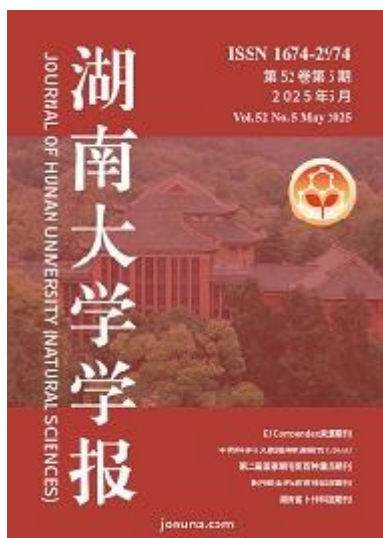




Journal of Hunan University (Natural Sciences)

Vol. 52 No. 5

May 2025

Available online at

<https://jionuns.com>



ELSEVIER
Scopus



Clarivate
WEB OF SCIENCE

Open Access Article

 <https://doi.org/10.55463/issn.1674-2974.52.5.14>

Strategies to Boost the Industrial Sector's Share of GDP and Curb Deindustrialization in Brazil

Wagner Cardoso^{*1}, Regiane Máximo Siqueira¹, Diogo Ferraz²

¹Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP-Bauru, Brazil

²Universidade de São Paulo – USP, Brazil

* Corresponding author: wagner_engprod@yahoo.com.br

Article History:

Received: April 2, 2025

Revised: May 6, 2025

Accepted: May 15, 2025

Published online: June 30, 2025

Abstract: Deindustrialization undermines economic performance in both advanced and emerging economies, yet few empirical studies translate expert knowledge into concrete industrial-policy priorities. This article identifies and ranks strategies for increasing the Brazilian industrial sector's share of gross domestic product (GDP) and reversing the country's deindustrialization trend. We first applied the DPSIR (Driving Forces–Pressures–State–Impact–Responses) framework to structure insights from specialists in economics, public law, scientific research, and public- and private-sector management who are directly involved in industrial development. We then used the TOPSIS multi-criteria decision method to order the recommended actions by implementation urgency. The results produce a clear hierarchy of policy measures, with the highest priority accorded to establishing a coherent medium-term industrial-planning agenda that reflects Brazil's present structural position. To our knowledge, this is the first study to integrate DPSIR and TOPSIS for the formulation and prioritization of national reindustrialization strategies, offering a replicable approach for economies facing premature deindustrialization.



Copyright: © 2025 by the authors. Licensee JHU

This article is an open-access article distributed under the terms and conditions of the Creative Commons Attribution License
<http://creativecommons.org/licenses/by/4.0/>

Keywords: Reindustrialization; Industrial policy; Structural change; DPSIR; TOPSIS; Brazil.

提升工业部门在 GDP 中的份额并遏制巴西去工业化的战略

摘要: 去工业化削弱了发达经济体和新兴经济体的经济表现, 然而能够将专家知识转化为具体产业政策优先事项的实证研究仍然匮乏。本文识别并排序了提升巴西工业部门在国内生产总值 (GDP) 中占比、扭转去工业化趋势的策略。首先, 我们应用 DPSIR (驱动力-压力-状态-影响-响应) 框架, 对经济学、公共法、科学研究以及公共与私营部门管理等领域、直接参与工业发展的专家洞见进行结构化整理; 随后采用 TOPSIS 多准则决策方法, 根据实施紧迫性对建议措施进行优先级排序。研究结果形成了清晰的政策措施层级, 最高优先级是制定反映巴西当前结构性定位的中期一致性工业规划议程。据我们所知, 这是首次将 DPSIR 与 TOPSIS 结合, 用于制定并排序国家再工业化战略, 为面临早熟去工业化的经济体提供了可复制的方法。

关键词: 再工业化; 产业政策; 结构变迁; DPSIR ; TOPSIS ; 巴西

1. Introduction

Manufacturing is the main driver of technical progress, raising the standard of living by increasing income and productive investment. This reinforces the idea that manufacturing production is a relevant development strategy for promoting the prosperity of a nation. [1,2] State that Brazil envisioned and experienced a period of industrial growth between 1930 and 1980, transforming its participation in Gross Domestic Product (GDP). However, Brazil's economic conjuncture deteriorated after the 1980s, primarily because of high inflation, and the last 30 years have witnessed a considerable drop in the industrial sector's relative participation in the Brazilian economy.

Various studies have determined that the Brazilian economy has undergone a process of deindustrialization [3, 4, 5, 6], one in which its industry has reduced overall participation in GDP in recent years. According to [2], this deindustrialization occurred because of a reduction in public (in the form of subsidies and public policies to promote industrial development) and private investment across a wide range of industrial sectors, placing the country at a disadvantage in terms of international competitiveness. Low investment is a reflection of the obstacles and inefficiencies across three spheres: government, companies, and universities (precisely, the spheres that make up the so-called triple propeller). Such obstacles arise from ineffective public policies, mismanagement, lack of planning, and lack of strategic vision, among many other factors [2].

Industrial policy aims to promote economic development by stimulating strategic sectors, innovation, and coordination among different economic

instruments [7]. They emphasized the need for clear policies, innovation, and a new institutional organization. The policy adopted by the government between 2003 and 2006, despite having positive aspects, such as an emphasis on innovation and clear goals, also identified weaknesses, such as incompatibility with macroeconomic policy, inconsistencies between economic instruments, deficiencies in infrastructure and the science, technology, and innovation system, as well as a lack of coordination and political will. To develop an effective industrial policy, [7] posits that it is essential to ensure compatibility with macroeconomic policy, coordinate economic instruments in a coherent manner, strengthen infrastructure and innovation systems, and ensure strong political commitment. This matter was similarly addressed by [4], who stated that significant failures in the continuity and coordination of industrial policies over the years, as well as a lack of long-term strategy and solid policies, caused fragmentation of the Brazilian industry and a lack of effective direction for its recovery. [8] Argues that the state should be seen as an active agent in the economy, capable of directing economic growth through innovative and inclusive public policies. The author proposes a new approach to public policy that emphasizes the importance of collaboration between the public and private sectors to foster innovation and to ensure that the benefits of economic growth are widely distributed. [8] suggests that a redefinition of the state's role would lead to more balanced and sustainable development, reduce economic inequalities, and promote social well-being through the creation of new markets and development opportunities.

In the context of the entrepreneurial condition identified by [8], research shows that developed countries are increasingly implementing industrial policies. The research carried out by [9] proposes that the implementation of industrial policies is vital to the economic development of a country for various reasons, such as: (i) promoting reindustrialization and modernization of the industrial sector; (ii) fostering technological innovation in strategic sectors; (iii) correcting market failures through financial support for long-term projects and sectors that require greater initial investment; (iv) creating high-quality jobs; (v) increasing economic resilience by strengthening national productive chains, with less dependence on imports in strategic sectors; (vi) fostering the use of regulations, government purchases, and public-private partnerships as industrial policy instruments; and (vii) encouraging the use of green technologies as a means of leading the country towards sustainable development and a low-carbon economy. According to [9], these reasons explain the growing intention of developed countries (such as the USA and China) to adopt and expand industrial policies as a means of facing contemporary economic challenges, promoting innovation, and ensuring economic competitiveness within the global setting.

Several studies agree that Latin America has generally failed to provide effective industrial development plans and efficient and long-term industrial policies. Latin America had, and in many cases still has, an economy based on commodity exports to the detriment of higher value-added manufactured goods. The situation in Brazil is not very different; the country has failed to develop competitive and well-managed industries across various sectors. Dependence on imported technology and inputs, coupled with a lack of investment in R&D, has compromised innovation and competitiveness in Brazil's national industry. Additionally, there have been failures in the continuity and coordination of industrial policies over time. The absence of a long-term strategy and consistent policies has resulted in fragmentation and a lack of effective direction for the promotion of Brazilian industry [10, 12, 13].

In this context, the research problem of the present article stems from the loss of relative participation of the industrial sector in Brazil's GDP and the absence of a plan for mitigating the process of deindustrialization in the country. To address this problem, the objective of the present research is to offer strategies that may increase the relative participation of the transformation industry in the national GDP. To this end, the DPSIR framework was chosen, being a method which is focused on identifying final objectives and means, as well as fully supporting the process of defining the criteria to be adopted for decision-making [14]. [15], it is relevant to note that DPSIR aims to analyze interconnections

between the environment and society, structuring the problem to be analyzed coherently and cohesively, and using an easy-to-understand methodology appropriate for non-specialists in the area of problem structuring methods.

This study contributes to the literature on industrial policy in many ways. First, although industrial policy studies have focused on building on a theoretical basis, there is a lack of investigations utilizing primary or quantitative data [16]. In this sense, the present article presents strategies for industrial development from the perspective of experts in the areas of economics, public management, private administration, public law, and academic researchers who, possessing demonstrable expertise in the area of economic development, agreed to participate in the research by responding to the study questionnaires. Second, this study is innovative in its application of the DPSIR and TOPSIS methods in the context of the formulation and prioritization of strategies to enhance industrial development. The DPSIR method is relevant in this context because it focuses on intermediate and final objectives and contributes to structuring the problem of deindustrialization in such a way that the connections between the actors are interrelated, generating a virtuous cycle. In addition, to identify the real need to prioritize expert responses after applying the DPSIR method, the TOPSIS method was adopted. The latter compares unit criteria and alternatives and functions as a technique that evaluates the proximity of ideas to an ideal solution and classifies and prioritizes responses using the geometric distance of this ideal solution [14]. Third, this study contributes to the formulation of strategies to promote industrial policies in Brazil. It is worth noting that this type of strategic formulation may also assist future studies in other developing countries that lack strategic plans within the industry, such as India and South Africa [10].

