, which led to the paralysis of many operations (Domingues et al, 2020). Minas Gerais, along with the state of Pará, is a major producer of iron ore in Brazil.

In Minas Gerais, the negative change in value added was mainly attributed to efficiency losses. The economy of Minas Gerais faced two significant supply shocks in 2019: the mining dam collapse and a frost that affected coffee production. Additionally, the biennial productivity cycle of coffee production further impacted its efficiency negatively. Farming and fishing also experienced a significant decrease in value added due to efficiency losses. Minas Gerais is the leading milk producer in Brazil and has the second-largest cattle stock (FJP, 2023). The 17.5% decrease in interregional exports, which contributed to the fall in value added, indicates a loss of competitiveness. This outcome was also noted by Leal Filho, Almeida and Barbosa (2021).

In comparison, the results for Minas Gerais were significantly different from those for Brazil. However, the negative supply shocks obscure this evaluation. The efficiency loss in Minas Gerais is primarily due to these shocks, and it is reasonable to assume that without them, the difference would not be as pronounced. In other words, international exports would have driven the increase in value added along with slight efficiency gains. These outcomes reinforce the ongoing deindustrialization, as these industries do not absorb much labor.

Table 5 and Table 6 present the results for manufacturing activities in Brazil and Minas Gerais. The value added for the entire manufacturing sector decreased between 2008 and 2019 in both Brazil and Minas Gerais. Additionally, the change attributed to efficiency was negative, even though international exports had a marginal positive effect. The change attributed to technology was also negative. The main positive influence came from household consumption. These results suggest that manufacturing activities in Brazil and Minas Gerais became less efficient and weakened their economic linkages. Therefore, if one expected these industries to gain productivity through globalization, this outcome does not support that claim.

Table 5: Change in the value added of manufacturing activities due to technological changes and changes in components of final demand - Brazil - 2008-2019 - (%)

Industry	**Technological Intensity**	**Brazil**						
		Changes in value-added (R$ milhões)	**Change attributed to (%):**					
			Value-added effects (efficiency)	**Technological effects**	**Final demand effects**			**Total**
					Household consumption	**Internacional exports**	**Other demands**	
Food and beverages	medium-low	-69.178	104,2	3,0	-12,4	2,1	3,1	**100**
Tobacco	medium-low	-131	-629,0	-4,2	530,8	175,4	27,0	**100**
Textiles and wearing apparel	medium-low	-11.079	16,5	34,5	29,3	9,9	9,8	**100**
Leather and related products	medium-low	-925	-729,1	234,4	457,3	230,0	-92,6	**100**
Paper and paper products	medium-low	2.368	-53,5	-48,5	96,0	179,0	-73,0	**100**

Printing and recording services	medium-low	-1.327	-120,3	324,4	-81,7	-15,2	-7,2	**100**
Coke and refined petroleum	medium-low	-25.010	129,0	14,3	-46,5	-3,8	6,9	**100**
Biofuels	medium-low	8.897	52,3	27,1	28,7	-1,7	-6,5	**100**
Chemical and chemical products	medium-high	-10.190	119,8	39,9	-33,6	-55,0	28,8	**100**
Soap and cleaning compound manufacturing, toilet preparation, other chemical manufacating	medium-high	-1.496	156,0	57,3	-82,6	-9,3	-21,3	**100**
Basic pharmaceutical products and pharmaceutical preparations	high	6.294	-9,1	30,8	82,3	8,8	-12,8	**100**
Rubber and plastic products	medium	-15.237	83,8	10,5	-9,4	1,0	14,1	**100**
Other non-metallic mineral products	medium	-21	-12.368,81	9.288,9	-5144,7	-1.093,0	9.417,64	**100**
Iron and steel mills and manufactured from purchased steel	medium	-11.442	40,8	65,4	-3,5	-15,8	13,0	**100**
Nonferrous metal production and processing and foundries	medium	-4.863	96,3	23,8	-13,5	-24,8	18,2	**100**
Fabricated metals products, except machinery and equipment	medium-low/medium-high	-3.539	-6,7	80,8	-28,2	-9,3	63,4	**100**
Computer, eletronic and optical products; eletrical equipment	medium-high/high	-2.280	-60,5	167,5	-248,4	108,7	132,7	**100**
Machinery and equipment; Repair and installation services of machinery and equipment	medium/medium-high	-10.801	9,5	49,2	-22,6	-0,7	64,6	**100**
Motor vehicles, trailers and semi-trailers	medium-high	-14.193	59,2	2,4	14,3	5,8	18,3	**100**
Other transport equipment	medium/medium-high/high	-30.908	25,2	26,2	13,6	4,4	30,5	**100**
Wood and products of wood; furniture; and other manufactured goods	medium-low/medium/	-6.179	39,7	72,0	-52,5	2,4	38,3	**100**

