Programa de Pós-Graduação
Desenvolvimento Regional
Mestrado e Doutorado

DOI: 10.17058/zohhoj43

Heterogenous industry effects on the economic growth of Minas Gerais municipalities

Michele Polline Veríssimo
Instituto de Economia e Relações Internacionais – Universidade Federal de Uberlândia – Uberlândia – Minas Gerais – Brasil
ORCID: https://orcid.org/0000-0002-8436-2134

Carlos César Santejo Saiani
Instituto de Economia e Relações Internacionais – Universidade Federal de Uberlândia – Uberlândia – Minas Gerais – Brasil
ORCID: https://orcid.org/0000-0002-4205-1514

Abstract
This paper investigates the industry share effects, compared to other sectors, on the economic growth of Minas Gerais municipalities. To this end, panel models are estimated using municipal data from 2002 to 2019 for the full sample of municipalities, by development level (low, medium and high GDP *per capita*) and mesoregions. The results indicate a positive contribution of the industrial share to the municipal GDP *per capita* growth, although its magnitude is smaller than those of the service and public sectors. The effects of Industry and services on economic growth are greater in more developed municipalities. In municipalities with low GDP per capita, the public sector is more relevant. Industry shows a higher potential for inducing economic growth in mesoregions with more consolidated industrial, agribusiness and services activities; however, no significant contribution was found in less dynamic mesoregions.

Keywords: Industry. Economic growth. Municipalities. Mesorregions. Minas Gerais.

Efeitos heterogêneos da indústria no crescimento econômico dos municípios de Minas Gerais

Resumo
Este artigo investiga os efeitos da participação da indústria, comparativamente a outros setores, sobre o crescimento econômico dos municípios de Minas Gerais. Para isso, são estimados modelos em painel com dados municipais de 2002 a 2019 para a amostra total dos munícipios e segmentados por nível de desenvolvimento (PIB *per capita* baixo, médio e alto) e em mesorregiões. Os resultados indicam contribuição positiva da participação da indústria no crescimento do PIB *per capita* municipal, embora em magnitude inferior aos setores de serviços e público. Os efeitos da indústria e dos serviços ao crescimento econômico são superiores nos municípios mais desenvolvidos. Nos municípios de PIB *per capita* baixo, o setor público é mais relevante. A indústria possui maior potencial de indução ao crescimento

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econômico nas mesorregiões com atividades industriais, do agronegócio e serviços mais consolidadas, mas não há contribuição significativa nas mesorregiões menos dinâmicas.

Palavras–chave: Indústria. Crescimento econômico. Municípios. Mesorregiões. Minas Gerais.

Efectos heterogéneos de la industria en el crecimiento económico de los municipios de Minas Gerais

Resumen
Este artículo investiga los efectos de la participación industrial, en comparación con otros sectores, en el crecimiento económico de los municipios de Minas Gerais. Para ello, se estiman modelos de panel con datos municipales de 2002 a 2019 para la muestra total de municipios y segmentados por nivel de desarrollo (PIB per cápita bajo, medio y alto) y mesorregiones. Los resultados indican que la participación de la industria contribuye positivamente al crecimiento del PIB per cápita municipal, aunque en menor magnitud que los sectores público y de servicios. Los efectos de la industria y los servicios sobre el crecimiento económico son mayores en los municipios más desarrollados. En municipios con bajo PIB per cápita, el sector público es más relevante. La industria tiene mayor potencial para inducir el crecimiento económico en mesorregiones con actividades industriales, agroindustriales y de servicios más consolidadas, pero no muestra una contribución significativa en mesorregiones menos dinámicas.

Palabras clave: Industria. Crecimiento económico. Municipios. Mesorregiones. Minas Gerais.

1 Introduction

Kaldorian theory posits that the industrial sector serves as the primary catalyst for economic growth, owing to its singular capacity to generate systemic multiplier effects across output, employment and aggregate income. Unlike agriculture or services, industry is characterized by distinct structural attributes—namely, static and dynamic economies of scale, high income elasticity of demand, and technological spillovers—which underpin its status as the 'engine of growth'. Nevertheless, contemporary studies increasingly emphasize the role of the service sector in driving employment. This shift recognizes that modern services provide critical knowledge-intensive inputs and facilitate complex intersectoral linkages, thereby establishing a sophisticated interdependence with industry and the broader economy.

Building upon this theoretical framework, the present study investigates the significance of the industrial sector, vis-à-vis alternative economic activities, in determining the growth rate of real GDP per capita across the municipalities of Minas Gerais. The empirical strategy employs panel data estimation techniques, utilizing a longitudinal dataset of municipal-level observations spanning the period from 2002 to 2019. The primary objective is to evaluate whether the impact of the industrial share on economic performance is significantly greater than that of the service and public sectors, while controlling for a comprehensive set of covariates that condition both the productive structure and aggregate growth trajectories.

Furthermore, this research pursues two ancillary objectives. First it seeks to ascertain whether the impact of industrial participation on economic growth exhibits heterogeneity relative to the level of municipal development. To do so, the sample is

stratified into three distinct subsamples based on the quintile distribution of average real GDP per capita over the observed period. Second, the study quantifies the sector-specific effects of industry across the twelve mesoregions of Minas Gerais, as defined by the Brazilian Institute of Geography and Statistics (IBGE). It is hypothesized that local specificities in sectoral composition precipitate divergent growth trajectories between municipalities and mesoregions. Specifically, more economically dynamic regions are expected to have more pronounced growth from industrial activity compared to those primarily reliant on agricultural or extractive industries.

Minas Gerais exhibits a productive and export profile that closely mirrors the national structure, characterized by an abundance of natural resources, specifically agricultural and mineral commodities (Montenegro; Costa, 2021). Consistent with broader Brazilian history, the state has undergone a secular decline in the relative importance of manufacturing (Vieira, 2019). While primary-commodity production yielded short-term benefits for Minas Gerais' economy (driven by the 'China shock' which bolstered demand for mineral extracts and inflated international prices) this trajectory has reinforced a primary-export-led orientation. Consequently, this specialization pattern may undermine long-term growth prospects (Libânio, 2008).

Like Brazil, Minas Gerais also stands out for its regional heterogeneity. The state encompasses a large number of municipalities, and these have significant socioeconomic inequalities (Costa et al.; 2012). It is also worth noting that the mesoregions are composed of municipalities with varying degrees of specialization in production, ranging from primary activities, such as agriculture and extractive industries (mining), to manufacturing and service industries with different levels of technological intensity.

This study contributes to the extant literature by providing robust empirical evidence on the sectoral determinants of economic growth in Minas Gerais. A key distinction of this analysis is the utilization of subnational, granular data (a field where aggregate national data predominates) while controlling for theoretically grounded factors identified in the economic literature. The research findings offer a framework for evidence-based public policies designed to catalyze the most promising sectors for regional development, particularly within low-income municipalities.

This article is organized as follows: Section 2 provides a theoretical review of the nexus between industrial activity and economic growth; Section 3 contextualizes the economic landscape of Minas Gerais; Section 4 details the empirical strategy and data; Section 5 discusses the results; and Section 6 offers concluding remarks.

2 Theoretical and Empirical Foundations

The relevance of sectoral analysis in explaining economic trajectories finds its theoretical foundation in the literature pioneered by Nicholas Kaldor. Within this framework (and in contrast to neoclassical paradigms centered on supply-side constraints such as factor endowments) long-term growth is conceptualized as being fundamentally demand-led. Given the heterogeneous structural properties inherent to different sectors, the composition of the productive structure emerges as a critical determinant of an economy's growth potential.

Kaldorian literature is based on the premise that the industrial sector possesses idiosyncratic properties that distinguish it from alternative economic

activities. Central to this view is the existence of increasing returns to scale, which facilitate the transmission of productivity gains across the economy and elevate aggregate efficiency. This dynamic arises because industry serves as the primary locus for capital accumulation and endogenous technological progress.

A substantial portion of the technological progress observed in agriculture and services is disseminated through the industrial sector, which provides the essential capital goods integrated into these activities. Moreover, industry is characterized by forward and backward linkages within the productive chain, which facilitate the generation of knowledge and technological spillovers (Oreiro; Feijó, 2010; Lamonica; Feijó, 2011; Tregenna; Andreoni, 2020; Rodrigues, 2021).

Thirlwall (2005) contends that agriculture and mining are subject to diminishing returns, primarily due to their lower capital and knowledge intensity relative to manufacturing, as well as their reliance on less-skilled labor. While primary-commodity-based economies may facilitate wealth accumulation, they frequently exhibit stagnant rates of innovation and entrepreneurship. Furthermore, such economic structures are associated with suboptimal socioeconomic indicators and a lack of both productive and export diversification. Low linkage capacity (arising from restricted upstream connections with other primary activities) often constitutes a significant bottleneck to sustained economic expansion (Nahas et al., 2019). As a result, productive structures oriented toward manufacturing, particularly those characterized by high technological content and export sophistication, catalyze more robust long-term growth trajectories than those anchored in agriculture and extractive industries (Thirlwall, 2005).

