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From Commodities to Bioeconomy: Shaping Brazil's Economic Future Over the Last Forty Years

Das *Commodities* à Bioeconomia: moldando o futuro econômico do Brasil ao longo dos últimos quarenta anos

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Abstract: This study examines Brazil's shift from manufactured exports to commodities and evaluates bioeconomy as a strategy to counter reprimarization. Trade liberalization and the early 21st century commodity boom deepened Brazil's dependence on primary products, increasing economic vulnerability. Using a literature review and descriptive analysis, the study concludes that bioeconomy-based industrialization can enhance value-added production, strengthen global value chain integration, and mitigate Dutch disease effects. This study contributes by linking structural economic transformation with sustainable reindustrialization, positioning bioeconomy as a viable path for Brazil's economic resilience.

Keywords: Reprimarization, Bioeconomy, Dutch Disease, Global Value Chains, Brazil.
JEL Classification: F14, O13, Q56

Resumo: Este estudo analisa a mudança do Brasil de exportações manufaturadas para *commodities* e avalia a bioeconomia como estratégia para reverter a reprimarização. A liberalização comercial e o *boom* das *commodities* do início do século XXI aprofundaram a dependência de produtos primários, aumentando a vulnerabilidade econômica. Utilizando revisão de literatura e análise descritiva, conclui que a bioindustrialização pode agregar valor, fortalecer a integração às cadeias globais de valor e mitigar a doença holandesa. O estudo contribui ao conectar transformação estrutural e reindustrialização sustentável, posicionando a bioeconomia como alternativa para a resiliência econômica do Brasil.

Palavras-chave: reprimarização, bioeconomia, doença holandesa, cadeias globais, Brasil.
Classificação *JEL*: F14, O13, Q56

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1. Introduction

Over the past forty years, Brazil's economic landscape has undergone significant transformations. In the 1980s, the country focused on import substitution and industrialization, leading to a diversified export profile predominantly composed of manufactured goods (Mattei; Santos Júnior, 2009). However, since the early 2000s, there has been a notable shift towards the export of agricultural and mineral commodities. This shift, known as reprimarization, has raised concerns about Brazil's economic vulnerability and its dependence on primary products (Oreiro; Feijó, 2010).

Trade liberalization policies implemented in the 1990s, coupled with the global commodity price boom in the early 21st century, significantly impacted Brazil's export dynamics (Medeiros e Cintra, 2015). While these changes spurred economic growth, they also exposed the country to the risks associated with commodity dependence, such as price volatility and the Dutch disease effect. The Dutch disease refers to the negative consequences of a resource-dependent economy, including currency appreciation and the decline of the manufacturing sector (Bresser-Pereira, 2020).

Thus, there is a notable change in Brazil's exports in a relatively short period of time. Although some theorists, such as Sachs *et al.* (1995), claim that a more open economy is subject to greater growth in the long run, it is important to emphasize that, in the case of Brazil, specifically in this period, the country opens the door to a possible vulnerability that may be decisive for future crises in the trade balance in the long term.

While the literature extensively discusses Brazil's process of deindustrialization and commodity dependence, few studies have examined the potential of bioeconomy as a viable pathway for reindustrialization in a sustainable manner. This paper contributes to bridging this gap by analyzing how bioeconomy strategies can be leveraged to counteract reprimarization, foster industrial upgrading, and enhance Brazil's position in Global Value Chains (GVCs) through innovation-driven sustainable development. By integrating structural economic change and bioeconomic transition, this study provides a novel perspective on the long-term trajectory of Brazil's productive structure.

Given this situation, what can be done for Brazil to restructure the growth of the manufactured products sector and, consequently, the added value linked to it? It is in this sense that this work seeks to understand what the bioeconomy is and how its incorporation into the production process would help the country to redefine its insertion in GVCs and conquer an important portion of the international trade of industrialized products, along with incentives for sustainable development.

The bioeconomy addressed in this work follows the concepts originated by Georgescu-Roegen (1971). Later these concepts were improved, based on the sustainable use of renewable biological resources for the mass production of goods, services, and energy, integrating scientific knowledge, advanced technologies, and sustainable practices to develop innovative solutions that are economically viable and ecologically responsible. In the Brazilian context, the application of bioeconomy principles holds particular relevance due to the country's vast biodiversity, strong agribusiness sector, and growing

biotechnology capabilities. Unlike traditional models of industrialization, which often rely on fossil-based inputs, Brazil has the opportunity to develop high-value-added industries centered around sustainable biological resources. This perspective aligns with the country's strategic need to diversify exports while reducing environmental impact and increasing technological complexity in production processes.

By adopting bioeconomy-based approaches, it is possible to reduce reliance on non-renewable resources, such as fossil fuels, and explore more sustainable alternatives. This includes the use of biomass as a feedstock to produce biofuels, bioplastics, biofertilizers, bioagricultural inputs, among other products. In addition, bioeconomy also involves the development of more efficient and environmentally friendly production processes, such as biotechnology, genetic engineering, and production in closed systems, aiming to minimize waste and negative impacts on the environment.

Thus, this study aims to analyze the shift in Brazil's export profile from manufactured goods to agricultural and mineral commodities, shaping the process of reprimarization of the economy, and explore the potential of bioeconomy as a strategy to reverse this trend. By incorporating bioeconomy principles, Brazil can add value to its primary products through technological advancements and sustainable practices, enhancing its Gross Domestic Product (GDP) and global value chain participation (Nobre; Nobre, 2018).

Methodologically, this study employs a structured review of economic trends and policy frameworks, supported by data on trade composition, industrial output, and bioeconomy sectors. This approach allows for an integrated analysis of structural transformation, drawing on both theoretical and empirical perspectives. We structured the paper as follows: the next section provides a comprehensive literature review on GVCs, reprimarization, Dutch disease, and bioeconomy. The methodology section describes the research methods and data sources employed in this study. The results section presents the findings on Brazil's export profile, global value chain participation, and the potential of bioeconomy. Finally, the discussion and conclusion sections summarize the key insights and propose policy recommendations for fostering a resilient and diversified economy.

2. Foundations of Economic Transformation Over the Past 40 Years

Over the past four decades, Brazil's economic structure has undergone profound transformations, shaped by global economic shifts, trade liberalization, and domestic policies. Understanding these changes requires an integrated perspective that considers both the structural evolution of the economy and potential strategies for sustainable development. To provide a comprehensive analysis, this section is divided into two parts.

The theoretical and empirical literature on global economic integration and structural change explores the key economic processes that have shaped Brazil's trajectory, including the role of GVCs, the phenomenon of reprimarization, deindustrialization, and the Dutch disease effect. It also examines the theoretical foundations of backward and forward

linkages and their implications for economic development. On the other hand, the bioeconomy as a strategy for economic reorientation section presents the bioeconomy as a viable alternative to Brazil's current export structure. It discusses the theoretical underpinnings of bioeconomy, its role in adding value to primary products, and the potential for repositioning Brazil within GVCs through sustainable innovation and technological advancement.

2.1. Theoretical and Empirical Literature on Global Economic Integration and Structural Change

During the last two decades of the twentieth century, the world witnessed major transformations in the form of global production and accumulation. Large transnational corporations become more relevant as organizers of global value chains, which, conceiving production on a global scale in a systemic way – and following a logic of maximizing their rate of profit on a global scale – locate the different stages of the production process in different regions of the planet according to the comparative advantages they can find in each of them. Therefore, from the 1980s and 1990s onwards, there was a greater fragmentation of production, stimulated by technological changes, especially in the areas of information technology and transportation. The transformations generated have led to a decentralization of production, in which companies develop a way to reduce production costs by inserting the global market in development, so that each stage of production is carried out in a location that has specialization in the activity in question (Hermida, 2017).

GVCs refer to the series of activities involved in the production of goods and services, from initial design to final delivery to the consumer. These activities are often distributed across multiple countries, with each country specializing in specific stages of production (Hermida, 2017). Technological advancements in information and transportation have driven the fragmentation of production, leading to increased efficiency and reduced costs (Zhang; Schimanski, 2014).