These are the main criteria for choosing the research object:

1. Contextual Relevance: Deindustrialization in Brazil, expressed by the decline in the industrial sector's share of GDP, was chosen because of its critical socioeconomic impact and the absence of structured public policies to mitigate it.

2. Gap in the Literature: The scarcity of empirical and quantitative studies on industrial policies [16], in contrast to predominant theoretical approaches, justifies the need for analyses based on primary data and multisectoral perspectives.

3. Structuring Methodology: The DPSIR framework was chosen for its ability to map causal relationships between society and the economic environment, structuring the problem in a coherent and accessible way, and identifying intermediate and final objectives for strategic decisions.

4. Analytical Innovation: The combination of DPSIR with the TOPSIS method allowed prioritizing responses

from experts (economics, public management, and law) based on proximity to ideal solutions, overcoming subjectivity in policy formulation.

5. Broad Applicability: The strategy aims not only to support Brazilian policies but also to serve as a model for developing countries (e.g., India and South Africa) that face similar challenges of deindustrialization without consolidated strategic plans.

By integrating the DPSIR method to map socioeconomic causalities and TOPSIS to prioritize strategic responses based on proximity to ideal solutions, this study identified, based on multisectoral experts (Economics, Public Law, Management), the urgency of implementing an industrial planning agenda in Brazil that includes technological modernization, targeted tax incentives, strengthening of open innovation policies, and public-private cooperation. Strategies that, in addition to mitigating the decline in the industrial sector's share of GDP, serve as a replicable model for developing countries (such as India and South Africa) that face deindustrialization without structured plans, thus consolidating an innovative approach by combining systemic diagnosis (DPSIR) and quantitative decision-making (TOPSIS) in the formulation of public policies.

This paper is structured into five sections, including the preceding section. Section 2 critically reviews the literature on deindustrialization in the world and Brazil. Section 3 presents DPSIR and TOPSIS methods. Section 4 discusses the results and applications of the methods. Section 5 concludes the paper by addressing the final considerations related to the contributions of the article.

2. Deindustrialization

The purpose of this section is to contextualize the process of deindustrialization, considering its influencer variables and nuances.

2.1 Industrialization worldwide

According to [17], deindustrialization in developed countries occurred due to a loss of industrial employment as a percentage of total employment, rather than due to industry's lost participation in GDP, indicating that such deindustrialization was mature. The author cites the United States, where the percentage of industrial employment over total employment has been constantly falling since the 1950s, from approximately 25% to less than 10% today. However, the participation of industry in GDP has remained constant during this period, supporting the view that the deindustrialization that occurred in the US and in other developed countries, such as England, Japan, Germany, and, more recently, China, was mature [17, 18].

In essence, there are three deindustrialization patterns in the world: (i) what happened in developed countries, where there was a significant drop in

industrial employment percentage over total employment, but a constant participation of industry in GDP; (ii) what happened in Asian countries, where there was an increase in the percentage of industrial employment over total employment and an increase in GDP; and (iii) what happened in Latin American and African countries, where there was a drop in both employment and industry participation in GDP [17].

Observing industrialization from the point of view of late industrialization, [18] states that the countries considered late industrializers (the US, Germany, and France) progressed based on the commercialization of surpluses produced initially by English industries, and then later on the national industry. This occurred because these countries soon learned to internally produce goods that had been previously imported from England, thus generating both the desired industrialization and qualified personnel to achieve it. Study [18] also emphasized that financing industrialization in the countries mentioned was mostly done through state investment or via investment banks. This was especially true in Germany, where banks make major capital contributions to the industry. Therefore, the late industrialization process reproduced the British production narrative and gave rise to national capitalism similar to English capitalism, making it possible for Germany, France, and the USA together as late industrializers [18, 17].

[18] posits that this amounted to the first wave of late industrialization. The second wave occurred during the Long Depression between 1873 and 1896, of which Russia and Japan were precursors, followed by others. Simultaneously, the second industrial revolution took place with the advent of electricity in factories, heavy chemistry, and combustion engines.

According to [19], the protectionism advocated by traditionalists to protect their industries against globalized production actually proved harmful to national economies, increasing production costs and making internal production and job maintenance unfeasible. As the authors attest, protectionism is a strategy that turns against an economy within a short period [19].

According to [19], neoliberals advocate that offshoring leverages the economy as it enables developing countries to increase their job rates in industry (because they have lower labor costs), while developed countries could deliver cheaper and more competitive products to the globalized world, allowing them to devote more time to the research and development of new products and technologies, thus adding value to the goods produced. Studies [19] and [4] warn that for neoliberalism to work, it is necessary to decrease state intervention in the marketplace. Some neoliberal economists, such as Howard Pack and Kamal Saggi, maintain that industrial policies are unnecessary when operating in a globalized and free-trade market.

Study [19] claimed that off-shoring by the USA has brought with it jobs and technologies (knowledge) to producing countries, while leaving a gap regarding learning and innovation. According to the authors, the reverse occurred in South Korea, which had an increase in domestic employment and industrial capacity focused on technology and a knowledge-oriented economy rather than inputs. This difference may be viewed as founded on the focus given in South Korea to knowledge and investment via the development of collaborative innovation networks (comprising real and effective partnerships between universities, companies, and governments) [19].

South Korea's recipe for success has been, [19] state, governmental investment in the form of political priority from the 2000s onwards, in the construction of an industrial ecosystem focused on innovation, and through the creation of research and development funding intended for innovation within governmental production institutes that, in collaboration with private companies, have produced new technologies and created a collaborative Korean innovation network. In the United States, while the Government gave simple tax credits for research and development and direct financial support to individual companies (as a rule, large corporations), the Korean government initially focused on innovative industrial networks and research consortia involving universities, companies (small and medium-sized), and the government itself [19].

China has achieved rapid growth since the introduction of economic reform and opening of its market to the world in 1978, lifting over 700 million people above the poverty line in the process. Since entering the World Trade Organization (WTO) in 2001, China has welcomed many factories to its shores, in search of lower manufacturing costs and an abundant supply of capital and technology, which, by means of knowledge, has enshrined its competitive advantage [20].

However, according to [21, 22, 23], China had the largest per capita income in the world until the 15th century, with many technological innovations (for the time). Despite losing its position as a world leader in terms of per capita income to Europe in 1500, it still boasted the largest national product until the early nineteenth century.

Studies [24, 25] stressed that China's industrial policy, based on the opening of its market between 1980 and 1990, was regulated and controlled by the state, ensuring that the plan was achieved. And since the 1990s, when the Chinese economy opened in its most dynamic form, and especially in 2001, when China joined the WTO, the country greatly strengthened and enhanced its export economy, determining the economic structures of many countries impacted by China's industrial prowess. The extent of China's investment in manufacturing exports meant that in 2007 there were 1.7

million jobs in the Research and Development (R&D) sector, more than 80% of which were scientists and engineers, a percentage exceeding that which existed in Japan, the United Kingdom, France, and Germany [24, 25].

According to [11], industrialization in Latin America followed the development of industries based on intensive labor and construction. The author claims that Latin American countries began the process of deindustrialization in the 1980s, before industry reached its peak in terms of technological development, which had a considerable impact on unemployment and income within the economically active population. This led these countries to focus their efforts on primary areas, such as mining, extraction, and agriculture, resulting in economic regression. In fact, the rise of globalization was a major cause of disruption for economies that were not sufficiently prepared to compete with the world's largest exporters at the global level. It is worth noting that this economic phenomenon was similarly faced by African countries [10].

The work of [26], which disseminated the concept of Dutch disease, is also noteworthy. The author states that Dutch disease is an economic phenomenon that occurs when the discovery or exploitation of natural resources, such as oil, natural gas, and minerals, or even an expanding economic sector, results in negative consequences for a country's economy.

Research [26] attests that Dutch disease usually manifests itself through three main mechanisms: (1) appreciation of local currency; (2) deindustrialization; (3) "Income effect" (with the exploitation of natural resources, a country experiences a significant increase in income and profits, which may lead to a general increase in wages and production costs in other sectors of its economy).

Another study [27] stated that taxation and economic development problems are interconnected. The tax potential of a country depends on administrative efficiency, distribution of income, use of resources, and political will to implement effective policies. According to the author, taxation plays a key role in promoting economic development.

2.2 Deindustrialization in Brazil

[3, 4] pointed out that Brazil's economic development was strongly influenced by a model of industrialization and import replacement, based on the belief that growth could be achieved through internal production and reduced external dependence. This led to a period of intense industrial activity and increased the production of manufactured goods within the country.

Protectionism was then applied to the national industry through high import tariffs and restrictions on the imports of manufactured products. These measures aim to foster internal production and stimulate industrial

sector growth. However, competition with imported products in terms of quality and cost [3, 4, 5, 6, 28].

[4] Notes that Brazilian industrial policy was marked by a series of state interventions that aimed to promote industrialization and boost economic growth. The author points out that the state played a central role in the formulation and implementation of these policies through the creation of tax incentives and subsidies, thereby protecting national industry. One of the main strategies adopted by Brazilian industrial policy was the substitution of imports. The country sought to stimulate internal production and reduce external dependence through high import taxes and commercial restrictions.

[4] Recognizes that this strategy was successful in boosting industrialization in Brazil, allowing the growth of key sectors of the economy, but pointing out that, despite the advances, the country failed to develop competitiveness and sophistication in a number of industrial sectors. The author argues that dependence on imported technology and inputs and a lack of investment in R&D are factors that impair innovation and the competitiveness of the national industry.

Additionally, there was a failure in the continuity and coordination of industrial policies over time; the lack of

a long-term strategy and inconsistent policies led to fragmentation and ineffectiveness in the promotion of the Brazilian industry [4].