To formalize the nexus between industrial activity and macroeconomic expansion, Kaldor developed a series of foundational propositions: 'Kaldor's Laws.' These laws analytically link aggregate output performance to the dynamics of manufacturing production (the First Law), industrial productivity growth (the Second Law), and the export-led growth engine (the Third Law). Additionally, by satisfying external demand, the industrial sector generates foreign exchange to finance imports, thereby relaxing the Balance-of-Payments constraint on long-term expansion – a principle often referred to as 'Thirlwall's Law' or Kaldor's Fourth Law. While, accelerating internal production and productivity and simultaneously easing external constraints through export-led competitiveness, the industrial sector acts as the primary determinant of self-sustaining economic growth.

The relevance of export-oriented production patterns is underscored by Thirlwall (2005) in his analysis of output growth rates compatible with long-term Balance-of-Payments (BoP) equilibrium and the subsequent process of international income convergence or 'catching up' between economies. Long-term expansion is contingent upon the ratio between the income elasticities of demand for exports and imports. Specifically, economies characterized by a specialization in manufactured goods and an import profile concentrated in primary commodities are positioned to achieve superior growth trajectories. Economies must pursue a structural transformation aimed at industrial promotion and technological upgrading, enhancing production sophistication and ensuring sustained long-term growth.

Conversely, several economies have experienced deindustrialization characterized by a diminishing share of manufacturing in output, employment, and exports (Tregenna, 2009; Oreiro; Feijó, 2010). This phenomenon is considered

'natural' in advanced economies when driven by rapid industrial productivity gains that reallocate labor toward the service sector, increasing its importance in the economy. In developing nations, this process is frequently 'premature,' manifesting before the industrial base has achieved a level of maturity compared to developed economies (Palma, 2005). In resource-intensive contexts, the discovery of new natural deposits or a surge in commodity prices precipitates substantial capital inflows, leading to a persistent appreciation of the real exchange rate. This appreciation erodes the competitiveness of the manufacturing sector—which typically lacks the cost advantages inherent to the primary sector—thereby rendering industrial activity economically unviable. The resulting contraction of manufacturing within the productive and export structures signifies a deindustrialization process induced by 'Dutch Disease' (Bresser-Pereira, 2007).

Contemporary studies contend that the service sector has emerged as the new 'engine' of economic growth. This perspective posits that services have evolved into providers of information and knowledge-intensive activities that generate externalities for other economic spheres (Giovanini; Arend, 2018). Given that the development of complex industrial processes requires specialized services characterized by high human capital and technological intensity, an interdependence has been established between the service and manufacturing sectors (Pereira, 2021; Giovanini, 2021).

The impact of the service sector on aggregate growth is contingent upon its internal composition. Advanced economies typically specialize in modern services characterized by high knowledge and technological intensity which exhibit elevated productivity levels and serve as primary catalysts for economic expansion. Developing economies are typically dominated by traditional services. These activities are generally characterized by a low-skilled labor force and stagnant productivity growth (Pereira, 2021).

The nexus between industrial activity and economic performance has been extensively scrutinized in the empirical literature, across diverse temporal and spatial domains, and employing a variety of methodological approaches**.** In a seminal cross-country analysis, Rodrik (2009) utilized fixed-effects panel regressions for a sample of developed and developing nations spanning 1960 to 2004. His findings reveal that an expansion in the industrial share of both output and employment exerts a positive influence on growth. Notably, these effects were more pronounced in economies that underwent rapid structural transformation, shifting resources from traditional, low-productivity toward modern, high-productivity activities.

Szirmai and Verspagen (2011) employed panel data estimations to evaluate the impact of value-added shares across industry, services, and agriculture on real GDP per capita growth for a sample of 88 developed and developing nations between 1960 and 2005. Their empirical findings suggest that the positive growth-enhancing effects of industrial participation were statistically significant until the 1990's. Subsequently, manufacturing sector has lost its role as an engine of growth, particularly among middle-income economies**.**

Utilizing descriptive analyses of sectoral GDP shares across agriculture, industry, and services, Naudé and Szirmai (2012) demonstrated that, in the post-1950, real GDP per capita growth rates in developing nations (except for Russia) closely

tracked the expansion of industry. Therefore, these cases represent economic 'catching up' occurring concomitantly with industrial development.

Vieira et al. (2014) investigated the effects of industry and manufacturing shares in both GDP and employment on aggregate economic growth. Their analysis utilized a panel of 82 developed and developing nations, controlling for initial per capita income, inflationary pressures, government expenditures, institutional quality, and human capital accumulation. Similarly, Tregenna (2015) examined the relationship between income levels and industrial employment shares. Both studies identified a positive and significant correlation between industrial participation and income growth across the 1970–2010 period, with these effects being more pronounced within the developing nations. Hence, Tregenna (2015) observes a structural shift from 2000 onwards, characterized by a diminishing impact of the industrial sector on economic expansion.

Mazhar and Rehman (2019) examined the long-term economic dynamics of industry and services across a heterogeneous sample of 52 countries with varying income levels between 1990 and 2013. Utilizing both linear and non-linear regression models, the authors evaluated sectoral value-added shares in GDP while controlling for initial per capita income, trade openness, institutional quality, and educational attainment. Their findings point out that structural transformation led by manufacturing activities facilitates long-term growth in GDP per capita, but an expansion toward the service sector tends to attenuate economic momentum.

Bashir et al. (2019) evaluated the nexus between sectoral value-added shares (specifically industry and agriculture) and Indonesia's GDP expansion using a Vector Error Correction (VEC) framework and Granger causality testing for the 1985–2017 period. Their results reveal a causal trajectory from industrial value-added and GDP toward agricultural output in the long run. What is more, the study identified bidirectional causality between industrial activity and economic growth in the short run.

Accounting for the disruptive impacts of the COVID-19 pandemic, Umaru et al. (2022) examined the influence of industrial production on economic growth in Nigeria. Utilizing quarterly data from 2010 to 2020, the authors employed Autoregressive Distributed Lag (ARDL) and Ordinary Least Squares (OLS) estimation techniques. The study confirms that industrial production has a positive effect on Nigerian GDP growth, providing an empirical basis for both periods of robust expansion and the recession when adverse economic conditions were observed.

Empirical investigations utilizing national data have yielded evidence supporting the pivotal role of the industrial sector in driving Brazilian economic performance. In a descriptive analysis spanning 1996 to 2013, Gobi and Castilho (2016) identified a positive correlation between Brazilian GDP and the expansion of both industrial output and exports. The authors attribute the country's low growth observed during this period to the rising share of low-technological-intensity segments within output, stagnant productivity in these activities, and the increasing 'primarization' of the exports.

Santos Junior and Sbardellati (2020) investigated the significance of the productive structure on Brazilian economic development by employing an input-output (I-O) matrix analysis, utilizing 2009 data for employment and industrial value-added. They noted superior linkage effects of manufacturing relative to the

agricultural and commercial sectors, underscoring the importance of activities such as steelmaking, automotive parts and vehicle, chemical elements, and oil refining.

Torezani (2021) evaluated the relative contributions of labor productivity, employment rates, and demographic transitions to variations in Brazilian per capita income between 1950 and 2010. The results indicate that income growth during this period was propelled by manufacturing and business services. While the agricultural sector experienced a contraction in its employment share, this was offset by a reallocation of labor from low-productivity activities toward more productive sectors, most notably construction and services.

Ribeiro et al. (2021) examined the regional dynamics of manufacturing across Brazil's five macro-regions, contending that the nation has undergone a process of 'premature' deindustrialization in recent decades. Their analysis reveals a systemic decline in manufacturing's share across all regions, noting that the tertiary sector failed to sufficiently compensate for the industrial contraction. Simultaneously, the expansion of agribusiness and mining precipitated a regressive specialization of both the productive and export structures. Furthermore, while a degree of industrial deconcentration was observed, it proved insufficient to reverse the historical concentration of high-technology manufacturing within the Southeast.

Araújo and Peres (2023) highlighted a contraction in the manufacturing sector's share of Brazilian GDP, which fell to 11.9% in 2020. This decline was particularly acute in high- and medium-high-technology industries, which lost significant ground to primary commodities and low-technology sectors, due to high interest rates and an appreciated exchange rate. This process of relative deindustrialization propagated through external sector variables, ultimately adversely impacted aggregate economic growth, employment levels, and labor productivity.

In subnational analysis, Ahuaji Filho and Raiher (2013) utilized panel data estimations incorporating both fixed and random effects to investigate the nexus between the spatial concentration of industrial activities by technological intensity and the economic trajectory of Paraná's microregions from 1995 to 2010**.** The authors found positive effects of industry on the growth of microregions, especially those characterized by a higher density of technology-intensive industries.

Fernandes et al. (2018) estimated panel data models to evaluate the relationship between the value-added of agriculture, industry, services, and public administration to aggregate GDP of 166 municipalities in Rio Grande do Norte between 2010 and 2013. Controlling for population size and development levels, the results confirmed that all sectors positively influenced municipal GDP. Yet, the industrial sector exhibited the lowest effect among the categories analyzed**.**

Mendes and Cabral (2020) conducted a Kaldorian analysis of the Rio de Janeiro economy by examining export performance between 2009 and 2019. Evidence indicates that the state's export profile became heavily concentrated in mineral extraction; however, the oil and gas industry failed to generate the necessary backward and forward linkages to diversify the export basket. The authors conclude that the low technological intensity in mineral products appears to jeopardize the state's long-term growth prospects. In turn, they advocate for public policies aimed at strengthening the density and diversification of the domestic productive chain.