Total	**-201.242**	**72,7**	**27,2**	**-18,6**	**-2,6**	**21,3**	**100**

Source: Own elaboration.
* The grey shaded lines indicate that the value-added change was negative; thus, a negative change attributed to any factor means that it mitigated the negative value-added change.

Table 6: Change in the value added of manufacturing activities due to technological changes and changes in components of final demand - Minas Gerais - 2008-2019 - (%)

Industry	Technological Intensity	Minas Gerais							
		Changes in value-added (R$ milhões)	Change attributed to (%):						
			Value-added effects (efficiency)	Technological effects	Final demand effects				Total
					Household consumption	Internacional exports	Interregional exports	Other demands	
Food and beverages	medium-low	-7.787	141,1	25,4	-12,5	-7,9	-47,5	1,4	**100**
Tobacco	medium-low	-675	106	1,5	66	-0,7	-71,2	-1,6	**100**
Textiles and wearing apparel	medium-low	-1.908	21	25,1	-0,9	7,4	46,7	0,6	**100**
Leather and related products	medium-low	1.292	90,4	-15,2	-57,9	-3,2	86,9	-1	**100**
Paper and paper products	medium-low	-719	74,4	20,4	-2,9	15,1	-10,3	3,3	**100**
Printing and recording services	medium-low	-204	-165,5	130,9	99,5	-0,1	55,9	-20,7	**100**
Coke and refined petroleum	medium-low	-379	825,1	-455,6	-408,9	-11,1	157,6	-7,2	**100**
Biofuels	medium-low	901	22,3	13,1	21,2	3,2	41,3	-1,1	**100**
Chemical and chemical products	medium-high	-1.217	131,9	86,5	-5,4	-23,4	-102,4	12,8	**100**
Soap and cleaning compound manufacturing, toilet preparation, other chemical manufacaturing	medium-high	-57	485	51,5	346,3	-11,3	-761,1	-10,4	**100**
Basic pharmaceutical products and pharmaceutical preparations	high	1.492	46,4	1,6	-5,7	10,1	47,3	0,3	**100**
Rubber and plastic products	medium	-1.447	72,7	29,1	-4,9	2,7	1,5	-1,1	**100**
Other non-metallic mineral products	medium	-318	-48	117	-15,3	1,1	99,4	-54,1	**100**
Iron and steel mills and manufactured from purchased steel	medium	-1.862	-102,2	2,7	-14,2	4,8	188,6	20,3	**100**
Nonferrous metal production and processing and foundries	medium	-79	239,4	593,4	-198,5	-1.207,00	573,2	99,6	**100**

Fabricated metals products, except machinery and equipment	medium-low/medium-high	1.827	59,3	25	13	1,1	12,2	-10,5	**100**
Computer, eletronic and optical products; eletrical equipment	medium-high/high	-4.355	14,6	27,3	-2,6	8	37,4	15,2	**100**
Machinery and equipment; Repair and installation services of machinery and equipment	medium/medium-high	3.753	6,3	72,1	6,4	4,5	36	-25,3	**100**
Motor vehicles, trailers and semi-trailers	medium-high	-831	-193,6	3,9	23,5	37,1	189,5	39,6	**100**
Other transport equipment	medium/medium-high/high	-2.723	-1,8	-3,4	-3,3	13,5	81	13,9	**100**
Wood and products of wood; furniture; and other manufactured goods	medium-low/medium/	954	81,4	-16,6	11,3	15,3	5,9	2,8	**100**
Total		**-14.342**	**78,8**	**12,0**	**-15,8**	**-6,8**	**10,9**	**20,8**	**100**

Source: Own elaboration.
* The grey shaded lines indicate that the value-added change was negative; thus, a negative change attributed to any factor means that it mitigated the negative value-added change.