Research [29] affirmed that the future of Brazilian industrial development depends primarily on the integration of the primary, secondary, and tertiary sectors – in a collaborative, innovative, and efficient network. The authors claim that Brazil has continued to undergo a process of deindustrialization, characteristic of Dutch disease, especially after the 1990s, but they believe that the process will be reversible with efficient public policies.

Figure 1 details the participation of industry in Brazil's GDP from 1947 to 2021. In 1985 industry participated 48% of the value added to Brazilian GDP, the highest value in the historical series.

After the Brazilian economy opened up to international competition in the 1990s, industrial participation in GDP fell, remaining stable (but low) between 1996 and 2013 at 26% on average.

After 2013, industrial participation in GDP continued to fall, reaching 21.1% in 2017, and the worst since the beginning of the series. Between 2014 and 2016, GDP fell by 8%.

Figure 1 – Industrial participation in GDP, from 1947 to 2021.



Source: CNI (2023).

Industry closed in 2021, with a participation of 23.6% in GDP, representing a slight recovery [30, 31]. These statistics clearly demonstrate a slowdown in Brazil's industry. However, it is important to note that the country holds 13th place in terms of participation in global transformation industry production, at 1.48%. In comparison, China holds first place with 24.83% and the

United States second place with 16.27% of global industrial production [31].

From an analysis of articles taken for bibliographic review drawn from the Web of Science, Scopus, and Scielo databases to determine the factors that led to the deindustrialization process in Brazil, the main factors presented by the authors selected are given in Table 1.

Table 1 – The main factors that led to the industrialization process in Brazil.

Factor	Description	Authors
1	Public policies to promote sectors in which Brazil already held a certain competitive advantage, such as agriculture, mining and construction, to the detriment of the other sectors of the economy	(NASSIF; FEIJÓ; ARAÚJO, 2014); (SAUER; BALESTRO; SCHNEIDER, 2017); (MAGACHO; MCCOMBIE; GUILHOTO, 2018)
2	Total and multilateral opening up of free trade in the 1990s	(FEIJÓ; STEFFENS, 2015)
3	Overvaluation of the exchange rate	(SOUZA, 2017); (OREIRO; MANARIN; GALA, 2021); (PAULA, 2016); (FEIJO; LAMONICA, 2019)
4	Outsourcing of manufacturing activities to service providers	(BERNARD; SMEETS; WARZYNSKI, 2017); (SQUEFF, 2012)
5	Migration of industry and employment to countries where production costs are lower	(SQUEFF, 2012)
6	Low rate of industrial investment	(SQUEFF, 2012)
7	Increased commodity exports, generating financial dependence	(CORDEN, 1984); (Furtado, 1974); (NASSIF; FEIJÓ; ARAÚJO, 2014); (SAUER; BALESTRO; SCHNEIDER, 2017); (MAGACHO; MCCOMBIE; GUILHOTO, 2018); (TRINDADE; COONEY; OLIVEIRA, 2015); (FEIJO; LAMONICA, 2019); (SANTOS; SPOLADOR, 2018)
8	High interest rates	(Bresser-Pereira; Araújo; Peres, 2020); (GAULARD, 2015); (OREIRO; PUNZO; ARAUJO, 2012); (CYPHER, 2015)
9	Inability to coordinate government policy	(OREIRO; PUNZO; ARAUJO, 2012); (CYPHER, 2015)
10	Chinese products at extremely competitive prices	(LIN; WANG, 2020); (FELIPE; MEHTA; RHEE, 2018); (Lábaj; Majzlíková, 2021); (JENKINS; BARBOSA, 2012); (JENKINS, 2015); (CALLEGARI; MELO; CARVALHO, 2018); (HIRATUKA; SARTI, 2017); (SILVA, 2019)
11	High tax burden	(KALDOR, 2021); (JENKINS; BARBOSA, 2012); (JENKINS, 2015); (CALLEGARI; MELO; CARVALHO, 2018)

3. Research method

This study adopted a qualitative and quantitative approach using DPSIR and TOPSIS methods. This research applied a survey of experience as a qualitative approach, in which industrial development experts were interviewed through questionnaires to better understand the problem. As a research method, a survey of experience is used to obtain a new view of a problem, seen through different prisms [32]. To apply the DPSIR and TOPSIS methods, a survey questionnaire was developed using questions based on these methods. Systematic literature review was additionally used in an attempt to identify the state of the art on the subject, thereby seeking to establish the main factors that led to Brazil's deindustrialization process according to researchers in the field [32].

The inclusion criteria for the specialists chosen to participate in the present research were those belonging to the areas of Economics, Public Law, Scientific Research, Public or Private Management; Economists operating for at least five years in private practice or in bodies related to economic development; lawyers specializing in public law; Professor-Researchers from public universities in the area of economics; public sector managers (current or former minister, secretary, superintendent, or other leadership roles in public

agencies linked to economic development); and directors, superintendents, or those in other leadership roles in private companies in the manufacturing sector. Considering the inclusion criteria, 170 specialists were contacted and invited to participate in the first research questionnaire, of which 21 responded (representing 12.35% of the total); for the second questionnaire, 19 of the 280 invitees responded (representing 6.79%); and for the third questionnaire, 8 of the 290 invitees responded (representing 2.76%). After considering the responses received, it was concluded that, although the sample size was small, the necessary distribution of professionals per area was obtained. It is important to note that the profile of each of the invited experts was studied prior to the invitation to participate in the research, strictly obeying the inclusion and exclusion criteria, as mentioned above.

The research questionnaire process was, as previously stated, divided into 3 phases: phase 1 covered the application of questionnaire 1, which dealt with the level of agreement of the specialists regarding each of the factors that led to deindustrialization; phase 2, questionnaire 2, related to the application of DPSIR with the participating experts; and phase 3, questionnaire 3, related to the TOPSIS method and how the most urgent strategies should be prioritized.

3.1 The DPSIR method

The vast majority of published works concern the environment and deal with problems related to land use and occupation, tourism, sustainability, and natural resource management, such as those found in [33, 34]. However, it should be noted that the application of the DPSIR method is not limited to the environmental field, and DPSIR adoption has been expanded to other fields as a result of two factors: (i) the DPSIR structure indicators linked to the political objectives that arise from the problem analyzed; and (ii) because it is simple and clear, DPSIR attracts political actors when the constructions are causal relationships [35].

DPSIR can be understood as an economic and social development (driving forces - D) that exerts pressure (P) on the environment, consequently changing the state (S) of the environment, causing impacts (I) on ecosystems, health, and society in general, resulting in a response (R) from society that feeds back to the driving forces, the state, and/or the impacts through mitigation, adaptation,

or healing actions [36, 37]. No publication has been found relating the DPSIR to industrialization. Notably, even when DPSIR applications exist in terms of development issues, they all consider the environment.

3.2 The TOPSIS method

According to [38], the creators of the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method did so to judge that the chosen alternative must have the shortest distance from the ideal and, as far as possible, from the negative ideal solution. The logic is simple: imagine that each attribute has increasing (or decreasing) utility, which makes it easy to think that the ideal solution is made up of all the best attribute values achievable, and the ideal negative solution is the worst attribute values achievable [38], which are classified in order of preference from the most ideal to the least ideal.

Table 2 – The main applications of DPSIR in terms of global economic development.

Article	Authors	Title	Main applications
1	Wu, Cao, Fang, Wang e Li (2022)	A systematic coupling analysis framework and multi-stage interaction mechanism between urban land use efficiency and ecological carrying capacity.	Presents a study on the unification of urbanization and economic efficiency through urban land use, enabling sustainable development.
2	Xu, Wang, Tang e Ye (2022)	Tourism circular economy: identification and measurement of tourism industry greening.	Proposes an evaluation indicator system for the greening of the tourism industry based on DPSIR and presents policy suggestions to improve the development of regional tourism greening.
3	Xiao, Chen, Wang e Lu (2022)	Regional green development level and its spatial spillover effects: empirical evidence from Hubei province, China.	DPSIR used to measure the level of green development in a Chinese region, and suggesting policy proposals for such development.
4	Sun, Zhu, Zhang, Zeng, Li, Wang, Dong e Zhou (2022)	New indices system for quantifying the nexus between economic-social development, natural resources consumption, and environmental pollution in China between 1978 and 2018.	DPSIR used to propose a new index system in order to ascertain the connection between complex socioeconomic, natural and environmental resources.
5	Li, Wang, Zhao, Zhao e Zhang (2021)	Research on the Evaluation of Real Estate Inventory Management in China.	DPSIR used to integrate economic, social and environmental factors to evaluate the performance of real estate management in China.
6	Toloi, Bonilla, Toloi, Silva e Nääs (2021)	Development Indicators and Soybean Production in Brazil.	Categorized the 30 largest soy producing municipalities in Brazil with the help of DPSIR to establish classification factors, based on the influence of soybean production on local economies, the number of jobs generated, and the impact on the environment.

The method is applied sequentially by calculating the weighted standard decision matrix of Equation 1 below, determining the positive and negative ideal solutions of

equations 2 and 3, calculating the separation measurement of equations 4 and 5, and calculating the relative proximity of the ideal solution of equation 6.

$$V = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1j} & \cdots & v_{1n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ v_{i1} & v_{i2} & \cdots & v_{ij} & \cdots & v_{in} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mj} & \cdots & v_{mn} \end{bmatrix} \quad [1]$$

$$\begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots & w_j r_{1j} & \cdots & w_n r_{1n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ w_1 r_{i1} & w_2 r_{i2} & \cdots & w_j r_{ij} & \cdots & w_n r_{in} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ w_1 r_{m1} & w_2 r_{m2} & \cdots & w_j r_{mj} & \cdots & w_n r_{mn} \end{bmatrix}$$

$$A^+ = \{(\max v_{ij} | j \in J), (\min v_{ij} | j \in J') | i = 1, 2, \dots, m\} = \{v_1^*, v_2^*, \dots, v_j^*, \dots, v_n^*\} \quad [2]$$

$$A^- = \{(\min v_{ij} | j \in J), (\max v_{ij} | j \in J') | i = 1, 2, \dots, m\} = \{v_1^-, v_2^-, \dots, v_j^-, \dots, v_n^-\} \quad [3]$$

$$S_i^+ = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^*)^2}, \quad i = 1, 2, \dots, m \quad [4]$$

$$S_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2}, \quad i = 1, 2, \dots, m \quad [5]$$

$$C_i^* = \frac{S_i^-}{S_i^+ + S_i^-}, \quad 0 < C_i^* < 1, \quad i = 1, 2, \dots, m \quad [6]$$

After executing the calculations, the alternatives are classified in order of preference, from the most ideal to the least ideal.