Regarding the state of Minas Gerais, Rodrigues and Simões (2004) measured the effects of the spatial concentration of industrial activities on social development

indicators across the 853 municipalities. The results evidenced that small municipalities hosting industrial clusters are more developed and exhibit a higher quality of life than their peers of similar size. For medium-sized municipalities, a robust interrelationship was found between industrial concentration indices and economic development indicators. In contrast, in large urban centers, while industrial agglomerations increase income levels, they do not significantly affect quality of life. The authors attribute this to the fact that metropolitan and specialized tertiary activities did not form a sufficiently relevant cluster to exert social influence.

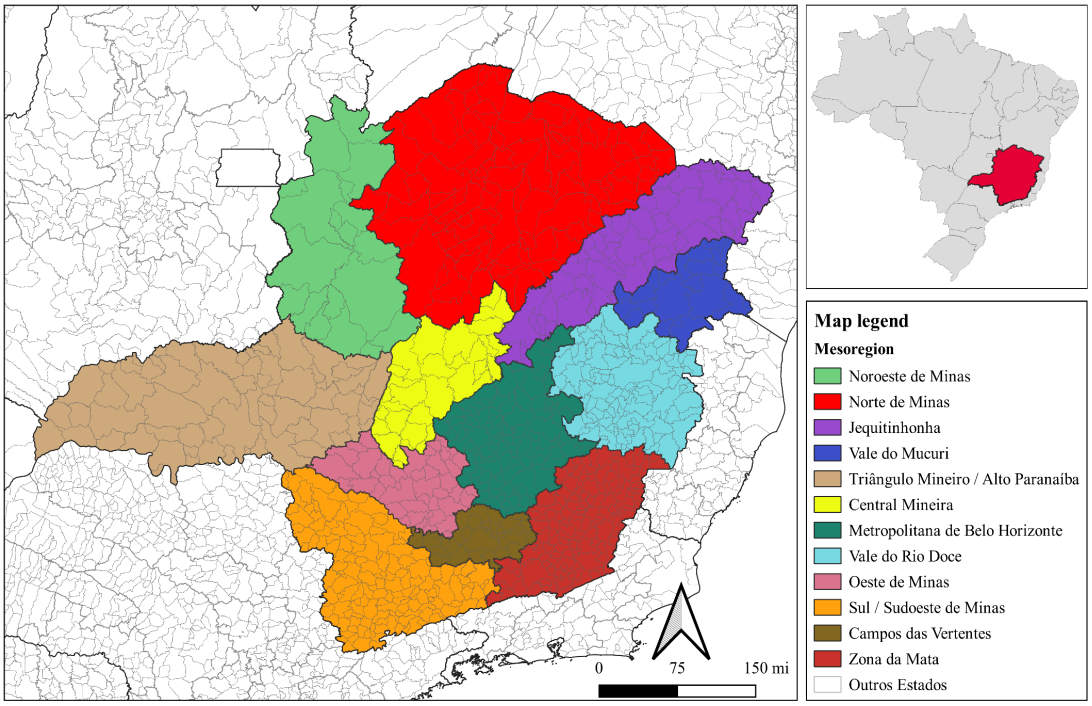
Rezende and Santos (2010) examined the spatial dynamics of productive activities in Minas Gerais by analyzing the relative shares of its 66 microregions in total income and population. Utilizing location quotients, they identified the degree of specialization of each microregion across economic activities. Their results indicate that microregions with the lowest shares of income generation are characterized by poorly diversified industrial bases. Conversely, the most developed microregions concentrate the largest portions of both income and population, supported by either highly diversified industrial sectors or a modernized agricultural segment.

Vieira (2019) emphasizes that Minas Gerais experienced a prolonged period of low dynamism during the 2000s, characterized by a 'primarization regression' of the industrial structure, the expansion of natural resource-intensive activities, and a decline in investment attractiveness. The shift in the development paradigm beginning in 1995—which had previously been structured by and around the State—posed significant challenges to initiating a durable phase of economic growth and productive modernization**.** This ultimately reflected in the erratic evolution of the state's GDP and a notable loss of density within the manufacturing industry.

3 Minas Gerais' Economic Activity

Table 1 presents the average participation of major sectors on the total Value Added (VA) across the municipalities of Minas Gerais, aggregated by mesoregion (see Figure 1), alongside the average per capita GDP (in constant 2019 BRL) for the 2002–2019 period. Furthermore, Table 2 delineates the productive configuration of these regions, while Table 3 provides specialized industrial indicators (specifically value added, employment levels, and labor productivity) disaggregated by mesoregion.

Figure 1 – Territorial division by mesoregions and municipalities in Minas Gerais



Source: IBGE. Author's elaboration.

Table 1 – Average sector participation and GDP per capita in the mesoregions of Minas Gerais (2002 a 2019)

Mesoregions	Sectoral Shares (% of VA)				GDP *per capita*
	Agriculture	Industry	Services	Public	
Noroeste de Minas	27.40	20.15	36.53	15.92	26,323.07
Norte de Minas	10.52	18.98	41.46	29.04	13,339.20
Jequitinhonha	12.61	9.03	37.86	40.50	9,059.53
Vale do Mucuri	9.39	12.60	46.94	31.07	12,068.28
Triângulo Mineiro/ Alto Paranaíba	11.61	31.26	45.12	12.01	37,585.84
Central Mineira	15.49	24.30	41.08	19.13	21,749.95
Metropolitana de Belo Horizonte	0.71	34.51	51.84	12.94	36,437.15
Vale do Rio Doce	4.42	32.88	42.48	20.22	20,574.06
Oeste de Minas	8.28	26.65	46.61	18.46	22,515.67
Sul/Sudoeste de Minas	9.34	24.74	49.14	16.78	25,704.38
Campos das Vertentes	8.87	22.22	47.63	21.28	19,340.57
Zona da Mata	6.16	20.83	51.34	21.67	19,187.94
Total Municipalities	10.40	23.18	44.84	21.58	21,990.47

Source: IBGE. Author's elaboration.

Table 2 – Productive configuration of mesoregions of Minas Gerais

Mesoregions	Principal Productive Activities
Noroeste de Minas	Agribusiness, Mineral Extraction (gold and zinc).
Norte de Minas	Livestock, Coal, Fruit farming, Ceramics industry, Apparel, Metallurgy, Pharmaceuticals.
Jequitinhonha	Mineral extraction (lithium), Family farming
Vale do Mucuri	Agriculture
Triângulo Mineiro/Alto Paranaíba	Mineral extraction, agriculture and livestock, agro-industries, services.
Central Mineira	Extraction of metallic and non-metallic minerals.
Metropolitana de Belo Horizonte	Mineral extraction, Ferroalloy industries, Casting products, Steel, Machinery and equipment, Automotive, Pharmaceuticals, Services.
Vale do Rio Doce	Mineral extraction, Iron and steel industry
Oeste de Minas	Footwear industry, Metallurgy
Sul/Sudoeste de Minas	Agriculture and livestock (coffee)
Campos das Vertentes	Livestock, cement industry, non-metallic minerals, auto parts, food industry, footwear and tourism.
Zona da Mata	Metallurgical industry, textiles and apparel, furniture industry, food industry.

Source: ACMinas (2022). Author's elaboration.

Table 3 – Industrial indicators in the mesoregions of Minas Gerais (2002 -2019)

Mesoregions	Industrial GVA (2019 BRL)	Industrial employment (%)	Industrial workers with high school education (%)	Productivity – GVA/Employment (2019 BRL/job)
Noroeste de Minas	1,843,369.17	13.68	57.74	216.98
Norte de Minas	3,772,984.03	14.15	53.32	145.42
Jequitinhonha	553,218.16	8.44	33.24	115.58
Vale do Mucuri	553,735.58	10.22	37.75	129.38
Triângulo Mineiro/Alto Paranaíba	22,459,355.17	18.28	45.75	241.53
Central Mineira	2,010,489.47	21.05	40.07	132.11
Metropolitana de Belo Horizonte	68,312,112.26	15.92	59.18	217.62
Vale do Rio Doce	10,002,359.2	18.41	53.40	225.95
Oeste de Minas	5,226,680.1	35.44	36.21	70.67
Sul/Sudoeste de Minas	13,778,492.1	26.72	48.94	106.06
Campo das Vertentes	2,181,412.78	18.69	45.37	118.67
Zona da Mata	7,857,128.58	21.81	39.09	92.50

Sources: IBGE e RAIS. Author's elaboration.

The data reveals that the productive structure of Minas Gerais is marked by significant sectoral heterogeneity. Between 2002 and 2019, the average municipal

Value Added (VA) was composed of agriculture (10.40%), industry (23.18%), services (44.58%), and public administration (21.58%). The average municipal per capita GDP stood at approximately BRL 22,000. These indicators exhibit substantial disparities across mesoregions— the average per capita GDP ranged from just over BRL 9,000 in the Jequitinhonha mesoregion to more than BRL 37,000 in Triângulo Mineiro/Alto Paranaíba.

