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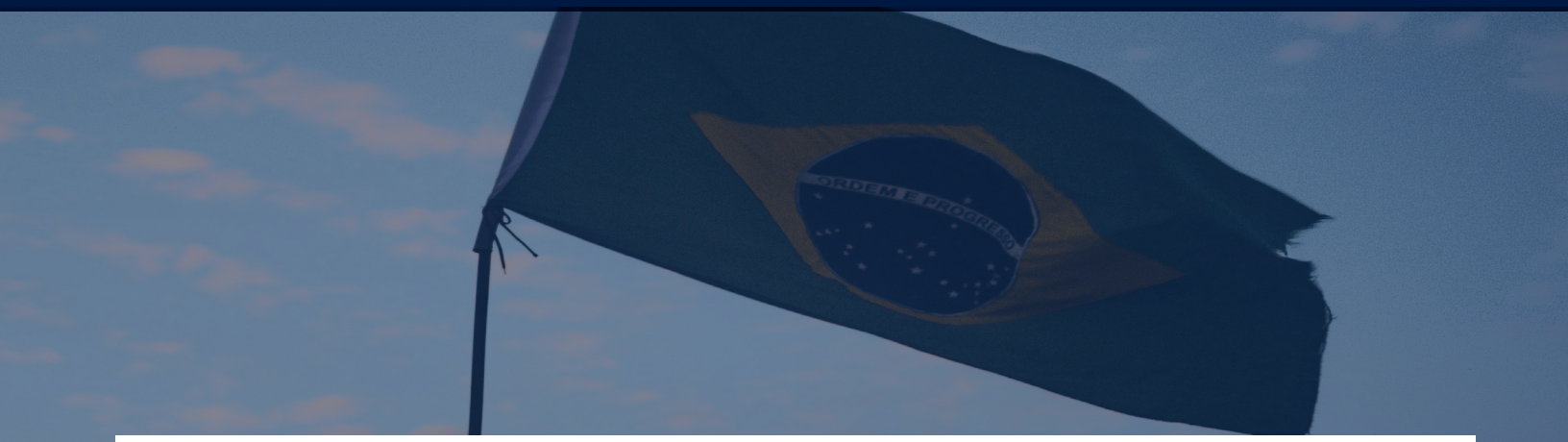


JANUARY 2024

REORGANIZATION OF GLOBAL VALUE CHAINS: ARE THERE OPPORTUNITIES FOR BRAZIL?

EXECUTIVE SUMMARY

Recent political, health, environmental, and economic disruptions are expected to lead to significant changes in current global value chain (GVC) trade arrangements. In this paper, we focus on Brazil as a potential new location for industrial plants and services activities in the context of a reshaping of the global value chains architecture. We explore hard data as well as qualitative information obtained through interviews with CEOs and managers of firms established in Brazil in several sectors. The results of the analysis suggest that the permanence of high trade costs faced by firms makes it very difficult to think of Brazil as an immediate option for the relocation of industrial segments of GVCs. However, the ongoing changes in the productive processes throughout the world, chiefly among them the transition to a low carbon economy and secondarily the huge technological changes led by digitization, offer a unique opportunity for the country. In particular, the country's comparative advantages in natural resources and the clean energy matrix may position Brazil as a desired location for firms in search of a clean, secure, and affordable supply of energy. To benefit from these transitions, however, Brazil needs to put in place reforms and policy actions to remove some key obstacles. Some of these actions involve the energy sector, addressing the distortions in the regulatory framework and in the formation of energy tariffs and the overlapping of institutional functions. Finally, key elements of the policy agenda are the improvement of the business environment and the reduction of trade costs and the high level of protectionism still adopted in Brazil.

Contents

INTRODUCTION

Trade in the twenty-first century has been characterized by the emergence of global value chains (GVCs). GVC trade expanded very rapidly between the early 1990s and 2010—the trade "long decade"—and slowed down after the great recession. The swift growth of GVCs after 1990 was driven by technological advances—in transportation, information, and communication—and by reduced trade barriers, which, in conjunction, encouraged manufacturers to extend production processes beyond national borders. Today, according to the World Bank's "2019 World Development Report," about half of world trade is conducted through GVCs. Many developing economies increased their share in global trade and production; the G7's share of world manufacturing fell from two-thirds in 1990 to less than half in 2010, with correspondent share gains for a handful of countries—above all China (Baldwin and Freeman, 2021).

Recent political, health, environmental, and economic disruptions have fueled concerns about the health of the current global value chain trade interdependence. These shocks added to recent technological and labor arbitrage trends that could favor the reshoring or relocation of firms and jobs. While there is still limited evidence of significant changes in both trade and investment flows, the mounting pressures arising from the increase in geopolitical tensions, including trade and investment restrictive measures, suggest that a scenario in which a significant reshaping of GVCs takes place cannot be considered irrelevant.

In this paper, we will focus on Brazil as a potential new location for industrial plants and services activities in the context of reshaping the global value chains architecture. Brazil does not immediately come to mind when industrial relocation is considered. With a structure of production and exports in which commodities feature prominently, geographically distant from main industrial hubs, and with a long history of protective policies and high trade costs, the country has not been a notable participant in GVC trade and has been deindustrializing. However, several aspects, among them the size of the domestic market, its clean energy matrix, and the sophisticated ecosystem of firms in the industrial, agribusiness, and services sectors, suggest that Brazil can potentially be considered an option for many firms, given the transition of the world economy toward decarbonization.[1]

Brazil has well-known comparative advantages to explore natural resource-based products in agribusiness, minerals, and oil and gas exploration. Consequently, these segments of the economy are the predominant commercial connection to international production networks and can be leveraged by decarbonizing the world economy.

In addition, the characteristics of Brazil's energy sector can potentially help maintain and attract industrial investments, a process identified as "powershoring" or "greenshoring." As discussed throughout the paper, these are opportunities and potential gains for the Brazilian economy. For them to materialize, a broad policy agenda must be implemented. This agenda is intense in the need for new regulatory frameworks (in the energy sector, hydrogen, critical minerals, and others) and for policy instruments directed at reducing the trade costs and the high level of protection of the economy.

1 The Brazilian economy offers diversification opportunities due to its market size and local resources, distinguishing it from other Latin American countries. This diversity is evident in Brazil's corporate landscape, featuring global companies spanning various sectors, including oil and gas, aeronautics, food and beverages, minerals, metal processing, financing, education, engineering, and digital services. In the first half of 2023, Brazil ranked as the world's second-largest recipient of foreign direct investment (FDI), following the United States. This position aligns with its significance to 400 Fortune 500 companies with activities in Brazil. Notably, Brazil is a major player in the global startup scene, securing the leading position in Latin America and ranking twenty-seventh globally according to the Global Startup Ecosystem Index. The country boasts 15 startups with valuations exceeding $1 billion, constituting 66% of all unicorns in Latin America.

Capturing the opportunities of decarbonization (and, to a lesser extent, also from the digital transformation) of the economy demands new answers. There is a new economy, new transactions, new economic actors, new regulatory demands, pressures for investment and innovation, and a new international environment.

The paper explores hard data as well as qualitative information obtained through interviews with CEOs and managers of firms established in Brazil in several sectors. All the interviewed firms have some level of integration into external markets, be it as exporters or importers or through non-trade relationships (investments abroad, connection to innovation hubs, etc.). No particular sector was targeted for the interviews.[2]

It is organized as follows: the second section describes many drivers of relocation of firms in the world. The third section explores Brazil's trade performance and limited connections to GVC trade, discussing the causes for this low integration and the obstacles to full insertion in GVCs. The fourth section discusses the main drivers of change in world economies—the decarbonization process and digitalization—and how Brazil is in a privileged position to offer adequate responses to this transition. Making extensive use of the interviews, the section presents the role of the natural resources base, a key asset for Brazil, in integrating into the world economy and describes recent changes and existing opportunities for other sectors. The final section presents the main challenges for public policy and makes specific policy recommendations.

THE (SEVERAL) CASES FOR RELOCATION OF FIRMS

Global value chains expanded rapidly between the early 1990s and 2010, strengthening the connection between trade and development. Two features distinguish GVCs from traditional trade: countries import to export, not only for domestic consumption; and transactions involve long-term, firm-to-firm relationships rather than anonymous spot market transactions. Fragmented production makes it possible for firms in developing countries to enter foreign markets at lower costs. They can benefit from specialization in niche tasks and gain access to larger markets for their output. In addition, within-firm flows of knowledge and technology become flows between countries.

Recent political, health, environmental, and economic disruptions have fueled concerns about the health of the current global value chain trade interdependence, triggering a narrative that emphasizes the **risks** and **vulnerabilities** of the international network of production:

- Tohoku earthquake (2011)
- U.S.-China trade war
- COVID-19 pandemic
- Russia's war on Ukraine
- Industrial policies renaissance

2 See Annex One for the list of firms interviewed. We would like to thank all the participants for their invaluable inputs and to the International Chamber of Commerce (ICC Brasil) and Brazilian-American Chamber of Commerce (AMCHAM Brasil) for their support to contact and organize meetings.

These shocks added to recent technological and labor arbitrage trends that could favor the reshoring or relocation of firms and jobs. These disruptions have triggered a narrative that suggests that global interdependence has gone too far. Corresponding policy proposals either stressed making GVCs shorter and more domestic (or more regional), more friendly, or more diversified. It is important, therefore, to assess the potential changes in the world landscape.

GVCS REORGANIZATION

The search for resilience of GVCs is not a new topic. The risks and costs of business operations (including insurance) have been rising in recent years associated with a range of events such as earthquakes, weather effects, cyber-attacks, value chain link failures, trade disputes, pandemics, and terrorism. The assessment of these risks was already part of the dashboard of the decision-making process of chain formation.[3]

What has changed is the intensity of this process. Increased risks have made the management of value chains more complex. Companies have learned—via insurance costs, freight, and supply disruptions—about the importance of balancing efficiency and resilience. The search for this balance is essentially a problem of risk management and analysis, anchored increasingly in using analytical tools to support decisions. The adjustment period to the pandemic added more complex layers to this evaluation. Companies had to make quick adjustments, assess specific vulnerability points, make strategic decisions about supply sources, create redundancies, redefine inventory policies, deepen information exchange with chain links, and make more critical decisions about reshoring and verticalization. Assessing the relative weight of efficiency vs. resilience increased the frequency and importance of business decisions.

The recent intensification of geopolitical tensions, particularly the growing antagonism between the United States and China, has triggered a round of U.S. policy actions aiming to protect some industrial segments from competition from China. As Canuto et al. (2023) pointed out, this adds a macro, industrial-policy level to the microeconomic, GVC-level pressures for a possible reorganization of global value chains. This new environment is illustrated by policy changes, particularly in the United States and Europe. The reorganization of global value chains is impacted by significant policy changes such as the Inflation Reduction Act in the United States and, in Europe, the Green Deal Industrial Plan.