4. Discussion

4.1 Factors that led to deindustrialization in Brazil

In the first phase of the survey with experts, 24 of 170 questionnaires were returned. A high percentage of the respondents (44.4%) had training in economics and 83.3% had at least 16 years of experience in the area. The career positions held were analysts and managers of private and/or public initiatives, finance/investment/research/research directors, university dean, investment bank director, university professors, consultants, an internationally renowned university course coordinator, and the director of a federal-level public agency. Regarding the geographical

distribution of the 24 specialists who responded, 21 were from the southeast region, one from the southern region, and two from the mid-west. Of these 24, 12 were private initiatives and 12 were civil servants. This demographic profile corroborates the knowledge base of the experts participating in the survey and provides credibility to the information collected.

The experts responded to the questionnaire by noting their agreement with the 11 factors that led to Brazil's deindustrialization: factors established through the bibliographic review. A 5-point Likert scale was used, varying between total or partial agreement, indifference, and total or partial disagreement. Table 3 presents the factors and their respective levels of agreement according to the experts who participated in Questionnaire 1, classified in descending order. The factors that had at least 50% agreement among experts were considered to have led to deindustrialization in Brazil. Eight factors, namely 9, 6, 8, 11, 3, 10, 2, and 5, reached this level of agreement. Table 3 presents this information as a means of validating the factors with the experts, by order of agreement, and with the objective of continuing to apply the other questionnaires that follow.

4.2 Strategies to reverse deindustrialization in Brazil

In Phase 2, the same specialists who answered Questionnaire 1 were invited to respond to Questionnaire 2, the DPSIR application, which consisted of five questions that contextualized DPSIR in the scenario evaluated. The questions were as follows:

1. Among the eight factors presented above that led to deindustrialization, which do you think are the true motivators of deindustrialization in Brazil? (D)
2. What pressures did the factors stated above trigger in the economic and industrial environment? (P)
3. How was the environment where the changes were affected by the pressures mentioned earlier? (S)
4. What impacts were generated by pressure in the state as a result of the factors that led to deindustrialization? (I)
5. What are your proposals to reverse the process of deindustrialization in Brazil? (R)

Table 3 – Factors that led to the deindustrialization of Brazil and the levels of agreement among experts, classified in descending order.

	Factors that led to desindustrialization in Brazil	Level of agreement
9	Inability to coordinate government policy	87,50%
6	Low rate of industrial investment	83,33%
8	High interest rates	75,00%
11	High tax burden	66,67%
3	Over valorization of the currency exchange rate	62,50%
10	Chinese products at extremely competitive prices	58,33%
2	Total and multilateral opening of free trade in the 1990s	50,00%
5	The migration of industry and employment to countries where production costs are lower	50,00%
1	Public policies to promote sectors in which Brazil already held a certain competitive advantage, such as agriculture, mining and civil construction, to the detriment of the other sectors of the economy	37,50%
7	Increased commodity exports, generating financial dependence	33,33%
4	Outsourcing of manufacturing activities to service provision sectors	20,83%

Each phase of the DPSIR was denoted as follows: D for Driving forces, P for Pressures, S for State, I for Impacts, and R for Responses. For each item relating to a specific phase, a unique sequential number corresponding to the letter representing its phase was given, such as D1, D2, etc. Similar answers were grouped according to their answers.

Table 4 – D – Driving forces

D - Driving forces
- Inability to coordinate governmental policy (D1);
- Low rate of industrial investment (D2);
- High interest rates (D3);
- High tax burden (D4);
- Over valorization of the currency exchange rate (D5);
- Chinese products at extremely competitive prices (D6);
- Total and multilateral opening of free trade in the 1990s (D7);
- Migration of industry and employment to countries where production costs are lower (D8).

Table 5 – P – Pressures.

P - Pressures
- Lack of stimulation for internal production and emphasis given to the importation of manufactured goods (P1);
- Retraction, lack of competitiveness and innovation (P2);
- Investments focused much more on reformulating depreciated productive capital than on expanding industrial productive capacity (P3);
- The ineffective coordination of governmental policy causes pressures in the economic and industrial environment, since it does not outline actions to improve infrastructure, incentives for industrial diversification or provide incentives for new companies (P4);
- Vicious cycle with poorly qualified labor and reduced job opportunities in medium and highly qualified occupations displaced to other countries (P5);
- Globalization (P6);
- Cost pressures and increased competition (P7);
- Instability and reduced profitability (P8);
- Low investment rates in the sector (P9);
- Stimulation of importation (P10);
- High production costs (P11);
- Stimulation of rentism (P12).

Table 6 – S – State.

S - State
- Unfavorable and uncompetitive business environment (S1);
- Lack of perspective and incentives for investment (S2);
- Pressured and strangled, where the brand strength is placed in check, to the detriment of the search for price (S3);
- Importing manufactured products and exporting commodities, resulting in job creation in lower value-added sectors and negative environmental impacts, since commodities are intensive consumers of natural resources, leading to the scale effect (S4);
- Migration of resources to the service sector (S5);
- Weak development of technological skills in Brazilian companies, especially those resulting from R&D efforts, even in sectors of low technological intensity (S6);
- Most Brazilian regions have suffered from deindustrialization, leaving companies with obsolete machinery, indebtedness and stiff competition from parallel substitute products (Made in China) (S7);
- External open market without a strategic selective counterpart (S8);
- Unstable and unprofitable markets (S9);
- Economic growth rates below the global average, unemployment and underemployment (S10).

Table 7 – I – Impacts.

I - Impacts
- Poor economic growth (I1);
- Little competitiveness among national companies (I2);
- Decrease in employment and tax collection (I3);
- Lower qualified employment (I4);
- Loss of knowledge (I5);
- Innovation policies more focused on credit than economic subsidy (I6);
- Unemployment in specialist sectors (I7);
- Closure of businesses within various economic sectors (I8);
- Reduced investment in R&D across companies (I9);
- Increase in the incidence of less-qualified services (I10);
- Increased distance from technological skills dominated by Brazil in relation to those abroad (I11);
- No replacement of obsolete capital (I12);
- Aging production lines, low quality and high costs (I13);
- No entry into Global Production Chains (I14);
- Lack of coordination between industrial and macroeconomic policies (I15);
- Drop in sectoral income and national income levels (I16);
- Reduction in investment in employee skills (I17);
- Decreased employee income (I18);
- Fall in the consumption of industrialized Brazilian products (I19);
- Retraction of the sector in the country (I20);
- Increased informality and socioeconomic inequality (I21).

Table 8 – R – Responses.

R - Responses
- Simplification of the Tax System with VAT (Value Added Tax) and Tax Reduction (Tax Reform) (R1);
- Economic public policies aimed at developing areas of excellence, bringing them to less privileged areas (R2);
- Institutional change, since economic decisions come from groups of individuals who act according to the institutions defined by Douglass North, and from individual conduct as well (while it does not change, no policy will be effective beyond the years of each government and despite formal rules and norms existing, policies need to stay beyond four-year terms, regardless) (R3);
- Critical analysis of the technological restrictions of industrial processes and products manufactured in relation to global markets, and, based on mapping from the analysis, establish financial means for research and development projects together with universities and research centers to reduce the existing technological gap (R4);
- Increase the industrial investment rate, with subsidized interest and other measures (e.g. economic subsidy) for sectors that generate more innovation in both products and processes, ranging from base industries to the aerospace industry (R5);
- A well-conducted opening up of commerce would help to strengthen industry (R6);
- Slightly undervalued exchange rate, but without causing spurious competitiveness under terms suggested by Fernando Fajnzylber (Fernando Fajnzylber was an important thinker for Latin American development and created the new theoretical approach to ECLAC (Economic Commission for Latin America and the Caribbean) in the 1990s, which led to the project of “Productive transformation with equity”. The main objective of his work was to overcome obstacles to constant economic growth and social exclusion in Latin America, seeking to create a development model that was less dependent and less excluding, while promoting economic growth and social equity). (R7);
- Investment in education at all levels (especially fundamental), incentivizing technical courses (R8);
- Implementation of a planning agenda that takes into account the current Brazilian position, with its weaknesses and potential (R9);
- Implementation of charging mechanisms and the liability of beneficiaries of targeted public resources, as well as public agents responsible for the implementation of industrial policies (R10);
- Industrialization in niches of opportunity (clear comparative advantages) seems to be a sustainable goal (R11);
- UNASUR (Union of South American Nations) regional block for CGV (Global Value Chain) in South America with lower transportation costs (R12);
- Mapping industries and identifying their challenges in recent years/decades, recognizing at the same time that it is worth understanding the process of change in value chains around the world and the technological challenges that currently present themselves. However, the establishment of a channel of permanent dialogue with industrial sectors and representatives is required, to design a broader industrial policy and at the same time coordinate with other macroeconomic policies, aiming to ensure competitiveness and international partnerships for national industry (R13);
- Concession for state-owned companies with gross fixed-capital formation goals (R14);
- Enable Direct Foreign Investment (DFI) in employment and income generating sectors: companies that are committed to bringing international monetary resources for investment in the country (R15);
- Monetary policy and National Infrastructure Investment Plan (R16);
- Continuity for the advancement of labor reform (R17);
- Administrative reform (R18);
- Minimum income for people with disabilities (R19);
- Recovery of the macroeconomic tripod (fiscal responsibility, inflation goals and floating exchange rate) (R20).
- Increased informality and socioeconomic inequality (I21).