According to Zhang and Schimanski (2014), GVCs provide valuable insights into a country's level of international integration and its position in the global division of labor. The Organization for Economic Cooperation and Development (OECD) and the World Trade Organization (WTO) have developed databases to analyze trade in value-added terms, offering a more comprehensive understanding of international trade dynamics. These databases reveal the extent to which countries are integrated into GVCs and highlight the importance of backward and forward linkages in global production networks (Johnson; Noguera, 2012).

Hermida (2017) notes that Brazil's participation in GVCs has been limited, particularly in high-value-added segments of production. This limited participation is partly due to structural issues within the Brazilian economy, including low levels of investment in research and development (R&D) and insufficient infrastructure. As a

result, Brazil's exports are predominantly composed of primary commodities with limited value addition (Baldwin, 2013).

The economic opening in Brazil can be understood in two distinct areas: the 'inward' opening, in which there were incentives to imports, such as the breaking of tariff and non-tariff barriers to imports, promoting greater competition in the domestic market; and the 'outward' opening, which consisted of expanding the international market with the aim of expanding exports (Mancuso; Oliveira, 2006). In view of this, at the beginning of the twenty-first century, there was a substantial increase in external demand for primary goods, generating intense pressure on commodity prices in the international market.

Within GVCs, the more production stages a final product undergoes, the greater the added value generated (Carneiro, 2015). However, Brazil's position in international trade has been shaped by structural factors that constrain its ability to capture these benefits. Trade liberalization, currency appreciation, and shifts in global demand have reinforced the country's specialization in primary and semi-manufactured goods, while other economies have advanced in high-value-added segments. As a result, Brazil has remained in a subordinate role in GVCs, with limited capacity to move up the value chain.

The fragmentation of production across GVCs has implications for economic development, as countries integrated into these chains can benefit from technology transfer, skill development, and productivity gains. However, the benefits of Global Value Chain (GVC) participation are not automatic and depend on a country's ability to upgrade its production capabilities and move up the value chain (Gereffi, 1999). For Brazil, enhancing its GVC participation requires addressing structural challenges and fostering an environment conducive to innovation and industrial development (Nassif; Bresser-Pereira; Feijó, 2017).

In addition to the consolidation of GVCs, reprimarization is another characteristic phenomenon of the last decades of the Brazilian economy. It is composed of the process by which an economy shifts from a diversified export profile, including manufactured goods, to one dominated by primary commodities. This phenomenon has been observed in Brazil since the early 2000s, leading to concerns about economic vulnerability and reduced industrial capacity (Oreiro; Feijó, 2010). Reprimarization often results in the economy becoming more susceptible to commodity price volatility and external shocks, which can undermine long-term economic stability (Medeiros, 2008).

Deindustrialization, which is often linked to reprimarization, involves a decline in the share of industrial employment and value-added in the economy (Rowthorn; Ramaswamy, 1999). In Brazil, several factors have driven deindustrialization, including trade liberalization, an overvalued exchange rate, and structural inefficiencies within the industrial sector (Oreiro; Feijó, 2010). These factors have led to a reduction in the competitiveness of Brazilian manufacturing and an increased reliance on commodity exports (Bresser-Pereira, 2020).

Medeiros and Cintra (2015) argue that the rise of China as a major global player has significantly influenced Brazil's economic trajectory. China's demand for raw materials has driven up commodity prices, benefiting Brazil's primary sector but also

contributing to deindustrialization by diverting resources away from manufacturing (Esquivel; Rodriguez-López, 2003). Global economic trends have thus reinforced the phenomenon of reprimarization, making it difficult for Brazil to reverse this process without targeted policy interventions (Bresser-Pereira; Marconi, 2008).

The 'commodity boom' had, in addition to other East Asian countries, China as the main responsible, which from the 2000s onwards showed a remarkable rise in the international market, becoming the largest exporting country and the second largest importer in the world from 2005 onwards (Medeiros; Cintra, 2015). In this context, China's role in its relationship with Brazil has a double effect, in that, while stimulating the production and export of primary goods demanding commodities, it also snatches away part of Brazil's area of activity as an exporter of manufactured products, intensifying the process of deindustrialization in the country (Assis; Silva, 2020).

Addressing reprimarization and deindustrialization requires a multifaceted approach, including policies to promote industrial diversification, enhance productivity, and support technological innovation (Nassif; Bresser-Pereira; Feijó, 2017). Strengthening backward and forward linkages within the economy can also help to create a more resilient and diversified industrial base (Hirschman, 1958).

Observing the context in which Brazil conducts its trade opening, in moments prior to the commodity boom, one should not disregard the susceptibility that the country places itself in relation to the Dutch disease. According to Bresser-Pereira (2020), the effects of the Dutch disease are based on the appreciation of the real exchange rate due to a sudden rise in commodity exports, which would harm the manufactured products sector, and, consequently, place the country in dependence on the basic products sector, accentuating deindustrialization, in addition to maintaining artificially high wages and generating an increase in unemployment.

In line with the process of reprimarization, the so-called Dutch disease effect stands out. The Dutch disease refers to the adverse effects of a booming primary sector on the rest of the economy, particularly the manufacturing sector. It is characterized by an appreciation of the real exchange rate due to increased foreign currency inflows from primary exports, which reduces the competitiveness of other export sectors (Bresser-Pereira; Marconi; Oreiro, 2009). This can lead to deindustrialization and increased economic dependence on the primary sector, exacerbating the challenges of reprimarization (Corden; Neary, 1982).

In Brazil, the symptoms of Dutch disease have been observed with the rise of commodity exports and the decline of the manufacturing sector (Bresser-Pereira, 2020). The appreciation of the Brazilian real, driven by high commodity prices and capital inflows, has made Brazilian manufactured goods less competitive on the global market (Corden, 1984). This has contributed to the deindustrialization process and increased the economy's vulnerability to external shocks (Bresser-Pereira, 2016).

The literature on Dutch disease emphasizes the importance of macroeconomic policies in mitigating its effects. For example, fiscal policies that save and invest a portion of the windfall gains from commodity exports can help to stabilize the economy and

support long-term development (Humphreys; Sachs; Stiglitz, 2007). Additionally, policies that promote diversification and value addition within the primary sector can reduce the economy's dependence on raw commodity exports and enhance its resilience to price fluctuations (Hausmann; Klinger, 2007).

Along with the symptoms described, it is worth analyzing the intrinsic effects of export policies of countries focused on manufactured products that are related to countries focused on basic products. Hirschman (1958) describes the relationship between the sectors of manufactured and basic products, calling backward linkage, the effect of increased demand for basic products generated by the growth of the manufacturing sector; and forward linkage, the effect of increased productivity in the manufacturing sector generated by the growth of the basic sector. Thus, the final gain of this relationship would be greater than the individual sum of the two areas of activity.

The forward and backward linkages are one of the concepts related to the Dutch disease, and which can help to understand how countries, despite having resources, are still stuck in underdevelopment. The concept proposed by Hirschman (1958) describes the relationships between different sectors of the economy. Backward linkages refer to the demand for inputs from upstream sectors, while forward linkages involve the supply of outputs to downstream sectors. Strong linkages can drive economic development by creating cumulative demand and productivity effects (Hirschman, 1958).

In the context of GVCs, backward linkages are essential for understanding a country's integration into global production networks. Countries with strong backward linkages are more likely to benefit from technology transfer and productivity gains, enhancing their position in the global economy (Johnson; Noguera, 2012). For Brazil, strengthening these linkages is crucial for upgrading its production capabilities and moving up the value chain (Nassif; Bresser-Pereira; Feijó, 2017).

Hermida (2017) highlights that Brazil's backward linkages in GVCs are relatively weak, particularly in high-tech and high-value-added sectors. This limits the country's ability to benefit from the spillover effects of GVC participation, such as technology transfer and skill development. Strengthening these linkages requires targeted policies to enhance industrial capabilities, foster innovation, and improve infrastructure (Baldwin, 2013).