Is this reorganization process going on already? There is mixed evidence, but it is increasingly evident that changes to the landscape, some still difficult to observe, are taking place.

Brazil has well-known comparative advantages to explore natural resource-based products in agribusiness, minerals, and oil and gas exploration.

On the one hand, aggregated trade data suggests limited changes up to now. As shown in Figure 1, international trade has been quite resistant to changes in the last five years, even factoring in the transitory, pandemic-triggered causes of this good performance (an increase in trade in goods and the temporary family income increases because of government responses to the pandemic).

3 See Baldwin and Freeman (2021) and the European Parliament (2021). The increase in risks is highlighted by various indexes. One such measure is the World Uncertainty Index, derived from the frequency of the term "uncertainty" in quarterly Economic Intelligence Unit reports, revealing a steady rise since 2012. Additionally, the World Trade Uncertainty Index (WTUI) remained stable for two decades but began to increase around the third quarter of 2018. Another significant indicator is the Supply Chain Risk Index (SCRI), which exhibited a 36% surge between 2010 and 2020. Moreover, assessing billion-dollar natural disasters in the United States as a proxy reveals a notable escalation, from an average of 5 events annually to 20 over the past 40 years (as per the Issue Brief: Supply Chain Resilience, CEA, November 30, 2023).

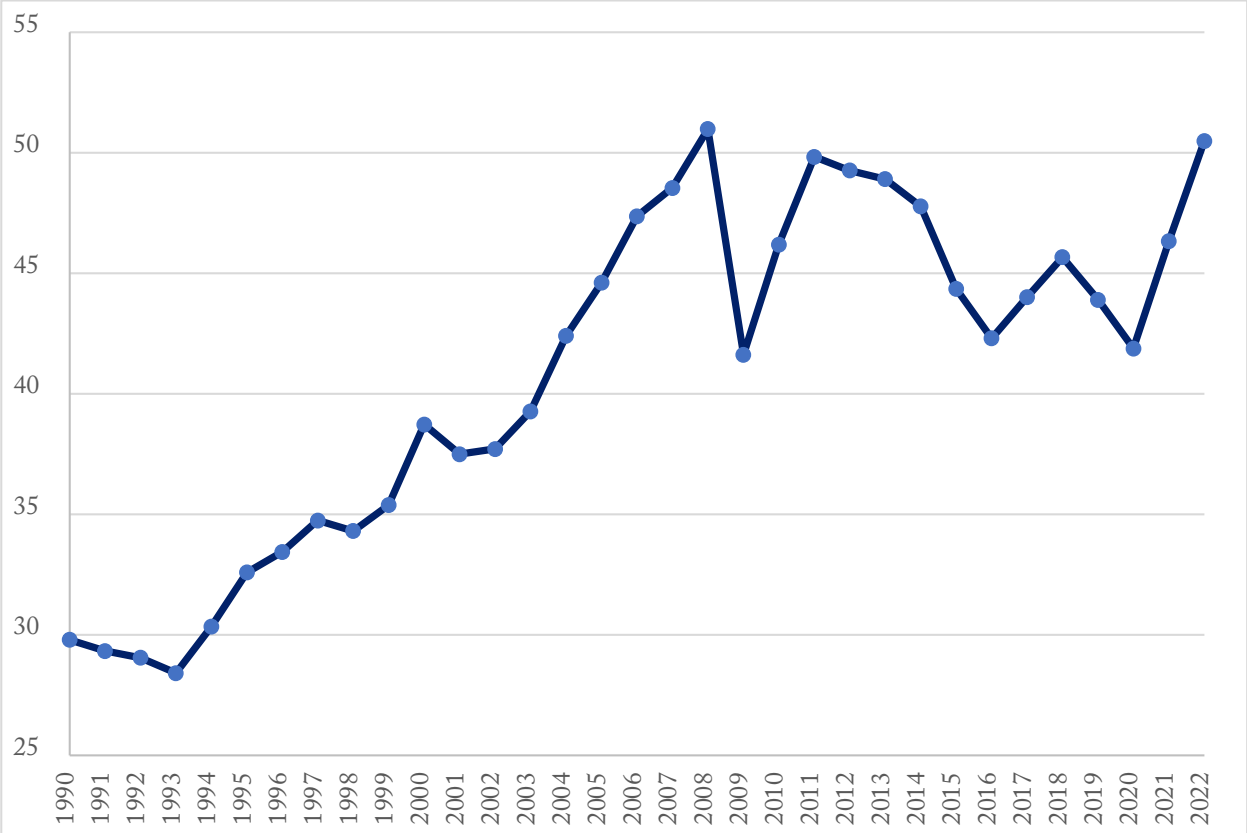
There are several possible explanations for the limited changes taking place so far, in addition to the obvious fact that some changes are quite recent. The force of inertia marks the reorganization of the GVCs. Numerous factors make relocation decisions more complex, such as capital intensity and scale, the intensity of the knowledge network and ecosystem network, access to resources, and the growth of markets. There is a need to change the supply chain, partner logistics, locations, routes and flows, and modes of transport. All this generates inertia and conspires, in many cases, toward conservative solutions. The combined costs and advantages of the already established network generate incentives to search for solutions aimed at resilience and security in the region itself.[4]

As pointed out by IMF (2023), in some cases, the sunk costs of building new infrastructure and the search costs of establishing new relationships in different countries tend to make the relocation of production an expensive endeavor. An interesting line of research points to mass modularity in a growing number of industries (Thun et al., 2021). Industries are characterized by several layers of highly specialized inputs that require deep capabilities and capital investment, limiting the possibility of replacing current suppliers. In these industries, moving links of a chain to another location is an incorrect simplification. [5]

4 Movements of investing companies in China, according to AmCham Shanghai (2021), are illustrative: 50.8% made investments in Southeast Asia, 30.2% in India, 34.9% in Mexico, and 22.2% in the United States.

5 The importance of the networks and the industry landscape is clear in the concrete case of Apple in China, as depicted in recent stories presented in the *Financial Times* (January 17 and 18, 2023).

Figure 1. World Merchandise Trade (% of GDP) – 1990-2022



Source: World Trade Organization and World Bank

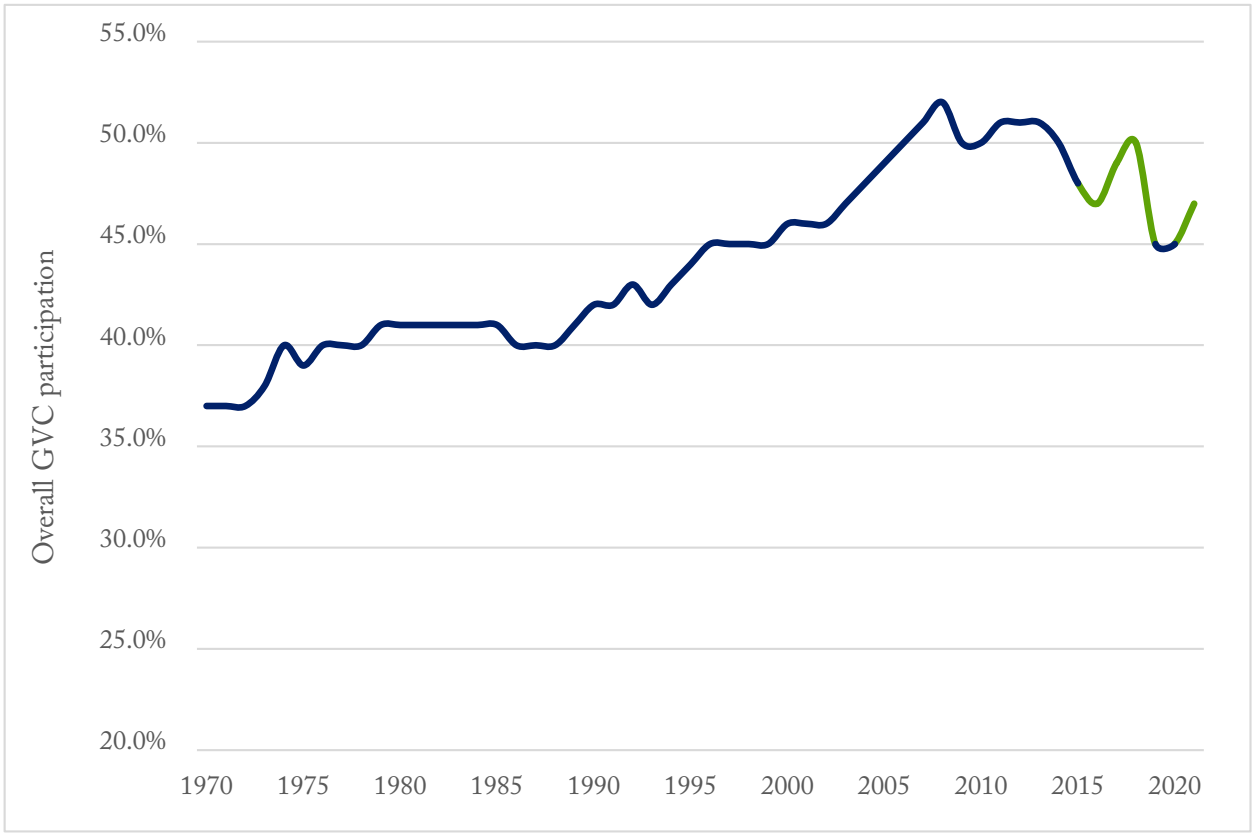
Yet changes are taking place and can be observed in more disaggregated data. Exploring several databases, Taglioni (2022) shows that GVC trade has been going up and down in recent years, but the trend since the Great Recession has been flat or even downward. Moreover, linkages with China also seem to be on a negative trend.

In this context, nearshoring, or the relocation of industrial plants to nearer (and perhaps friendlier) countries to the United States and Western countries, has emerged as a possible opportunity for Latin America to regain some impulse on attracting foreign investments, industrialization, and growth. Can nearshoring change the trade (and growth) landscape in Latin America?

So far, Latin American countries do not look like significant contenders in this fight to attract new activities. An exercise done at the IDB in 2021 looking at the impact of the tariffs imposed by the United States on Chinese products as part of the so-called "trade war" suggests that, except perhaps for Mexico, short-term nearshoring gains have not been significant for Latin American and Caribbean (LAC) countries. The low (and declining) similarity between the composition of exports from most LAC countries and China to the United States can help explain this. LAC countries' role as suppliers of manufacturing goods has been dwindling, driven by competition from China and other Asian economies and their strong demand for commodities from LAC. Long-term structural weaknesses (e.g. education, infrastructure, and institutions) and gross macroeconomic mismanagement add to this picture.

So far, Latin American countries do not look like significant contenders in this fight to attract new activities.

Figure 2. World GVC Trade 1970-2020



Source: Taglioni 2022; Note: Green highlights changes post-2016.

