

Economic growth and productive sectors: recent empirical data on middle-income countries

Aline de Souza Vicente, Luciano Ferreira Gabriel
and Luciano Dias de Carvalho

Received: 15/05/2022
Accepted: 26/09/2024

Abstract

This article examines how structural change affected economic growth in middle-income developing countries between 1960 and 2019, especially in Brazil (between 1948 and 2020), using the vector autoregression (VAR) model and panel data. The VAR model suggests that structural change in Brazil resulted in the services sector having a greater impact on economic growth owing to the transfer of resources from high-productivity sectors to low-productivity sectors, which reduced the rate of economic growth. Panel data suggest that economic growth in the sample of countries continues to be heavily influenced by the industrial sector and that the weaker momentum of the industrial sector in Brazil is one of the reasons why the country is falling behind.

Keywords

Economic growth, economic structure, structural adjustment, productivity, industrial sector, middle-income countries, Brazil.

JEL classification

L6, L8, O1, O11, O14

Authors

Aline de Souza Vicente holds a master's degree in economics (stricto sensu postgraduate programme) from the Federal University of Viçosa in Brazil. Email: alinnetr@hotmail.com.

Luciano Ferreira Gabriel is a professor and researcher in the Department of Economics and Finance at the Federal University of Juiz de Fora (UFJF), and a professor in the economics postgraduate programme at the Federal University of Viçosa and the applied economics postgraduate programme at UFJF. He is also a productivity fellow at the National Council for Scientific and Technological Development in Brazil. Email: lucianofg@gmail.com.

Luciano Dias de Carvalho is a professor and researcher in the Department of Economics and a professor in the economics postgraduate programme at the Federal University of Viçosa in Brazil. Email: lucianodc@gmail.com.

I. Introduction

Classical development economics literature and structuralist literature (Economic Commission for Latin America and the Caribbean (ECLAC))¹ establish a close relationship between the sectoral composition of an economy and its economic growth rate. There are strong arguments in the economic literature for sector specificity in economic growth behaviour, which implies that a unit of value added is not necessarily equivalent across economic sectors, in terms of its growth-inducing or growth-enhancing effects (Tregenna, 2009).

Porcile, Spinola and Yajima (2023) explain that a country's sectoral composition may be captured by its pattern of international specialization, as expressed in the income elasticity of its exports and imports. Hence, institutional dimensions, power relations between classes and the government and, primarily, productive structures play a fundamental role in shaping economic outcomes.

Over the past few decades, the relationship between structural changes and economic growth has become an important topic for the economy and has piqued the interest of various authors, such as Kaldor (1966), Kuznets (1966), Baumol (1967), Pasinetti (1993) and, more recently, Ngai and Pissarides (2007), Rodrik (2013a and 2013b), Nassif, Feijó and Araújo (2015), Vu (2017), Lavopa and Szirmai (2018), and Gabriel and Ribeiro (2019).

Rodrik (2013a) maintains that one key determinant of economic growth is structural change —the emergence and expansion of new sectors and the transfer of labour from traditional activities to modern ones.² More specifically, Su and Yao (2016) examined the specific role of the manufacturing industry as the leading driver of economic growth for middle-income countries. They found that industry is imbued with three main characteristics that are key to economic growth: industry drives services, not the other way around; there is a strong link between a decline or an increase in manufacturing sector growth and a decline or an increase in service sector growth in both the short run and the long run; and development of the manufacturing industry not only promotes incentives for saving, but also accelerates the pace of technological accumulation and, compared with other sectors, enhances the utilization of human capital and national institutions.

Felipe and others (2012) make it clear that the classical literature on economic development shows that what differentiates countries, and what determines their fortunes, is their production structure and the specific characteristics of the products that they export, primarily tradable goods such as manufactured goods. In addition, Gala (2017) explains that a country's economic development and per capita income levels depend to a large extent on its productive capabilities and its capacity to produce more complex and sophisticated goods.

This study investigates empirically how structural change between 1960 and 2019 affected economic growth in 31 middle-income developing countries, meaning developing countries with per capita income of between US\$ 3,996 and US\$ 12,375 (at 2019 prices). Special attention is paid to Brazil, which has been falling behind in the past few decades,³ and for which the period examined runs from 1948 to 2020 owing to the availability of data. We use the econometric tools of panel data for the heterogenous sample of countries and vector autoregression (VAR) methodology for Brazil. Using these two methodologies, we are able to contrast the results of Brazil with those of a representative sample of developing countries in the same income bracket.

¹ See examples of classical economic development authors in Myrdal (1957), Rosenstein-Rodan (1943) and Hirschman (1958), among others.

² In the manufacturing industry or in the sector of the most sophisticated services, such as information and communications technologies (ICTs), software engineering and finance.

³ See Nassif, Feijó and Araújo (2015).

Given the large number of countries that are experiencing premature deindustrialization, some authors have recently asserted that industrial growth has become a more difficult route to development (Eichengreen and Gupta, 2013; Rodrik, 2016). Despite the importance of manufacturing, there is a growing literature presenting the increasing influence of the services sector as the new driver of economic growth in developing economies (Maroto-Sánchez and Cuadrado-Roura, 2009; Szirmai and Verspagen, 2015). The services sector accounts, on average, for over 60% of gross domestic product (GDP) in advanced economies and some activities, such as software development, financial services and tourism, play an important role as leading economic activities that boost economic growth, for example in India (Dasgupta and Singh, 2005).

In view of the recent debate on the importance of the manufacturing sector and its implications for the sustained growth of developing countries, as well as the increasing influence of the services sector on growth, this article contributes to the literature by presenting a renewed understanding of the role of the manufacturing sector in relation to other sectors, both in Brazil and in a heterogeneous sample of middle-income countries. The dynamic relationships presented in the article complement the empirical literature on several issues concerning the importance of the manufacturing sector for developing economies, and for Brazil in particular.

II. Economic sectors and growth: brief review of the literature and empirical data

From early contributions in the literature on economic development (such as Chenery, 1960; and Kuznets, 1966) to more recent studies on sources of economic growth and recovery (such as McMillan, Rodrik and Verduzco-Gallo, 2014), a long tradition in economic thought links economic development with structural change. This process refers to the progressive shift of the economy from the production of simple goods, typically labour— or natural resource-intensive, to the manufacture of complex and more sophisticated goods, typically capital— and technology-intensive goods.

On the basis of a few classical authors in this debate, such as Kaldor (1966) and Kuznets (1966), it can be said that economic growth and structural change are closely intertwined. This can be seen when there is a transfer of resources and labour from a less productive sector, such as agriculture, to a more productive sector, such as the manufacturing sector, across the different stages of development. Kaldor (1967) in particular empirically demonstrated the manufacturing sector's overriding influence on the rate of economic growth and presented various empirical arguments on the special role of manufacturing for economic growth, including the sector's high productivity (Kaldor, 1967, p. 12), its forward and backward linkage effects (Kaldor, 1967, p. 23), and its influence on demand according to Engel's law⁴ (Kaldor, 1967, p. 29).

On this basis, almost no country has been able to achieve and sustain a high standard of living without significant developments in its manufacturing sector, except for a few oil-rich countries and small tax havens (Chang, 2016). The tradable manufacturing sector is a major channel through which a developing economy reduces its technological gap. The main vehicle for learning and adopting technology is investment. In the manufacturing industry, high levels of capital and investment are required and this creates strong externalities for other sectors. Furthermore, the manufacturing sector has a higher potential for productivity growth because it has a greater capacity to achieve higher levels of capital accumulation, economies of scale and technological progress, compared with agriculture and some services (Haraguchi, Cheng and Smeets, 2017; Lavopa and Szirmai, 2018; Szirmai, 2012).

⁴ According to Engel's law, as a family's income declines, the share of its spending on food increases and the share of its spending on other consumer goods, such as healthcare and leisure, decreases.

According to Haraguchi, Cheng and Smeets (2017), the linkage effects are especially strong in manufacturing, which offers better backward linkages (in general) as well as forward linkages for resource-based industries than the agriculture and services sectors. This means that an increase in manufacturing output boosts output even more both in the manufacturing sector itself and in other sectors, through direct output linkages and indirect multiplier effects, such that the manufacturing sector drives growth across the broader economy (Gabriel and Ribeiro, 2019). In countries with a relatively high level of income in particular, high-tech industries — such as chemicals and motor vehicles — make significant contributions to employment in industry-related services, especially business services, owing to the linkage effect (UNIDO, 2013).

Even more importantly, modern services such as telecommunications, financial services, software development, logistics and transport are seen as having considerable technological momentum and thus are also regarded as potential drivers of economic growth. According to Lavopa and Szirmai (2018), the successful development of services in India and other countries has resulted in the proposition that other developmental paths, not necessarily driven by the manufacturing sector, are also possible.