4.3 Action Prioritization: Application of TOPSIS

In Phase 3, 290 questionnaires were sent (Questionnaire 3) to experts in the area of economic development, encompassing economic science, engineering, administration, and law. Although only eight experts responded, a low number were expected because the questionnaire included 160 questions as a result of the application of the TOPSIS method. The participants in this phase comprised six economists, a lawyer, and an engineer. Six of the participants had over

16 years of experience. In terms of location, six specialists hailed from the southeastern region of Brazil, one from the southern region, and one from the mid-west.

5. Results

The experts were asked to indicate (on a 5-point Likert scale) the extent to which they agreed that a certain response resolved a certain factor that led to deindustrialization. The experts' responses were then calculated as the average of the response and factor, as presented in Table 9.

Table 9 – Result of the averages of expert responses for each factor that led to deindustrialization.

SPECIALISTS' RESPONSES TO RESOLVE THESE FACTORS	Inability to coordinate public policy (F1)	Low industrial investment rate (F2)	High interest rates (F3)	High tax burden (F4)	Exchange rate overvaluation (F5)	Chinese products at extremely competitive prices (F6)	Total and multilateral opening of free trade in the 1990s (F7)	Migration of industry and employment to countries where production costs are lower (F8)
- Simplification of the tax system with VAT reduction of taxes and rates (tax reform) (R1);	6,00	6,25	3,50	6,75	3,50	5,50	4,50	6,25
- Economic public policies aimed at developing areas of excellence and bringing them to less privileged areas (R2);	7,50	7,25	2,75	4,75	2,75	5,50	6,00	6,50
- Institutional change, as economic decisions start from groups, individuals who act according to the institutions defined by Douglass North, as well as individual conduct (while not changing, no policy will be effective beyond the years of each government and despite the existing formal rules and norms, policies need to stay beyond at least 4 years, regardless) (R3);	5,50	4,75	3,75	4,50	4,50	4,75	4,75	5,25
- Critical analysis of the technological restrictions of industrial processes and products manufactured in relation to the international market. Based on mapping from the analysis, therefore, establish financing lines for research and development projects together with universities and research centers to reduce the existing technological gap (R4);	7,00	6,50	3,50	5,00	3,50	6,25	5,00	6,75
- Increase the industrial investment rate, with subsidized interest and other measures (e.g. economic subsidy) for sectors that generate more innovation in both products and processes, but ranging from the base industry to the aerospace industry (R5);	6,25	7,00	3,75	4,75	4,00	5,00	5,50	5,75
- Well-conducted open commerce aids in strengthening industry (R6);	5,00	4,00	3,50	3,25	3,25	3,25	4,50	3,75
- Slightly undervalued exchange rate, but without causing spurious competitiveness under Fernando Fajnzylber (Fernando Fajnzylber was an important thinker for Latin American development and created the new theoretical approach to ECLAC in the 1990s, which led to the project of "productive transformation with equity." His work had as its main objective to overcome obstacles to constant economic growth and social exclusion in Latin America, seeking to create a development model that was less dependent and less excluding, while promoting economic growth and social equity). (R7);	5,50	5,75	3,75	4,00	6,00	5,00	5,50	5,75
- Investment in education at all levels (especially fundamental), stimulating technical courses (R8);	7,00	6,50	3,00	4,00	3,25	5,00	4,75	7,25
- Implementation of a planning agenda that takes into account the current Brazilian position, with its weaknesses and potential (R9);	7,75	7,75	5,00	6,00	6,00	6,75	6,50	7,50
- Implementation of charging mechanisms and liability for beneficiaries of targeted public resources, as well as public agents responsible for the implementation of industrial policies (R10);	6,25	5,50	3,00	4,50	3,75	4,25	4,75	4,50
- Industrialization in niches of opportunity (clear comparative advantages) seems to be a sustainable goal (R11);	5,75	6,25	2,25	3,25	3,25	6,25	6,00	6,75
- UNASUR regional block for CGV (Global Value Chain) in South America with lower transportation costs (R12);	5,00	5,25	2,50	3,75	4,75	6,25	6,00	6,00
- Mapping industries and identifying their challenges in recent years/decades; at the same time deciding whether it is worth understanding the process of change in value chains around the world and the technological challenges that currently present themselves. However, this needs the establishment of permanent dialogue with industrial sectors and representatives to design a broader industrial policy and at the same time coordinate with other macroeconomic policies, aiming to ensure competitiveness and international partnerships for the national industry (R13);	6,75	7,25	3,25	4,25	5,25	7,25	6,25	7,00
- Concession of state-owned companies with fixed gross capital goals (R14);	5,00	4,25	2,75	3,00	2,50	3,00	4,00	4,00
- Enabling Direct Foreign Investment (DFI) in employment and income generating sectors, companies that are committed to bringing international monetary resources for investment in the country (R15);	4,75	4,75	3,50	3,75	4,50	3,00	4,50	4,75
- Política monetária e plano nacional de investimentos em infraestrutura (R16);	7,25	6,00	5,75	5,00	4,25	5,50	5,75	5,50
- Continuity of advancement in labor reform (R17);	3,25	2,75	1,75	2,75	2,00	2,75	3,00	4,00
- Administrative reform (R18);	3,50	2,75	2,75	3,50	2,50	2,25	3,25	3,75
- Minimum income for people with disabilities (R19);	5,50	5,25	2,75	2,50	2,50	3,25	4,00	4,25
- Recovery of Macroeconomic Tripod (Fiscal Responsibility, Inflation Goals and Floating Exchange) (R20).	3,75	4,00	3,25	4,75	4,25	3,25	3,75	3,75

Following this, a step-by-step TOPSIS analysis was carried out to build the normalized, weighted standardized matrix, the positive and negative ideal solutions, the separation measures, the relative proximity of the ideal solution, and the classification in the order of preference, as shown in Table 10.

As can be seen, the priority response according to the experts following the application of the TOPSIS method is R9, which states that resolving the factors that led to

deindustrialization, and thus mitigating the ongoing deindustrialization process, requires the implementation of a planning agenda that considers the current Brazilian position, with its weaknesses and potential. Thus, the order of priority continues until the least prioritized, which, according to the same experts, is R17, to resolve the factors that led to the deindustrialization of Brazil requires a continuation of labor reforms.

Table 10 – Responses to resolve the factors that led to Brazil's deindustrialization after application of the TOPSIS method, classified by priority order.

SPECIALISTS' RESPONSES TO RESOLVE THE FACTORS	Relative proximity to the ideal solution (Ci*)
- Implementation of a planning agenda that takes into account the current Brazilian position, with its weaknesses and potential (R9);	0,8869
- Monetary policy and National Infrastructure Investment Plan (R16);	0,7142
- Mapping industries and identifying their challenges in recent years/decades; at the same time deciding whether it is worth understanding the process of change in value chains around the world and the technological challenges that currently present themselves. However, this needs the establishment of permanent dialogue with industrial sectors and representatives to design a broader industrial policy and at the same time coordinate with other macroeconomic policies, aiming to ensure competitiveness and international partnerships for the national industry (R13);	0,6494
- Critical analysis of the technological restrictions of industrial processes and products manufactured in relation to the international market. Based on mapping from the analysis, therefore, establish financing lines for research and development projects together with universities and research centers to reduce the existing technological gap (R4);	0,6046
- Increase the industrial investment rate, with subsidized interest and other measures (eg economic subsidy) for sectors that generate more innovation in both products and processes, but ranging from the base industry to the aerospace industry (R5);	0,5957
- Simplification of the tax system with VAT, reduction of taxes and rates (tax reform) (R1);	0,5920
- Slightly undervalued exchange rate, but without causing spurious competitiveness under Fernando Fajnzylber (Fernando Fajnzylber was an important thinker for Latin American development and created the new theoretical approach to ECLAC in the 1990s, which led to the project of "productive transformation with equity." His work had as its main objective to overcome obstacles to constant economic growth and social exclusion in Latin America, seeking to create a development model that was less dependent and less excluding, while promoting economic growth and social equity). (R7);	0,5658
- Public economic policies aimed at developing areas of excellence and bringing them to less privileged areas (R2);	0,5549
- Investimento em educação em todos os níveis (com destaque para a básica), estímulo aos cursos técnicos (R8);	0,5185
- Institutional change, as economic decisions start from groups, individuals who act according to the institutions defined by Douglass North, as well as individual conduct (while not changing, no policy will be effective beyond the years of each government and despite the existing formal rules and norms, policies need to stay beyond at least 4 years, regardless) (R3);	0,4912
- UNASUR regional block for CGV (Global Value Chain) in South America with lower transportation costs (R12);	0,4617
- Implementation of collection mechanisms and liability for beneficiaries of targeted public resources, as well as public agents responsible for the implementation of industrial policies (R10);	0,4560
- Industrialization in niches of opportunity (clear comparative advantages) seems to be a sustainable goal (R11);	0,4548
- Enabling Direct Foreign Investment (DFI) in employment and income generating sectors, companies that are committed to bringing international monetary resources for investment in the country (R15);	0,3896
- Recovering the Macroeconomic Tripod (Fiscal Responsibility, Inflation Goals and Floating Exchange) (R20).	0,3407
- Well-conducted open commerce aids in strengthening industry (R6);	0,3169
- Minimum income for people with disabilities (R19);	0,3002
- Concession of state-owned companies with gross fixed capital formation goals (R14);	0,2421
- Administrative reform (R18);	0,1519
- Continuity in the advance of labor reform (R17);	0,0407

6. Conclusion

The present research concludes that the strategies to maximize industry participation in GDP and mitigate the process of deindustrialization, using the DPSIR and TOPSIS methods, according to the experts (Table 10),

may be summarized as follows: (i) implementation of a planning agenda that considers the current Brazilian position, with its weaknesses and potentials; (ii) creation of a monetary policy and national plan for infrastructure investments; (iii) mapping of industries and identifying

their challenges in recent years/decades, and at the same time understanding the process of changes in the value chains around the world and the current technological challenges, establishing a permanent channel of dialogue with sectors and industrial representatives to design a broader industrial policy and simultaneously coordinate with other macroeconomic policies, aiming to ensure competitiveness and international partnerships for the national industry.