In 2019, the main industry in both Brazil and Minas Gerais was food and beverage manufacturing. In both cases, the loss in efficiency was the primary factor for the decrease in value added. In Minas Gerais, the second main manufacturing industry was iron and steel mills and manufacturing from purchased steel. The negative change in value added in this industry was mainly due to negative effects from interregional exports, despite an increase in efficiency. Machinery and equipment; repair and installation services of machinery and equipment, was the second most important manufacturing activity in Brazil and the third in Minas Gerais. In Brazil, the value-added loss in this sector was primarily due to negative effects from investments (other demands), whereas in Minas Gerais, the value-added gain was accompanied by positive technological effects.

In Brazil, the only industry in which value added increased significantly due to positive value-added effects was biofuel manufacturing. In Minas Gerais, besides biofuel manufacturing, the industries of leather and related products, basic pharmaceutical products and pharmaceutical preparations, fabricated metal products, except machinery and equipment, wood and wood products; furniture; and other manufactured goods also experienced similar positive results.

Among these industries, basic pharmaceutical products and pharmaceutical preparations are classified as high technological intensity. In Brazil, although value added increased, positive technological effects and increased household consumption were the main drivers, while the value-added coefficient contribution was negative. In Minas Gerais, efficiency gains and interregional exports played important roles.

Considering the industries classified as medium-high or high technology, the overall change in value added was negative, driven by the negative contributions of the value-added coefficient and technological effects. However, in Brazil, efficiency gains along with household consumption helped mitigate the value-added loss in computer, electronic, and optical products; electrical equipment. In Minas Gerais, a similar pattern was observed in the motor vehicles, trailers, and semi-trailers industry, which was also positively impacted by interregional exports.

In conclusion, the purported increase in efficiency across all technological intensities as a driver of structural change does not seem to hold in Brazil and Minas Gerais. Consequently, workers may not have been displaced due to efficiency gains. However, the negative impact of technological effects indicated that the linkages of the manufacturing sector weakened. The fragmentation of production appears to be the main culprit behind the ongoing deindustrialization, leading displaced workers to move to the service sector.

By applying a structural decomposition analysis, Magacho and Rocha (2022) showed that the substitution of national inputs for imported inputs contributed negatively to Brazilian economic growth between 2010 and 2013. From 2013 to 2016, although imports stopped increasing, final demand dropped substantially. Similarly, Aguilar et al. (forthcoming) found comparable results for Minas Gerais during the period between 2008 and 2016. In the absence of an industrial policy, Brazilian manufacturing will continue to shrink. The competitiveness of Asian producers, especially China, will undermine national production. This is not a consequence of decreasing demand for these products, but a policy choice (Palma, 2019).

Moreover, although the overall results were very similar for Brazil and Minas Gerais, there were important differences between the two. The Brazilian computer, electronic, and optical products; electrical equipment industry gained efficiency, whereas in Minas Gerais it lost efficiency. Conversely, in Minas Gerais, the basic pharmaceutical products and pharmaceutical preparations, as well as the motor vehicles, trailers, and semi-trailers industries, augmented their efficiency, while in Brazil, these industries saw a reduction in efficiency. The same pattern was observed in the iron and steel mills and manufacturing from purchased steel industry. Therefore, these results seem to highlight the productivity difference - or lack thereof - in key industries between Minas Gerais and the rest of Brazil.

Looking at the remaining two industrial activities presented in Table 7 - electricity, gas, water supply, sewerage and waste management, and construction and construction works - the results were diverse. In the former, the value added increased in Brazil, driven by household consumption, while in Minas Gerais, the value added declined due to the negative effect of the value-added coefficient. In the latter, value added rose in both regions, but in Minas Gerais, efficiency decreased and was accompanied by a significant positive effect from investments (other demands), including the construction of buildings, infrastructure, and related services (FJP, 2021).