As for the services sector, Haraguchi, Cheng and Smeets (2017) explain that business services are increasingly becoming an integral part of manufacturing activities. Development of the manufacturing industry and structural change therefore play a key role in the development of these modern services. Nonetheless, as globalization advances, manufacturing in global value chains is increasing. This shift, which has accelerated in certain industries in particular since the end of the 1980s, can reduce national output linkages and induction effects to stimulate the economy. Nevertheless, the manufacturing sector continues to show a higher potential for productivity growth owing to its capacity for stronger capital accumulation, economies of scale and technological progress, compared with agriculture and less productive traditional services⁵ (Szirmai, 2012).

Szirmai (2012) and Szirmai and Verspagen (2015), using empirical analyses and stylized facts, present arguments to support the hypothesis that industry acts as a driver of growth, as also noted in Haraguchi, Cheng and Smeets (2017). According to them, there is a strong positive correlation between the level of development of the manufacturing sector and per capita income in emerging countries. The transfer of resources from agriculture to the manufacturing sector provides a structural change advantage, particularly for developing countries. However, the transfer of resources from the industrial sector to services may produce a structural change disadvantage, if the latter generates few higher-productivity activities (Baumol, 1967). According to Szirmai and Verspagen (2015, p. 47), the manufacturing sector offers special opportunities for capital accumulation, one of the aggregate sources of economic growth, and greater economies of scale. Productive investments in the manufacturing sector, such as in mining and construction, are capital-intensive. In addition, the manufacturing or processing industry tends to include more technologically advanced activities, which facilitates externalities and indirect diffusion of technology.

With regard to technological progress, Lima, Gabriel and Jayme (2022) analyse empirically how the manufacturing industry, disaggregated into subsectors by research and development (R&D) intensity, influences the level of economic complexity of a sample of 28 countries between 1963 and 2012. The empirical results suggest that allocation of workers to manufacturing activities with higher R&D investment has a positive impact on the level of productive sophistication of all the countries analysed, whereas in the sectors with lower R&D investment, the positive impact is greater in emerging countries, and lower (or negative) in advanced countries.

In the same vein as Szirmai (2012) and Szirmai and Verspagen (2015), Marconi, Reis and Araújo (2016) examine the hypothesis of manufacturing as a driver of growth using Kaldor's laws for a sample of 63 countries: 32 low- and middle-income countries (with per capita income of between US\$ 1,036 and US\$ 4,085) and 31 high- and middle-to-high-income countries (per capita income above US\$ 4,085).

⁵ Less productive traditional services are those linked to restaurants and specific public sector bureaucracies, for example.

The study covers the period 1990–2011. The results confirm the validity of Kaldor's laws, since they prove that stronger growth in industrial output leads to higher economic growth (Kaldor's first law) and to higher industrial productivity (Kaldor's second law) in both income groups. The effect was greater in low- and middle-to-low-income countries.

Rodrik (2013a) emphasizes two key trends that affect economic growth in the long run. First, growth depends on the accumulation of fundamental capabilities in the form of human capital and institutions, as underscored by Romer (1990) and Acemoglu, Johnson and Robinson (2005), respectively. However, these capabilities have high set-up costs and exhibit complementarities that tend to yield slow growth pay-offs until a certain level of accumulation has been reached. The second important point is that economic growth results from structural change, the transfer of labour from lower-productivity activities to modern higher-productivity activities, as noted in structuralist literature.

According to Rodrik (2013a, p. 5), high-output growth is enabled by the fact that the positive effects of industrialization can be generated even in the presence of a low level of fundamental capabilities. This means that a country can experience significant structural changes even with low levels of human capital and weak institutions. However, as Rodrik (2013a) points out, the policies needed to accumulate fundamental capabilities and those required to foster structural change overlap. The first entail a much broader range of investments and time for positive results to be achieved, and the second may take the form of much more limited measures, such as promoting the export of manufactured goods.

Rodrik (2013b) demonstrated empirically that the manufacturing industry exhibits strong unconditional convergence:⁶ industries that start at lower levels of initial value added per worker experience more rapid growth in productivity. Naturally, the rate of conditional convergence is faster in countries with better institutions and human capital, stronger trading ties and higher levels of financial development, but manufacturing continues to play its role as a driver of growth even in countries with weak governance and lower levels of human capital development (Rodrik, 2013a and 2013b).

Along the same lines as Rodrik (2013a and 2013b), Szirmai and Verspagen (2015) tested the relationship between the value added share of manufacturing and per capita GDP growth with a panel of 92 countries. The relationship was examined for three periods (1950–1970, 1970–1990 and 1990–2005) and compared with the results of the services sector. The study, which focused primarily on the results of conservative Hausman-Taylor (1981) estimations, presents the contribution of the manufacturing industry to per capita GDP growth conditional on the level of education and stage of development. The authors showed that the manufacturing industry acts as a driver of growth for low- and middle-income countries, provided they have a sufficient level of human capital. Such growth driving features were not found for the services sector. The findings for more recent periods indicate that a higher level of human capital (at least seven to eight years of education) is necessary for the manufacturing industry to drive growth in developing countries.

Haraguchi, Cheng and Smeets (2017) analysed empirically whether the importance of the manufacturing industry in developing countries has changed in terms of development quality (role of manufacturing as a driver of growth) and development quantity (relative share of manufacturing value added and employment in GDP and in total employment, respectively). Upon assessing these factors, the authors argue that the importance of the manufacturing industry in economic development remained unaltered during the periods analysed (1970–1990 and 1990–2013).

According to Haraguchi, Cheng and Smeets (2017), even after 1990, the manufacturing sector in developing countries still meets the conditions to be described as a driver of economic development, especially to achieve high sustained growth while retaining at least the same size in GDP and total employment as in the period from 1970 to 1990. Thus, the authors conclude that premature deindustrialization in many developing countries has not been caused by changes in the capability of the sector to act as a driver of growth, or even by the quantity of manufacturing activities (in terms of employment and value added), but

⁶ The sample used by Rodrik (2013b) covers up to 118 countries from 1965 to 2005.

is mostly attributable to failures of manufacturing development⁷ in a large number of developing countries amid rapid development of the manufacturing sector in a small number of countries, thus resulting in a concentration of manufacturing activities in countries such as China.

Unlike Rodrik (2016) and Eichengreen and Gupta (2013), Haraguchi, Cheng and Smeets (2017) are not pessimistic about the possibility of emerging countries achieving economic development through the industrial sector. According to them, following its success in labour-intensive industries, China is likely to upgrade its industrial structure following in the footsteps of high-income countries, which focus more on capital. Once this happens, there may be greater opportunities for current low- and middle-income countries to pursue manufacturing activities in global value chains and regain their importance despite their premature deindustrialization.

The authors also acknowledge that despite these opportunities, further liberalization of international trade and the growing role of global value chains in production and in manufacturing trade may have intensified price competition in international trade and given clear advantages to specific countries with economies of scale and agglomeration.

According to Lavopa and Szirmai (2018), countries that fall into the poverty or middle-income trap are countries that have been unable to sustain their structural transformation with regard to structural change and reduction of the technological gap.⁸ In the specific case of middle-income countries, the trap would be failing to move from competitiveness in low-wage activities and routinized tasks to competitiveness in knowledge-based production using cutting-edge technological innovations.

As for middle-to-high-income countries, Lavopa and Szirmai (2018) explain that the main challenge is to narrow the productivity gap (promotion of innovation and structural change which increases productivity) rather than to increase the size of the modern sector.⁹ As production across global value chains becomes more important, reducing productivity gaps entails upgrading within these chains and capturing segments within them with greater competitive edge potential.

Countries that have overcome the middle-income trap, such as the Republic of Korea, have used trade, industrial and technological policies with growing international competitiveness.¹⁰ In that case, the expansion of the modern sector was accompanied by a narrowing of the technological gap. According to Lavopa and Szirmai (2018), this trajectory contrasts with that observed in Brazil, where the reduction of the technological gap could not be sustained and, furthermore, where there has been intense deindustrialization since the 1980s.

Doré and Teixeira (2023), upon analysing the specific case of the long-run economic growth of Brazil (from 1822 to 2019), found that structural change is of critical importance as an element to explain the country's industrialization. According to the authors, although the abundant natural resources in Brazil have helped to boost the primary sector of the economy throughout its history, specific policies and investments propelled manufacturing activities, especially after the 1930s, helping to enhance industrial development and, consequently, economic growth. Lastly, the results of Doré and Teixeira (2023) suggest that the premature deindustrialization of Brazil after the 1980s contributed to a large extent to the country's near-stagnation growth in the years that followed.

⁷ Through defective industrial policies or adverse effects of comparative advantages, for example.

⁸ For that analysis, the authors propose a novel index that captures the salient features of this structural transformation by looking at two variables for which long-term cross-country data are available: the share of labour force employed in modern sectors (structural dimension) and labour productivity in the modern sectors relative to labour productivity at the international frontier (technological dimension). The new index combines both variables into a single measure of structural modernization.

⁹ Lavopa and Szirmai (2018) identify the modern sectors as mining, manufacturing, utilities, construction and tradable services (that is, transport and telecommunications, and financial and professional services).