Despite recognizing that the respondents of the present research mostly derive from the southeastern region of Brazil, the opinions thus stated are believed to be representative of the Brazilian industry as a whole, given that the industrial sector focuses on this region. In addition, the application of these strategies through government action plans following the priority order established by TOPSIS offers the potential to positively impact Brazil's industrial sector and economy as a whole. This is justified by the fact that, as previously elucidated, its industrial sector plays a crucial role in boosting a nation: because even in the age of technology, the transformation industry has the ability to generate income at scales larger than other sectors of the economy, even those that have a similar level of employment, precisely because of the scalability factor that industry has, one which needs other collaborative networks so that it is productive, efficient and generates financial assets for a nation.

If public authorities choose to invest in the future implementation of the strategies proposed by the specialists consulted in the present study, Brazil may witness a reversal in the process of deindustrialization. This would place the country in a more advantageous economic position than it currently enjoys. Furthermore, it is worth noting that the strategies suggested by experts in relation to Brazil can equally serve as a guide in other developing countries where deindustrialization processes, with analogous characteristics, have been similarly faced.

In brief, the present study contributes to the expansion of scientific knowledge on the theme of deindustrialization by introducing a new application of DPSIR and TOPSIS as a method of analysis, alignment, triggering, and prioritization of strategic responses to the problem of Brazilian deindustrialization, paving the way for future research on the operationalization of such strategies.

Based on the strategies prioritized by experts - contextualized planning agendas, monetary policy linked to infrastructure investments, sectoral mapping integrated with macroeconomic policies, and ongoing dialogue with global value chains – it is recommended that Brazilian public managers adopt a sequential and multisectoral action plan aligned with the order of urgency defined by the TOPSIS method to reverse deindustrialization. This implies:

1. Creating a technical-industrial council with representatives from the government, private sector, and academia responsible for monitoring the implementation of strategies and adjusting them to global dynamics (e.g., technological transition, reshoring);

2. Linking fiscal and credit policies to sectoral productivity and innovation goals, ensuring synergy between logistics infrastructure, clean energy and technological training;

3. Institutionalizing international cooperation channels to attract investments in strategic sectors (e.g., bioeconomy and semiconductors) and replicating successful partnership models in countries such as South Korea and Germany. The application of these measures would not only strengthen the national industry but would also position Brazil as a reference for developing nations (e.g., India and South Africa) that face similar challenges, using the DPSIR-TOPSIS framework as an adaptable model for diagnosis and prioritization.

This study paves the way for future research on three main fronts:

1. Methodological expansion: Testing the combined application of DPSIR-TOPSIS in reindustrialization contexts in other countries, comparing results, and adjusting criteria to local realities (e.g., protectionism vs. trade openness);

2. Sectoral in-depth analysis: Analyzing the heterogeneous impacts of the proposed strategies in specific industrial subsectors (e.g., advanced manufacturing vs. traditional industries), considering variables such as automation, labor, and regulatory costs.

3. Policy monitoring: Develop dynamic indicators to assess the effectiveness of strategies over time, integrating real-time data (big data) and predictive models that capture the effects of externalities (e.g., sustainability and regional inequality).

In addition, it is urgent to explore political and institutional barriers to the implementation of recommendations, such as lobbying by competing sectors (e.g., agribusiness) and regulatory instability, which are topics that have not been addressed in the literature. Finally, the integration of artificial intelligence into the DPSIR-TOPSIS framework could optimize the prioritization of responses in scenarios of global uncertainty, consolidating a new line of interdisciplinary research between industrial economics and data science.

ACKNOWLEDGEMENTS

We thank the experts who enriched this research with their know-how in the form of the answers submitted to the questionnaires, and the Higher Education Personnel Improvement Coordination (Capes) Program for its support to UNESP/Bauru PPGE. The third author also wishes to acknowledge the support of the National

Council for Scientific and Technological Development (CNPq), Process no. 311036/2022-8.

Author Contributions

Conceptualization, Wagner Cardoso; methodology, Wagner Cardoso and Regiane Máximo Siqueira; software, Wagner Cardoso; validation, Wagner Cardoso, Regiane Máximo Siqueira and Diogo Ferraz; formal analysis, Wagner Cardoso, Regiane Máximo Siqueira and Diogo Ferraz; investigation, Wagner Cardoso; resources, Wagner Cardoso and Regiane Máximo Siqueira; data curation, Wagner Cardoso and Regiane Máximo Siqueira; writing—original draft preparation, Wagner Cardoso; writing—review and editing, Wagner Cardoso, Regiane Máximo Siqueira and Diogo Ferraz; visualization, Wagner Cardoso, Regiane Máximo Siqueira and Diogo Ferraz; supervision, Wagner Cardoso and Regiane Máximo Siqueira; project administration, Wagner Cardoso; funding acquisition, Wagner Cardoso and Regiane Máximo Siqueira. All the authors have read and agreed to the published version of the manuscript.

Funding statement

The authors did not receive support from any organization for the submitted work.

Conflict of interest

On behalf of all the authors, the corresponding author states that there are no conflicts of interest. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

Data availability statement

The data used in this study are available upon request from the authors to ensure transparency and promote research replicability.

References

- [1] Morceiro, P. (2012). Desindustrialização na economia brasileira no período de 2000-2011: abordagens e indicadores. *Cultura Acadêmica*.
- [2] Fries, C. E., Müller Filho, R., Ferentz, D., & Christmann, F. (2019). DIAGNÓSTICO DO GRAU DE DESENVOLVIMENTO E DOS FATORES DE IMPACTO NA IMPLEMENTAÇÃO DA INDÚSTRIA 4.0 NO SETOR INDUSTRIAL CATARINENSE. *Simpósio de Pesquisa Operacional e Logística da Marinha - Publicação Online*. <https://www.proceedings.blucher.com.br/article-details/diagnostico-do-grau-de-desenvolvimento-e-dos-fatores-de-impacto-na-implementao-da-industria-40-no-setor-industrial-catarinense-34499>
- [3] Furtado, C. (1974). *O mito do desenvolvimento econômico*. Círculo do Livro.
- [4] Tavares, M. (1979). *Da substituição de importações ao capitalismo financeiro: ensaios sobre economia brasileira*. Zahar Editores.
- [5] Jenkins, R. (2015). Is Chinese competition causing deindustrialization in Brazil? *Latin American Perspectives*, 42(6), 42–63. <https://doi.org/10.1177/0094582x15593553>
- [6] Jenkins, R., & Barbosa, A. de F. (2012). Fear for manufacturing? China and the future of industry in Brazil and Latin America. *The China Quarterly*, 209, 59–81. <https://doi.org/10.1017/s0305741011001482>
- [7] Suzigan, W., & Furtado, J. (2006). Política industrial e desenvolvimento. *Revista de Economia Política*, 26(2), 163–185. <https://doi.org/10.1590/s0101-31572006000200001>
- [8] Mazzucato, M. (2022). The Inclusive Entrepreneurial State: Collective Wealth Creation and Distribution. *Institute for Fiscal Studies: London, UK*, 1.
- [9] Juhász, R., Lane, N., & Rodrik, D. (2023). *The new economics of industrial policy*. National Bureau of Economic Research.
- [10] van Neuss, L. (2018). Globalization and deindustrialization in advanced countries. *Structural Change and Economic Dynamics*, 45, 49–63. <https://doi.org/10.1016/j.strueco.2018.02.002>
- [11] van Neuss, L. (2018). The drivers of structural change. *Journal of Economic Surveys*, 33(1), 309–349. <https://doi.org/10.1111/joes.12266>
- [12] Bresser-Pereira, L. C., & Gala, P. (2010). Macroeconomia estruturalista do desenvolvimento. *Brazilian Journal of Political Economy*, 30(4), 663–686. <https://doi.org/10.1590/s0101-31572010000400007>
- [13] Bárcena, A., Bielschowsky, R., Torres, M., (2022). *El Pensamiento De La CEPAL (2009-2018): hacia una estrategia neoestructuralista de desarrollo basada en un enfoque de derechos*. *El Trimestre Económico*. 73–109.
- [14] Marttunen, M., Lienert, J., & Belton, V. (2017). Structuring problems for Multi-Criteria Decision Analysis in practice: A literature review of method combinations. *European Journal of Operational Research*, 263(1), 1–17. <https://doi.org/10.1016/j.ejor.2017.04.041>
- [15] Bell, S. (2012). DPSIR=A Problem Structuring Method? An exploration from the “Imagine” approach. *European Journal of Operational Research*, 222(2), 350–360. <https://doi.org/10.1016/j.ejor.2012.04.029>
- [16] Ferraz, D., Falguera, F. P. S., Mariano, E. B., & Hartmann, D. (2021). Linking economic complexity, diversification, and industrial policy with sustainable development: A structured literature

review. *Sustainability*, 13(3), 1265. <https://doi.org/10.3390/su13031265>

[17] Rodrik, D. (2015). Premature deindustrialization. *Journal of Economic Growth*, 21(1), 1–33. <https://doi.org/10.1007/s10887-015-9122-3>

[18] Oliveira, C. A. (2003). *Processo de industrialização: do capitalismo originário ao atrasado*. Unesp.