Due to its abundance of natural and human resources, Minas Gerais possesses a diversified economy anchored in mining (iron ore, steel, niobium, and gold), agribusiness (coffee, dairy, and cattle farming), and a manufacturing sector that encompasses the automotive, electronics, textiles, footwear, and metallurgical industries. This is complemented by a growing tourism sector, emerging innovation hubs, and a sophisticated service chain. The state maintains a prominent position in international trade, particularly through the export of iron ore, coffee, and soybeans (ACMINAS, 2022). Nevertheless, this statewide productive diversification is essentially an aggregate of distinct regional specializations (Table 2). This results in a persistent spatial dualism, where dynamic, modernized areas with superior socioeconomic indicators coexist with stagnant regions characterized by lower standards of living (Rezende; Santos, 2010; Cirino; González, 2011).

By ranking the development levels of the mesoregions based on their average per capita GDP during the period under analysis, it is observed that the most developed areas—namely Triângulo Mineiro/Alto Paranaíba, the Belo Horizonte (BH) Metropolitan Region, and Noroeste de Minas—are characterized by extractive industries and diversified manufacturing segments across various technological intensities. These include agro-industries and footwear (low-tech); metallurgy (medium-low tech); automotive and petrochemicals (medium-high tech); and pharmaceuticals (high-tech).

These mesoregions exhibit high levels of industrial productivity, which partly reflects a larger share of high-skilled labor and elevated value-added, particularly in the Belo Horizonte Metropolitan Region and Triângulo Mineiro/Alto Paranaíba mesoregions. These areas are also characterized by a significant service sector, whereas the agricultural and public sectors generally contribute proportionally less to the municipal value added. Additionally, these regions occupy strategic geographical positions that foster robust interregional linkages; notably, the central location of the Triângulo Mineiro/Alto Paranaíba mesoregion establishes it as a major national logistical hub.

The intermediate development levels mesoregions—namely Sul/Sudoeste, Oeste, Central Mineira, Vale do Rio Doce, Campo das Vertentes, and Zona da Mata—concentrate their economic activities in agribusiness and low-technology industrial segments, linked to metallic and non-metallic mineral extraction, textiles, metallurgy, footwear, furniture, and auto parts. Although the industrial share of total employment ranges from 18.4% (Vale do Rio Doce) to 35.4% (Oeste), these sectors employ a smaller proportion of highly educated labor and generate lower value-added compared to the most developed mesoregions. Thus, with the exception of Vale do Rio Doce, industrial productivity in these areas remains significantly below that of the state's leading regions.

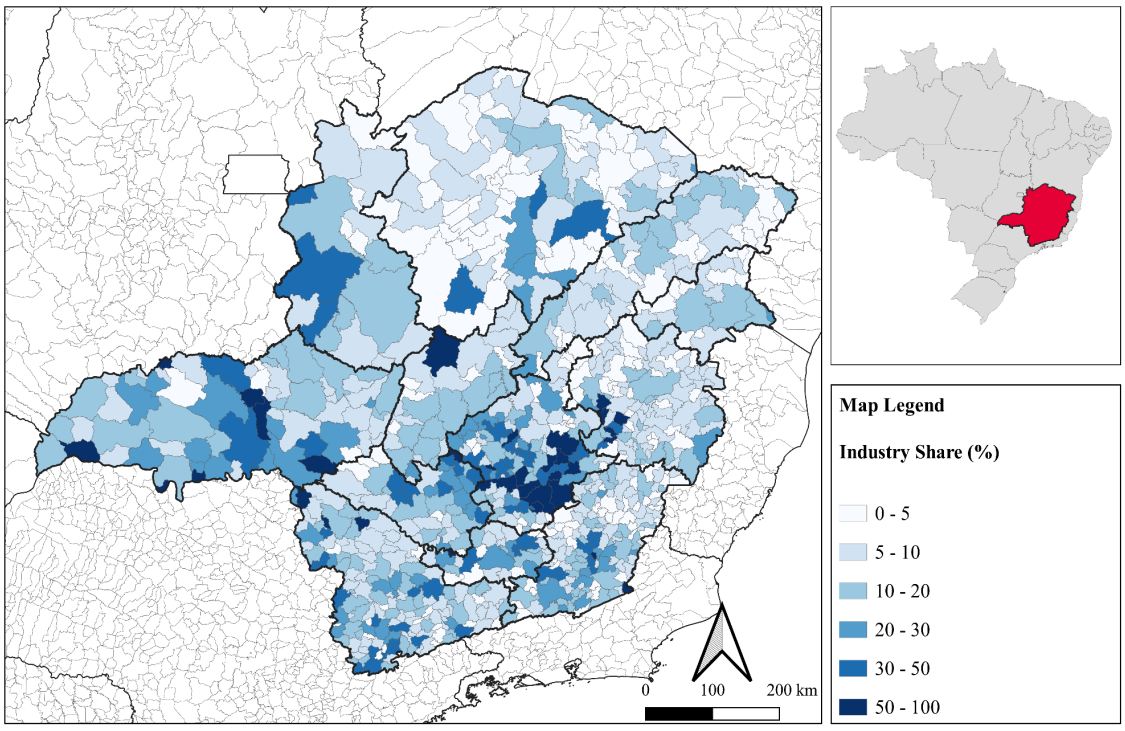
In the least developed mesoregions—Norte, Jequitinhonha, and Vale do Mucuri—the industrial sector provides a smaller relative contribution, while

agriculture and the public sector prevail on the municipal value-added. In Jequitinhonha and Mucuri mesoregions, industry accounts for a minimal share of employment and value added, and the workforce is characterized by lower qualification levels. By contrast, industrial productivity in these regions outperforms that of intermediate-development mesoregions, such as Sul/Sudoeste, Zona da Mata, and Oeste.

Although Norte de Minas is considered underdeveloped on average, it employs a significant proportion of high-skilled labor and exhibits high productivity levels. This performance is largely driven by the presence of the pharmaceutical industry in Montes Claros and metallurgical activities in Pirapora (ACMINAS, 2022). On the other hand, these localized industrial strengths do not translate into a high per capita GDP for the mesoregion as a whole. The region encompasses numerous small municipalities with economies anchored in traditional primary activities and characterized by persistently low-income levels.

Figure 2 illustrates the spatial distribution of the average industrial share in total municipal value added for the period from 2002 to 2019[1].

Figure 2 – Spatial distribution of the industrial share (%) in total municipal value added in Minas Gerais (2002–2019)



Source: IBGE. Author's elaboration.

Most municipalities exhibit average industrial shares ranging from 0% to 10%, with a representative number of these located in the Norte de Minas, Jequitinhonha, and Vale do Mucuri mesoregions—areas where, generally, agricultural activities predominate. Conversely, the Triângulo Mineiro/Alto Paranaíba, Noroeste de Minas,

[1] Figures A.1, A.2, and A.3 in the Appendix present maps corresponding to the shares of the service, public, and agricultural sectors, respectively.

and particularly the Belo Horizonte Metropolitan Region—characterized by extractive and manufacturing activities of varying technological intensities —contain the highest concentration of municipalities with an average industrial share exceeding 30%.

4 Empirical Strategies and Data

The proposed estimations are carried out using fixed effects (FE) and random effects (RE) panel data models. Under FE, the regressions are performed using Ordinary Least Squares (OLS) with all variables expressed as deviations from their means over the analyzed period (the within estimator). Thus, for a given municipality, each variable takes its respective value in a specific year minus its mean for the total period. The FE method is most appropriate if the unobserved variables are correlated with the explanatory variables. In contrast, models estimated by RE are suitable if the unobserved effects are uncorrelated with the explanatory variables. In this case, the regressions are performed via Generalized Least Squares (GLS) (Baltagi, 2021). The choice between models is determined by the Hausman test, whose null hypothesis is that the RE estimators are consistent. If the test statistic is significant, the null hypothesis is rejected, indicating that the FE model is more appropriate.

To empirically investigate the sectoral effects on the economic growth of municipalities in Minas Gerais, models are estimated based on equation (1) using annual municipal data from 2002 to 2019[2].

$$\Delta Y_{it,t+3} = \alpha_0 + \alpha_1 ind_{it} + \alpha_2 W_{it} + \alpha_3 A_t + \mu_i + \varepsilon_{it} \quad (1)$$

Where $\Delta Y_{it,t+3}$ represents the dependent variables for municipality i in year t; and α_0 is the intercept. The term ind_{it} denotes the explanatory variable of interest, with α_1 being its associated coefficient. The vector W_{it} contains the control variables, while $\alpha_2$represents the vector of their respective coefficients. To account for temporal variations A_t corresponds to a vector of year dummies (2002 as the reference year) or a crisis dummy (period from 2014 onwards), with α_3 representing the associated coefficients. Finally, μ_i denotes the municipal fixed effects, and ε_{it} is the error term.