¹⁰ Porcile, Spinola and Yajima (2023) have developed a formal model for economic growth defined by the balance-of-payments constraint, in which one of the possible scenarios is developmentalist policies, such as those implemented in the Republic of Korea. In this case, the objective is to obtain a competitive exchange rate while implementing a strong industrial policy to foster learning and structural change.

III. Methodology

1. Econometric model

The first method used in this study was the VAR model, as explained and justified below, taking into account the econometric tests performed. This method is used to analyse the effects of structural change in the Brazilian economy on the country's economic development. The VAR model is appropriate when there are uncertainties surrounding the identification of the endogenous and exogenous variables. In the VAR (p) system, the behaviour of the variables, broadly speaking, is driven by the p -lags of the explained variable and by the p -lags of the explanatory variables. According to the VAR methodology, the following specification is used for real GDP (the main variable of interest):

$$\Delta y_t = \sum_{k=1}^p \alpha_k \Delta y_{t-k} + \sum_{k=1}^p \beta_k \Delta sector_{t-k+1} \dots \sum_{k=1}^p \sigma_{késimo} \Delta n.sector_{t-k+1} + \mu_t \quad (1)$$

where Δy_t is the real GDP growth rate of Brazil from one year to another; Δy_{t-k} is the rate of change of real GDP over the period t lagged for up to k periods (years); $\Delta sector_{t-k+1}$ is the real rate of change of the sector of interest over the period t lagged for up to $t-k+1$ years; $\Delta n.sector_{t-k+1}$ represents the real rate of change of the n th sector ($n.sector$) over the period t lagged for up to $t-k+1$ years; and μ_t is the random error term. In addition, $\alpha_k, \beta_k, \sigma_{késimo}$ are the parameters to be estimated up the n th sector ($n.sector_{t-k+1}$). The economic sectors are shown in table 1. To test for stationarity, the augmented Dickey-Fuller test and the Phillips-Perron test were used. Given that there can be drawbacks to the augmented Dickey-Fuller test stemming from a higher propensity towards failing to reject a null hypothesis when it is false, the decision was made to use the Phillips-Perron test as well. Table 1 shows the variables used in the VAR model.

In addition to the tests for stationarity and for selecting the optimal lag for the VAR model (see section IV.1), a cointegration analysis of the Brazilian economic series was performed. The Johansen cointegration tests of the complete model, both in logarithm (at level) and without any transformation (series in real terms), found no cointegration between the time series. The results for the complete model, including the results of the trace test and the eigenvalue test, are shown in tables A2.1 and A2.2, respectively. Given that the time series, at level, were not cointegrated, but rather stationary at first difference, the VAR (p) method is the most appropriate method (Enders, 2004).¹¹

The econometric method chosen to determine how structural change can affect a country's economic growth was a panel data model using a sample of 31 middle-income countries (economies with a per capita income of between US\$ 3,996 and US\$ 12,375 at 2019 prices) over the period 1960–2019. That way, the results for Brazil could be contrasted with a heterogenous sample of developing countries.

The following specification was used:

$$realgdppc_{it} = \beta_0 + \beta_1 aggdp_{it} + \beta_2 indshare_{it} + \beta_3 servshare_{it} + \beta_4 gfkforshare_{it} + \beta_5 trade_{it} + \beta_6 openness_{it} + \beta_7 inflationrate_{it} + \mu_t + \eta_i + u_{it} \quad (2)$$

where β_j are the parameters to be estimated; μ_t is the specific time effect; η_i captures the unobserved effects for each country i that do not change over time; and u_{it} is the idiosyncratic error term.

In equation (2), $realgdppc_{it}$ represents the per capita GDP growth rate; $aggdp_{it}$ is the explanatory variable, representing the share of the agriculture sector; $indshare_{it}$ represents the share of the industrial (manufacturing) sector, and $servshare_{it}$ represents the share of the services sector. All sector shares

¹¹ According to Enders (2004), if the series were not stationary but instead cointegrated, the vector error correction (VEC) should be adjusted.

are in real terms and as a percentage of each country's real GDP. Control variables were also added, such as $gfkforshare_{it}$, which represents gross fixed capital formation; $ttrade_{it}$, which represents the terms of trade; $openness_{it}$, which represents the openness of the economy; and $inflationrate_{it}$, which represents inflation. Lastly, subscript i represents the countries, while subscript t represents the years.

2. Description of the data

For the application of the VAR model, data on the Brazilian economy were obtained from the System of National Accounts, available on the platform of the Brazilian Institute of Geography and Statistics and the Institute of Applied Economic Research. The purpose of the System of National Accounts is to provide basic data on the country's economic development. The available data cover the period 1948–2020, which is why that period was chosen for the analysis.

Table 1 contains a description of the variables used in the two approaches to the VAR model. The estimation of the model was divided into two parts: in the first, a limited model with the rate of change of economic growth and the rate of change of the three economic sectors (agriculture, industry and services) was used; in the second, more specific variables were used. A total of eight variables were used: $GFCE$, gross fixed capital formation; $AGDP$, agriculture GDP; $IGDP$, industry GDP; $GFCE_{M}$, gross fixed capital formation in machinery and equipment; $SGDP$, services sector GDP; $MGDP$, manufacturing GDP; $TGDP$, trade GDP; and GDP , total GDP.

Table 1
Description of the variables used in the vector autoregression model

Variable	Description	Source
$\Delta GFCE$	Annual percentage change in gross fixed capital formation	Estimates based on data from the Institute of Applied Economic Research (IPEA, 2021) and the Brazilian Institute of Geography and Statistics (IBGE, 2020), base year 2010.
$\Delta AGDP$	Real annual change in agriculture GDP	Estimates based on IPEA (2021) and IBGE (2020), base year 2010.
$\Delta IGDP$	Annual percentage change in industry GDP	Estimates based on IPEA (2021) and IBGE (2020), base year 2010.
$\Delta GFCE_{M}$	Annual percentage change in gross fixed capital formation in machinery and equipment	Estimates based on IPEA (2021) and IBGE (2020), base year 2010.
$\Delta SGDP$	Annual percentage change in services sector GDP	Estimates based on IPEA (2021) and IBGE (2020), base year 2010.
$\Delta MGDP$	Real annual change in manufacturing GDP	Estimates based on IPEA (2021) and IBGE (2020), base year 2010.
$\Delta TGDP$	Real annual change in trade GDP	Estimates based on IPEA (2021) and IBGE (2020), base year 2010.
ΔGDP	Real annual change in total GDP	Estimates based on IPEA (2021) and IBGE (2020), base year 2010.

Source: Prepared by the authors using data from Institute of Applied Economic Research (IPEA), IPEADATA [online], available at www.ipeadata.gov.br [consulted on 17 December 2021], and Brazilian Institute of Geography and Statistics (IBGE), "SCN - Sistema de Contas Nacionais" 2020 [online], available at <https://www.ibge.gov.br/estatisticas/economicas/industria/9052-sistema-de-contas-nacionais-brasil.html?edicao=35337>.

Note: Data for all variables were obtained by consulting the national accounts for the period 1948–2020, available in IBGE (2020) and IPEA (2021).

Country data for the panel data model were obtained from the World Bank World Development Indicators database¹² or the Penn World Table 10.01.¹³ The former contains a series of World Bank development indicators, while the latter is a country data set developed by Feenstra, Inklaar and Timmer (2015). Annual data cover the period 1960–2019 and a sample of 31 middle-income countries.¹⁴ Table 2 contains a summarized description of all variables used in the panel data model.

¹² See [online] <https://databank.worldbank.org/source/world-development-indicators>.

¹³ See [online] <https://www.rug.nl/ggdc/productivity/pwt/>.

¹⁴ Albania, Argentina, Belarus, Belize, the Bolivarian Republic of Venezuela, Botswana, Brazil, Bulgaria, China, Colombia, Costa Rica, the Dominican Republic, Ecuador, Gabon, Georgia, Guatemala, Indonesia, the Islamic Republic of Iran, Jamaica, Jordan, Lebanon, Libya, Malaysia, Mexico, Namibia, Paraguay, Peru, the Russian Federation, South Africa, Thailand and Türkiye.

Table 2
Description of the variables used in the panel data model

Variable	Description	Source
<i>realgdp</i>	Per capita GDP (<i>Constant dollars at 2010 prices</i>)	Penn World Table 10.01
<i>aggdps</i>	Agriculture, forestry and fishing, value added (<i>Percentages of GDP</i>)	Penn World Table 10.01
<i>indshare</i>	Industry, value added (<i>Percentages of GDP</i>)	Penn World Table 10.01
<i>servshare</i>	Services, value added (<i>Percentages of GDP</i>)	Penn World Table 10.01
<i>gfkforshare</i>	Gross fixed capital formation (<i>Percentages of GDP</i>)	World Development Indicators
<i>ttrade</i>	Terms of trade adjustment	World Development Indicators
<i>openness</i>	Trade openness index (<i>Percentages of GDP</i>)	World Development Indicators
<i>inflationrate</i>	Inflation, consumer prices (<i>Annual percentages</i>)	World Development Indicators

Source: Prepared by the authors using World Bank, “World Development Indicators (WDI)” [online database], available at <https://databank.worldbank.org/source/world-development-indicators>; and R. C. Feenstra, R. Inklaar y M. P. Timmer, “The next generation of the Penn World Table”, *The American Economic Review*, vol. 105, No. 10 (2015).