Box 1. Earlier Trends of Relocation: Wage Arbitrage and Automation

The driving factors of the offshoring initiated in the 1990s are subject to new constraints but remain references for decision-making: the quality of the economic environment, the density of the industrial ecosystem, and the relative costs.

The rise in wages in China was already altering locational decisions in Asia before the more recent shocks took place. Investments in labor-intensive and low-efficiency activities tend to seek location in low-cost countries. Even before the tension with the United States, there were movements of displacement of production from China to lower-cost Asian countries and even to Mexico. This is the case of Nike's sneaker production: according to the Reshoring Institute (see their website), in 2020, 40% of production was in Vietnam, 26% in Indonesia, and 21% in China. In the case of the iPhone—a labor-intensive product—locational decisions are associated with diversification of risk, costs, labor supply and enablement, and potential for market growth.

It is relevant to consider wage costs when discussing opportunities for Brazil and Latin America. In comparative exercises, Brazil's wage costs for machine operators and production workers are well above Thailand, Malaysia, Vietnam, Mexico, and India and slightly higher than China. In the case of supervisors and managers, the costs in Brazil are higher than in these countries: China, the United Kingdom, and Spain (see Figure 3).

Automation has also been perceived as an element that could lead to the relocation of industrial plants associated with wage pressure.

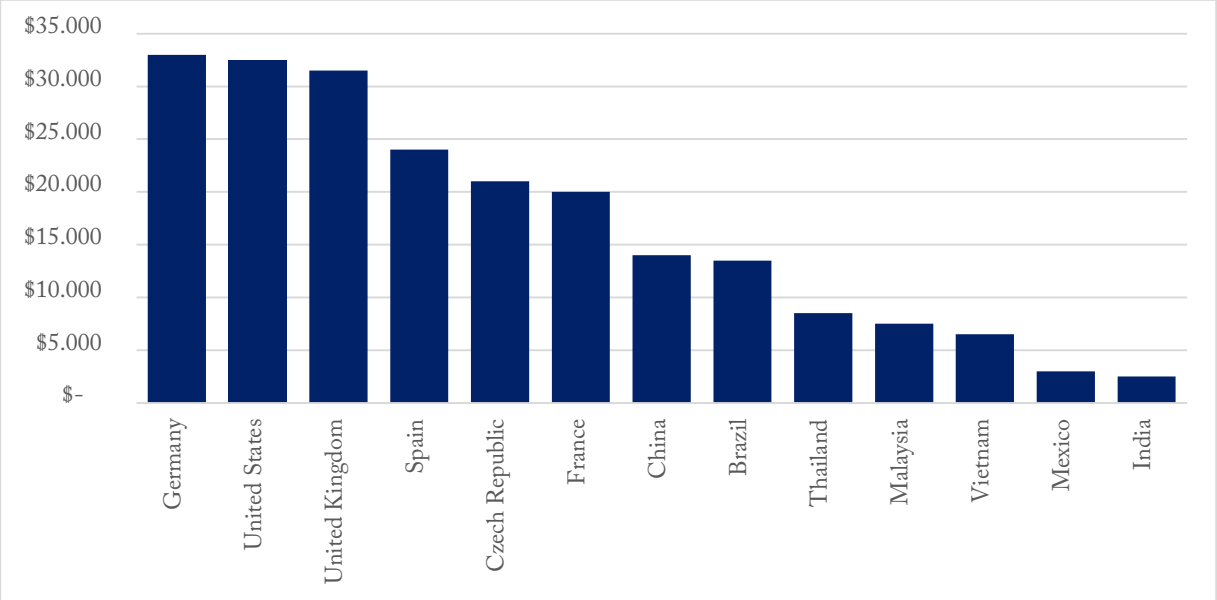
However, in examining the economic factors that impact the reorganization of GVCs, it is appropriate to examine digital technologies. These are technologies that generate differentiated impacts. AI, Cloud, and 5G facilitate outsourcing and offshoring. Automation, 3D, robots, and computerized manufacturing can enable the reduction of fragmentation.

Automation is the key element to generating compensatory possibilities for other costs, such as wages and transportation, and to create other forms of value, such as quality, energy efficiency, and lead times. Despite the reduced cost of robots and other digital technologies, adopting these technologies is slow and selective. Until you have more widespread cases of greenfield projects, a typical company will automate parts of the processes, such as focusing on complex assemblies and welding.

Studies for the United States and Brazil have shown the potential for cost reductions of more than 25% in many projects (Bank of America Institute, 2023; ECLAC, 2018). In Brazil, due to the productivity differential, the gains may be more expressive than in a typical American firm because of the combined effect of the application of technology and the low productivity of existing processes.

While observed changes have been limited up to now, the question remains whether the persistence and intensification of geopolitical tensions will increase the likelihood of reshaping GVCs, creating opportunities for countries in the region. Here we are dealing with conjectures, but it seems reasonable to imagine that firms have been considering a more disruptive change given the intensification of the

Figure 3. Average Salaries of Production Workers / Machine Operators (World)



Source: Reshoring Institute, Global Labour Rate Comparisons (2022)

geopolitical tensions, particularly the tension between the United States and China. Anecdotal evidence suggests that Mexico has been benefiting in recent months from some redirection of investment flows as new investments in China dwindle.

There are two categories of opportunities for the reorganization of GVCs. The first encompass those that result from assessments of security and resilience risks of GVCs, evolution of technologies, and relative costs. The second involves those that are directly affected by particular public policies inspired by national security and aspirations of technological leadership, such as the cases associated with national security (dual use, such as semiconductors), competitiveness in critical technologies (quantum computing, AI, electric vehicles [EVs], etc) and self-sufficiency (food, medicines, pharmaceuticals).

In the case of semiconductors, electric vehicles, batteries, clean technologies, and AI, the scale of incentives and subsidies aimed at breaking dependence on China and ensuring American leadership in these technologies changes the game's rules and could have significant impacts. It should be noted that China has shown substantive advances in all these areas. In solar panels, it is one of the most competitive and efficient producers; in batteries, it is the largest global producer; electric vehicles, produced by Chinese and foreign companies in China, have been gaining increasing market share. China's dominance in mass-production manufacturing makes its companies a relevant pivot in relocation decisions.

China is an important locus of relocation decisions. There are several levels at which this process develops. Chinese companies respond to the effects of tariffs and increased risks by diversifying production sites in Asia. Chinese investors have participated in the development of industrial parks dedicated to attracting Chinese companies to countries such as Mexico. In India, labor-intensive Final Assembly, Test, and Pack (FATP) operations imported from China are set up by Taiwanese companies. Major global auto companies have developed partnerships with Chinese battery companies. A Ford project with a Chinese company for a battery plant in the United States has come under fire, and even localization has been refused by some states.

In a way, in many cases, the GVCs' reorganization decisions conspire in the direction of an "Asian nearshoring." The growth of the Asian market, geographical proximity, the existence of established networks, and the routes, flows, and modes of transport make the region a first alternative for decisions that seek to increase the resilience and security of GVCs.

Relocation will be the product of assessing political risks and economic considerations, including assessing incentives for change. The first option of the strategy of companies with investments in China will not be to abandon China but to diversify new investments in other countries. The Chinese market will always be an attraction, and there are the exit costs associated with intellectual property, divestments, penalties, and political consequences. The evolution of geopolitical tension will be an important determinant of decisions and result in the reduction of the role of economic considerations.

It is on this narrow corridor that the opportunities for Brazil in this new environment must be assessed. Understanding the economic costs and the decision matrix of the reorganization of GVCs is the first clue to identifying where the opportunities are located.

THE POWERSHORING STORY

The most recent "-shoring" is powershoring. This idea emerges from the need to accelerate the transition to low-emission economies and highlights the importance of abundant, green, and secure energy for firms. Its urgency was highlighted by the gas shortages associated with the Russian war on Ukraine, and the importance of this factor in firms' decision-making is still to be assessed. In any case, this is an area in which Latin American countries can boast some competitive advantages. Given the high supply of renewable energy available, Brazil appears as a strong potential candidate to replace fossil-based production in the countries of origin of the investments.

According to Arbache and Esteves (2023),

> *"The central idea behind the notion of Powershoring is that climate change and geopolitical factors have opened a window of opportunity for countries with comparative advantages in the production of clean and renewable energy to attract energy-intensive manufacturing plants in their production processes. Therefore, Powershoring refers to a business strategy of production location, like other locational strategies, such as Offshoring, Reshoring, or Nearshoring."*

The increase in the frequency and intensity of extreme weather events puts more pressure on countries to accelerate the adoption of policies that contribute to reducing the emission of greenhouse gases (GHGs). This trend may represent an opportunity for countries that, like Brazil, have comparative advantages in producing renewable and clean energy.

As will be discussed in subsequent sections, of the various factors that affect GVCs (and industrial firms) throughout the world and that are changing—technologies, relative costs, trade policies, reactions to the environment and climate, changes in consumer preferences—the decarbonization process and the search for reliable, clean, and secure energy are the ones expected to generate new opportunities for Brazil, leveraging its comparative advantages in natural resources and the progress achieved in obtaining a clean energy matrix.

BRAZIL: TRADE PERFORMANCE AND PARTICIPATION IN GLOBAL VALUE CHAINS

As it is widely recognized, Brazil's participation in global value chains (GVC) is very limited. There are several reasons for this limited participation: an inspection of the main determinants for countries' participation in GVCs identified in the literature (see Table 1) shows that the Brazilian economy is not a high performer in most of them. This is true in the case of both non-policy determinants, such as geography, and most of the policy determinants, chiefly among them the level of protection of the economy.

This occurs even though the country has been one of the main destinations of FDI since the 1990s, after the successful stabilization of the economy. As Sturgeon et al. (2013) noted, the large internal market provides a strong incentive for foreign companies to invest there. However, with very high trade costs, Brazil has been chosen by foreign investors almost exclusively for tariff-jumping investments rather than as a destination for export-oriented investments. In addition, as also noted in Sturgeon, public policies in Brazil have been characterized by focusing on the development of fully independent domestic industries, separate from GVCs, rather than trying to integrate industries into the global economy.

RECENT TRADE PERFORMANCE AND PARTICIPATION IN GVCS

Historically, Brazil and South America participate in value chains mainly from an upstream position as suppliers of raw materials that will be processed in other economies. Since the beginning of the twenty-first century, the main trade connection between the region has been through exports of agricultural and mineral commodities, initially to developed countries and, more recently, to China and other countries in Asia. As depicted in Table 1, Brazilian manufactured exports to the world have lost weight, although there are still significant trade flows between the countries of the region (mainly between Brazil and its partners in Mercosur) in a few industrial sectors. In the most recent period (2020-2022), Brazilian exports of primary goods and natural resource-based industrial goods added up to 77% of total exports.