The dependent variable is the economic growth rate ($\Delta Y_{it,t+3}$), which corresponds to the (equivalent) annual growth rate of the municipality's real GDP per capita, deflated by the Extended National Consumer Price Index (IPCA) – base year 2019[3]. The rates are calculated for a three-year forward-looking interval. This follows a common practice in growth determinant analysis by measuring the effects over

[2] The period is justified by the fact that it restricts the investigation to the period prior to the instability caused by the Covid-19 pandemic.

[3] Although the implicit GDP deflator is more commonly used to calculate real GDP, the IPCA was employed as it is the most widely publicized price index in Brazil. Moreover, the deflator may undergo periodic revisions due to changes in GDP calculation methodology, as occurred in 2002. This choice does not compromise the analysis, as the estimated relationships between variables are based on changes over time and differences between municipalities, with monetary corrections applied using the same annual indices across all municipalities.

time of variables from previous years, thereby minimizing endogeneity problems (Szirmai; Verspagen, 2011)[4].

The primary explanatory variable of interest is the industry share in the total value added (VA) of each municipality (ind_{it}), following Rodrik (2009), Naudé and Szirmai (2012), Vieira et al. (2014), and Tregenna (2015). Traditionally, the manufacturing share in GPD is the standard measure used to represent the level of industrialization in an economy. Albeit, due to the unavailability of data for all Brazilian municipalities and years analyzed—which would allow for the disaggregation of manufacturing from other secondary sector components such as mining, public utilities (electricity generation and distribution, water treatment and distribution, and piped gas production and distribution), and construction—total industrial value added will serve as a proxy to measure the effects of manufacturing activity on the economic growth of the municipalities in Minas Gerais.

Given that IBGE decomposes municipal GDP into four sectors and the shares of three are considered—the exception being agriculture (to eliminate the problem of perfect multicollinearity)—the coefficients associated with the controlled sectors represent the differences in effects of their shares relative to the effect of the uncontrolled one. Thus, the coefficient of the explanatory variable of interest (α_1) indicates the effect of industry on economic growth relative to the effect of agriculture.

The model specification is anchored in international literature, such as Szirmai and Verspagen (2011), Naudé and Szirmai (2012), Vieira et al. (2014), and Mazhar and Rehman (2019). These studies evaluated the effects of sectoral shares—with an emphasis on industry and services—on real GDP per capita growth in both developed and developing economies. These works commonly control for covariates that affect the configuration of the productive structure (addressing endogeneity and selection bias) and growth, drawing on different strands of economic debate. Therefore, the present study contributes by applying a traditional analysis from the literature to a subnational context, evaluating the state of Minas Gerais and its municipalities (mesoregions) characterized by sectoral specificities and disparities in socioeconomic indicators.

The covariates (W_{it}) are described in Table 4. The inclusion of real GDP per capita is justified by the income convergence hypothesis, which predicts a negative relationship between the "initial" income level and the growth rate, consistent with neoclassical growth models. Population growth is a proxy for labor force dynamics. High school education is used as a proxy for human capital, which may capture the effects of productivity gains by workers. The public spending controls for

[4] Estimations using static panel data (FE or RE) have limitations. The main one being the lack of treatment for endogeneity of the dependent variable, whose dynamics in the current period may depend on its lagged value. We correct this problem by employing the growth of GDP per capita for three years ahead. Another limitation is the lack of instrumentation for the explanatory variables. However, applying instruments (along with time dummies) would render the estimations inoperable due to the high loss of degrees of freedom, even after adopting *laglimits* or *collapse* commands in dynamic estimations. The choice of FE and RE methods is justified by the possibility of treating specific uncontrolled attributes of the municipalities in Minas Gerais, which are characterized by high heterogeneity.

government stimulus to growth, while investment/spending controls for the role of public expenditure composition, based on the hypothesis that investments may be relatively more productive than other types of spending. The tax collection/revenue aims to capture whether municipalities with higher shares of own tax collection in total revenues are, on average, more efficient in stimulating the economy.

Table 4 – Explanatory variables

Variables	Descriptions	Expected Signs	Sources
Industry	Ratio of industrial value added to total gross value added	Positive	IBGE
Services	Ratio of services value added to total gross value added	Positive	
Public sector	Ratio of public administration value added to total gross value added	Positive	
GDP *per capita*	Real GDP per capita (2019 R$/BRL thousands)	Negative	
Population growth rate	Three-year population growth rate	Positive	
High school/ Secondary education	Ratio of employees with a high school education or higher to total formal employment.	Positive	RAIS
Public expenditures	Public expenditures – current and capital (2019 R$)	Positive	STN
Investment/ Expenditures	Ratio of public investment to total public expenditures.	Positive	
Tax Collection/ Revenue	Ratio of own-source tax revenue (taxes, fees, and contributions) to total public revenues.	Positive	

Source: Author's own elaboration. Note: IBGE – Brazilian Institute of Geography and Statistics; Rais-Annual Social Information Report; STN – National Treasury Secretariat.

For comparisons between the potential impacts of industry and other sectors on economic growth, the estimations include the shares of the services and public sectors in total municipal VA. Recent studies argue that services can become the "engine" of growth due to the interdependent relationship between this sector and industry (Giovanini; Arend, 2018; Pereira, 2021; Giovanini, 2021), which stimulates the economy especially in more developed locations that provide modern services. In contrast, the public sector (which aggregates public education and health, among other services) generally has a significant share of VA, particularly in smaller municipalities that tend to have less developed productive structures, low dynamism, and limited diversification (Balzan, 2021).

In addition to the time-varying observed attributes (covariates) and the time-invariant unobserved attributes that differ across municipalities (municipal fixed effects), year dummies are controlled to capture the effects of unobserved attributes that are constant across municipalities but vary over time. These time-fixed effects may result, for instance, from institutional and macroeconomic changes that affect

economic growth heterogeneously over time but in a similar manner across municipalities. Alternatively, the models are estimated by excluding the year dummies and including a "crisis dummy" equal to 1 for the post-2014 years. The aim is to control for the effects of the economic and political-institutional crisis — Operation "Lava Jato", presidential impeachment, and political polarization— that characterized the Brazilian economy during the period.

Models based on equation (1) are estimated for the full sample of municipalities in Minas Gerais with the available data, as well as for two sets of municipalities (subsamples). The first consists of segmenting the municipalities into different levels of average GDP per capita during the analyzed period as a proxy for the level of economic development. The municipalities are ranked according to quintiles of its distribution into a) Low GDP (1st quintile) – low development; b) Medium GDP (2nd, 3rd, and 4th quintiles) – medium development; and c) High GDP (5th quintile) – high development. Thus, it is investigated whether the results are heterogeneous according to development levels. This approach stems from the hypothesis that sectoral shares may have distinct effects on growth according to the level of economic development.

The second set corresponds to the municipalities segmented according to the twelve mesoregions for Minas Gerais defined by the IBGE, with specific estimations for each municipality. It should be noted that the productive structure of Minas Gerais is quite heterogeneous (Vieira, 2019), ranging from mesoregions with a strong mineral extraction activity to others characterized by agribusiness or a more diversified industrial base. They are also marked by socioeconomic disparities, where some exhibit high social and income indicators, while in others, the indicators are similar to those of poorer economies (Santos; Pale, 2014). Descriptive analyses provided at the beginning of the next section characterize the economic profile of microregions in Minas Gerais**.**

Thus, it is evaluated whether the effects of industry on economic growth are heterogeneous according to regional productive specificities. It is assumed, following Rezende and Santos (2010), that regions with higher industrial shares in value added have a greater capacity to stimulate economic growth, especially in those with more consolidated industrial activities.

5 Results and discussion

The estimation results are reported in Tables 5 and 6. Overall, the Hausman test indicated that the fixed effects models are more appropriate than the random effects models (the test statistics are significant). Therefore, only the results from the fixed effects estimations are reported [5].

Table 5 shows the results for the full sample and the subsamples according to development levels (quintiles of the average GDP per capita), using two specifications: Model 1, which controls for year dummies; and Model 2, in which these are replaced by the crisis dummy.

[5] Due to space limitations, Table 5 presents the results for explanatory and control variables, and the diagnostic statistics (R^2 and Hausman test). Table 6 reports only the results for the sectoral variables and the crisis dummy. The remaining coefficients and statistics are available upon request.

In the total sample, the industry coefficients are positive and statistically significant, suggesting that, on average, increases in the industrial share stimulate the economic growth of the municipalities in Minas Gerais, as advocated by the Kaldorian literature and international evidence (Rodrik, 2009; Vieira et al., 2014; Tregenna, 2015; Mazhar; Rehman, 2019). The services and public sectors share coefficients are also generally positive, significant, and larger in magnitude than those of the industrial share. This indicates that industry is relevant for stimulating municipal growth, but the shares of services and the public sector have higher average effects. These results are supported by studies that highlight the role of services in growth (Giovanini; Arend, 2018; Pereira, 2021).