Forward linkages are also important for economic development, as they facilitate the integration of domestic industries into global markets. By developing strong forward linkages, Brazil can increase the value-added content of its exports and reduce its dependence on raw commodity exports (Gereffi, 1999). This can help to create a more diversified and resilient economy, capable of withstanding external shocks and sustaining long-term growth (Hausmann; Rodrik, 2003).

Given these structural challenges, the Brazilian economic trajectory demands a strategic shift to mitigate the risks associated with excessive reliance on primary commodities. The loss of industrial capacity, coupled with the constraints imposed by a commodity-dependent export model, limits the country's ability to generate high-value-added production and technological advancements. Addressing these vulnerabilities

requires an economic model that integrates technological innovation, sustainability, and industrial upgrading. The bioeconomy emerges as a promising alternative, offering pathways to increase Brazil's participation in GVCs while fostering economic and environmental resilience.

2.2. Bioeconomy as a Strategy for Economic Reorientation

In the context of GVCs, the debate on development assumes the following central question: 'how' to increase the value added created domestically, allowing the dynamization of the economy, considering its geographical and population dimensions, through the appropriation of the value that remains for local producers (in the form of profit and remuneration of labor), enabling the expansion of employment, income and, above all, technical progress in Brazil? The bioeconomy presents itself as a promising strategy.

International experiences highlight the transformative potential of bioeconomy as a strategic reindustrialization tool. The European Union (EU), for instance, has implemented a bioeconomy strategy that integrates sustainable innovation into global value chains, promoting biotechnology-based industries, circular economy models, and value-added agricultural products (European Commission, 2022). Similarly, the United States (US) has advanced bio-based industries through federal investments in research and commercialization, fostering sectors such as biofuels, biopharmaceuticals, and precision agriculture (USDA, 2021).

Bioeconomy refers to the use of biological resources and processes to produce goods and services in a sustainable and environmentally friendly manner. It encompasses various sectors, including agriculture, forestry, fisheries, and biotechnology. The concept of bioeconomy is rooted in the work of Georgescu-Roegen (1971), who highlighted the unsustainability of traditional economic growth models based on finite resources (Cechin; Veiga, 2010).

In Brazil, the bioeconomy already represents a significant portion of economic activity. The National Bank for Economic and Social Development (*BNDES*) estimates that bioeconomy-related sectors contributed approximately $326 billion to the national economy, with potential for rapid expansion through investments in research, industrial upgrading, and sustainable supply chains (Silva; Pereira; Martins, 2018). Areas such as biofuels, forest-based industries, and biomaterials hold particular promise for enhancing Brazil's role in GVCs while reducing environmental impacts.

Nobre and Nobre (2018) emphasize the potential of the bioeconomy to transform Brazil's economy by adding value to its abundant natural resources. By leveraging advancements in biotechnology, Brazil can develop new products and processes that enhance sustainability and economic resilience. The bioeconomy offers a promising path for increasing the value-added content of Brazil's exports, reducing dependence on primary commodities, and promoting sustainable development.

The development of a bioeconomy in Brazil requires a supportive policy framework, including investments in R&D, infrastructure, and education. Additionally, fostering collaboration between the public and private sectors can help to drive innovation and create new market opportunities (Nassif; Bresser-Pereira; Feijó, 2017). By prioritizing bioeconomy, Brazil can enhance its global competitiveness, create high-quality jobs, and promote environmental sustainability (Cechin; Veiga, 2010).

To fully capitalize on this potential, Brazil must integrate bioeconomic policies with its industrial and trade strategies. This requires targeted incentives for research and development, streamlined regulatory frameworks, and alignment with sustainability goals outlined in international agreements. By doing so, Brazil can mitigate the risks associated with reprimarization and establish a more resilient and diversified economic structure.

Therefore, in view of the transformations that have occurred in the last 40 years, synthesized in the fragmentation of production chains, in the reprimarization of the Brazilian economy and in the urgency of consolidating sustainable production processes, the bioeconomy presents itself as a safe way to put Brazil back on a level of relevance in international trade. That said, this study presents and analyzes in the following sections the performance of the export agenda in the light of the trade opening of the 1990s, evidencing the process of reprimarization and the backward and forward effects on the Brazilian economy. Nevertheless, it evaluates how the bioeconomy could contribute to the addition of value and to the growth of the economy.

3. Methods

This study employs a combination of descriptive and econometric analysis to examine the shift in Brazil's export profile from primarily manufactured goods to predominantly agricultural and mineral commodities since the 2000s. The methodological approach involves a comprehensive literature review, and the analysis of secondary data sourced from reputable databases and institutions.

To analyze the structure of Brazil's export profile, we relied on the International Standard Industrial Classification (ISIC) data from the Comex Stat. However, the ISIC data does not directly provide export values by aggregated factors, which required methodological adjustment. To facilitate the analysis, we reclassified the data into three broad categories: basic products, semi-manufactured products, and manufactured products. This conversion followed the criteria established in the methodological note issued by the secretariat of intelligence and trade statistics (in Portuguese, the *Subsecretaria de Inteligência e Estatística de Comércio Exterior – SITEC*) of Brazil (2020).

The classification process involved mapping ISIC product codes to aggregated factors based on their level of processing and industrial transformation. Basic products include raw agricultural and extractive commodities with minimal processing. Semi-manufactured products encompass goods that have undergone an initial transformation but require further processing. Manufactured products are those that have reached the final

stage of production with high value-added content. This approach aligns with methodologies commonly used in trade and industrial analysis to assess export composition and structural shifts in global value chains.

As shown in Table 1, the data illustrate Brazil's export profile by aggregated factor and industry from 2015 to 2019. The conversion process, explicitly defined in the *SITEC* (Brazil, 2020) methodological note, ensures consistency in categorizing export values across these three groups. This methodology allows for a more structured comparison of export composition, particularly in the context of reprimarization trends and global value chain integration.

Table 1: Exports - Aggregated Factor x ISIC - Percentage Distribution

Aggregated Factor	ISIC	2015	2016	2017	2018	2019	Average
Basic Products	Agriculture	99.99	99.99	99.99	99.99	99.99	99.99
	Manufacturing Industry	18.00	16.82	16.34	16.54	18.93	17.33
	Extractive Industry	99.99	99.64	99.88	100.00	100.00	99.90
	Other Products	15.40	17.85	17.05	39.37	58.79	25.69
Semi-manufactured Products	Agriculture	0.01	0.01	0.01	0.01	0.01	0.01
	Manufacturing Industry	21.54	24.62	23.12	21.65	21.76	22.11
	Other Products	0.40	0.18	0.29	0.34	0.36	0.31
Manufactured Products	Agriculture	0.00	0.00	0.00	0.00	0.00	0.00
	Manufacturing Industry	60.47	63.03	61.81	59.31	59.31	60.57
	Extractive Industry	0.01	0.36	0.12	0.00	0.00	0.10
	Other Products	4.60	9.90	7.30	12.28	40.11	14.84

Source: *SITEC* (Brazil, 2020). ISIC Methodological Note, International Classification of All Economic Activities. Feb. 2020.

Table 1 shows the percentage distribution of Brazil's exports by aggregated factor and industry. It highlights a significant reliance on basic products, particularly from agriculture and the extractive industry. The data indicate that manufactured products, while still present, constitute a smaller portion of the export profile. This trend underscores the shift towards reprimarization, where the export economy becomes more dependent on raw materials and less on high-value manufactured goods.

We expanded the analysis to include structural break tests. Structural break tests, such as the Wald test, are widely used in time series analysis to identify points of significant change within data, as discussed by Perron (1989) on unit root hypotheses under structural breaks. We applied Wald tests to detect significant shifts in the export profile from 2000 to

2022. Using these results, we created dummy variables to represent key breaks, such as the commodities boom (2003-2013), and a global (2008) and a national (2014-2016) crisis. Additionally, we also performed Dickey-Fuller Generalized Least Squares (DF-GLS) test to ensure the initial non-stationarity of the series and validate the assumptions for regression models. The DF-GLS test, introduced by Elliott, Rothenberg, and Stock (1996), provides a robust method for testing unit roots, particularly in economic time series.