The strong demand for primary goods from China and Asia has impacted both quantities exported and prices. Therefore, Brazilian exports have been increasingly skewed toward primary and resource-based goods and less to medium- to high-technology goods, as shown in Table 1.

It is thus not surprising that, as pointed out by many authors (Callegari et al. [2018], Hollweg and Rocha [2019], among others), Brazil's participation in GVCs is characterized by intense forward participation as a primary product supplier and low backward participation, with reduced use of imports in exports. In fact, Brazil's relatively low engagement concerning GVCs is reflected when looking at measures of what Brazil buys (backward participation) and sells (forward participation). The first measure captures the foreign value-added content embodied in Brazil's gross exports, while the second measures the domestic value added embodied in a third-party country's gross exports.

Overall, data suggests that Brazil's participation in GVCs is reduced when compared to international peers.

Overall, data suggests that Brazil's participation in GVCs is reduced when compared to international peers and is relatively stronger on the seller (forward)

Table 1. A Snapshot of Brazilian Exports 2010-2022

Group	2010-2015		2016-2019		2020-2022	
Description	Value	Part.	Value	Part.	Value	Part.
	(US$ Millions)	%	(US$ Millions)	%	(US$ Millions)	%
Primary Goods	**76,857**	**34.6**	**84,579**	**39.9**	**123,461**	**44.9**
Industrial Products	**138,388**	**62.2**	**122,167**	**57.7**	**145,870**	**53.1**
Natural Resource Based	**75,479**	**33.9**	**62,663**	**29.6**	**88,709**	**32.3**
Agriculture Based	28,858	13	26,733	12.6	31,512	31,512
Non-agriculture Based	46,622	21	35,930	17	57,196	20.8
Low Technology	**10,940**	**4.9**	**9,558**	**4.5**	**9,541**	**3.5**
Textiles, Apparel, and Footwear	4,802	2.2	3,741	1.8	3,267	1.2
Other	6,138	2.8	5,817	2.7	6,273	2.3
Medium Technology	**41,564**	**18.7**	**41,109**	**19.4**	**40,186**	**14.6**
Automotive	11,359	5.1	11,446	5.4	8,885	3.2
Processes	16,439	7.4	15,829	7.5	19,598	7.1
Engineering	13,765	6.2	13,834	6.5	11,704	4.3
High Technology	**10,404**	**4.7**	**8,837**	**4.2**	**7,434**	**2.7**
Electronics	3,907	1.8	2,819	1.3	3,058	1.1
Other	6,497	2.9	6,018	2.8	4,376	1.6
Other Goods	**7,139**	**3.2**	**5,137**	**2.4**	**5,380**	**2**
Total Brazil	**222,384**	**100**	**211,883**	**100**	**274,710**	**100**

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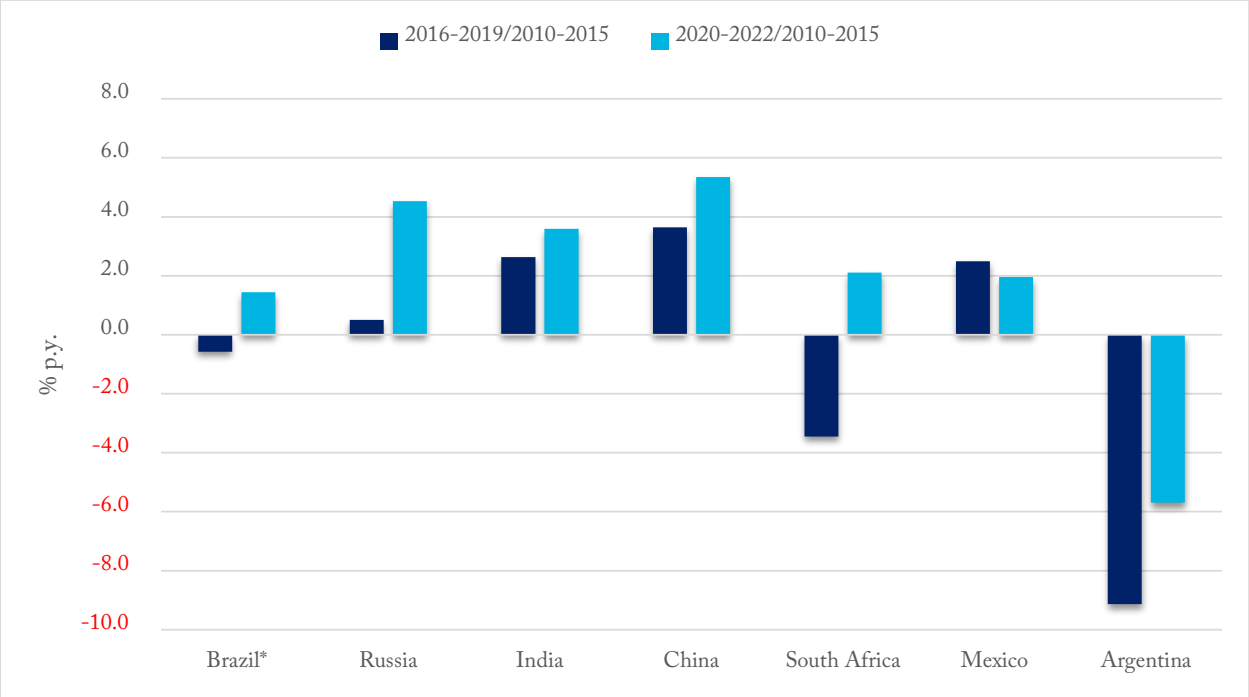
side than on the buyer (backward) side. Brazil's performance differs substantially across sectors: when considering GVC-intensive sectors in which Brazil is relatively competitive (agribusiness, metal production, automotive, and chemicals), Hollweg and Rocha (2018) show that in these sectors the country is relatively stronger on the seller (forward) side than on the buyer (backward) side. This is not the case for Brazil's automotive sector, where its GVC participation is low compared to its peer countries. The agribusiness in Brazil shows both strong forward and backward linkages while having a reasonable level of participation overall compared to some of its comparators, such as Mexico and Turkey.

The trade of parts and components gives another measure of GVC participation. Figure 4 presents the average annual growth of parts and components exports in the last 12 years. The figure includes the BRICS countries as well as Mexico and Argentina. As expected, Brazil, South Africa, and Argentina show the less positive performance, being among the countries that had the lowest growth in parts and components exports during the period. China, followed by India, Mexico, and Russia, show a stronger performance.

Figure 4. Exports of Parts and Components – Brazil and Selected Countries 2010-2022



*Source: *Secex/MDIC and other countries Comtrade/UN.*

Table 2. World Exports in Three GVC Industries – 1992-2022

	1992	2008	2014	2018	2022	CAGR 1992-2008	CAGR 2008-2014	CAGR 1992-2014	CAGR 2014-2018	CAGR 2018-2022
World Merchandise Exports	3,786,844	16,148,864	17,550,661	17,963,377	19,198,767	9.49%	1.40%	7.22%	0.58%	1.68%
Brazil Merchandise Exports	35,793	197,942	225,098	231,890	334,463	11.28%	2.17%	8.72%	0.75%	9.59%
World Exports in 3 "GVC Industries"	1,705,303	7,018,218	5,024,041	5,407,776	5,051,826	9.25%	-5.42%	5.03%	1.86%	-1.69%
Brazil Exports in 3 "GVC Industries"	14,282	47,591	26,945	27,289	22,717	7.81%	-9.05%	2.93%	0.32%	-4.48%
Share	40%	24%	12%	12%	7%					
Electronic Hardware	1,312	7,246	1,460.7	1,353.5	1,318.8	11.27%	-23.43%	0.49%	-1.89%	-0.65%
Motor Vehicles	7,800	34,524	20,186.8	22,450.3	17,624.5	9.74%	-8.56%	4.42%	2.69%	-5.87%
Textile, Apparel and Footwear	5,170	5,821	5,297.1	3,485.1	3,755.7	0.74%	-1.56%	0.11%	-9.94%	1.89%
World Merchandise Exports Less 3 Industries	2,081,541	9,130,646	12,526,620	12,555,601	14,146,941	9.68%	5.41%	8.50%	0.06%	3.03%
Brazil Merchandise Exports Less 3 Industries	21,511	150,351	206,460	212,270	315,308	12.92%	5.43%	10.83%	0.70%	10.40%

OBS: CAGR (Compound Annual Growth Rate). Source: Sturgeon (2016) for the 1992-2014 data and authors' elaboration for the recent period.

Brazil's limited participation in GVC trade is also shown by the performance of some of the sectors that have been driving GVC trade. Sturgeon (2016) shows that between 1992 and 2014, when global trade grew very rapidly while exports of three complex assembly industries—electronic hardware, motor vehicles, and textile/apparel/footwear—grew at the same pace as global trade (7.9% per year)[6], Brazil's export performance of these GVC sectors was poor, with a growth rate of only 3.8% in the same period. Consequently, notes Sturgeon, the share of these three "GVC-intense" sectors in Brazil's export basket fell in the period of fast expansion of GVCs, from 40% in 1992 to just 14% in 2014. We updated the Sturgeon exercise (using a slightly modified classification) and found no change in the trend in recent years (see Table 2).

A recent update of the Trade in Value Added (TIVA) database shows that little has changed in recent years. Figure 5, extracted from the WTO database, shows a slight increase in the foreign value-added content of Brazilian exports.

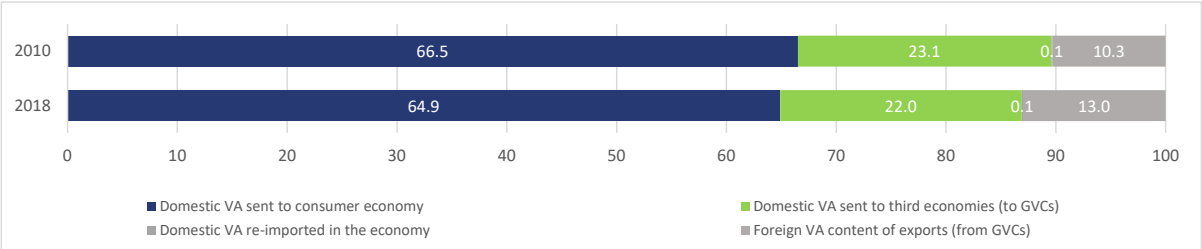
More recently, Guimaraes (2022) provided a more disaggregated analysis of Brazilian industrial companies' participation in GVCs using unexplored information in the database offered by the annual industrial survey collected by the National Statistics Institute (IBGE). The annual industrial survey asks firms to provide an estimate of the proportion of total sales that are exported and of total input acquisitions that are imported. As this is asked as an estimate and not hard data, it is not regularly published by the IBGE.

Based on the data, Guimaraes (2022) identifies that only two industrial sectors (out of 24) present simultaneously high coefficients of imported inputs as well as relevant export coefficients, i.e., they present significant insertions, upstream and downstream, into global value chains—the sectors are other transport equipment and machinery and equipment.