The lower potential of industry to induce GDP per capita growth compared to other sectors may reflect the relative loss of manufacturing share in total output, as suggested by Bresser-Pereira and Marconi (2008) and Oreiro and Feijó (2010) in their analyses of deindustrialization in the Brazilian economy. Importantly, industrial value added incorporates not only manufacturing but also the results of mining activities, public utilities, and civil construction; therefore, these segments may overestimate the actual manufacturing contribution to growth.

In Minas Gerais, the extractive sector is a source of competitive advantage due to the significant endowment of natural resources. This sector was substantially benefited during the 2000's from high prices and growing Chinese demand for primary products (Libânio, 2008). Additionally, the civil construction industry was bolstered during this period by investments from the Growth Acceleration Program (PAC) and government incentives from the "Minha Casa, Minha Vida" program.

Regarding the subsamples categorized by economic development levels, the estimated coefficients for the industrial share are positive and significant for Middle and High GDP municipalities, with larger magnitudes in the latter, consistent with the findings of Vieira et al. (2014). In Low GDP municipalities, the coefficients are negative. The services effects are positive and significant only in High GDP municipalities. Therefore, there is evidence of a greater relevance of industry and services in more developed municipalities, where modern and technology-intensive activities tend to predominate. These activities employ a more skilled workforce and generate higher multiplier effects on output, as pointed out by Pereira (2021).

The public sector coefficients are positive and significant across all levels of development, but the magnitudes are larger in the High GDP municipality group. This can be justified, considering other factors, by the fact that these locations concentrate more comprehensive and consolidated public education and health systems, which subsidize productivity in other economic sectors.

Table 5 – Results (fixed effects) full sample and subsamples by development level (2002 to 2019)

Variables	Total Sample		Low GPD		Middle GPD		High GPD	
	Model 1	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*
Industry	0.12414***	0.11743***	-0.07464**	-0.05808*	0.09155***	0.10924***	0.28901***	0.35458***
	(0.01440)	(0.01511)	(0.03076)	(0.03288)	(0.01788)	(0.01842)	(0.03976)	(0.04142)
Services	0.16625***	0.09013***	0.01233	-0.01919	0.02919	-0.04143*	0.40661***	0.41280***
	(0.01770)	(0.01847)	(0.03072)	(0.03197)	(0.02087)	(0.02137)	(0.04920)	(0.05131)
Public	0.71957***	0.75321***	0.12887***	0.23194***	0.42225***	0.48026***	0.88994***	0.99611***
	(0.01672)	(0.01719)	(0.03180)	(0.02641)	(0.02644)	(0.02374)	(0.06829)	(0.07063)
Per capita GPD	-0.00194***	-0.00215***	-0.02385***	-0.01825***	-0.00929***	-0.00932***	-0.00183***	-0.00197***
	(0.00006)	(0.00006)	(0.00123)	(0.00079)	(0.00040)	(0.00033)	(0.00009)	(0.00010)
Population growth rate	0.44859	0.48703	1.07455**	0.60169	-0.12144	-1.05471*	1.61289**	124.620
	(0.37288)	(0.39033)	(0.52474)	(0.57076)	(0.59456)	(0.61542)	(0.76304)	(0.78112)
High school/secondary education	0.01921*	-0.07638***	-0.01777**	0.01242	0.01919	0.04877***	0.11975***	-0.04024
	(0.00980)	(0.00776)	(0.00872)	(0.00906)	(0.01285)	(0.01105)	(0.04170)	(0.02906)
Public expenditures	-0.00000	-0.00000*	-0.00000	0.00000	0.00000	0.00000	-0.00000	-0.00000
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Investments/ expenditures	0.02840***	-0.00522	0.02042**	-0.01078	0.00184	-0.01585*	0.08393***	0.07325***
	(0.00784)	(0.00770)	(0.00981)	(0.00991)	(0.00964)	(0.00926)	(0.02269)	(0.02282)
Tax collection/revenues	-0.03514	-0.20703***	-0.39457**	-1.42750***	-0.13431	-0.50692***	0.22133	-0.04866
	(0.08125)	(0.07816)	(0.16906)	(0.16225)	(0.09585)	(0.09155)	(0.20280)	(0.20092)
Crisis *dummy*		-0.02539***		-0.01142***		-0.01943***		-0.02165***
		(0.00178)		(0.00225)		(0.00213)		(-0.02165)
Constant	-0.25610***	-0.18048***	0.10272***	0.06166***	-0. 03521**	-0.00607	-0.33206***	-0.28734***
	(0.01032)	(0.01013)	(0.02434)	(0.01780)	(0.01582)	(0.01306)	(0.03700)	(0.03666)
Annual dummies	Sim	Não	Sim	Não	Sim	Não	Sim	Não
R^2 (*Within*)	0.4263	0.3524	0.5878	0.5066	0.4559	0.4037	0.4478	0.3694
Hausman test	1,744.57***	1,987.76***	420.89***	375.93***	2,518.70***	3,308.58***	31.16***	34.77***
Observations	12,443	12,443	2,485	2,485	7,458	7,458	2,500	2,500

Source: Author's own elaboration. Note: Robust standard errors in parentheses. Statistical significance at 1% (***), 5% (**) and 1% (*).

Table 6 – Results (fixed effects) – mesoregions of Minas Gerais (2002 a 2019)

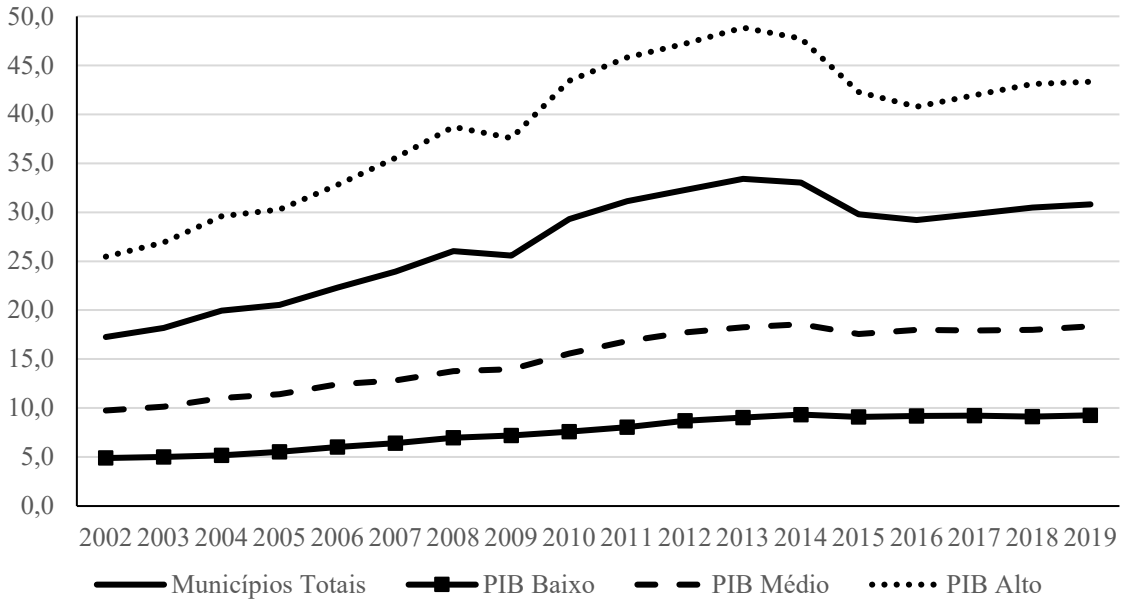
Mesoregions	Industry		Services		Public		*Crisis Dummy*	Observations
	Model 1	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*	*Model 2*	
Noroeste de Minas	-0.32272***	-0.17359**	-0.20062	-0.14859	0.11344	0.47905***	-0.01554	284
	(0.07825)	(0.07777)	(0.13226)	(0.13300)	(0.18249)	(0.17466)	(0.01027)	
Norte de Minas	0.17585***	0.20399***	0.19145**	0.14853*	0.51567***	0.48674***	-0.04869***	1,301
	(0.06091)	(0.06548)	(0.08293)	(0.08617)	(0.06506)	(0.06968)	(0.00757)	
Jequitinhonha	-0.03559	-0.02477	-0.09106	-0.12807**	0.37000***	0.37635***	-0.01106**	738
	(0.04990)	(0.04945)	(0.05887)	(0.05869)	(0.07219)	(0.06097)	(0.00505)	
Vale do Mucuri	0.13283	0.18799**	0.22610**	0.12786	0.46465***	0.44790***	-0.01048	332
	(0.08269)	(0.08479)	(0.10394)	(0.10152)	(0.09701)	(0.07937)	(0.00691)	
Triângulo Mineiro/Alto Paranaíba	0.17917***	0.20681***	0.28067***	0.21572***	1.24745***	1.36561***	-0.01274*	960
	(0.04855)	(0.04959)	(0.06876)	(0.06954)	(0.09487)	(0.09203)	(0.00681)	
Central Mineira	0.08993	0.09141	0.34695***	0.23914***	0.33654***	0.38179***	-0.02299***	444
	(0.10543)	(0.10480)	(0.08784)	(0.08708)	(0.11019)	(0.10365)	(0.00815)	
Metropolitana de Belo Horizonte	0.18455***	0.19348***	0.34670***	0.16184*	0.46816***	0.60358***	-0.03101***	1,530
	(0.06686)	(0.07220)	(0.07901)	(0.08578)	(0.08392)	(0.08907)	(0.00735)	
Vale do Rio Doce	0.23794***	0.20912***	-0.04833	-0.08512**	0.64263***	0.50800***	-0.01476***	1,494
	(0.03991)	(0.04116)	(0.03978)	(0.04118)	(0.03894)	(0.03704)	(0.00342)	
Oeste de Minas	0.23060***	0.29391***	0.32674***	0.27264***	0.45993***	0.69429***	-0.01896***	646
	(0.05821)	(0.06057)	(0.07335)	(0.07627)	(0.10997)	(0.09708)	(0.00674)	
Sul/Sudoeste de Minas	0.08978***	0.10545***	0.06858*	0.04341	0.89775***	0.92745***	-0.01824***	2,132
	(0.03277)	(0.03458)	(0.03537)	(0.03685)	(0.04306)	(0.04376)	(0.00391)	
Campos das Vertentes	-0.19418***	-0.13505*	0.18263***	0.17984**	0.43659***	0.60946***	-0.00838	528
	(0.07033)	(0.06992)	(0.06919)	(0.07029)	(0.09829)	(0.09197)	(0.00756)	
Zona da Mata	0.02342	-0.01703	-0.09813***	-0.17570***	0.56066***	0.52754***	-0.01674***	142
	(0.03282)	(0.03395)	(0.03616)	(0.03692)	(0.03916)	(0.03743)	(0.00336)	