[19] Kim, K. M., & Kwon, H.-K. (2017). The state's role in globalization: Korea's experience from a comparative perspective. *Politics & Society*, 45(4), 505–531. <https://doi.org/10.1177/0032329217715614>

[20] Lin, J. Y., & Wang, Y. (2020). Seventy years of economic development: A review from the Angle of new structural economics. *China & World Economy*, 28(4), 26–50. <https://doi.org/10.1111/cwe.12340>

[21] Harvey, D. (2012). *O neoliberalismo: histórias e implicações*. Loyola.

[22] Harvey, D. (2016). *17 contradições e o fim do capitalismo*. Boitempo.

[23] Ruiz, R. M. (2006). *Polarizações e desigualdades: desenvolvimento regional na China. Texto para Discussão*. UFMG/Cedeplar. <https://core.ac.uk/download/pdf/6519975.pdf>

[24] Masiero, G., & Coelho, D. B. (2014). A política industrial chinesa como determinante de sua estratégia going global. *Brazilian Journal of Political Economy*, 34(1), 139–157. <https://doi.org/10.1590/s0101-31572014000100009>

[25] Nolan, P. (2002). China and the global business revolution. *Cambridge journal of economics*, 26(1), 119–137. <https://doi.org/10.1093/cje/26.1.119>

[26] Corden, W. M. (1984). Booming Sector and Dutch Disease Economics: survey and consolidation. *Oxford Economic Papers*, 359–380.

[27] Kaldor, N. (2021). El papel de la tributación en el desarrollo económico. *El Trimestre Económico*, 88(352), 1215–1244. <https://doi.org/10.20430/ete.v88i352.1346>

[28] Callegari, J., Melo, T. M., & Carvalho, C. E. (2018). The peculiar insertion of Brazil into global value chains. *Review of Development Economics*, 22(3), 1321–1342. <https://doi.org/10.1111/rode.12386>

[29] Bacha, E. & Bolle, M. (2015). *O futuro da indústria no Brasil: desindustrialização em debate*. Civilização Brasileira.

[30] Mishra, A. K., Theertha, A., Amoncar, I. M., & Manogna. (2022). Equity market integration in emerging economies: a network visualization approach. *Journal of Economic Studies (Glasgow, Scotland)*, 50(4), 696–717. <https://doi.org/10.1108/jes-07-2021-0343>

[31] CNI-Confederação Nacional da Indústria. (2023). *Perfil da Indústria Brasileira*. Confederação Nacional da Indústria. Obtido 23 de fevereiro de 2023,

de

<https://industriabrasileira.portaldaindustria.com.br/grafico/total/producao/#/industria-total>

[32] Gil, A. C., & Reis Neto, A. C. dos. (2021). Survey de Experiência como Pesquisa Qualitativa Básica em Administração. *Revista de Ciências da Administração*, 22(56), 125–137.

<https://doi.org/10.5007/2175-8077.2020.e74026>

[33] Gupta, S. (2015). Decoupling: a step toward sustainable development with reference to OECD countries. *International Journal of Sustainable Development and World Ecology*, 22(6), 510–519. <https://doi.org/10.1080/13504509.2015.1088485>

[34] Wu, Q., Cao, Y., Fang, X., Wang, J., & Li, G. (2022). A systematic coupling analysis framework and multi-stage interaction mechanism between urban land use efficiency and ecological carrying capacity. *The Science of the Total Environment*, 853(158444), 158444.

<https://doi.org/10.1016/j.scitotenv.2022.158444>

[35] Gari, S. R., Newton, A., & Icely, J. D. (2015). A review of the application and evolution of the DPSIR framework with an emphasis on coastal social-ecological systems. *Ocean & Coastal Management*, 103, 63–77. <https://doi.org/10.1016/j.ocecoaman.2014.11.013>

[36] Maxim, L., Spangenberg, J. H., & O'Connor, M. (2009). An analysis of risks for biodiversity under the DPSIR framework. *Ecological Economics: The Journal of the International Society for Ecological Economics*, 69(1), 12–23. <https://doi.org/10.1016/j.ecolecon.2009.03.017>

[37] Trevizan, F. F., Siqueira, R. M., Aragão, A. de S., Dos Santos, H. H., & de Oliveira Sabino, F. H. (2022). A Meta-Analytic framework for developing protocols to attend child and adolescent victims of sexual violence. *International Journal of Environmental Research and Public Health*, 19(9), 5233. <https://doi.org/10.3390/ijerph19095233>

[38] Hwang, C.-L., & Yoon. (1981). *Multiple Attribute Decision Making: methods and applications a state-of-the-art survey*. Springer Verlag.

参考文献:

[1] Morceiro, P. (2012 年)。2000-2011 年期間巴西經濟的去工業化：方法和指標。學術文化。

[2] Fries, C. E., Müller Filho, R., Ferentz, D., & Christmann, F. (2019). 診斷聖卡塔琳娜州工業部門實施工業 4.0 的發展程度和影響因素。海軍運籌學與後勤研討會 - 在線出版物。

<https://www.proceedings.blucher.com.br/article-details/diagnostico-do-grau-de-desenvolvimento-e-dos->

fatores-de-impacto-na-implementao-da-industria-40-no-setor-industrial-catarinense-34499

[3] 富爾塔多, C. (1974 年)。經濟發展的神話。書圈。

[4] 塔瓦雷斯, M. (1979 年)。從進口替代到金融資本主義：關於巴西經濟的論文。Zahar 編輯。

[5] 詹金斯, R. (2015 年)。中國的競爭是否導致了巴西的去工業化？拉丁美洲視角, 42 (6), 42-63。 <https://doi.org/10.1177/0094582x15593553>

[6] 詹金斯, R., 和巴博薩, A. de F. (2012 年)。對製造業的擔憂？中國以及巴西和拉丁美洲工業的未來。中國季刊, 209, 59-81。 <https://doi.org/10.1017/s0305741011001482>

[7] Suzigan, W. 和 Furtado, J. (2006)。產業政策與發展。政治經濟學雜誌, 26 (2), 163-185。 <https://doi.org/10.1590/s0101-31572006000200001>

[8] 馬祖卡托, M. (2022 年)。包容性創業國家：集體財富創造和分配。財政研究所：英國倫敦, 1。

[9] Juhász, R., Lane, N., & Rodrik, D. (2023)。產業政策的新經濟學。國家經濟研究局。

[10] 范諾伊斯, L. (2018 年)。發達國家的全球化和去工業化。結構變化與經濟動態, 45, 49-63。 <https://doi.org/10.1016/j.strueco.2018.02.002>

[11] van Neuss, L. (2018 年)。結構性變化的驅動力。經濟調查雜誌, 33 (1), 309-349。 <https://doi.org/10.1111/joes.12266>

[12] Bresser-Pereira, L. C., & Gala, P. (2010)。結構主義發展巨集觀經濟學。巴西政治經濟學雜誌, 30 (4), 663-686。 <https://doi.org/10.1590/s0101-31572010000400007>

[13] Bárcena, A., Bielschowsky, R., Torres, M., (2022)。拉加經委會思考 (2009-2018)：邁向基於權利的方法的新結構主義發展戰略。經濟季。73-109。

[14] Marttunen, M., Lienert, J., & Belton, V. (2017)。實踐中多標準決策分析的結構問題：方法組合的文獻綜述。歐洲運籌學雜誌, 263 (1), 1-17。 <https://doi.org/10.1016/j.ejor.2017.04.041>

[15] 貝爾, S. (2012 年)。DPSIR=A 問題結構化方法？對「Imagine」方法的探索。歐洲運籌學雜誌, 222 (2), 350-360。 <https://doi.org/10.1016/j.ejor.2012.04.029>

[16] Ferraz, D., Falguera, F. P. S., Mariano, EB, & Hartmann, D. (2021)。將經濟複雜性、多元化和產業政策與可持續發展聯繫起來：結構化文獻綜述。可持續性, 13 (3), 1265。 <https://doi.org/10.3390/su13031265>

[17] 羅德里克, D. (2015 年)。過早的去工業化。經濟增長雜誌, 21 (1), 1-33。 <https://doi.org/10.1007/s10887-015-9122-3>

[18] 奧利維拉, CA (2003 年)。工業化進程：從原始資本主義走向落後。不。

[19] Kim, K. M., & Kwon, H.-K. (2017)。國家在全球化中的作用：比較視角下的韓國經驗。政治與社會, 45 (4), 505-531。 <https://doi.org/10.1177/0032329217715614>

[20] 林, JY 和王, Y. (2020 年)。經濟發展七十年：從新結構經濟學的角度回顧。中國與世界經濟, 28 (4), 26-50。 <https://doi.org/10.1111/cwe.12340>

[21] 哈威, D. (2012 年)。新自由主義：歷史和影響。洛約拉。

[22] 哈威, D. (2016 年)。17 矛盾和資本主義的終結。博伊坦普。

[23] 魯伊斯, RM (2006)。兩極分化和不平等：中國的區域發展。用於討論的文字。UFMG/Cedeplar 的。 <https://core.ac.uk/download/pdf/6519975.pdf>

[24] Masiero, G., & Coelho, D. B. (2014)。中國的產業政策是其全球發展戰略的決定因素。巴西政治經濟學雜誌, 34 (1), 139-157。 <https://doi.org/10.1590/s0101-31572014000100009>

[25] 諾蘭, P. (2002)。中國和全球商業革命。劍橋經濟學雜誌, 26 (1), 119-137。 <https://doi.org/10.1093/cje/26.1.119>