A more disaggregated analysis, at a 4-digit level, shows that only the companies of seven of the 98 groups are, on average, relatively integrated upstream and downstream with the global value chains. Of these seven groups, aircraft has both very high coefficients (92% and 84%) and machinery and equipment for use in mineral extraction and construction has a relevant import coefficient and high export coefficient (61%). These segments of the Brazilian industry are genuinely integrated into global value chains. The other five groups have similar imported input coefficients (37% or 38%). However, the importance of exports to their companies differs, with the share of exported production of the trucks and buses group (34%) higher than those of other products, artificial and synthetic fibers and products, and various chemical preparations (all 22%) and machine tools (27%).

6 This figure, however, masks a more rapid expansion of intermediate goods exports, that grew at 8.5% per year in the same period (see Sturgeon, 2016, pages 8 and 9).

Figure 5. The Value Added (VA) Components of Gross Exports, 2010 and 2018 (% Share in Total Gross Exports)



Source: WTO

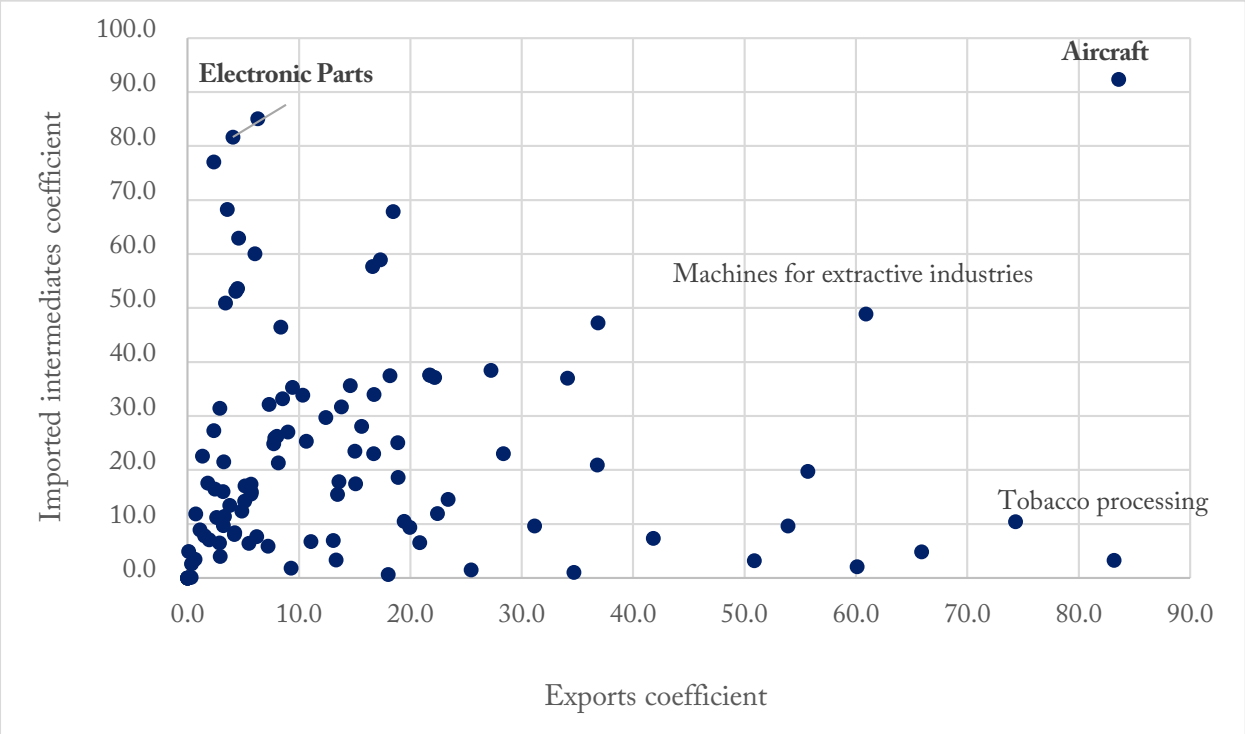
This detailed analysis allows Guimaraes (2022) to identify a group of sectors that exports a more significant share of the production but has reduced imported input coefficients—it covers 58 CNAE[7] groups that account for 59% of the net sales revenue of the transformation. This segment comprises groups that includes intermediate goods in general, those using inputs from agricultural and extractive mineral activities, and semi-durable and non-durable consumer goods. There is a strong presence of multinational companies in these segments. In this context, the evolution of the way companies in this segment are integrated into global value chains in downstream activities depends largely on the strategies of multinational companies.

Finally, there is no evidence so far that recent changes triggering GVCs reorganization have produced any change in the Brazilian landscape. While most of the changes are too recent (and even developing as we write) to allow for a thorough assessment of their impacts, some changes, like the trade war between the United States and China, started a few years ago and allow for some examination of its impacts on U.S. imports as well as impacts on the rest of the world's exports to the United States. A recent IDB paper (IDB, 2022) tried to shed some light on this issue by developing some econometric exercises for LAC countries' exports. While the exercises are not exhaustive, they do not capture the impact of the COVID-19 shock nor the recent escalation of geopolitical tensions. However, they provide an initial idea of the latent advantages that countries in the region could offer.

A first exercise looks at trends in targeted Chinese exports before and after the event (the U.S. tariff shock). The estimation is based on monthly data for the 12 months before and after the event to establish its impact's magnitude and statistical significance. The results show very limited potential trade diversions to LAC, mostly concentrated in Mexico. In the case of Brazil, targeted-good exports do not show a

7 CNAE is the Portuguese acronym for National Classification of Economic Activities.

Figure 6. Coefficients of Export and Import by Industrial Sector in Brazil, 2019



Source: Guimarães 2022

consistent and distinctively positive trend after the shock. Given the diverse nature of the region, a more detailed exercise tries to estimate the cross-price elasticity of substitution between Chinese and LAC exports to the United States. Here, the paper finds some evidence of scattered country- and sector-specific gains in the region that are distributed across a wide range of goods—from natural resources to capital– and labor–intensive goods. Brazil shows potential for export increase to the U.S. market in a couple of sectors but a limited potential compared to other countries in the region like Mexico, Chile, and some countries in Central America. [8]

THE CAUSES FOR BRAZIL'S LOW PARTICIPATION IN GVC TRADE

Why is Brazil's participation in GVC trade so low? Several factors, both non-policy and policy related, contribute to this low participation. It may be helpful to start with a quick recollection of the literature on the main determinants of GVC participation.

Determinants of GVC participation

Which factors determine GVC participation across countries? Do factors that affect traditional trade have differential impacts on GVC trade?

According to OECD (2015), the main factors can be broadly grouped into two categories: non-policy factors, or factors that are not easily influenced by policy, at least in the short to medium term, and policy factors. Among the first, they include domestic market size (the larger, the lower the backward engagement of a country) and location. Location is considered one of the main non-policy determinants of GVC participation: evidence suggests that because GVC activity is organized around large manufacturing hubs, the larger the distance to the main manufacturing hubs in Europe, North America, and Asia, the lower is the backward (buyer) engagement.

The main policy factors are openness to trade and foreign investment, trade-related policies, such as trade facilitation, intellectual property protection, logistics performance, infrastructure, and the quality of institutions.

Several recent papers have tried to address this issue and quantitatively identify the main drivers of countries' participation in GVC trade, most identifying the variables strongly correlated with GVC participation.

Urata and Waek (2020) use data from the World Bank's Enterprise Surveys, covering 111 countries and 38,966 firms from 2009 to 2018. They identify as main country-related factors openness to trade and foreign direct investment inflows, availability of educated people, well-developed infrastructure, efficient logistics, and good governance. These are factors that facilitate firms' participation in GVCs and increase the level of such participation.

One of the main reasons for Brazil's low participation in GVCs is the limited openness to trade.

Results from an econometric analysis conducted by Fernandes et al. (2020) using cross-country IV regressions show that the key determinants of backward GVC participation are, in order of importance, factor endowments, geographical location, political stability, tariffs and FDI inflows, and domestic industrial capacity.

8 See IDB (2022).

In addition to using an instrumental variables approach, which allows the authors to claim causality, this study also identifies the relative weight of each explanatory factor. Overall, factor endowments can explain 43% of the backward GVC participation shares in the IV cross-sectional regression, which is the most important determinant, followed by distance (21%), political stability (18%), tariffs and FDI (13%), and domestic industrial capacity (4%).

Trade Costs in Brazil

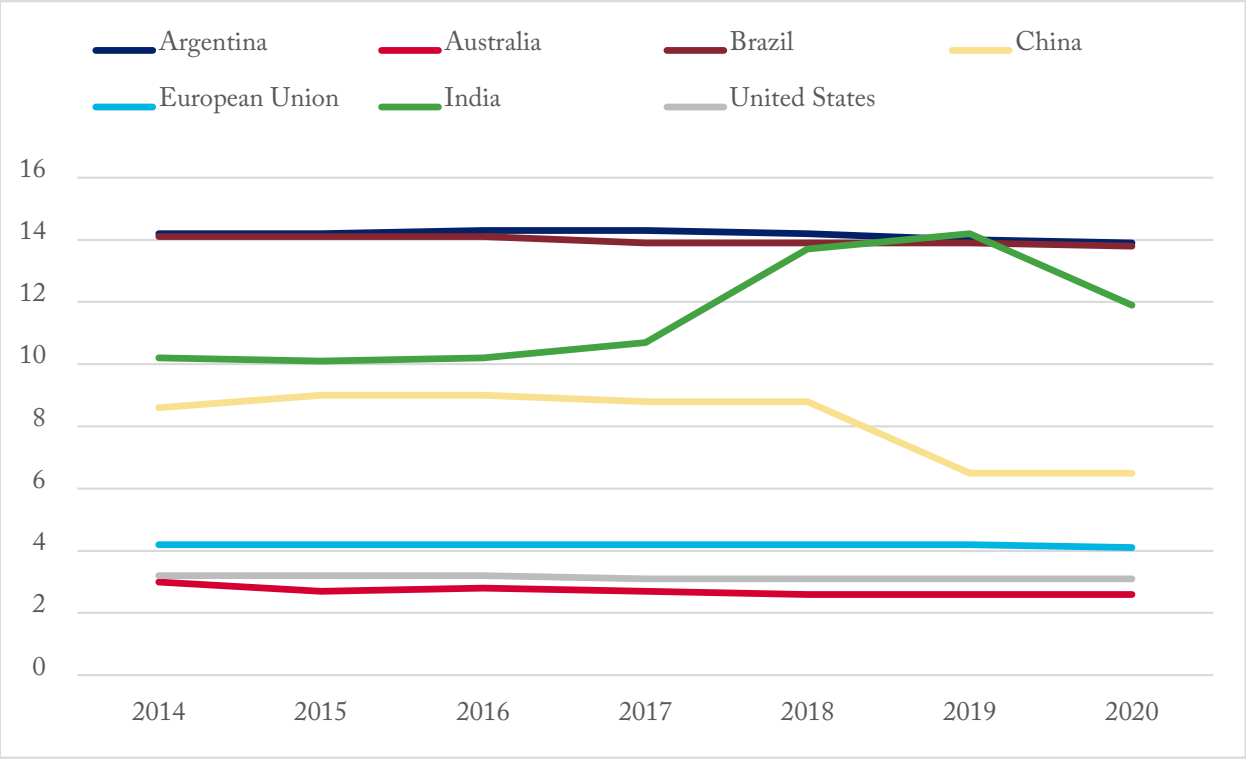
One of the main reasons for Brazil's low participation in GVCs is the limited openness to trade. This reflects the use of a wide range of protective trade policies, which includes high tariff barriers on imports. Brazil's average MFN tariff for manufactured goods is 13.8%—one of the highest rates compared to other emerging and advanced economies (Figure 7).