Source: Author's own elaboration. Note: Robust standard errors in parentheses. Statistical significance at 1% (***), 5% (**) and 1% (*).

Some covariates results are worth highlighting. The negative coefficients for GDP per capita corroborate the income convergence hypothesis for the municipalities of Minas Gerais. Population growth has a positive impact on economic growth only in Low and High GDP municipalities models which control year dummies. Significant coefficients for high school (human capital) indicate that this factor is relevant for stimulating the economy in Middle and High GDP municipalities. The tax revenue has negative average effects on economic growth, refuting the hypothesis that a higher share of own-source revenue would lead to more efficient policies. The coefficients associated with the investment-to-spending ratio were not significant, suggesting that investments do not appear to be relatively more productive in stimulating the economy than other types of expenditures.

It is also observed that the Brazilian politico-economic crisis starting in 2014 negatively impacted, on average, economic growth of the municipalities in Minas Gerais. In the full sample and the subsamples categorized by development levels, the crisis dummy coefficients are negative and significant, representing average reductions in growth rates during the crisis years. Complementing this analysis, Figure 3 shows that the negative effects of the crisis reversed the growth trends of the average municipal GDP per capita observed since 2002, with drops in levels occurring in 2015 (more pronounced in the most developed municipalities), followed by more subdued growth thereafter, without reaching the levels seen in 2014.

Figure 3 – Evolution of the average municipal GDP per capita (2019 R$ thousands), by development level (2002 -2019).



Sources: IBGE, RAIS and STN. Author's elaboration.

Table 6 presents the results for the municipalities divided according to the mesoregions of Minas Gerais. It is observed that the increase in industrial share has heterogeneous regional effects on economic growth. In more developed mesoregions, where mining activities (gold, iron ore, and niobium extraction) are strongly integrated into the international market, agribusiness (coffee and soybeans)

is consolidated, and the manufacturing sectors encompass greater technological intensities and productivity, the increase in industrial share positively affects economic growth. This is the case in the Triângulo Mineiro/Alto Paranaíba and the Belo Horizonte Metropolitan Region. Positive effects of the industrial share on economic growth are also observed in mesoregions with intermediate development, such as the Vale do Rio Doce, Oeste, and Sul/Sudoeste, as well as in the Norte de Minas. Despite being less developed, the latter region has ceramics, apparel, metallurgy, and pharmaceutical industries characterized by a highly skilled workforce and high productivity (Table 3).

However, the growth-inducing effects of the services sector (except in the Vale do Rio Doce) and, especially, public administration are greater than those of industry. These results can be justified, among other likely factors, by the interrelationships established between services and industrial activities, particularly in the Belo Horizonte Metropolitan Region, which incorporates centers of excellence in information technology and biotechnology, and in the Triângulo Mineiro/Alto Paranaíba mesoregion, which serves as a major national distribution center. These mesoregions concentrate more robust education and health systems, fostering human capital and, consequently, labor productivity.

In contrast, in mesoregions focused on extraction and traditional agricultural activities — such as the Noroeste (high GDP per capita); Central Mineira, Campo das Vertentes, and Zona da Mata (medium GDP per capita); Jequitinhonha and Vale do Mucuri (low GDP per capita) — an increase in the industrial share does not impact (non-significant coefficients) or has negative effects on economic growth. Similar results are observed for services, except in Central Mineira, Campos das Vertentes, and Vale do Mucuri mesoregions. In these cases, the public sector's share is relatively more productive.

Finally, there is evidence of negative effects from the crisis dummy in all mesoregions of Minas Gerais with more developed industries. Political-institutional uncertainties tend to undermine investment decisions, particularly harming sectors linked to the manufacturing industry. In contrast, in the Noroeste, Vale do Mucuri, and Campo das Vertentes, the estimated coefficients are not significant. This may be due to their productive structures being primarily composed of primary activities (agriculture and extraction) and natural resource-based industries, which are more influenced by external factors—especially those related to commodity prices and Chinese demand (Libânio, 2008)—and less by internal economic crisis.

6 Concluding remarks

This study investigated the effects of the industrial share, compared to other sectors, on the economic growth of Minas Gerais municipalities. Municipal data from 2002 to 2019 were applied in panel data regressions. Overall, the results showed the importance of industry in inducing growth, particularly in more developed municipalities situated in mesoregions with more dynamic industrial structures. These findings align with those obtained by Rodrik (2009), Szirmai and Verspagen (2011), Vieira et al. (2014), and Mazhar and Rehman (2019) regarding the role of industry in the growth of developed economies.

The evidence further indicated that the sectoral shares effects on economic growth of Minas Gerais municipalities are heterogeneous, as the contribution of industry is surpassed by the increasing share of services, particularly in municipalities with medium and high GDP per capita and in more developed mesoregions, such as Triângulo Mineiro/Alto Paranaíba and the Belo Horizonte Metropolitan region. This suggests the existence of interdependence and complementarity between industry and services, as discussed by Giovanini and Arend (2018) and Pereira (2021). In less developed municipalities and less dynamic mesoregions, the public sector was found to play a greater role in stimulating growth, as argued by Balzan (2021). Finally, detrimental impacts of the post-2014 Brazilian crisis were observed in regions with higher industrial shares.

Considering these heterogeneous industrial effects on growth and the productive and socioeconomic disparities among Minas Gerais mesoregions, the implementation of active industrial policies aimed at areas with less dynamic industries and innovation systems is essential. Such policies should facilitate economic diversification by increasing technologically advanced activities interconnected with modern services, serving as key instruments to enable output growth and promote income convergence across the state's regions.

Another growth strategy involves leveraging potential on local natural resources by adding value to existing production chains, especially in regions heavily based on agricultural and extractive activities. Thus, by developing new comparative advantages beyond agriculture and mining, there is an opportunity to reduce the dependence of the Minas Gerais economy on exogenous factors, such as international prices and demand, which may compromise sustained long-term growth.

This research has some limitations. First, the IBGE Municipal National Accounts database does not allow for the disaggregation of manufacturing value added from total industrial value added. Consequently, analyzing industry in aggregate terms may obscure the actual role of manufacturing activity (or the effects of deindustrialization) on the economic growth of Minas Gerais municipalities, as it includes the contribution of the extractive, construction, and public utility industrial services sectors in the estimates.

Another limitation is the absence of other variables that are crucial to discussing regional growth and development that extend beyond the sectoral configuration of the productive structure. These include microeconomic inter-municipal phenomena, such as the role of industrial clusters, regional leakages, dormitory towns, and natural resource-supplying municipalities. While these factors were not the scope of this study, they constitute a future research agenda, which will allow for further evaluation of spillover effects on growth resulting from the specialization characteristics of various productive activities across municipalities. Importantly, future research should discuss the contribution of the productive and export configurations of Minas Gerais municipalities to the analysis of deindustrialization and economic growth potential.

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Michele Polline Veríssimo. Doutora em Economia. Universidade Federal de Uberlândia. Professora e pesquisadora. E-mail: micheleverissimo@ufu.br.

Carlos César Santejo Saiani. Doutor em Economia. Universidade Federal de Uberlândia. Professor e pesquisador. E-mail: ssaiani@ufu.br.