[26] 科登, WM (1984)。蓬勃發展的部門和荷蘭疾病經濟學：調查和整合。牛津經濟論文, 359-380。

[27] 卡爾多, N. (2021 年)。稅收在經濟發展中的作用。經濟區, 88 (35 2), 1215-1244。 <https://doi.org/10.20430/ete.v88i352.1346>

[28] Callegari, J., Melo, TM, & Carvalho, CE (2018)。巴西融入全球價值鏈的獨特性。發展經濟學評論, 22 (3), 1321-1342。 <https://doi.org/10.1111/rode.12386>

[29] Bacha, E. & Bolle, M. (2015 年)。巴西工業的未來：爭論中的去工業化。巴西文明。

[30] Mishra, A. K., Theertha, A., Amoncar, I. M., & Manogna. (2022)。

新興經濟體的股票市場整合：一種網路可視化方法。*經濟研究雜誌*（蘇格蘭格拉斯哥），50（4），696-717。 <https://doi.org/10.1108/jes-07-2021-0343>

[31] CNI-全國工業聯合會。（2023）。*巴西工業概況*。全國工業聯合會。2023年2月23日從 <https://industriabrasileira.portaldaindustria.com.br/grafico/total/producao/#/industria-total> 檢索

[32] 吉爾, A. C., & Reis Neto, A. C. dos. (2021)。作為管理中基礎定性研究的經驗調查。*管理科學雜誌*, 22（56），125-137。 <https://doi.org/10.5007/2175-8077.2020.e74026>

[33] 古普塔, S. (2015年)。脫鉤：參考經合組織國家邁向可持續發展的一步。*國際可持續發展與世界生態學雜誌*, 22（6），510-519。 <https://doi.org/10.1080/13504509.2015.1088485>

[34] Wu, Q., Cao, Y., Fang, X., Wang, J., & Li, G. (2022)。城市土地利用效率與生態承載力的系統耦合分析框架和多階段交互機制。*總體環境科學*, 853（158444），158444。 <https://doi.org/10.1016/j.scitotenv.2022.158444>

[35] Gari, S. R., Newton, A., & Icely, J. D. (2015)。對DPSIR框架的應用和演變的回顧，重點是沿海社會生態系統。*海洋與沿海管理*, 103，63-77。 <https://doi.org/10.1016/j.ocecoaman.2014.11.013>

[36] Maxim, L., Spangenberg, JH, & O'Connor, M. (2009)。DPSIR框架下的生物多樣性風險分析。*生態經濟學：國際生態經濟學會雜誌*, 69（1），12-23。 <https://doi.org/10.1016/j.ecolecon.2009.03.017>

[37] Trevizan, F. F., Siqueira, R. M., Aragão, A. de S., Dos Santos, H. H., & de Oliveira Sabino, F. H. (2022)。一個元分析框架，用於制定照顧兒童和青少年性暴力受害者的協定。*國際環境研究與公共衛生雜誌*, 19（9），5233。 <https://doi.org/10.3390/ijerph19095233>

[38] Hwang, C.-L., & Yoon. (1981)。多屬性決策：方法和應用：最先進的調查。施普林格出版社。

Appendix A: References in table 1 and 2

Bernard, A. B., Valerie, & Warzynski, F. (2017)。Rethinking deindustrialization. *Economic Policy*, 5-38。 <https://doi.org/10.1093/epolic/eiw016>

Bresser-Pereira, L. C., Araújo, E. C., & Costa Peres, S. (2020)。An alternative to the middle-income trap. *Structural Change and Economic Dynamics*, 52, 294-312。 <https://doi.org/10.1016/j.strueco.2019.11.007>

Cypher, J. M. (2015)。Emerging contradictions of Brazil's Neo-developmentalism: Precarious growth, redistribution, and deindustrialization. *Journal of Economic Issues*, 49(3), 617-648。 <https://doi.org/10.1080/00213624.2015.1071961>

Feijo, C., & Lamonica, M., Tostes. (2019)。Policy space in a financially integrated world: The Brazilian case in the 2000s. *Panoeconomicus*, 66(1), 51-67。 <https://doi.org/10.2298/pan160502002f>

Feijó, F. T., & Steffens, C.. (2015)。Comércio internacional, alocação do trabalho e a questão da desindustrialização no Brasil: uma abordagem utilizando equilíbrio geral computável. *Revista De Economia Contemporânea*, 19(1), 135-161。 <https://doi.org/10.1590/198055271916>

Felipe, J., Aashish, & Rhee, C. (2018)。Manufacturing matters...but it's the jobs that count. *Cambridge Journal Of Economics*, 19, 139-168。

Gaulard, M. (2015)。The Brazilian deindustrialization: financialization is not guilty. *Brazilian Journal of Political Economy*, 35(2), 227-246。 <https://doi.org/10.1590/0101-31572015v35n02a02>

Hiratuka, C., & Sarti, F. (2017)。Transformações na estrutura produtiva global, desindustrialização e desenvolvimento industrial no Brasil. *Brazilian Journal of Political Economy*, 37(1), 189-207。 <https://doi.org/10.1590/0101-31572016v37n01a10>

Lábaj, M., & Majzlíková, E. (2021)。Drivers of deindustrialisation in internationally fragmented production structures. *Cambridge Journal of Economics*, 46(1), 167-194。 <https://doi.org/10.1093/cje/beab046>

Li, W., Weng, L., Zhao, K., Zhao, S., & Zhang, P. (2021)。Research on the evaluation of real estate inventory management in China. *Land*, 10(12), 1283。 <https://doi.org/10.3390/land10121283>

Magacho, G. R., McCombie, J. S. L., & Guilhoto, J. J. M. (2018)。Impacts of trade liberalization on countries' sectoral structure of production and trade: A structural decomposition analysis. *Structural Change and Economic Dynamics*, 46, 70-77。 <https://doi.org/10.1016/j.strueco.2018.04.003>

Nassif, A., Feijó, C., & Araújo, E. (2014)。Structural change and economic development: is Brazil catching up or falling behind? *Cambridge Journal of Economics*, 39(5), 1307-1332。 <http://www.jstor.org/stable/24695970>

OCDE (1993)。OECD core set of indicators for environmental performance reviews, Organization for economic cooperation and development. OCDE。

Oreiro, J. L., Punzo, L. F., & Araújo, E. C. (2012)。Macroeconomic constraints to growth of the Brazilian

economy: diagnosis and some policy proposals. *Cambridge Journal of Economics*, 36(4), 919–939. <https://doi.org/10.1093/cje/bes010>

Oreiro, J., Luis, Manarin, L., Luiz, & Gala, P. (2021). complexidade econômica e sobrevalorização cambial: o caso do Brasil (1998-2017). *PSL Quarterly Review*, 313–341.

Paula, G. M. (2016). Deindustrialization in Brazil? Em *The New Brazilian Economy* (pp. 63–85). Palgrave Macmillan US.

Santos, P. F. A., & Spolador, H. F. S. (2018). Produtividade Setorial e Mudança Estrutural no Brasil – Uma Análise para o Período 1981 a 2013. *Revista Brasileira de Economia*, 72(2). <https://doi.org/10.5935/0034-7140.20180011>

Sauer, S., Balestro, M. V., & Schneider, S. (2017). The ambiguous stance of Brazil as a regional power: piloting a course between commodity-based surpluses and national development. *Globalizations*, 15(1), 32–55. <https://doi.org/10.1080/14747731.2017.1400232>

Silva, J. A. (2019). Regional deindustrialization: concepts, causes, effects and the Brazilian case. *Gestão & produção*, 26(4). <https://doi.org/10.1590/0104-530x4682-19>

Souza, F. E. P. de. (2017). Para que desta vez seja diferente. *Estudos Avançados*, 31(89), 111–123. <https://doi.org/10.1590/s0103-40142017.31890012>

Squeff, G. C. (2012). *Desindustrialização em debate: aspectos teóricos e alguns fatos estilizados da economia brasileira*. Radar: tecnologia, produção e comércio exterior. https://portalantigo.ipea.gov.br/agencia/images/stories/PDFs/livros/livros/20150415_livro_dinamica_macross_etorial.pdf

Toloi, M. N., Vituri, Bonilla, S., Helena, Toloi, R., Carlo, Silva, H. R., Oliveira, & Nääs, I. (2021). *Development Indicators and Soybean Production in Brazil. Agriculture*.

Trindade, J. R., Cooney, P., & de Oliveira, W. P. (2015). Industrial trajectory and economic development: Dilemma of the re-primarization of the Brazilian economy. *The Review of Radical Political Economics*, 48(2), 269–286. <https://doi.org/10.1177/0486613415591807>

Xiang, Bokuan, Shuai, Heng, Kuai, Bin, Zhanfeng, & Zhou, C. (2022). New indices system for quantifying the nexus between economic-social development, natural resources consumption, and environmental pollution in China during 1978-2018. *Science Of The Total Environment*, 150–180.

Xiao, Y., Jun, Xiaolin, & Lu, X. ([s.d.]). *Regional green development level and its spatial spillover effects: empirical evidence from hubei province, china. Ecological Indicators*.

Xu, A., Wang, C., Tang, D., & Ye, W. (2022). Tourism circular economy: Identification and measurement of tourism industry ecologization. *Ecological Indicators*, 144(109476), 109476. <https://doi.org/10.1016/j.ecolind.2022.109476>

Word count (excluding references): 8,777 words.

Peer-review record:

- *Fast-track status:* Not fast-tracked
- *First-round reviews received:* 3 reports
- *Revision cycles completed:* 3 rounds
- *Final version submitted:* May 17, 2025

Disclaimer/Publisher's Note:

The views, opinions and data expressed in this article are solely those of the authors and do not necessarily reflect those of the *Journal of Hunan University (Natural Sciences)* or its editors. The journal and its editorial staff accept no responsibility for any injury to persons or damage to property resulting from the ideas, methods, instructions or products discussed herein.