Brazil is an outlier when it comes to the level of tariff protection granted to industrial products. In 2020, only nine countries had higher average import tariffs for non-agricultural products than Brazil: Algeria, Argentina, Bhutan, Cameroon, Comoros, Gabon, Iran, Venezuela, and Zimbabwe[9]. No economic or social criteria justify this level of tariff protection for industrial goods.

Another characteristic of the Brazilian import's protection structure is its lack of selectivity. The country has high tariffs for inputs and capital goods compared to the rest of the world, but tariffs on consumption goods are even higher, meaning that in some sectors, such as automobiles or textiles, the effective rate of protection of domestic producers is in triple digits (Reis et al., 2018).

9 More recently, India has joined the group of countries with average MFN tariffs for industrial goods higher than Brazil's average rate.

Figure 7. Average MFN Tariff Applied to Non-agricultural Products 2014-2020



Source: Cindes (2022, based on WTO - https://timeseries.wto.org/)

Overall, apart from the trade liberalization episode of the early 1990s, the import tariff structure in Brazil did not see major changes until 2019, when some steps were taken, notably on IT equipment and capital goods (WTO 2022 and Centre for Studies in Integration and Development (CINDES) 2022)[10]. Even after the modest liberalization rounds undertaken in 2020-2021, Brazil continues to adopt high tariffs for capital goods and intermediate products compared to its peers. Brazilian average most-favored nation (MFN) tariffs for capital goods are the highest compared to those adopted by Asian and Latin American countries (Table 3). For intermediate products, only India surpasses Brazil in terms of average tariffs.

The manufacturing sector's adoption of new environmental and climate technologies would benefit from a new tariff treatment for environmental goods.

High tariffs on intermediate and capital goods imports negatively impact the industry's average productivity (Rios and Motta Veiga, 2018). A recent research compilation prepared by the Swedish Board reinforces that the empirical evidence of productivity effects from improved access to intermediate goods is particularly strong and consistent. According to the report, the main policy implication is to remove tariffs and other import barriers to intermediate goods. There is no point in saving import tariffs on intermediate goods as "chips" for future trade negotiations.[11]

Brazil has been a heavy adopter of trade remedies, particularly anti dumping measures (AD), accounting for 6% of the total antidumping measures applied by WTO members in force in December 2022[12] (Figure 8). The country is tied with China in the rank of countries applying antidumping measures (both in the fifth position). However, while China is the world's third-largest importer, Brazil occupies only the twenty-seventh position in the rank of world importers.

10 Since 2020, MFN tariffs of several manufactured goods have been reduced by 20%, in two rounds of 10%. The first round was incorporated in the Mercosur's Common External Tariffs. The second round was temporary and was due to terminate in December 2023.

11 See Kommerscollegiom, page 23

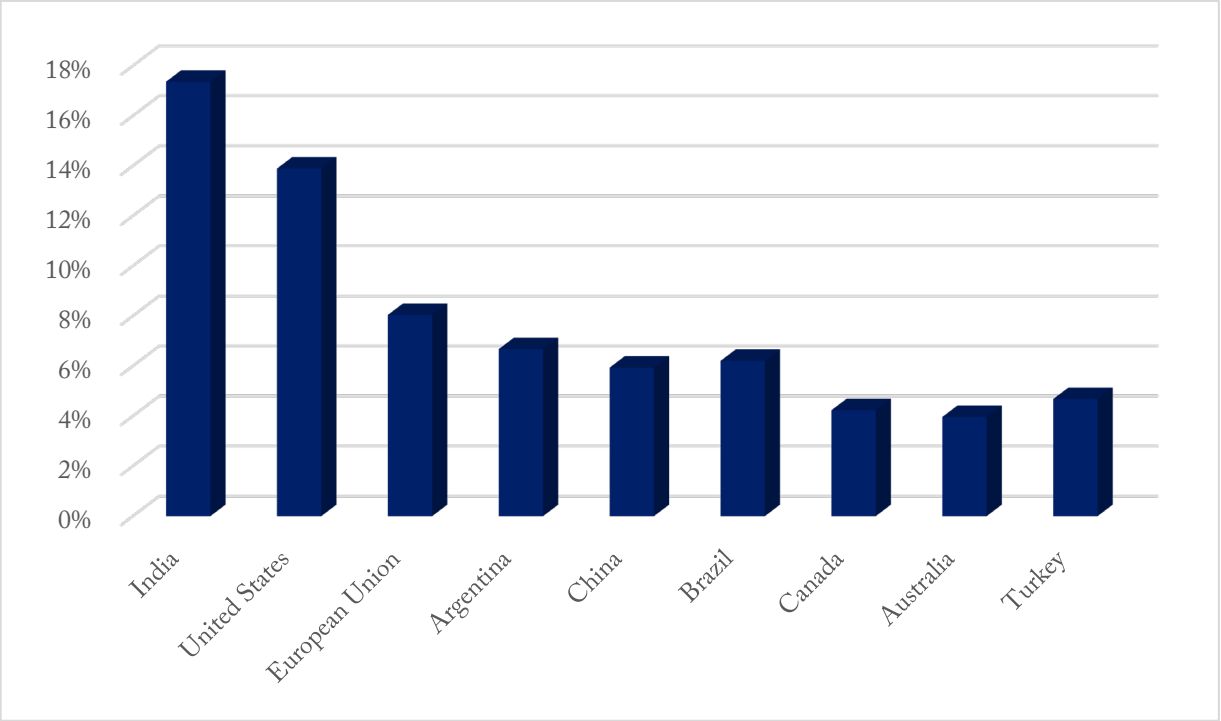
12 "Trade Remedies Data Portal." Home - Trade Remedies Data Portal. https://trade-remedies.wto.org/en

Table 3. Average MFN Tariff: Intermediate Products and Capital Goods

Countries	Capital Goods		Intermediate Products	
	2000	2021	2000	2021
Brazil[1]	13.1	11.8	12.5	9.7
China[2]	14.7	5.9	14.2	6.9
Philippines[2]	4.4	4.7	6.2	5.2
India[2]	25.9	10.1	32.7	10.3
Indonesia[2]	5.1	9.3	7.2	6.7
Malaysia[2]	11.5	7.7	8.3	7.7
Mexico [2]	14.3	4.5	14	2.9
Thailand[2]	9.5	10.2	14.5	9.7

Sources: (1) Secex/MDIC and (2) WITS and classification compatible with GCE Secex/MDIC.

Figure 8. Use of Trade Remedies in Selected Countries



Source: https://trade-remedies.wto.org/en

AD measures are often applied to the imports of intermediate goods. In the case of Brazil, chemicals, plastics, rubber, steel, and other metals account for 65% of the measures in force. Levied over the imported value already charged with high tariff rates, AD measures can make intermediate goods very expensive in Brazil, negatively impacting the abovementioned productivity and competitiveness.

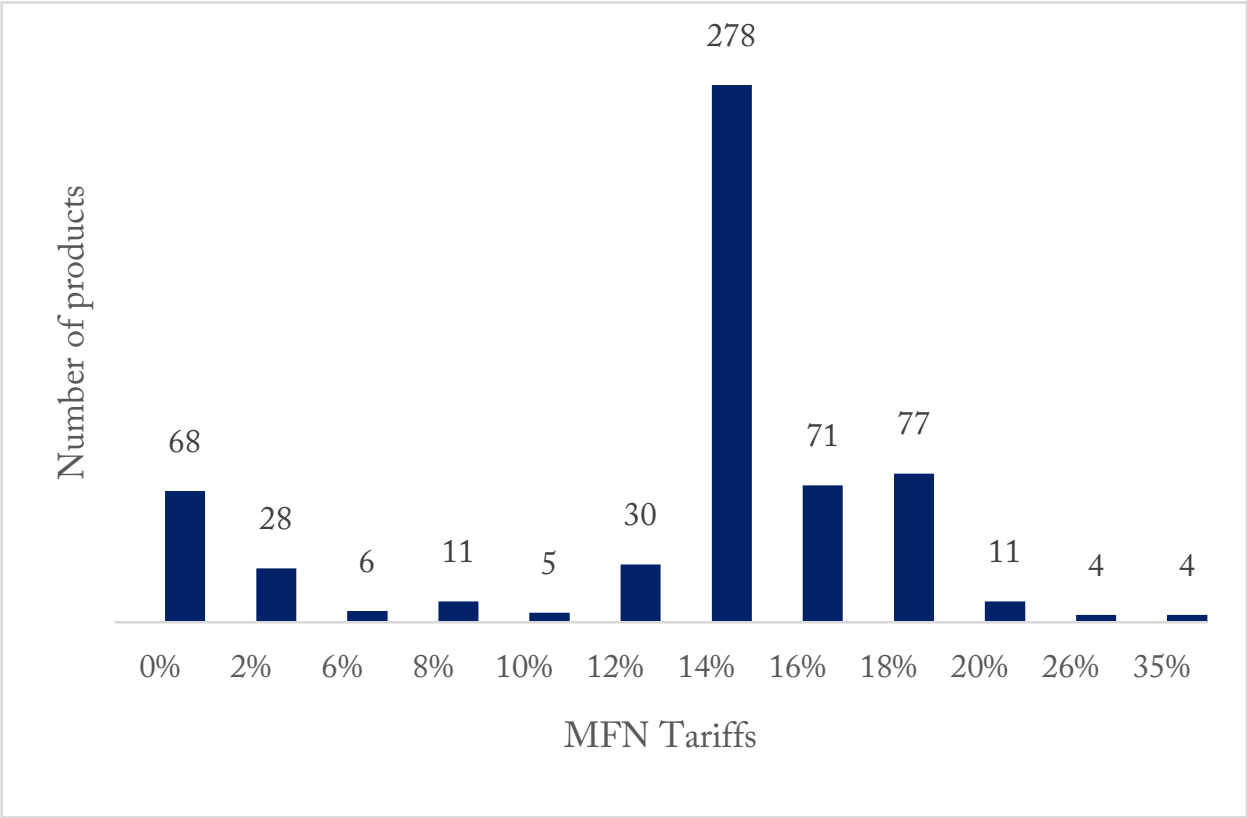
In comparison to the Latin American region or with the Asian countries, Brazil has the lowest number of [PTA] agreements.