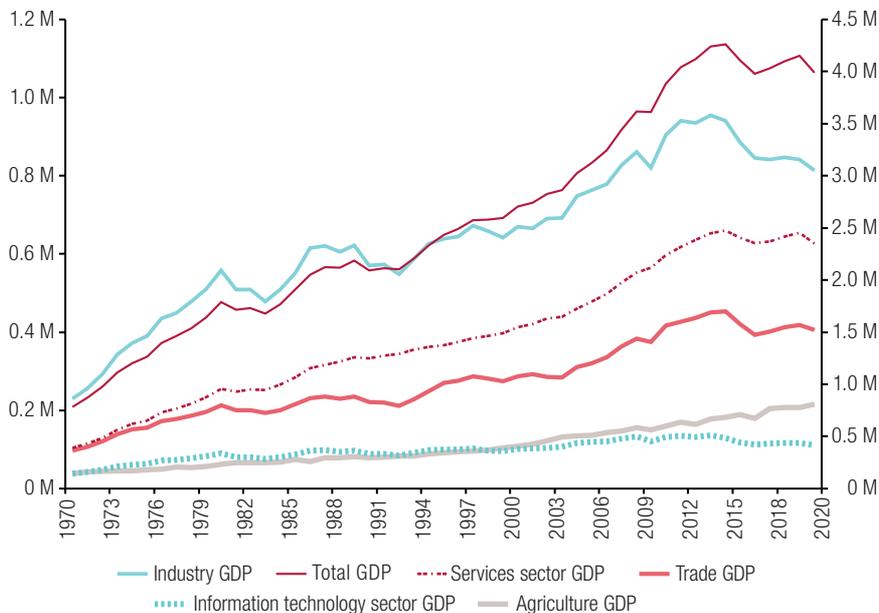
IV. Results and discussion

1. Vector autoregression model for Brazil

The VAR model was used to evaluate the effects of the structural change of the Brazilian economy on economic performance over the period 1948–2020. To that end, the analysis of the model was divided into two parts: the first is a limited model, with only four variables, while the second is a more complete model, with eight variables.

Figure 1 below shows trends in GDP of certain sectors and of the economy as a whole. As shown, in recent years, GDP has risen across all sectors and subsectors, as has total GDP. Agriculture GDP and trade GDP have recorded constant growth, which contrasts with the accelerated growth in services sector GDP. The same results have not been achieved, however, by the industrial sector and the manufacturing subsector, which have declined as a share of total GDP.

Figure 1
Brazil: trends in GDP of various sectors and of the economy as a whole, 1970–2020



Source: Prepared by the authors using data from Brazilian Institute of Geography and Statistics (IBGE).

Note: Real variables at constant prices (base year 2010) were used. The period 1970–2020 was chosen owing to a lack of data on industry GDP and services sector GDP.

According to Nakabashi, Scatolin and Cruz (2010), the growth of the services and trade sector accelerated precisely as industry was losing momentum in the Brazilian economy, during the 1980s, as shown in figure 1. According to Arbache (2015), in Brazil from 1985 onward, growth in services sector GDP accelerated at the expense of the industrial sector and the agriculture sector, whose respective shares of total GDP declined. That acceleration, however, could also be linked to the rise in urbanization and to the demographic transformation of the country, so much so that the services sector already accounted for 70% of GDP from 2013 onward.

Given that one of the prerequisites for using the VAR model is that the series used in the model must be stationary, the annual data were first tested for stationarity using the augmented Dickey-Fuller test. Decisions regarding the selection of the lag and whether to include a constant or trend were made using the Schwarz information criterion, with a limit of four lags. Table 3 shows that all series are stationary at 1%, and thus there is no impediment to using the VAR model.¹⁵

Table 3
Brazil: series stationarity testing, augmented Dickey-Fuller test

Variable	Number of lags	Constant/trend	Level
$\Delta GFCF$	0 lags	Constant and trend	-4.41*
$\Delta AGDP$	0 lags	Constant	-13.16*
$\Delta IGDP$	1 lag	Constant	-11.26*
$\Delta SGDP$	1 lag	Constant	-7.86*
$\Delta MGDP$	0 lags	Constant and trend	-7.21*
$\Delta TGDP$	0 lags	Constant	-5.08*
$\Delta GFCFME$	0 lags	Constant and trend	-6.04*
ΔGDP	0 lags	Constant	-4.17*

Source: Prepared by the authors.

Note: Null hypothesis: the variable has a unit root (i.e. it is not stationary). An asterisk denotes the rejection of the null hypothesis (1%).

The augmented Dickey-Fuller test can, however, have drawbacks, such as a higher propensity towards failing to reject a null hypothesis when it is false. For that reason, the Phillips-Perron test was also performed. As shown in table 4, once again all series were stationary at 1%, and thus there is no impediment to using the VAR model.

Table 4
Brazil: series stationarity testing, Phillips-Perron test

Variable	Number of lags	Constant/trend	Level
$\Delta GFCF$	0 lags	Constant and trend	-4.41*
$\Delta AGDP$	0 lags	Constant	-14.68*
$\Delta IGDP$	1 lag	Constant	-11.41*
$\Delta SGDP$	1 lag	Constant	-7.86*
$\Delta MGDP$	0 lags	Constant	-5.51*
$\Delta TGDP$	0 lags	Constant	-5.05*
$\Delta GFCFME$	0 lags	Constant	-5.21*
ΔGDP	0 lags	Constant	-4.08*

Source: Prepared by the authors.

Note: Null hypothesis: the variable has a unit root (i.e. it is not stationary). An asterisk denotes the rejection of the null hypothesis (1%).

To determine how many lags to consider in the estimation of the VAR model, the following tests were performed: the Akaike information criterion, the Schwarz information criterion, the Hannan-Quinn information criterion and the final prediction error criterion. Table 5 shows the selection tests for the limited

¹⁵ Section III.1 contains an explanation of why it is appropriate to use the VAR model instead of the VEC model, as well as an account of the results of the Johansen cointegration test.

model (i.e. the model with fewer variables). As shown, one lag, two lags and four lags were the only results indicated by the selection tests. Accordingly, the decision was made to consider the number of lags indicated by the most tests (i.e. where the number of lags identified by the different tests varied, the number of lags identified by the majority was selected for the model). Therefore, only one lag should be considered in the VAR model with fewer variables. Table 6 shows the selection tests for the complete model (i.e. the model with more variables). It also indicates that the results of the estimation should only consider one lag.

Table 5
Brazil: lag selection tests for the limited model, annual, 1948–2020

Lag	Final prediction error criterion	Akaike information criterion	Hannan-Quinn information criterion	Schwarz information criterion
1	1283522	25.415	25.675*	26.073*
2	1148578*	25.299	25.767	26.483
3	1186586	25.318	25.995	27.029
4	1170226	25.278*	26.164	27.516
5	1417068	25.428	26.522	28.192
6	1388969	25.344	26.646	28.634

Source: Prepared by the authors.

Note: The variables considered in this test are: $\Delta GFCF$, $\Delta AGDP$, $\Delta IGDP$ and $\Delta SGDP$. The asterisk denotes the number of lags selected under that criterion.

Table 6
Brazil: lag selection tests for the complete model: annual, 1948–2020

Lag	Final prediction error criterion	Akaike information criterion	Hannan-Quinn information criterion	Schwarz information criterion
1	5.50e+09	45.118	46.043*	47.450*
2	5.09e+09	44.970	46.717	49.373
3	4.87e+09*	44.733	47.302	51.209
4	5.69e+09	44.486*	47.877	53.034

Source: Prepared by the authors.

Note: The variables considered in this test are: $\Delta GFCF$, $\Delta AGDP$, $\Delta IGDP$, $\Delta SGDP$, $\Delta MGDP$, $\Delta TGDP$, $\Delta GFCFME$ and ΔGDP . The asterisk denotes the number of lags selected under that criterion.

In the first approach, gross fixed capital formation ($\Delta GFCF$) was used, considering the growth rate of each sector ($\Delta AGDP$, $\Delta IGDP$ and $\Delta SGDP$). Table 7 shows the estimated results for each of these variables, taking into account just one lag in accordance with the selection criteria.

Table 7
Brazil: results of the estimations of the VAR model, limited model, 1948–2020

	$\Delta GFCF$	$\Delta AGDP$	$\Delta IGDP$	$\Delta SGDP$
$\Delta GFCF$ (L1)	0.044 (0.220)	-0.068 (0.061)	0.010 (0.157)	0.067 (0.120)
$\Delta AGDP$ (L1)	0.085 (0.388)	-0.430 (0.107)***	0.058 (0.277)	-0.074 (0.213)
$\Delta IGDP$ (L1)	0.285 (0.535)	0.297 (0.148)**	0.371 (0.382)	0.179 (0.294)
$\Delta SGDP$ (L1)	0.606 (0.441)	-0.208 (0.122)*	0.538 (0.315)*	0.670 (0.242)***
Constant	0.803 (2.544)	5.1013 (0.706)	0.690 (1.817)	1.222 (1.397)

Source: Prepared by the authors.