Table 7: Change in the value added due to technological changes and changes in components of final demand – Brazil and Minas Gerais - 2008-2019 - (%)

Industry	**Changes in value-added (R$ milhões)**	**Change attributed to (%):**						
		Value-added coefficient (efficiency)	**Technological effects**	**Final demand effects**				**Total**
				Household consumption	**Internacional exports**	**Interregional exports**	**Other demands**	
Brazil								
Electricity, gas, water supply, sewerage and waste management	32.356	-32,6	42,2	80,1	10,7	-	-0,4	**100**
Construction and	43.291	106,2	-3,8	4,5	2,4	-	-9,4	**100**

construction works							
Total	**75.648**	**46,9**	**15,9**	**36,8**	**6,0**	**-**	**-5,6**	**100**
Minas Gerais								
Electricity, gas, water supply, sewerage and waste management	-3.914	140	11	-39,1	-5,2	-4,7	-2	**100**
Construction and construction works	4.670	-95,9	70,6	4,8	-0,1	-17,2	137,8	**100**
Total	**756**	**-1.317**	**380**	**231,6**	**26,2**	**-82,0**	**861,8**	**100**

Source: Own elaboration.
* The grey shaded lines indicate that the value-added change was negative; thus, a negative change attributed to any factor means that it mitigated the negative value-added change.

In Brazil and Minas Gerais, both industries represent a similar share of the industrial sector (less than 4%). The construction industry in Minas Gerais was negatively impacted by the Brazilian economic crisis (2015-2016). Regarding the utilities industries, the electricity sector in Minas Gerais is highly dependent on rainfall and relies on outdated infrastructure (Leal Filho et al., 2021), which may have hindered its productivity. Additionally, its share in the Brazilian industry value-added decreased from 17.7% to 9.9% (FJP, 2024).

Shifting to the service sector, Table 8 and Table 9 display the results for Brazil and Minas Gerais. In both cases, the value added increased, driven mainly by changes attributed to household consumption. Despite the population not becoming wealthier, they are consuming more services, thus stimulating the sector. Additionally, the linkages between the service sector and other industries have increased, revealing its growing importance as an input supplier. This is confirmed by the positive change attributed to technological effects in services provide to companies.

Table 8: Change in the value added of service sector due to technological changes and changes in components of final demand - Brazil - 2008-2019 - (%)

Industry	Brazil						
	Changes in value-added (R$ milhões)	Change attributed to (%):					
		Value-added effects (efficiency)	Technological effects	Final demand effects			Total
				Household consumption	Internacional exports	Other demands	
Wholesale and retail trade; repair services of motor vehicles and motorcycles	40.367	-220,4	39,8	286,2	39,3	-45,0	**100**
Transportation and storage services	46.457	13,2	13,8	58,9	24,1	-10,0	**100**
Accommodation and food services	24.004	-49,6	-17,3	160,3	1,7	4,9	**100**
Information and communication services	103.891	51,5	4,7	17,3	5,7	20,7	**100**

Financial and insurance services	107.571	9,2	-8,4	94,1	2,6	2,5	**100**
Real state services	160.858	6,2	3,1	90,5	0,3	0,0	**100**
Services provided to companies	95.216	2,3	38,5	40,5	17,6	1,0	**100**
Public administration, public education and health services, defense and compulsory social security services	96.987	-28,6	-7,5	6,4	1,2	128,5	**100**
Private education and health services	35.132	29,7	7,7	42,4	5,0	15,2	**100**
Arts, entertainment and recreation; other services	34.147	-73,0	1,8	181,4	1,0	-11,2	**100**
Domestic services	10.166	0,0	0,0	100,0	0,0	0,0	**100**
Total	754.795,7	6,9	-8,1	76,6	7,5	17,2	**100**

Source: Own elaboration.

Table 9: Change in the value added of service sector due to technological changes and changes in components of final demand – Minas Gerais - 2008-2019 - (%)

Industry	**Minas Gerais**							
	Changes in value-added (R$ milhões)	**Change attributed to (%):**						
		Value-added effects (efficiency)	**Technological effects**	**Final demand effects**				**Tot.**
				Household consumption	**Internacional exports**	**Interregional exports**	**Other demands**	
Wholesale and retail trade; repair services of motor vehicles and motorcycles	2.341	-532,2	54,2	424,8	45,8	169,4	-62	**100**
Transportation and storage services	-2.964	198,9	-351	-157,7	17,1	386,2	6,6	**100**
Accommodation and food services	2.792	-16,3	26	72,3	15,5	-2,3	4,8	**100**
Information and communication services	5.402	34,5	-22,4	42,3	-0,1	8,1	37,6	**100**
Financial and insurance services	3.156	-13,6	31,7	88,3	0,9	-16,7	9,4	**100**
Real state services	16.343	-5,4	1,5	106,7	0,5	0,4	-3,7	**100**
Services provided to companies	24.528	12,8	52,5	8	-0,2	9,2	17,8	**100**
Public administration, public education and health services, defense and compulsory social security services	16.643	20,2	8,2	0,8	0,1	-0,1	70,8	**100**