We then estimated econometric models, including an ARIMA, with dummy variables integrated to assess the statistical significance of structural breaks on the export dynamics of three key sectors (agriculture, extractive, and manufacturing). The ARIMA model, as popularized by Box *et al*. (2015), remains a cornerstone in the time series econometrics, allowing for dynamic modeling and forecasting while addressing stationarity and autocorrelation concerns. The residuals from these models were tested for stationarity, confirming the adequacy of the specifications. These adjustments add robustness to the previews descriptive focused analysis. The inclusion of these econometric techniques, following the approaches of Hamilton (1994) on time series dynamics, enhances the methodological rigor and the reliability of our findings.

In addition to export data, this study examines import profiles to provide a comprehensive view of Brazil's trade dynamics. Table 2 presents the percentage distribution of Brazil's imports by aggregated factor and industry from 2015 to 2019. This data helps to understand the demand for distinct types of goods within the Brazilian market and their impact on the domestic economy.

Table 2 reveals that, like exports, most Brazil's imports consist of manufactured products. This indicates a dependency on foreign manufactured goods to meet domestic demand, which further emphasizes the shift towards an economy reliant on primary products for exports.

Adopting the average column as a reference for all years, it is possible to convert the ISIC classification data to aggregated factors. The study period spans from 2000 to 2022. Using the data collected, we made a historical comparison to evaluate the trajectory of the export profile.

To analyze Brazil's participation in GVCs, we used Trade in Value Added (TiVA) indicators from the OECD (2021). We made a comparison of Brazil's participation with the global average for both forward and backward linkages.

To determine the potential of bioeconomy in Brazil, we conducted a literature review to highlight the various possibilities of using bioeconomy with raw materials available in the national territory. Additionally, we analyzed recent developments in bioeconomy in the US to draw a parallel with Brazil, seeking ways for this expanding technology to contribute.

The methodological approach combines the quantitative analysis of these data with qualitative insights from the literature review. This dual approach provides a comprehensive understanding of the structural changes in Brazil's economy and the potential role of bioeconomy in reversing the trend of reprimarization. By analyzing historical data and contemporary policy impacts, this study aims to offer a strategic

perspective on how bioeconomy can enhance Brazil's economic resilience and sustainability.

Table 2: Imports - Aggregated Factor x ISIC - Percentage Distribution

Aggregated Factor	ISIC	2015	2016	2017	2018	2019	Average
Basic Products	Agriculture	99.51	99.68	99.59	99.62	99.72	99.62
	Manufacturing Industry	1.58	1.64	1.90	1.71	1.49	1.67
	Extractive Industry	83.15	90.30	94.97	92.57	94.24	91.06
	Other Products	40.56	33.05	52.32	61.69	45.54	45.54
Semi-manufactured Products	Agriculture	0.14	0.13	0.15	0.15	0.15	0.15
	Manufacturing Industry	4.54	4.53	4.86	5.02	5.03	4.80
	Other Products	0.23	0.63	0.62	0.65	0.59	0.54
Manufactured Products	Agriculture	0.35	0.19	0.26	0.23	0.11	0.23
	Manufacturing Industry	93.88	93.83	93.24	93.27	93.38	93.52
	Extractive Industry	16.85	9.61	3.07	7.43	5.76	8.94
	Other Products	59.21	59.30	66.33	47.05	37.71	53.92

Source: *SITEC* (Brazil, 2020). ISIC Methodological Note, International Classification of All Economic Activities. Feb. 2020.

4. Results

This section presents the findings from the analysis of Brazil's export profile, its participation in GVCs, and the potential of bioeconomy as a transformative strategy. We organized the results into three principal areas: trends in Brazil's export profile, GVC participation, and the potential impact of bioeconomy.

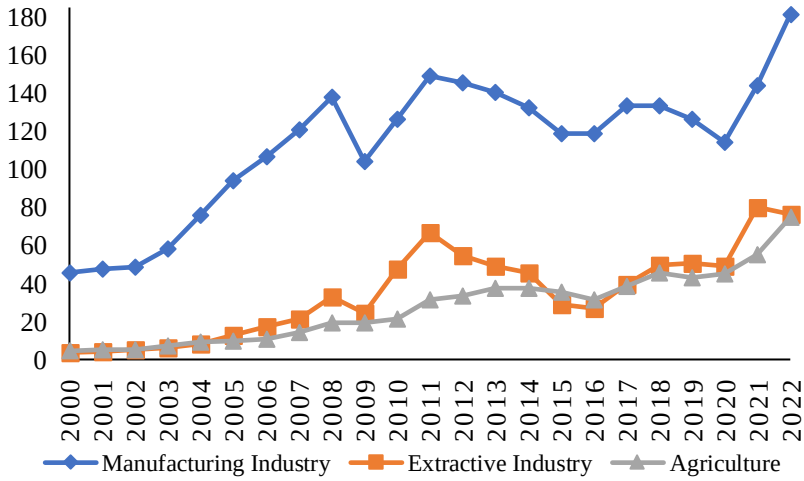
4.1. Trends in Brazil's Export Profile

Over the past four decades, Brazil's export profile has experienced a significant shift from predominantly manufactured goods to agricultural and mineral commodities. Various global and domestic factors, including trade liberalization policies, changes in global demand, and commodity price fluctuations, have driven this shift.

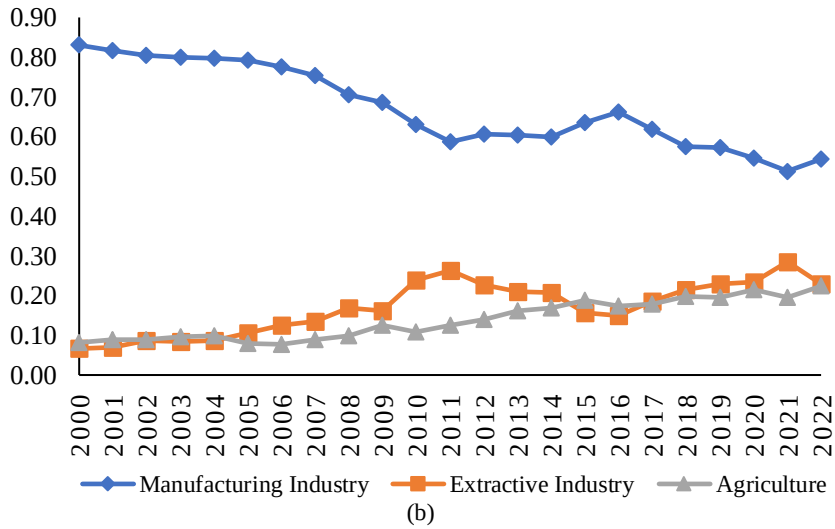
Initially, we conducted an analysis to examine how Brazil's export profile has been shifting since the 2000s, with a trend towards basic products while high-value-added products have been losing ground. This analysis was enriched by employing econometric methods, including structural break tests and ARIMA models, to better understand the dynamics underlying these trends. We collected the data used for this analysis from Comex Stat, an official portal for accessing Brazil's foreign trade statistics. In the historical data section, the period was set from 2000 to 2022, the most recent year with complete data. For detailed analysis, we used the ISIC Section option, classifying the data into: Manufacturing Industry, Extractive Industry, Agriculture, and Other Products.

The data collected allowed to perform a historical comparison to evaluate the trajectory of Brazil's export profile. Figure 1 shows the historical pattern of export values in Brazil, illustrating a clear trend towards an increasing share of basic products. Additionally, structural break tests confirmed significant shifts in 2008, during the global financial crisis, and in 2014-2016, coinciding with a domestic economic crisis (Table 3). The ARIMA models, incorporating dummy variables for these breaks, further demonstrated their impact, particularly highlighting a pronounced increase in agricultural exports during the commodities boom (2003-2013).