Note: Standard deviation indicated within parentheses. Significance of 10% (*), 5% (**) and 1% (***). Limited model. Only one lag is considered, in accordance with the selection criteria.

Table 7 shows that five of the variables have a statistical significance level of 10%, 5% or 1%. Three of those fall under the first lag of $\Delta SGDP$, influenced by $\Delta AGDP$, $\Delta IGDP$ and $\Delta SGDP$. In other words, it is

shown that the rate of growth in services sector GDP, lagged for one period, has a significant impact on the rates of growth in agriculture GDP, industry GDP and services sector GDP. Moreover, a 1-percentage-point increase in the rate of growth in services sector GDP provokes a 0.2-percentage-point decrease in the rate of growth in agriculture GDP and a 0.53-percentage-point increase in the rate of growth in industry GDP.

Other studies have reached similar conclusions. Cruz and others (2007), for example, analysed the decline in industry in terms of its share of employment and of value added in the economy (GDP) and the expansion of the services sector. They found evidence of a decline in manufacturing in terms of its share of employment, as well as evidence of an increase in the share of services subsectors, such as public administration and trade.

Statistically significant variables were the rate of growth in agriculture GDP, which had a negative impact on its own rate of growth, and industry GDP, which had a positive impact on agriculture GDP.

The results align with those of Nakabashi, Scatolin and Cruz (2010), in that the agriculture sector affects its own performance, but not that of any other sector. This means that the agriculture sector does not have any influence on the growth rate of the economy as a whole; in other words, it has no indirect impact on the growth rate of other sectors. The industrial sector, however, has a positive impact on the agriculture sector.

The limited model shows that the most significant sector, in terms of its pull on other sectors, was the services sector, which had a negative impact on the agriculture sector but a positive impact on both the industrial sector and its own lagged behaviour. It is thus shown that, in Brazil, the services sector has a significant impact on the industrial sector: a 1-percentage-point increase in the services sector has a 0.538-percentage-point impact on the industrial sector.

Table 8 shows the results of the estimations of the complete model, which has the following additional variables: the rates of change in manufacturing GDP ($\Delta MGDP$), trade GDP ($\Delta TGDP$), gross fixed capital formation in machinery and equipment ($\Delta GFCFME$) and total GDP (ΔGDP). This model yields more data for analysing the relationship between structural changes and economic growth.

According to Nakabashi, Scatolin and Cruz (2010), gross fixed capital formation in machinery and equipment may be the most interesting variable for determining the growth rates of the various economic sectors; manufacturing GDP may provide more information on technology and productivity in the sector; and total GDP may be interesting for observing how other sectors interact with the economy as a whole and how total GDP can interact with each sector. Trade GDP was also included to analyse whether it behaves similarly to services sector GDP.

Table 9 shows that the first lag of $\Delta GFCF$ has a significant, positive impact on $\Delta IGDP$, $\Delta SGDP$, $\Delta GFCFME$ and on its own coefficient ($\Delta GFCF$), as well as a significant, negative impact on $\Delta AGDP$. This suggests that gross fixed capital formation mainly influences the industrial and services sectors.

In contrast, the first lag of $\Delta GFCFME$ has the opposite effect of $\Delta GFCF$: a significant, positive impact on $\Delta AGDP$ and a significant, negative impact on $\Delta IGDP$, $\Delta SGDP$, $\Delta GFCF$ and on its own coefficient ($\Delta GFCFME$). This suggests that, between 1948 and 2020, gross fixed capital formation in machinery and equipment mainly influenced the agriculture sector.

Another important result pertains to the behaviour of total GDP. In addition to its lag having a positive impact, significant to 1%, on its own coefficient, it also influences $\Delta TGDP$ and $\Delta MGDP$: a 1 — percentage — point increase in the rate of growth in total GDP raises the rate of growth in trade GDP by 1.12 percentage points and the rate of growth in manufacturing GDP by 1.74 percentage points. This suggests that the total GDP growth rate has a positive influence primarily on two economic subsectors: trade and manufacturing.

Other significant variables, in addition to the constant, were the rate of growth in agriculture GDP ($\Delta AGDP$) on its own coefficient and the rate of growth in services sector GDP ($\Delta SGDP$) on its own coefficient. The other variables ($\Delta TGDP$, $\Delta IGDP$ and $\Delta MGDP$) did not have any significant coefficient, which suggests that they did not influence the growth of the Brazilian economy between 1948 and 2020.

Table 8
Results of the estimations of the VAR model, complete model, 1948–2020

	$\Delta GFCF$	$\Delta GFCFME$	ΔGDP	$\Delta AGDP$	$\Delta TGDP$	$\Delta IGDP$	$\Delta MGDP$	$\Delta SGDP$
$\Delta GFCF$ (L1)	0.694 (0.309)**	1.092 (0.435)**	-0.103 (0.077)	-0.154 (0.088)*	-0.095 (0.104)	0.484 (0.222)**	-0.114 (0.133)	0.415 (0.170)**
$\Delta GFCFME$ (L1)	-0.534 (0.199***)	-0.934 (0.280)***	0.050 (0.050)	0.102 (0.057)*	0.050 (0.067)	-0.390 (0.143)***	0.021 (0.085)	-0.250 (0.109)**
ΔGDP (L1)	-1.894 (1.847)	-3.890 (2.597)	1.271 (0.464)***	0.765 (0.530)	1.121 (0.624)*	-0.603 (1.327)	1.744 (0.178)**	-0.553 (1.016)
$\Delta AGDP$ (L1)	0.258 (0.414)	0.210 (0.582)	-0.071 (0.104)	-0.495 (0.119)***	-0.089 (0.140)	0.225 (0.297)	0.027 (0.178)	0.129 (0.227)
$\Delta TGDP$ (L1)	1.047 (1.151)	2.337 (1.619)	-0.265 (0.289)	-0.508 (0.330)	-0.250 (0.389)	0.185 (0.827)	-0.401 (0.495)	-0.297 (0.633)
$\Delta IGDP$ (L1)	-0.120 (0.721)	0.662 (1.014)	0.223 (0.181)	0.142 (0.207)	0.257 (0.243)	0.428 (0.518)	0.358 (0.310)	0.200 (0.396)
$\Delta MGDP$ (L1)	1.029 (0.939)	1.257 (1.320)	-0.353 (0.235)	-0.027 (0.269)	-0.253 (0.317)	0.364 (0.674)	-0.507 (0.403)	0.542 (0.516)
$\Delta SGDP$ (L1)	0.856 (0.596)	0.046 (0.837)	-0.141 (0.149)	-0.077 (0.177)	-0.188 (0.201)	0.386 (0.428)	-0.220 (0.256)	0.547 (0.327)*
<i>Constant</i>	0.784 (3.423)	5.219 (4.813)	1.099 (0.860)	4.145 (0.983)***	1.133 (1.157)	0.875 (2.458)	-0.655 (1.472)	2.122 (1.889)

Source: Prepared by the authors.

Note: Standard deviation indicated within parentheses. Significance of 10% (*), 5% (**) and 1% (***). Complete structural model. Only one lag is considered, in accordance with the selection criteria.

Notably, $\Delta IGDP$ and $\Delta MGDP$ did not have any significant coefficient, which could reflect their decline in terms of their share of total GDP in recent years. Bonelli and Pessôa (2010) found the same result.

In the limited model, results show the importance of the services sector for its own growth rate and demonstrate its relevance in determining the agriculture GDP growth rate and the industry GDP growth rate. In other words, the services sector acted as a driver of economic growth over the period 1947–2020. In the complete model, gross fixed capital formation had a positive impact on the services sector and, especially, on industry, while gross fixed capital formation in machinery and equipment had a positive and statistically significant impact on agriculture GDP. Total GDP was a driver of growth for the manufacturing and trade subsectors.

That last finding suggests that economic growth (or the expectation of such growth) may create more investment opportunities for manufacturing in particular. In other words, the growth of the manufacturing sector is endogenous to the behaviour of the economy, so it is not the most relevant sector in terms of its influence on ΔGDP .