Submetido em: 02?05/2024 Aprovado em: 06/05/2026

CONTRIBUIÇÃO DE CADA AUTOR

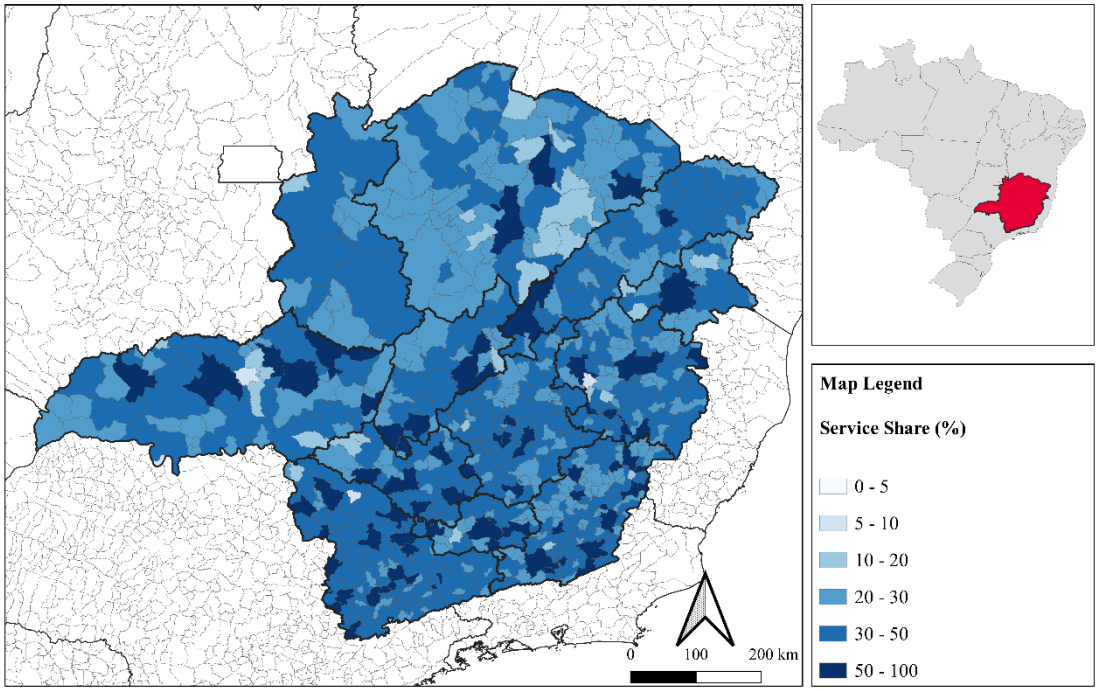
Conceituação (Conceptualization) - Michele Polline Veríssimo, Carlos César Santejo Saiani
Curadoria de Dados (Data curation) - Carlos César Santejo Saiani
Análise Formal (Formal analysis) - Michele Polline Veríssimo, Carlos César Santejo Saiani
Obtenção de Financiamento (Funding acquisition) - Michele Polline Veríssimo
Investigação/Pesquisa (Investigation) - Michele Polline Veríssimo, Carlos César Santejo Saiani
Metodologia (Methodology) - Carlos César Santejo Saiani
Administração do Projeto (Project administration) - Michele Polline Veríssimo
Recursos (Resources) - Michele Polline Veríssimo
Software - Carlos César Santejo Saiani

Supervisão/orientação (Supervision) - Michele Polline Veríssimo, Carlos César Santejo Saiani
Validação (Validation) - Michele Polline Veríssimo, Carlos César Santejo Saiani
Visualização (Visualization) - Michele Polline Veríssimo, Carlos César Santejo Saiani
Escrita – Primeira Redação (Writing – original draft) - Michele Polline Veríssimo, Carlos César Santejo Saiani
Escrita – Revisão e Edição (Writing – review & editing) - Michele Polline Veríssimo, Carlos César Santejo Saiani

Fontes de financiamento:
Esta pesquisa foi financiada pela Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG), Edital Nº 001/2021 - DEMANDA UNIVERSAL, projeto APQ-01004-21 "Comércio Internacional, Crescimento Econômico, Emprego, Crise e Pandemia do COVID-19 nos Municípios de Minas Gerais e do Brasil".

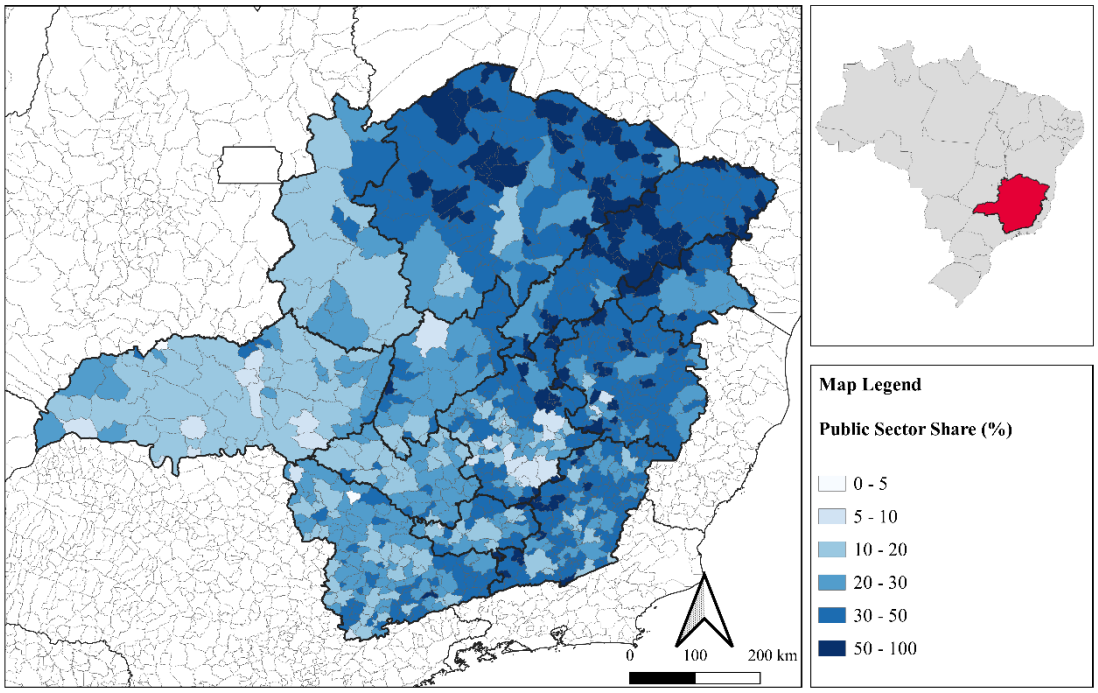
APPENDIX

Figure A.1 – Territorial distribution of service shares (%) in total municipal value added (2002 -2019)



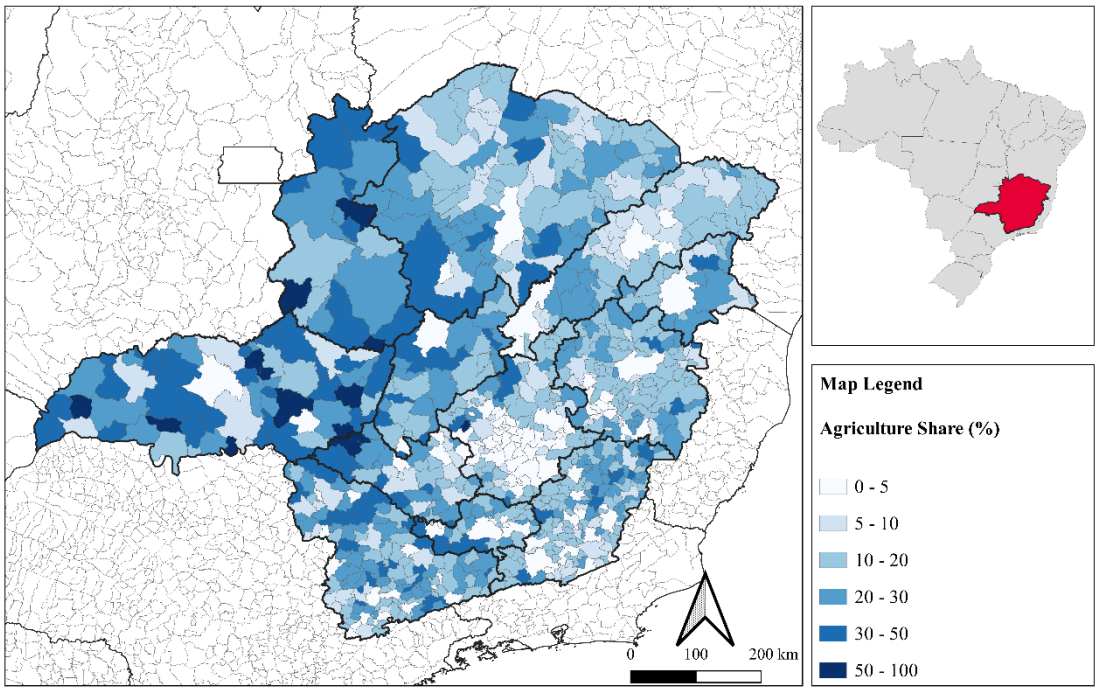
Source: IBGE. Author's elaboration

Figure A.2 – Territorial distribution of public sector shares (%) in total municipal value added (2002 -2019)



Source: IBGE. Author's elaboration

Figure A.3 – Territorial distribution of agricultural sector shares (%) in total municipal value added (2002 -2019)



Source: IBGE. Author's elaboration