Figure 1: Trends in Brazil's Export Composition (2000-2022)



(a)



(b)

Source: Comex Stat (2023), ISIC description, data in billions of dollars (USD).

Figure 1 demonstrates a significant shift in the export composition, with manufacturing products decreasing in proportion while agricultural and extractive products dominate. In panel (a), Brazilian exports are presented in billions of USD, and in panel (b), as a proportion of total exports.

Table 3: Structural Break and ARIMA Results, Brazilian Export Sectors, 2000-2022

Sector	Estimated Break Date	Significant Events	ARIMA Results
Manufacturing	2009	Global Financial Crisis	AR(1): 1.54 ($p < 0.001$) Crisis 2008: 0.22 ($p = 0.002$)
Extractive	2013	Commodity Price Stabilization	AR(1): 1.47 ($p < 0.001$) Crisis 2008: 0.44 ($p = 0.037$)
Agriculture	2015	National Economic Crisis	AR(1): 1.51 ($p < 0.001$) Boom Commodities: 0.08 ($p = 0.516$)

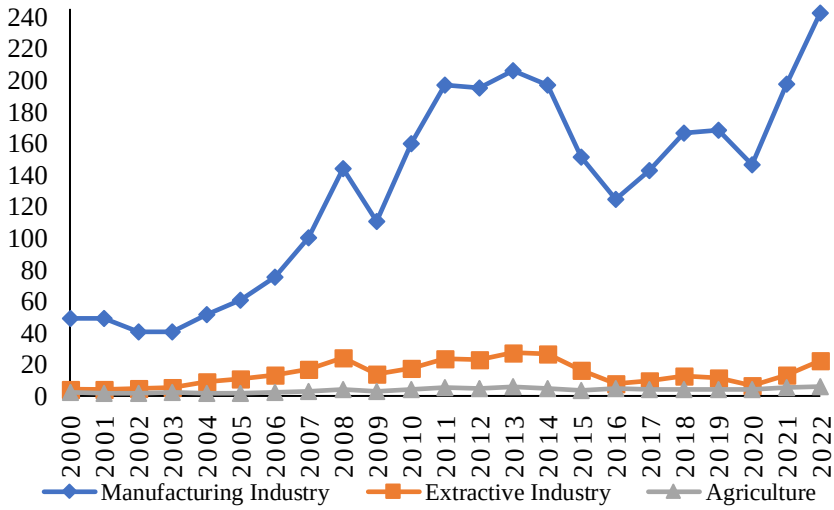
Source: Authors' calculations based on Stata outputs. The table summarizes the structural break tests (Wald statistics) and ARIMA models estimated for export sectors, highlighting key coefficients and events.

The results in Table 3 reinforce the trend observed in Figure 1, with structural breaks aligning with key global and domestic economic events. This trend highlights the process of reprimarization, where the export economy becomes increasingly dependent on raw materials. These structural breaks underscore the vulnerability of Brazil's export economy to external shocks, particularly during the 2008 global financial crisis and the 2015 domestic recession. The ARIMA results confirm the significant role of these events in reshaping sectoral dynamics, particularly the increasing dependence on agricultural exports during commodities booms. The implications of these shifts are significant. While the

export of agricultural and mineral commodities has provided substantial revenue streams, especially during periods of high commodity prices, it has also exposed the Brazilian economy to greater volatility and external shocks. These findings corroborate theoretical perspectives, such as those of Hamilton (1994) on economic shocks and Perron (1989) on structural changes in time series, illustrating the vulnerability of export-dependent economies. The reliance on commodities makes the economy vulnerable to fluctuations in global market prices and demand, which can lead to economic instability (Bresser-Pereira, 2020).

To provide a comprehensive view of the import dynamics, we conducted a similar analysis on Brazil's import profile. This helps understand the demand for distinct types of goods within the Brazilian market and their impact on the domestic economy. Figure 2 illustrates the historical pattern of import values in Brazil, indicating a high reliance on manufactured products.

Figure 2: Trends in Brazil's Import Composition (2000-2022)



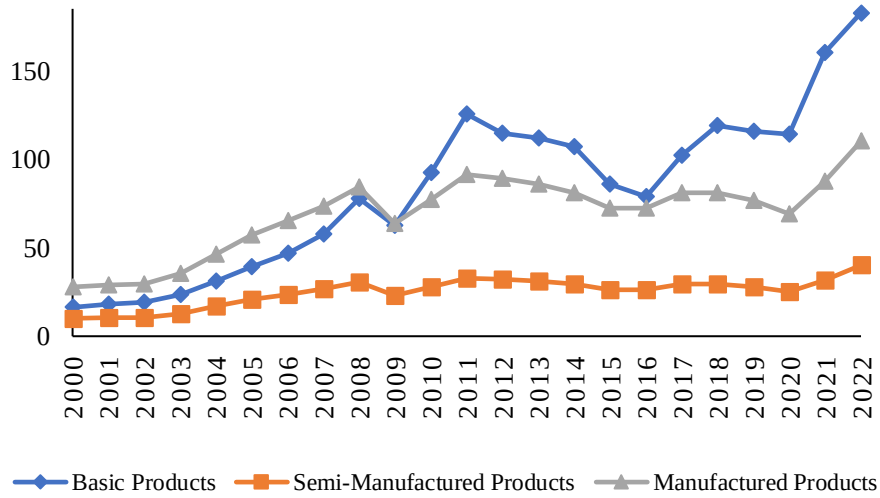
Source: Comex Stat (2023), ISIC description, data in billions of dollars (USD).

Figure 2 reveals that, despite the shift towards exporting basic products, Brazil still heavily imports high-value-added manufactured goods. This underscores the economy's dependency on foreign manufactured products to meet domestic demand, further emphasizing the trend towards reprimarization.

From the year 2000 onwards, Brazilian exports and imports registered significant growth. In this context, the prominent role played by the extractive industry and agriculture is noteworthy, driven by the increasing global demand for commodities. In the international market, Brazil stands out in agribusiness due to its productive capacity and the competitiveness of its products, such as soybeans, corn, beef, and poultry, among others.

However, the classification used so far is not adequate for our analysis. Therefore, we converted the data to the aggregate factor classification, using Tables 1 and 2 presented earlier in Section 3 of this study. Applying this conversion, we obtained the results for exports and imports shown in Figures 3 and 4.

Figure 3: Exports by Aggregate Factor (2000-2022)



Source: Own calculations and elaboration based on *SITEC* methodological note (Brazil, 2020), data in billions of dollars (USD).

Figure 3 illustrates the trend in Brazil's export composition when classified by aggregate factors. At the beginning of the 2000s, the share of manufactured products was higher than that of basic products. However, there was a reversal in 2009, and the differential decreased significantly by 2016, followed by an increase from that year onwards. Although the absolute numbers of manufactured product exports have increased, their proportion relative to basic products has declined substantially.

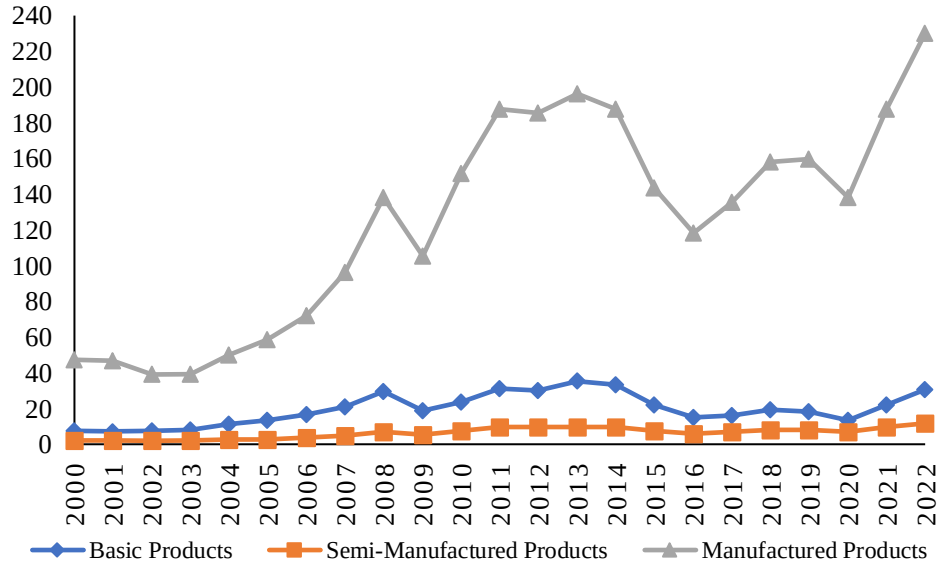
To complement the export analysis, Figure 4 provides insights into Brazil's import composition, showing a persistent higher proportion of imported manufactured products throughout the analyzed period.