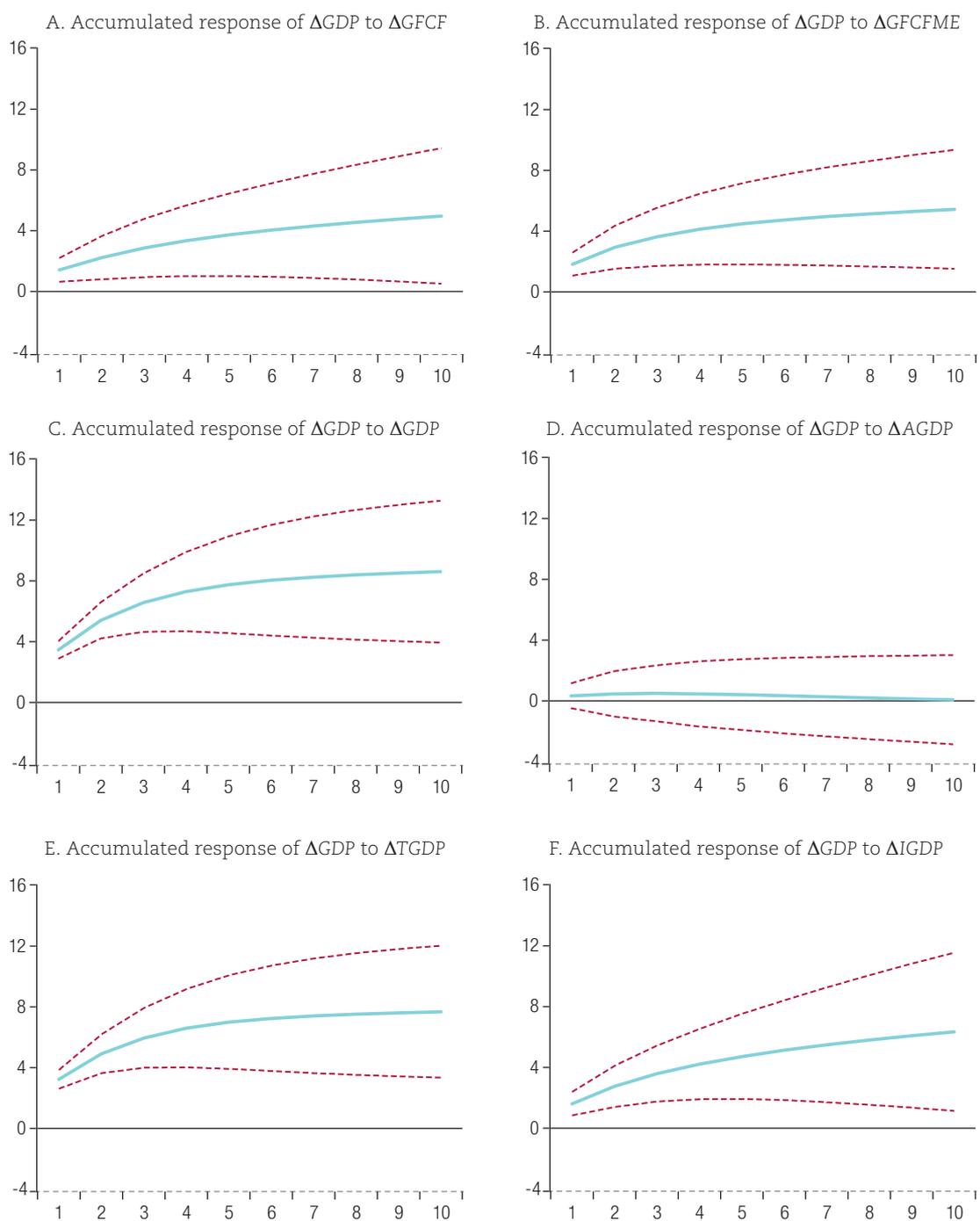
The results for Brazil suggest that structural change documented over the course of the period diminished the importance of the industrial sector for economic growth, because the transfer of the workforce from high-productivity sectors (industry) to low-productivity sectors (mainly trade and services) dampened the rate of economic growth (see figure 1), as well as the industrial sector's influence on other sectors (as shown in the analysis of the VAR model).

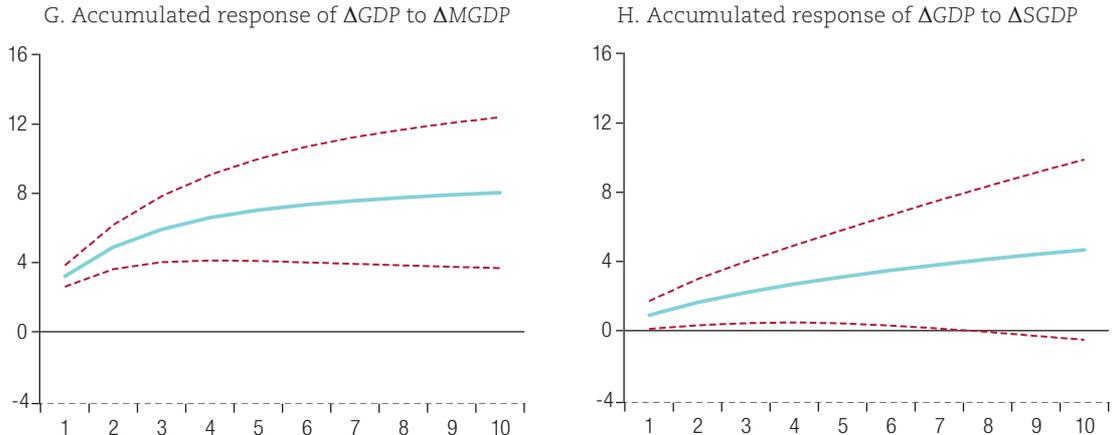
Figure 2 shows the impulse response analysis of the VAR (1) model. Impulse response functions reveal the behaviour of the analysed time series when the value of the residuals of a given variable change in response to an exogenous shock (one standard deviation). In this manner, it is possible to observe the behaviour of and the relationships between the time series related to GDP of Brazil.¹⁶

¹⁶ See Spinola (2020) for an analysis of how exogenous shocks to the trade balance, foreign growth, the real exchange rate and domestic income affect Argentina, Brazil, Colombia and Mexico. See also Teixeira, Missio and Dathein (2022) for an analysis of the relationship between functional income distribution, aggregate demand and capacity utilization for the Brazilian economy between 2000 and 2015. In both studies, VAR and VEC methods were used.

Figure 2

Brazil: impulse response functions, VAR model (1), complete model

Accumulated response to generalized 1-standard-deviation innovations with a standard error of ± 2 



Source: Prepared by the authors on the basis of estimates made using the EViews 9.0 software.

To estimate the impulse response functions of the subfigures of figure 2, the generalized impulse response function method was chosen, in which, in this case, results are not affected by the ordering of the variables in the VAR systems. Cumulative 10-year periods were considered. Looking at the macrosectors, a 1-standard-deviation shock to $\Delta SGDP$ produces a cumulative positive impact of no more than 4% on ΔGDP , while the same shock to $\Delta MGDP$ produces a cumulative positive impact of 8% on ΔGDP . In addition, a 1-standard-deviation shock to $\Delta IGDP$ produces a cumulative impact of 5% after 10 periods. As shown, a 1-standard-deviation shock to $\Delta AGDP$ produces a very low, near-zero cumulative impact at the end of the period (0.1%) on ΔGDP . In addition, the cumulative impact of a shock to $\Delta TGDP$ on ΔGDP amounted to 7.47% after 10 periods. Lastly, the shocks to $\Delta GFCF$ and $\Delta GFCFME$ have a similar impact on ΔGDP , in particular a cumulative impact of approximately 4%.

The results of the impulse response functions suggest that the stimuli (exogenous shocks) to manufacturing ($\Delta MGDP$) have a considerable (the strongest) impact on the behaviour of GDP over time, in accordance with the estimations of the VAR (1) model.

The analysis of the stability of the VAR (1) model is shown in figure A1.1, which confirms that all roots lie within the unit circle. The resulting eigenvalues confirm that the estimations are stable. Given that all eigenvalues are within the unit circle, the estimated VAR (1) model satisfies the stability condition.

For the autocorrelation test, the Breusch-Godfrey test, also known as the Lagrange multiplier test, was used, and the resulting p -value was 0.4373. Considering a significance of 5%, the test did not reject the null hypothesis that autocorrelation does not exist. In other words, there is no autocorrelation between the residuals. For the heteroscedasticity test, the autoregressive conditional heteroscedasticity test was used, considering a maximum of eight lags. Using this test, the null hypothesis of homoscedasticity, up to a significance level of 5%, was not rejected until the third lag (with a p -value of 0.87).

In view of these results, a fundamental question that should be asked, mainly for the purposes of drawing a contrast with the positive results of the services sector, as shown, is whether industry has ceased to be relevant for economic growth in a representative sample of middle-income countries, such as Brazil. That question is addressed in section IV.2.

2. Panel data estimations

The Hausman test was used to decide whether the panel data models should be estimated with fixed or random effects. Under the null hypothesis that the models are equal, the fixed- and random-effects models are consistent if correctly specified, but the fixed-effects model is inefficient relative to the random-effects model (Wooldridge, 2010).

In the Hausman test, the fixed-effects model was found to be the most appropriate, with a 5% significance level. Nevertheless, the authors also performed the modified Wald test for heteroscedasticity in a fixed-effects regression model, the Wooldridge test for serial correlation in the panel model and the Collin test for multicollinearity. In order to detect heteroscedasticity and autocorrelation at the 5% significance level, the least squares method with panel-corrected standard errors was used. The variance inflation factor (VIF) test did not detect multicollinearity problems.