As noted by Cindes (2022), this characteristic of Brazil's protection structure also undermines the industrial sector's decarbonization objectives. An exercise by Cindes based on an OECD list of 248 environmental goods—the Comprehensive List of Environmental Goods (CLEG)—identified that Brazilian imports of products from this list account for 9% of the value of the country's total imports. Brazil applies an average tariff of 14% on the products included in CLEG, compared to 5.8% in industrialized countries, 3.9% in Mexico, and 6.9% in Indonesia. More than 80% of the products in this list face import tariffs above 10% when entering the Brazilian market (Figure 9).

The manufacturing sector's adoption of new environmental and climate technologies would benefit from a new tariff treatment for environmental goods.[13] This theme should be on the agenda of Brazilian policies aimed at reducing emissions and will be part of any effort to increase Brazil's participation in GVCs.

13 Moreira and Dolabella (2022), building on a Shapiro (2021) study, found out in a recent paper that most Latin American countries adopt higher tariff rates for dirtier goods than cleaner goods. This is the case of Brazil. They follow Shapiro's interpretation that a negative (positive) correlation between tariffs and a good's emission intensity implies a subsidy to (a tax on) CO_2 emissions. Argentina and Brazil have the highest estimated subsidies (approximately $10 per ton of CO_2 equivalent), applying Shapiro's methodology.

Figure 9. Brazil: Tariffs on Environmental Goods



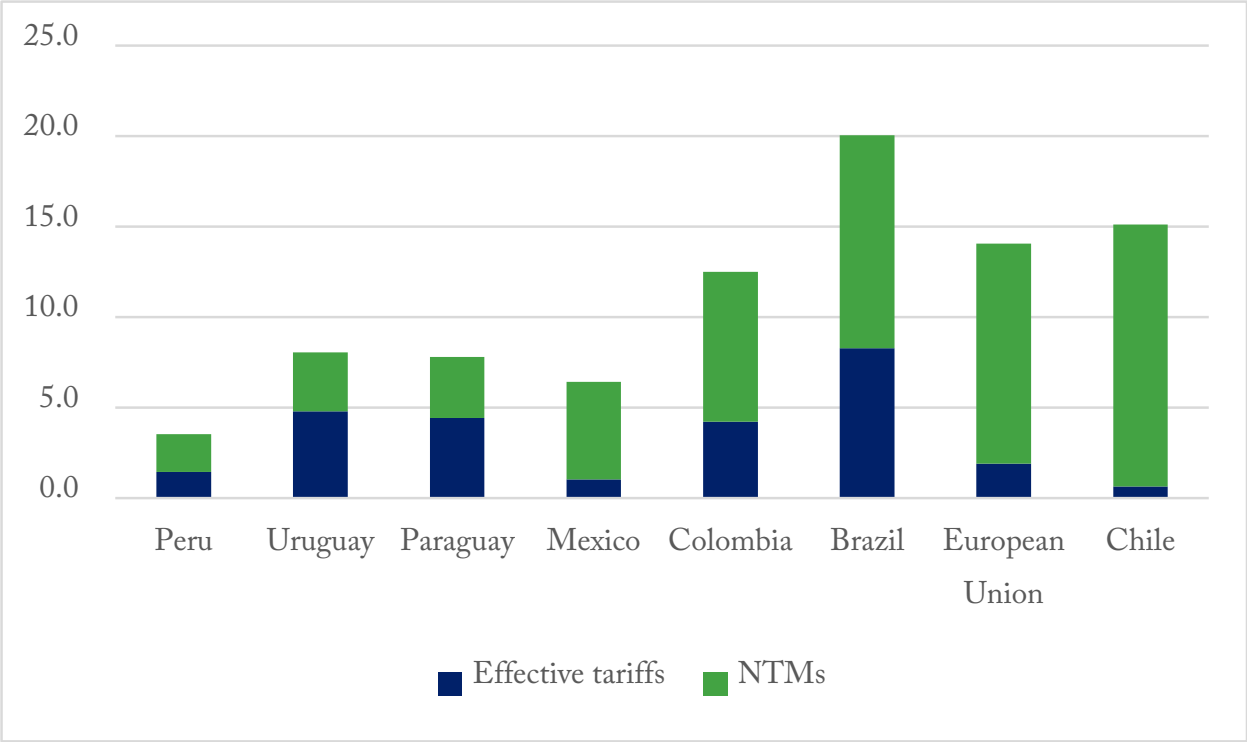
Source: WITS - https://wits.worldbank.org/

Beyond tariffs, non-tariff measures (NTMs) and procedural obstacles in Brazil are widespread, raising the costs of trade. The ad valorem equivalent of NTMs—a measure of the effective restrictiveness of NTMs—is almost 12% (Figure 10). According to NTM data by the United Nations Conference on Trade and Development (UNCTAD), the coverage ratios, or the percentage of imports subject to at least one NTM, are high in Brazil compared to other countries. While certain NTMs, particularly regarding sanitary and phytosanitary measures and technical barriers, may serve legitimate purposes, others might be driven by protectionist interests. [14]

The fragmentation of the production process into global value chains has increased the importance of services in international product flows. The increasing aggregation of technology to the production of goods makes the competitiveness of products increasingly linked to the competitiveness of services. A report prepared by CNI (2020) presents figures that underscore this trend for Brazil: a) the percentage of services within the total value of production of the manufacturing industry increases from 9.2% in 2005 to 23.9% in 2015; b) the share of services value added on the total exports of goods and services rose from 38.9% in 2005 to 46.2% in 2016, a figure while still below the average of OECD countries is higher than non-OECD countries; c) the share of services value added in the manufacturing sector is 35.1% in 2016, with imports accounting to 6.4%.

14 Estimates used in simulation analyses, discussed in Reis et al (2018), suggest that NTMs in Brazil further increase import cost, on average, by about 12%.

Figure 10. Average Ad Valorem Equivalent of Tariffs and NTMs, 2015: Brazil vs Selected Peers



Source: Reis et al., 2018, based on estimations using UNCTAD TRAINS and UN COMTRADE data

This trend gains further significance in the context of the transition toward Industry 4.0 and supports the idea of multinationals in Brazil playing a more robust role as a hub in the regional market, a point emphasized in our interviews with business leaders. Companies stressed the importance of gaining access to technologies and business services and the costs associated with the tax system. According to the CNI report, the tax incidence on the imports of technical services in Brazil, essential for the incorporation of technology, varies between 41% and 51% of the value of the operation, representing a significant discrimination in relation to domestic providers that collect, on average, 18%—another example of trade protectionism jeopardizing the competitiveness of Brazilian production processes and their integration to GVCs.

The number and depth of preferential trade agreements (PTAs) are important channels for increasing participation in GVCs. Given the increasing unbundling of export goods production, PTAs have become the primary vehicle to bring in new disciplines (such as competition policy, intellectual property, investment, etc.) that allow factories to connect across borders in a seamless way.

The frequency and depth of PTAs have been increasing substantially (Matoo, Rocha, and Ruta, 2020). Evidence presented by Hollweg and Rocha (2018) also suggests that GVC-related trade—proxied with trade in parts and components—is higher on average for countries that have signed deeper agreements, where the depth of an agreement is the number of legally enforceable provisions. Brazil has not followed this trend. In comparison to the Latin American region or with the Asian countries, Brazil has the lowest number of agreements. More consistent progress has taken place in recent years, with the conclusion of negotiations with the European Union and the European Free Trade Association (EFTA), but their

conclusion is still uncertain, and such initiatives will take a long time to generate effective results due to the difficulties of ratification, and because of the long-agreed schedules for the elimination of import tariffs after the entry into force of the agreements (Cindes, 2022).

Regional trade agreements are particularly important for the flourishing of global value chains[15]. Backward-type measures of GVCs show that these production chains have a strong regional feature. In fact, the three "world factories"—Asia, Europe, and North America—are characterized by high foreign value added (VA) in exported VA and high regional VA in foreign VA. CAF (2021) shows that Latin America has low regional VA in foreign VA. Brazil, in particular, shows low participation in both forward and backward regional linkages (see Figure 11). This is probably related to the composition of exports (as previously shown, Brazil's primary exports are mainly directed to Asia, North America, and Europe) and to the country's low overall level of imports. While an enlargement and rule harmonization of existent regional trade agreements could incentivize the regional value chains in the region (see IDB [2018] for a discussion about alternatives), there are important structural limitations to the expansion of regional value chains, such as the composition of trade of most countries in the region as well the deficiencies in physical infrastructure.

It is widely recognized (WTO, 2022; Cindes, 2022; Reis et al., 2018; Canuto et al., 2014; among many others) that to participate thoroughly in GVC trade, Brazil also needs to address deeply entrenched competitiveness challenges, traditionally referred to as "Custo Brasil." This includes a group of policies whose implementation is relevant to allow domestic producers to take advantage of the new opportunities generated by liberalization, as well as to train themselves to face competition from imported products. This group includes, among others, taxation, business environment, infrastructure, workforce skills, and innovation policies.

The resilience of trade protectionism in Brazil has contributed to the country's low level of engagement in the previous cycles of globalization.