Figure 4 reveals that the fraction of imported manufactured products has consistently been greater than that of other products. This gap has been widening each year, highlighting Brazil's increasing reliance on foreign industrialized goods. This scenario underscores Brazil's propensity to depend on imported high-value-added products while specializing in the export of low-value-added goods. The analyzed trends emphasize the need for Brazil to develop strategies to enhance its participation in GVCs and reduce economic vulnerability.

The shift towards a higher proportion of basic products in exports and a persistent reliance on manufactured imports reveals significant structural challenges within the

Brazilian economy. Addressing these challenges requires comprehensive policy measures aimed at enhancing industrial capabilities, fostering innovation, and improving infrastructure. Strengthening the manufacturing sector and diversifying the export base are crucial steps towards achieving sustainable economic growth and reducing external vulnerabilities.

Figure 4: Imports by Aggregate Factor (2000-2022)



Source: Own calculations and elaboration based on *SITEC* methodological note (Brazil, 2020), data in billions of dollars (USD).

By focusing on adding value to its abundant natural resources and integrating more deeply into GVCs, Brazil can improve its economic resilience and create opportunities for sustainable development. Now, we will delve into the specifics of Brazil's participation in GVCs and explore the potential of the bioeconomy as a transformative strategy for the country's economic future.

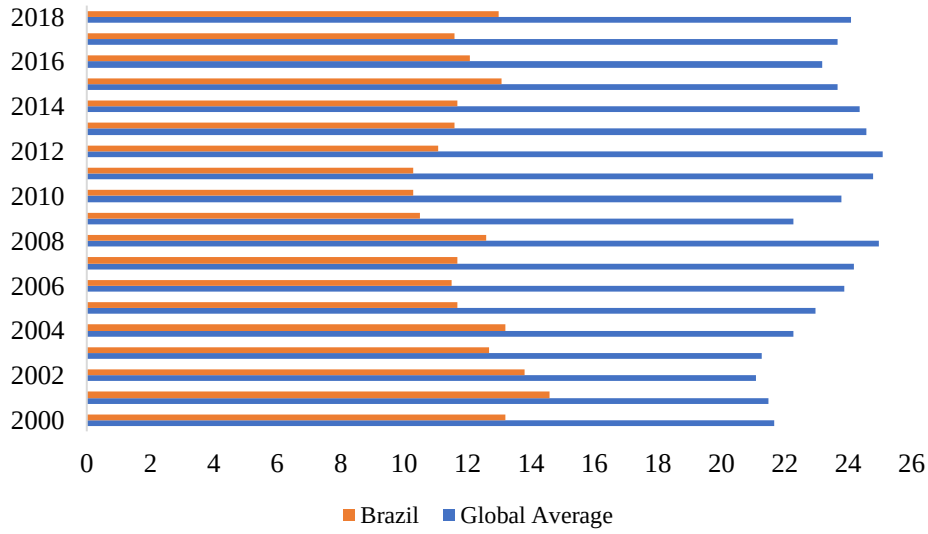
4.2. Global Value Chain Participation

Brazil has significantly increased its export volume from the 2000s to 2022, as observed in the previous results. However, this increase stems from primary sector goods. We can see the consequences of this in the analysis of Brazil's participation in GVCs. A country's participation in GVCs is an essential factor to consider when studying its influence on foreign trade and the value-added composition incorporated into the final product.

For this analysis, we used the TiVA indicators from the OECD (2021) for the period from 2000 to 2018, which is the most recent year with available data. Among the main indicators, we selected data on backward and forward linkages. Figures 5 and 6 show the results for Brazil and the global average.

Figure 5 presents the backward participation rates for Brazil compared to the global average. Backward participation refers to the foreign value added that is incorporated into a country's exports. The figure indicates that Brazil has lower backward participation than the global average, reflecting a lower integration into global supply chains in terms of importing intermediate goods for its export production.

Figure 5: Backward Participation – Global Average vs. Brazil



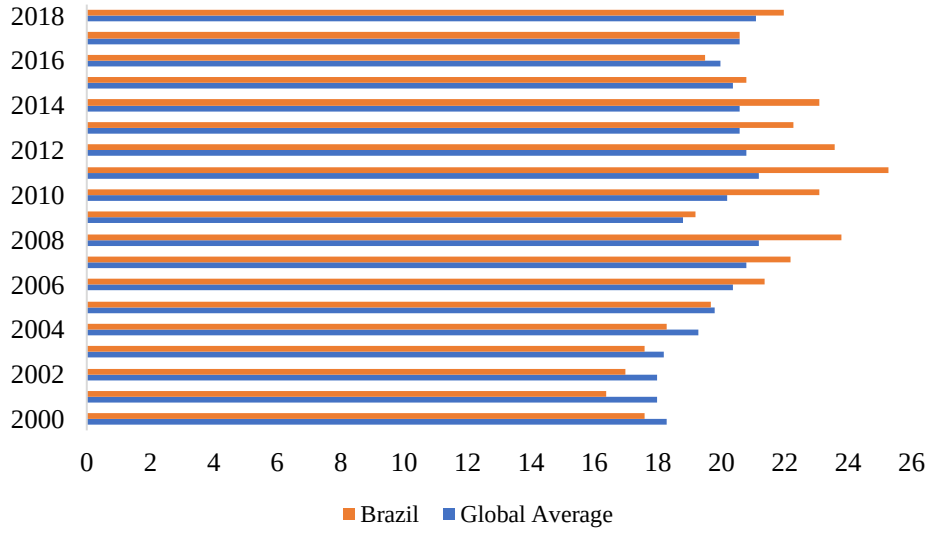
Source: OECD (2021).

Figure 6 shows, similarly, the forward participation rates. These rates measure the domestic value added that is embedded in foreign exports. Figure 6 shows that Brazil's forward participation is high, indicating that the production of other countries' exports uses Brazilian exports as inputs. This high forward participation aligns with Brazil's significant exports of raw materials and intermediate goods.

As previously noted, a sizable portion of Brazil's exports consists of basic products, i.e., low value-added goods. Consequently, other countries import goods produced in Brazil and use them in the production of intermediate or final goods, where most of the value is added. This results in Brazil having a high forward linkage participation compared to the global average. Conversely, Brazil's production has a low percentage in backward linkages compared to the global average due to the low value-added of its exports.

Another relevant factor to mention is the impact of the commodity boom on Brazil's participation. While there was a decline in backward participation from 2001 to 2011, we also observed an increase in forward participation. This indicates that, while Brazil's integration into the supply chains of intermediate goods production decreased, its role as a supplier of raw materials for other countries' exports increased.

Figure 6: Forward Participation – Global Average vs. Brazil



Source: OECD (2021).

Finally, it is worth highlighting the results for China, given that the country has high levels of both backward and forward participation relative to the global average. This comparison allows us to consider the possibility of Brazil following similar steps by investing in fields such as bioeconomy to increase backward participation without necessarily sacrificing significant parts of its already established export profile.