Linear regression with panel-corrected standard errors calculates estimates for linear cross-sectional time series models where the parameters are estimated by ordinary least squares regression or Prais-Winsten regression. When computing the standard errors and the variance-covariance estimates, the disturbances are assumed, by default, to be heteroscedastic and contemporaneously correlated across panels. To solve this problem, the least squares method with panel-corrected standard errors was used. The results of these estimations are presented in the present section.

Table 9 shows the results of the estimation of equation (1) using the least squares method with panel-corrected standard errors for the panel data of the sample of middle-income countries. In all estimations, the share of the agriculture sector (*aggdps*) has a negative and significant impact on the per capita GDP growth rate (*realgdppc*). This suggests that the agriculture sector negatively influences the per capita GDP growth rate in middle-income economies.

Table 9
Sample of middle-income countries (31 countries): panel-corrected
standard errors estimation for panel data, 1960–2019

	(1)	(2)	(3)	(4)	(5)
	<i>realgdppc</i>	<i>realgdppc</i>	<i>realgdppc</i>	<i>realgdppc</i>	<i>realgdppc</i>
<i>aggdps</i>	-63.22*** (-8.56)	-66.71*** (-8.07)	-114.7*** (-13.09)	-119.2*** (-13.89)	-119.4*** (-16.89)
<i>indshare</i>	21.55*** (5.35)	20.84*** (5.41)	30.45*** (5.59)	28.62*** (5.43)	31.22*** (6.78)
<i>servshare</i>	3.557 (0.96)	4.448 (1.20)	10.65* (2.06)	13.04** (2.68)	15.86*** (3.86)
<i>gfkforshare</i>		37.54*** (9.39)	43.08*** (10.26)	43.92*** (9.83)	45.36*** (10.50)
<i>ttrade</i>			-2.34e-13 (-1.56)	-1.69e-13 (-1.10)	-2.51e-13* (-1.71)
<i>openness</i>				-4.286* (-2.57)	0.0845 (0.06)
<i>inflationrate</i>					0.0518 (0.44)
<i>_cons</i>	5 353.7*** (14.51)	4 405.2*** (13.41)	5 075.0*** (11.25)	5 217.1*** (12.31)	4 432.1*** (13.39)
<i>N</i>	1 211	1 166	1 029	1 029	860

Source: Prepared by the authors.

Note: T-statistic in parentheses. Asterisks: * p < 0.05; ** p < 0.01; *** p < 0.001.

In contrast, the relationship between the share of the industrial (manufacturing) sector (*indshare*) and the per capita GDP growth rate (*realgdppc*) was positive and significant in all estimations. This suggests that the industrial sector, as a driver of growth in the economy and whose impact on the per capita GDP growth rate was almost 100% greater than that of the services sector (see estimation 5), positively influenced the per capita GDP growth rate. The services sector (*servshare*) had a positive influence in all estimations, but was statistically significant only in specifications (3), (4) and (5).

As for the control variables, gross fixed capital formation (*gfkforshare*), a proxy for investment, presented a positive and significant coefficient in all estimations. According to Vieira and Veríssimo (2009), the investment rate is important for growth in any country. These authors highlight the importance of increasing the investment rate in the medium and long term for achieving and sustaining higher rates of economic growth.

The results for the terms of trade variable (*ttrade*) vary depending on the estimation. In the more complete estimated model (see the fifth column), this variable is negative and statistically significant, which suggests that the terms of trade have a negative effect on the economic growth rate. This effect may be associated with possible overvaluations of the exchange rate owing to improved terms of trade in this type of economy. However, further empirical research is needed in that regard.

The openness of the economy (*openness*) and inflation (*inflationrate*) did not present significant coefficients in the more complete model (see the fifth column). This may indicate a loss of importance of these two variables for the per capita GDP growth rate of the economy when other control variables are taken into account.

V. Final considerations

In view of the empirical studies that suggest that structural change has occurred differently over time in developed and emerging countries, leading to differing patterns of economic growth, the aim of this study was to identify how structural change affected economic growth in developing countries between 1960 and 2019 such that countries like Brazil are falling behind.

The present paper contributes to the existing literature by empirically analysing the relationship between structural changes and economic growth using two main econometric methods: (i) the vector autoregression (VAR) model and (ii) panel data microeconometrics.

The first method was used to analyse the effects of structural change in the Brazilian economy on its own development. The VAR model, applied to the period 1948–2020, was employed.

The results obtained for Brazil suggest that, in the structural change process analysed, the importance of the industrial sector for economic growth declined owing to the transfer of labour from high-productivity sectors, such as industry itself, to low-productivity sectors such as services and trade (in aggregate). This led to a decrease in the influence of the industrial sector on the growth rate of the economy. In any case, when the manufacturing sector experiences an exogenous shock, it tends to have stronger accumulated responses than other sectors, especially the services sector.

The aim of the second method was to use panel data to analyse the effects of structural change on a sample of middle-income economies during the period 1960–2019. Important results were observed: the relationship between the share of the industrial sector and the per capita GDP growth rate (*realgdppc*) was positive and significant in all estimations. The results therefore indicate that, between 1960 and 2019, industry was the sector that had the greatest influence on the per capita GDP growth rate in the sample of middle-income countries analysed.

The difference in the results obtained from each method suggests that the increase in the income gap in Brazil (its falling-behind trajectory) when compared with other middle-income countries and with developed countries is due partly to structural change being excessively concentrated in services and trade, sectors that have a smaller impact on the growth rate of per capita income.

In a future empirical study, the same panel data exercise will be carried out using a sample of high-income countries. In the light of the literature studied, it is hypothesized that industry will have a heterogeneous impact on economic growth: the services sector is expected to predominate in part of the sample, while the industrial sector will be even more important in economies that are closer to the technological frontier and have a higher number of patent registrations.

Bibliography

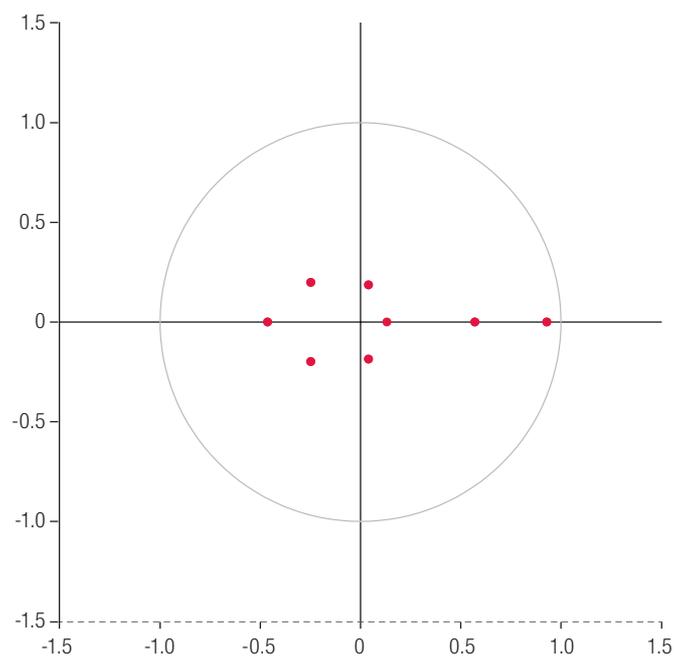
- Acemoglu, D., S. Johnson and J. A. Robinson (2005), "Institutions as a fundamental cause of long-run growth", *Handbook of Economic Growth*, vol. 1, P. Aghion and S. N. Durlauf (eds.), North-Holland.
- Arbache, J. (2015), "Produtividade no setor de serviços", F. De Negri and L. R. Cavalcante (coords.), *Produtividade no Brasil: desempenho e determinantes*, vol. 2, Brasília, Institute of Applied Economic Research (IPEA)/Brazilian Agency for Industrial Development (ABDI).
- Baumol, W. J. (1967), "Macroeconomics of unbalanced growth: the anatomy of urban crisis", *The American Economic Review*, vol. 57, June.
- Bonelli, R. and S. A. Pessôa (2010), "Desindustrialização no Brasil: um resumo da evidência", *Texto para Discussão*, No. 7, Getulio Vargas Foundation (FGV).
- Chang, H.-J. (2016), *Economics: The User's Guide*, London, Penguin.
- Chenery, H. B. (1960), "Patterns of industrial growth", *The American Economic Review*, vol. 50, No. 4, September.
- Cruz, M. J. V. and others (2007), "Uma análise do impacto da composição ocupacional sobre o crescimento da economia brasileira", *Revista EconomiA*, No. 8, December.
- Dasgupta, S. and A. Singh (2005), "Will services be the new engine of Indian economic growth?", *Development and Change*, vol. 36, No. 6, November.
- Doré, N. I. and A. A. C. Teixeira (2023), "The role of human capital, structural change, and institutional quality on Brazil's economic growth over the last two hundred years (1822–2019)", *Structural Change and Economic Dynamics*, vol. 66, September.
- Eichengreen, B. and P. Gupta (2013), "The two waves of service-sector growth", *Oxford Economic Papers*, vol. 65, No. 1, January.
- Enders, W. (2004), *Applied Econometric Time Series*, second edition, New York, Wiley.
- Felipe, J. and others (2012), "Product complexity and economic development", *Structural Change and Economic Dynamics*, vol. 23, No. 1, March.
- Feenstra, R. C., R. Inklaar and M. P. Timmer (2015), "The next generation of the Penn World Table", *The American Economic Review*, vol. 105, No. 10.
- Gabriel, L. F. and L. C. S. Ribeiro (2019), "Economic growth and manufacturing: an analysis using Panel VAR and intersectoral linkages", *Structural Change and Economic Dynamics*, vol. 49, June.
- Gala, P. (2017), "Desenvolvimento econômico: divisão do trabalho, retornos crescentes e complexidade", *Complexidade econômica: uma nova perspectiva para entender a antiga questão da riqueza das nações*, Rio de Janeiro, International Celso Furtado Center for Development Policies/Contraponto.
- Haraguchi, N., C. F. C. Cheng and E. Smeets (2017), "The importance of manufacturing in economic development: has this changed?", *World Development*, vol. 93, May.
- Hausman, J. A. and W. E. Taylor (1981), "Panel data and unobservable individual effects", *Econometrica*, vol. 49, No. 6, November.
- Hirschman, A. O. (1958), *The Strategy of Economic Development*, New Haven, Yale University Press.
- IBGE (Brazilian Institute of Geography and Statistics) (2020), "SCN - Sistema de Contas Nacionais" [online] <https://www.ibge.gov.br/estatisticas/economicas/industria/9052-sistema-de-contas-nacionais-brasil.html?edicao=35337>.
- IPEA (Institute of Applied Economic Research) (2021), IPEADATA [online] www.ipeadata.gov.br [accessed on 17 de December 2021].
- Kaldor, N. (1967), *Strategic Factors in Economic Development*, New York State School of Industrial and Labor Relations, Cornell University.
- _____(1966), *Causes of the Slow Rate of Economic Growth of the United Kingdom: An Inaugural Lecture*, Cambridge, Cambridge University Press.
- Kuznets, S. (1966), *Modern Economic Growth: Rate, Structure and Spread*, London, Yale University Press.
- Lavopa, A. and A. Szirmai (2018), "Structural modernisation and development traps: an empirical approach", *World Development*, vol. 112, December.
- Lima, R. M. N., L. F. Gabriel and F. G. Jayme Jr. (2022), "Manufacturing and economic complexity: a multisectorial empirical analysis", *Investigación Económica*, vol. 81, No. 322, October–December.
- Marconi, N., C. F. B. Reis and E. C. Araújo (2016), "Manufacturing and economic development: the actuality of Kaldor's first and second laws", *Structural Change and Economic Dynamics*, vol. 37, June.
- Maroto-Sánchez, A. and J. Cuadrado-Roura (2009), "Is growth of services an obstacle to productivity growth? A comparative analysis", *Structural Change and Economic Dynamics*, vol. 20, No. 4, December.