Private education and health services	-6.632	52,2	-25,3	93,5	0,1	0,4	-20,9	**100**
Arts, entertainment and recreation; other services	9.011	13,6	-15,6	115,7	-0,8	-4,9	-8	**100**
Domestic services	1.102	0	0	100	0	0	0	**100**
Total	71.722,0	-19,5	37,6	64,9	1,4	-8,1	23,7	**100**

Source: Own elaboration.
* The grey shaded lines indicate that the value-added change was negative; thus, a negative change attributed to any factor means that it mitigated the negative value-added change.

Moreover, in some industries the value-added coefficient contributed negatively, indicating a loss in efficiency. In Brazil, this was true for wholesale and retail trade; repair services of motor vehicles and motorcycles, accommodation and food services, public administration, public education and health services, defense and compulsory social security services, and arts, entertainment and recreation; other services. In Minas Gerais, this negative contribution occurred in wholesale and retail trade; repair services of motor vehicles and motorcycles, transportation and storage services, accommodation and food services, financial and insurance services, private education and health services. Therefore, there were some different between the results for Brazil and Minas Gerais.

In Minas Gerais, two industries experienced a negative change in value added: transportation and storage services and private education and health services. In the first case, this was due to the negative supply shock in the mining industry, where the production is exported via trains (FJP, 2021). In the second case, the main determinant was the negative effect of household consumption. In contrast to Brazil, Minas Gerais GDP *per capita* (US$ 2016 PPP) decreased, which may have influenced this outcome.

In sum, in these sector the results from Brazil and Minas Gerais were similar and pointed to two key trends: the growing share of household consumption of services, despite both Brazil and Minas Gerais still being in an intermediate stage of development, and the increasing interlinkages between the service sector and the rest of the economy. These findings suggest that, to a certain extent, deindustrialization may stem from a shift in preferences toward the service sector and the growing symbiosis between services and other industries, as claimed by Baldwin (2016).

6. Concluding remarks

From 2008 to 2019, the deindustrialization process in Brazil and Minas Gerais intensified. A structural decomposition analysis of value-added during this period suggests that efficiency losses, along with weakened sectoral linkages, were the main drivers of this process. Therefore, although the literature usually indicates that efficiency gains drive structural change towards the service sector, this does not seem to be the case for Brazil and Minas Gerais.

The growth share of the service sector was led by household consumption and stronger linkages with the rest of the economy. In this sense, this result suggests that even in a less developed economy, the rise of consumption services may contributes to deindustrialization. Additionally, the increasing reliance of manufacturing on services as inputs also contributed to this trend.

During this same period, the primary sector increased its value-added, driven mainly by international exports. Additionally, it improved its efficiency. Hence, this may also have contributed positively to the growth of the service sector. Since these activities do not absorb much labor, displaced workers may have moved towards the service sector. In Minas Gerais, however, the primary sector's value-added decreased. The main factors underlying this decline were negative supply shocks in mining activities and coffee production. This explains the difference in outcomes between Brazil as a whole and Minas Gerais.

In general, the results for Minas Gerais were very similar to those for Brazil. This suggests that the state also represents a microcosm of Brazil in relation to the deindustrialization process. In this vein, it may serve as a good test ground for industrial policies.

However, there are some particularities in the economy of Minas Gerais. In the primary sector, it relies mainly on mining and coffee production, while soybeans and oil extraction are very important in Brazil. Therefore, supply or demand side shocks on these industries reverberated differently in each entity.

In the manufacturing industry, metallurgical production is very prominent in Minas Gerais, whereas coke and refined petroleum are more significant in Brazil overall. Additionally, in the service sector, financial services have a greater share in Brazil. These differences impacted the results of the structural decomposition analysis. In industries where Minas Gerais was more specialized, the efficiency loss was attenuated, while in those where it was less specialized, the loss was aggravated.

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