It is worth noting that the Global Supply Chain Pressure Index (GSCPI), developed by the Federal Reserve Bank of New York, provides additional insights into the recent dynamics of global supply chains. The GSCPI aggregates data on transportation costs, delivery times, and other supply chain indicators to measure disruptions and pressures in global trade networks. While this study does not directly analyze the GSCPI, future research could leverage its insights to further explore how supply chain pressures influence Brazil's participation in GVCs and its export profile. For more details on the GSCPI, see Benigno *et al.* (2022) and Di Giovanni *et al.* (2022).

The insights drawn from the analyses of this paper underscore the necessity for Brazil to develop strategies that can enhance its participation in GVCs. By focusing on adding value to its exports and improving backward participation, Brazil can achieve a

more balanced and resilient economic structure. The subsequent subsection will explore the Dutch Disease, trying to identify if Brazil faces it due to its reliance on commodity exports and its impact on the country's economic structure.

4.3. Dutch Disease in Brazil

There is no consensus in the literature about the existence of Dutch Disease in Brazil. Nassif (2008) initially argued that Brazil had not suffered from deindustrialization, but rather a shift in the pattern of international specialization. However, in later analyses, Nassif *et al.* (2020) recognize that the persistent overvaluation of the Brazilian real and the expansion of commodity exports have contributed to a premature deindustrialization process. Coutinho *et al.* (2012) highlight that the erosion of the manufacturing sector's competitiveness has intensified, reinforcing structural vulnerabilities in the Brazilian economy.

Batista (2009) argues that Brazil does not suffer the same detrimental effects as the Netherlands due to the diversification of its export portfolio and the sophistication of futures markets and interbank transactions. Despite the increase in commodity exports, Brazil does not face the risk of Dutch Disease due to differences in export volume and the share of these products (Batista, 2009).

On the other hand, authors like Bresser-Pereira (2020), and Lacerda and Nogueira (2008) argue that after the economic liberalization of the 1990s, there was a significant abandonment of policies to neutralize Dutch Disease in the country. This was noticeable in the early 2000s with the increase in commodity exports, which rose from 23% in 2000 to 33% in 2007; the appreciation of the real against the dollar, reaching 37% between 2005 and 2008; and the reduction of the industrial sector's impact on the total GDP, decreasing from 43.5% in 1992 to 41.1% in 2007.

Souza (2019) presents a study on commodity price shocks and relates the impact suffered by Brazil to changes in the Chinese market during the commodity boom. This shift contributed to a greater focus on exporting basic products, especially with the high demand for commodities due to fiscal stimulus after the 2008 financial crisis (Souza, 2019). As a result, the share of commodity exports in Brazilian merchandise exports remained around 60% between 2010 and 2015, consolidating Brazil among commodity-dependent developing countries and the real among 'commodity currencies' (Souza, 2019). The findings of Souza (2019) suggest that China's demand alone influences approximately 35% of Brazilian commodity exports. More recently, Canuto (2021) explores the broader macroeconomic consequences of commodity dependence in Latin America, including Brazil. Canuto, Dinh, and Aynaoui (2024) argue that while China's demand for raw materials fueled economic growth, it also exacerbated structural challenges by reinforcing the country's reliance on low-value-added exports. This dynamic has hindered efforts to diversify and modernize the industrial base, increasing Brazilian vulnerability to external shocks.

Therefore, it is possible to say that there are symptoms of Dutch Disease in Brazil, such as the loss of the export share of manufactured products in favor of basic products, the previously observed deindustrialization, and the strong dependence on commodities for the trade balance. However, it is not possible to categorically affirm the presence of Dutch Disease in Brazil, as the reduction in industrial participation has not yet shown to be significant in the total GDP. Nevertheless, some authors suggest that Brazil should adopt countercyclical measures to mitigate these effects. Strategies such as creating a sovereign wealth fund to stabilize revenues from commodity exports and implementing targeted industrial policies have been proposed to counterbalance the structural impacts of overreliance on natural resources (Bresser-Pereira, 2020; Nassif *et al.*, 2020). These measures aim to reduce the long-term risks associated with commodity dependency while fostering economic diversification.

4.4. Potential of Bioeconomy

Brazil needs, then, to find alternative ways to enhance its presence in GVCs and increase its backward participation. This necessitates a greater presence in the export of manufactured goods, making efficient use of resources that offer the country a competitive advantage. The bioeconomy emerges as a strategic alternative to address the challenges of reprimarization and limited integration into GVCs. By focusing on value-added production derived from Brazil's unique biodiversity, the bioeconomy offers an opportunity to diversify exports, enhance backward linkages, and reduce economic dependence on primary commodities. As previously discussed, the export profile of the country has increasingly shifted towards basic products, reflecting a vulnerability to external shocks. By integrating bio-industrial activities into GVCs, Brazil can leverage its unique natural resources to enhance economic resilience and global competitiveness. This subsection explores this potential of the bioeconomy in Brazil, highlighting its capacity to transform the economic landscape of the country while promoting sustainable development.

Nobre and Nobre (2018) discuss how to leverage the benefits of the Amazon rainforest to contribute to the production of manufactured goods while maintaining sustainable development through bio-industries. We could adopt a third way for the use of the Amazon territory, distinct from the previous approaches: the first being the delineation of conservation territories and the second, sustainable use for agriculture, livestock, mining, and energy (Nobre; Nobre, 2018). The third way would utilize the technological advancements of the Fourth Industrial Revolution to harness the value of nature in physical, digital, and biological domains.

Three types of failures in tropical sustainable development are identified by Nobre and Nobre (2018): conceptual failures, such as viewing the Amazon solely as a source of commodities; knowledge failures, including insufficient investment in research and land use monitoring; and implementation failures, such as not recognizing the risks of implementing inefficient government policies and the lack of diversification in public and

private sector economic activities in these areas. For instance, The Rockefeller Foundation (2015 *apud* Nobre; Nobre, 2018) considered forest products solely for their extractive value, reporting low returns, such as $10 per hectare per year for non-timber products and $20 for sustainable tree extraction.

Conversely, Nobre and Nobre (2018) assert that over 200 plant species in the Amazon region have the potential to provide raw materials for an initial low-cost bioeconomy. These include nutritionally valuable assets such as açaí (*Euterpe oleracea*), camu-camu, cumaru-ferro, murici, taperebá, Brazil nut, cupuaçu, among others. Beyond nutritional properties, we can also use Amazonian raw materials in the essence and oil industry to produce cosmetics and perfumes. For example, cumaru-ferro is used in perfumery, and açaí oil, rich in omega 6 and antioxidants, is used in cosmetics for its skin-nourishing, revitalizing, and moisturizing properties (Nobre; Nobre, 2018).

Additionally, various indigenous traditional medicine materials have been researched, such as chichuá (*Maytenus guianensis Klotzsch ex Reissek*), with anti-leishmaniasis and antimicrobial compounds; guaraná (*Paullinia cupana*) for treating Alzheimer's disease; priprioca (*Cyperus articulatus L.*) with anticonvulsant properties; babaçu (*Orbignya phalerata*) with wound-healing compounds; sacaca (*Croton cajucara Benth.*) with hypoglycemic and ulcer-healing properties; pracaxi (*Pentaclethra macroloba Willd.*) with anti-hemorrhagic activity and natural larvicide; and estoraque (*Ocimum micranthum Willd.*) with antifungal and antioxidant properties.

Even commonly exploited products can find new uses, such as natural rubber (*Hevea brasiliensis*), which we can utilize in high-tech applications like artificial skin (*Biocure*) through biomechanics, and latex compounds used in advanced heat-dissipating tires, anti-corrosive coatings, among others. This comprehensive field of bioeconomy demonstrated by Nobre and Nobre (2018) is based on just one of many ecosystems in Brazil, indicating the potential for expanding bioeconomic activities throughout the country to optimize economic potential. To understand the potential impact of bioeconomy on the Brazilian economy, first, notice that the global bioeconomy has gained increasing relevance in recent years, particularly in the EU and the US, where national bioeconomy strategies have been implemented to promote innovation and value-added production (Bugge; Hansen; Klitkou, 2016; OECD, 2021). In the EU, the bioeconomy accounts for approximately 11% of GDP and employs over 17 million people (European Commission, 2022). Meanwhile, in the US, federal investment in bio-based industries has led to significant growth in renewable materials and bioenergy production (USDA, 2021).