- McMillan, M., D. Rodrik and Í. Verduzco-Gallo (2014), “Globalization, structural change, and productivity growth, with an update on Africa”, *World Development*, vol. 63.
- Myrdal, G. (1957), *Economic Theory and Under-Developed Regions*, London, Gerald Duckworth & Co.
- Nakabashi, L., F. D. Scatolin and M. J. V. Cruz (2010), “Structural change in Brazilian economy and its effects upon economic growth”, *Revista de Economia Contemporânea*, vol. 14, No. 2, August.
- Nassif, A., C. Feijó and E. Araújo (2015), “Structural change and economic development: is Brazil catching up or falling behind?”, *Cambridge Journal of Economics*, vol. 39, No. 5, September.
- Ngai, L. R. and C. A. Pissarides (2007), “Structural change in a multi-sector model of growth”, *The American Economic Review*, vol. 97, No. 1, March.
- Pasinetti, L. (1993), *Structural Economic Dynamics: A Theory of the Economic Consequences of Human Learning*, Cambridge, Cambridge University Press.
- Porcile, G., D. Spinola and G. Yajima (2023), “Growth trajectories and political economy in a Structuralist open economy model”, *Review of Keynesian Economics*, vol. 11, No. 3.
- Rodrik, D. (2016), “Premature deindustrialization”, *Journal of Economic Growth*, vol. 21, No. 1, March.
- (2013a), “The past, present, and future of economic growth”, *Working Paper*, No. 1, Global Citizen Foundation.
- (2013b), “Unconditional convergence in manufacturing”, *The Quarterly Journal of Economics*, vol. 128, No. 1, February.
- Romer, P. M. (1990), “Endogenous technological change”, *Journal of Political Economy*, vol. 98, No. 5, part 2, October.
- Rosenstein-Rodan, P. N. (1943), “Problems of industrialisation of Eastern and South-Eastern Europe”, *The Economic Journal*, vol. 53, No. 210/211, June–September.
- Spinola, D. (2020), “Debating the assumptions of the Thirlwall model: a VECM analysis of the balance of payments for Argentina, Brazil, Colombia, and Mexico”, *Working Paper Series*, No. #2020-001, United Nations University-Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT).
- Su, D. and Y. Yao (2016), “Manufacturing as the key engine of economic growth for middle-income economies”, *ADB Working Paper Series*, No. 573, Asian Development Bank Institute (ADB).
- Szirmai, A. (2012), “Industrialisation as an engine of growth in developing countries, 1950–2005”, *Structural Change and Economic Dynamics*, vol. 23, No. 4, December.
- Szirmai, A. and B. Verspagen (2015), “Manufacturing and economic growth in developing countries, 1950–2005”, *Structural Change and Economic Dynamics*, vol. 34, September.
- Teixeira, F. O., F. J. Missio and R. Dathein (2022), “Distribution and demand in Brazil: empirical evidence from the structural and aggregative approaches”, *Journal of Post Keynesian Economics*, vol. 45, No. 4.
- Tregenna, F. (2009), “Characterising deindustrialisation: an analysis of changes in manufacturing employment and output internationally”, *Cambridge Journal of Economics*, vol. 33, No. 3.
- UNIDO (United Nations Industrial Development Organization) (2013), *Industrial Development Report 2013. Sustaining Employment Growth: The Role of Manufacturing and Structural Change*, Vienna.
- Vieira, F. V. and M. P. Veríssimo (2009), “Crescimento econômico em economias emergentes selecionadas: Brasil, Rússia, Índia, China (BRIC) e África do Sul”, *Economia e Sociedade*, vol. 18, No. 3, December.
- Vu, K. M. (2017), “Structural change and economic growth: Empirical evidence and policy insights from Asian economies”, *Structural Change and Economic Dynamics*, vol. 41, June.
- Wooldridge, J. M. (2010), *Econometric Analysis of Cross Section and Panel Data*, second edition, The MIT Press.

Annex A1

Vector autoregression model (1) stability conditions

Figure A1.1
Inverse roots of the autoregressive characteristic polynomial



Source: Prepared by the authors on the basis of estimates made using the EViews 9.0 software.

Annex A2

Johansen cointegration tests

Table A2.1
Unrestricted Johansen cointegration rank test
(Trace)

Hypothesized	Trace		0.05	
Number of cointegrating equations	Eigenvalue	Statistic	Critical value	Probability*
None	0.389364	83.86497	83.93712	0.0706
At most 1	0.276651	49.33715	60.06141	0.2875
At most 2	0.171011	26.66675	40.17493	0.5457
At most 3	0.097525	13.53834	24.27596	0.5760
At most 4	0.080255	6.355372	12.32090	0.3940
At most 5	0.007107	0.499267	4.129906	0.5428

Source: Prepared by the authors.

Note: Trace test indicates no cointegration at the 0.05 level. * *P*-values calculated in accordance with J. G. MacKinnon, A. A. Haug and L. Michelis, "Numerical distribution functions of likelihood ratio tests for cointegration", *Journal of Applied Econometrics*, vol. 14, 1999.

Table A2.2
Unrestricted Johansen cointegration rank tests
(Eigenvalue)

Hypothesized	Maximum eigenvalue		0.05	
Number of cointegrating equations	Eigenvalue	Statistic	Critical value	Probability*
None	0.389364	34.52783	36.63019	0.0862
At most 1	0.276651	22.67040	30.43961	0.3363
At most 2	0.171011	13.12841	24.15921	0.6814
At most 3	0.097525	7.182963	17.79730	0.7926
At most 4	0.080255	5.856106	11.22480	0.3663
At most 5	0.007107	0.499267	4.129906	0.5428

Source: Prepared by the authors on the basis of estimates made using the EViews 9.0 software.

Note: Maximum eigenvalue test indicates no cointegration at the 0.05 level. * *P*-values calculated in accordance with J. G. MacKinnon, A. A. Haug and L. Michelis, "Numerical distribution functions of likelihood ratio tests for cointegration", *Journal of Applied Econometrics*, vol. 14, 1999.