Mesquita and Alencar (2022) analyze bioeconomy advancements in the US and the EU. In the US, the National Bioeconomy Blueprint project, based on strategies to utilize bioeconomy for economic growth, includes i. supporting investments in Research, Development, and Innovation (RD&I) projects that will underpin the future bioeconomy; ii. facilitating the transition of bio-inventions from research labs to the market, including a focus on translational and regulatory sciences; iii. developing and reforming regulations to reduce barriers, increase the speed and predictability of regulatory processes, and lower costs while protecting human and environmental health; iv. updating training programs and

aligning academic institutions' incentives with workforce needs; and v. identifying and supporting opportunities for public-private partnerships and pre-competitive collaborations.

By 2013, the BioPreferred program, which encourages the production and consumption of bioproducts, reported approximately $369 billion in added value to the US economy, with direct employment of 1.5 million Americans and 4 million indirect jobs. More recent figures from Nasem (2020, *apud* Mesquita; Alencar, 2022) indicate that the bioeconomy accounts for 5% of the US GDP, representing around $960 billion. Given that the bioeconomy accounts for 11% of GDP in the EU and approximately 5% in the US (European Commission, 2022; USDA, 2021), rich Brazilian biodiversity and existing bio-industrial activities present an untapped potential for similar or even greater contributions to its economy.

Drawing a parallel with Brazil, Mesquita and Alencar (2022) highlight the country's natural characteristics and investment in agricultural RD&I. Bio-industrial activities, which account for the largest share of Brazil's Bio-GDP, have significant potential to integrate into high-value GVCs, particularly in sectors such as cosmetics, pharmaceuticals, and advanced biomaterials. For instance, products like açaí oil and natural rubber could be positioned as premium inputs in global industries, strengthening Brazil's backward linkages. However, to fully capitalize on bioeconomy, Mesquita and Alencar (2022) suggest several practices to enhance its potential.

First, it is crucial to develop a national bioeconomy strategy, following a well-defined bioeconomy concept to guide field development and prioritize and integrate stakeholders efficiently. Additionally, creating an appropriate regulatory framework that legally integrates bioeconomy into economic activity is essential. A good example is the Green Patents program by the National Institute of Industrial Property (*INPI*), which aims to expedite the analysis of patent applications related to environmental technologies and identify innovative technologies that society can quickly adopt.

Furthermore, continuous public and private investment in agricultural RD&I and other cutting-edge sectors related to bioeconomy, such as engineering and computer and information sciences, is necessary. Finally, developing a method for measuring and monitoring bioeconomic activity is relevant, as it is not yet well-defined in statistical analyses of economic activities in the country. Despite this, *BNDES*, using OECD data, estimated the value of the Brazilian bioeconomy in 2016 (Silva; Pereira; Martins, 2018) at $285.9 billion in Brazil and $40.2 billion for sales of economic activities located in other countries, totaling $326.1 billion.

Pinto and Lima (2022) state that the bioeconomy represents about 20% of Brazil's GDP, equivalent to R$ 1.447 trillion in 2019. Activities include using biological resources and biomass for food, feed, biological products, and bioenergy production. However, it is important to note that we also included basic and semi-manufactured product-generating activities in the overall calculation. Still, it is worth highlighting that 53.7% of the Bio-GDP consists of bioindustrial activities, which make up the largest share of the total.

According to Pinto and Lima (2022), the value of Bio-GDP is composed of plant-based activities (R$ 357.75 billion, or 24.7% of the total), animal-based activities (R$ 115.76 billion, or 8.0% of the total), extractive activities (R$ 41.15 billion, or 2.8% of the total), 100% bioindustrial activities (R$ 777.59 billion, or 53.7% of the total), and partially bioindustrial activities (R$ 154.52 billion, or 10.7% of the total).

OECD estimates indicate that by 2030, the global contribution of biotechnology could reach up to $1 trillion annually, distributed among health ($260 billion annually), primary production ($380 billion annually), and industrial sectors ($420 billion annually), with a forecast that 80% of pharmaceutical products will be developed through biotechnology (Dias; Carvalho, 2017).

Utilizing General Equilibrium Models (GEM) and Dynamic Optimization Models (DOM), Nobre *et al.* (2023) demonstrated that by 2050, the GDP of the bioeconomy in the Legal Amazon could reach R$ 38.5 billion. This value is 73% higher than it would be in a scenario where greenhouse gas (GHG) emissions from economic activities are not limited, and deforestation is not controlled. Additionally, the authors estimate that the bioeconomy could generate approximately 365 thousand new jobs, which would be filled by minority groups such as Black and Indigenous people. According to Nobre *et al.* (2023), these are possibilities to promote a just and sustainable economic transition in the Legal Amazon.

However, for these possibilities to materialize, the support of public policies is necessary. According to Clement *et al.* (2024), the expansion of the bioeconomy in the Amazon depends on establishing a 'standing forest paradigm'. In other words, it is essential to develop policies that guarantee minimum prices, value ecosystem services, and certify products, as well as genuinely value local communities and their traditional knowledge. Queiroz-Stein *et al.* (2024) highlight that the implementation of policies promoting the bioeconomy can generate various positive spillovers, such as scientific and technological development, rural development, and social inclusion, reflecting the complexity and importance of discussions about the future of sustainability governance in Brazil.

In this context, the bioeconomy not only offers opportunities for Brazil to diversify its export base but also to create sustainable economic growth. By aligning with global trends in bio-based industries, Brazil can strengthen its participation in GVCs, particularly in sectors demanding high-value inputs, and contribute to the global sustainability agenda. These strategies underline the importance of public policies and investment to foster a bioeconomy capable of driving structural economic transformations.

5. Final Considerations

The analysis of data collected from Comex Stat revealed a concerning trend in Brazil's export profile since the last 40 years, especially since the 2000s. While basic products have gained prominence, high value-added products have lost their share. The reversal in the relative share between manufactured products and basic products in 2009 evidenced this shift, worsening from 2016 onwards.

Although the absolute numbers of manufactured product exports have increased, their proportion relative to basic products has diminished significantly. Conversely, import data reveal that the share of imported manufactured products has always been higher during the period analyzed, and this gap has been widening over the years.

This scenario points to Brazil's growing dependence on foreign industrialized products while the country specializes in low value-added goods. This situation has negative consequences for Brazil's participation in GVCs, reflecting a position of lesser relevance in the international context.

The analysis of backward and forward linkage indicators, compared to the global average, provides important insights into Brazil's participation in GVCs. The country shows high forward linkage participation, resulting from the share of Brazilian inputs incorporated into the production of foreign manufactured goods. On the other hand, Brazil's backward linkage participation is low compared to the global average, due to the low value-added of its exports. This trend worsens as the export profile leans towards the primary sector, as demonstrated.

Regarding the analysis of Dutch Disease, although there is no consensus on its presence in Brazil, it is evident that there are relevant points to be constantly monitored. These include policies to neutralize the disease, the perceptible deindustrialization in recent years, and the greater emphasis on the primary sector in the export profile.

In conclusion, the analysis highlights the need for Brazil to find ways to increase its participation in GVCs, especially in backward linkages. To this end, we propose adopting a bioeconomy-based approach for sustainable production of manufactured goods through bio-industries.

Compared with the US, the positive economic impact of the bioeconomy is evident, with significant numbers in added GDP value and job creation. However, we emphasize that Brazil needs to adopt appropriate practices to leverage its potential in the bioeconomy, such as developing a national strategy, establishing a suitable regulatory framework, investing in research and development, and creating a method for measuring and monitoring bioeconomic activity.

By effectively implementing these strategies, Brazil can enhance its role in GVCs, reduce economic vulnerability, and promote sustainable development through the bioeconomy. This transition would not only add value to its abundant natural resources but also position Brazil more competitively on the global stage.

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