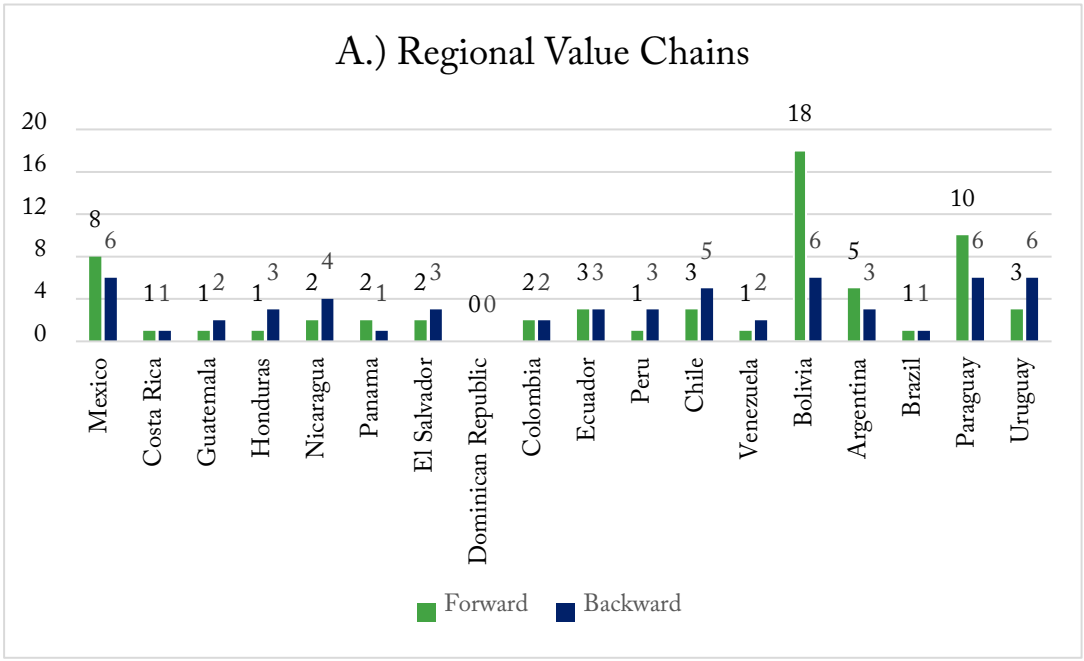
While the list of competitiveness obstacles is long and can sometimes become a wish list, there are reasons to believe that some changes that are taking place in the world, combined with recent and ongoing reforms, can lead to new significant opportunities for Brazil. The resilience of trade protectionism in Brazil has contributed to the country's low level of engagement in the previous cycles of globalization. Recent evolution in the domestic and international contexts adds new arguments in favor of trade policy reforms in Brazil.

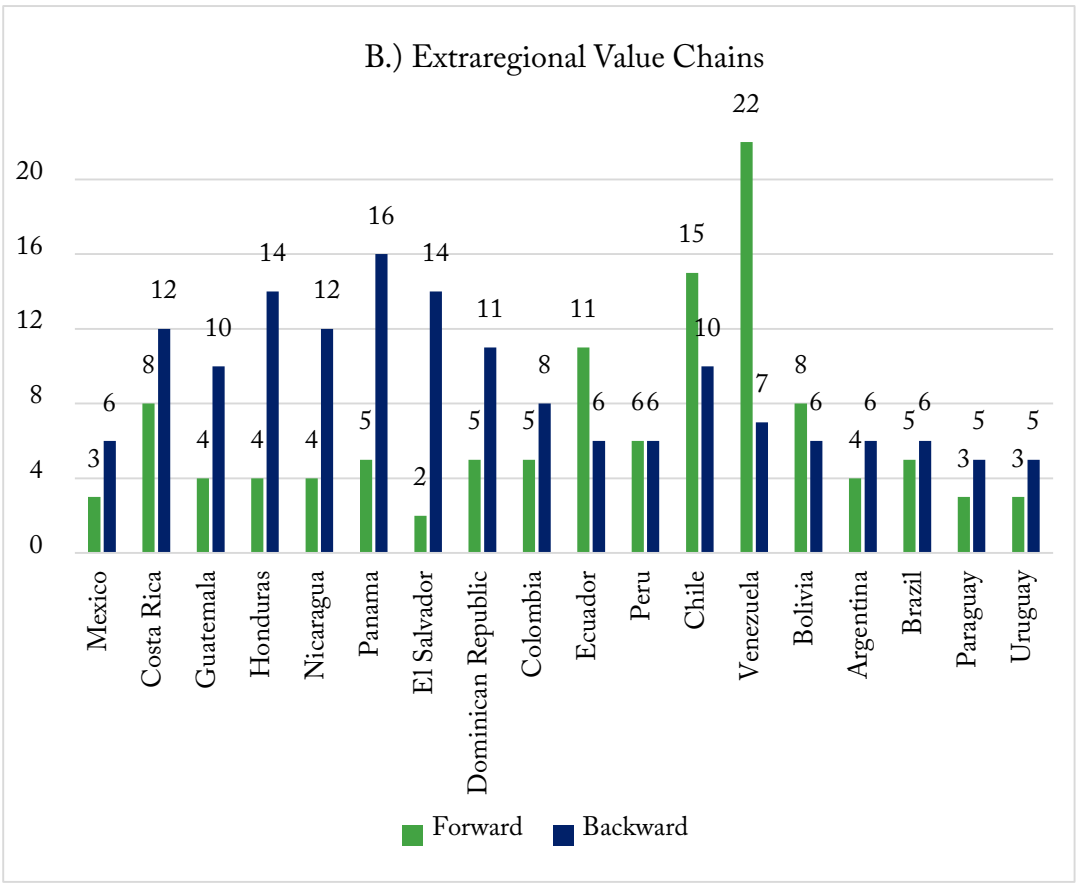
The reshaping of value chains in the world can open opportunities for the country. Taking advantage of these opportunities will depend on reducing obstacles to companies acting by the logic of value chains: import costs are one of the biggest obstacles to such integration. Moreover, in times of increasing concerns regarding the resilience of supply chains, trade liberalization can represent an insurance policy, expanding the sources of supply of inputs and raw materials for domestic producers.

In addition, the world industrial sector will operate a double structural transition in the coming years—digitization and decarbonization. The participation of Brazilian industry in this process requires a reduction in costs and obstacles to the international trade of goods and services. Last but not least, the

15 As noted by Baldwin, the expression "global value chains" is not the most appropriate to describe the changes that took place at the end of the twentieth century. We are talking about networks of production, rather than value chains. And most of them are regional, not global.

Figure 11. Participation of Regional and Global Backward and Forward VA in Total Value Added (2015)





Source: CAF, 2021.

traditional economic arguments in favor of trade liberalization—based on its positive effects on efficiency and productivity and on the real income of the poorest strata of the population—keep their validity for an economy like the Brazilian one.

There is not much novelty in the debate of trade reforms in Brazil. As the country has not engaged in trade liberalization reforms (unilaterally or in the free trade agreement [FTA] mode) since the beginning of the nineties, the main challenge continues to be the "normalization" of the Brazilian trade policy (CINDES, 2022). This means making trade policy converge with the country's peers. The trade reform in Brazil should focus on the instruments used to manage imports of goods and services: tariffs, non-tariff measures, barriers to trade in services, and trade negotiations.

The opening up of the economy is a necessary, though not sufficient, condition to improve the country's ability to seize the opportunities of the changing landscape. So, it remains crucial that the country implement the reforms aimed at reducing the so-called "Brazil cost." On the one hand, trade liberalization should not be put on hold, waiting for the reduction of the "Brazil cost." However, implementing the reforms that will lead to the reduction of these costs will guarantee better results for the trade policy reform.

This includes a group of policies whose implementation is relevant to allow domestic producers to take advantage of the new opportunities generated by liberalization. This group of policies includes, among others, taxation, business environment, infrastructure, workforce skills, and innovation. CINDES (2022) presents a broad and very detailed set of trade policy proposals along these lines.

Box 2. The Political Economy of Protectionism in Brazil

According to Motta Veiga and Rios (2019), the resilience of protectionism in Brazil relies on the role of two main factors in shaping trade policy in the country: interests and ideas.

First, interests matter. Common sense suggests that manufacturing interests still dominate the trade policymaking in Brazil, considering that the protection structure heavily favors this sector. It would also be expected that a high level of conflict exists between industrial sectors demanding protection and agriculture and services business representatives calling for trade liberalization. As the process of the deindustrialization of the Brazilian economy deepens and the industrial sector loses its share in the country's GDP, the interests of this sector should be losing ground in trade policy.

While the manufacturing sector has benefitted from tariff and non-tariff protection instruments and has been able to deploy a broad and efficient structure to influence trade policy, it is not Brazil's only sector with protectionist interests. Conflict over trade policy between industrial sectors demanding protection and agriculture business representatives has not played a relevant role in the dynamics of the political economy of trade policy.

Box 2. The Political Economy of Protectionism in Brazil cont.

On the one hand, some economically relevant agriculture segments are oriented to the domestic market and do not want to face competition from imported goods. Their interests converge with those of the manufacturing sector. On the other hand, the agribusiness sector became competitive and saw its exports grow rapidly, largely benefiting from high international prices and strong demand from Asian countries during a large share of the period herein considered. These exports can rely on drawback mechanisms to benefit from the exemption of the costs of industrial tariffs (and other taxes charged to imports) when importing agricultural inputs for production.

This leads to a situation where export-oriented and internationally competitive sectors (agribusiness or manufacturing) do not press for trade liberalization in Brazil. On the contrary, especially in the case of export-oriented manufacturing sectors, they support the protectionist status quo that guarantees the maintenance of some non-residual level of tariff protection.

So, in an apparent paradox, the level of conflict between the export-oriented agricultural sectors, on one side, and industrial and farming sectors competing with imports, on the other, is low—if any—in Brazil. It has emerged at particular moments, in the Free Trade Agreement of the Americs (FTAA) and with the Mercosur-EU negotiations. However, most of the time, the export-oriented sectors do not push for domestic liberalization.

The implications of those interests' configuration for the political economy of trade policy are two-fold:

1. On the trade negotiations front, export-oriented agricultural sectors are the only offensive interest, but their presence in the negotiations arena varies according to circumstances. In the last few years, those sectors did not act as a counterweight to the defensive interests in trade negotiations as they were focused on the Asian markets.

2. On the unilateral trade policy front, no pressure favoring liberalization comes from the business sector, either agricultural or manufacturing.

The second main conclusion is that ideas are essential to explain this resilience. First, there is a widespread perception that Brazil owes its diversified industry base to the import substitution model of industrialization. Second, the matching of a protected and large domestic market with the stimulus for foreign investment as an engine to spur national production is perceived as a winning strategy for industrialization.

These views are widespread among policymakers and business representatives in Brazil and continue to receive support from some academics. This is why, even in the absence of specific lobbies or pressures, the Brazilian bureaucracy continues to devise policy mechanisms to stimulate the increase of domestic content in national production and to avoid the pressure of imported goods competition.

HOW CAN BRAZIL INTEGRATE FURTHER? THE GREENSHORING PATH

The important transitions taking place in the world, particularly the move toward decarbonizing production processes and the digitalization of economies and the industrial sector, open significant opportunities for a country like Brazil. The country's comparative advantages in natural resources and the clean energy matrix position Brazil as a frontrunner for investment attraction as long as the search for a clean, secure, and affordable energy supply becomes a key driver for firms' relocation. The powershoring—or perhaps, more generally, the greenshoring—story can offer immense opportunities for the country.

The main driver of change—environment/climate—fits nicely with Brazil's comparative advantages. The abundance of natural resources is a unique feature of Brazil compared to other countries. Due to the endowment of factors, the natural resource base will continue to stand out in Brazilian exports and is a source of opportunity for participation in new value chains and to scale nobler functions of the chain, such as product differentiation, greater influence in distribution chains, and consolidation of brands in agribusiness.

Based on its natural resources endowment, Brazil has developed a network of companies, research institutions, and supporting ecosystems that has allowed productivity gains and created opportunities for more complex forms of integration into value chains. Several interviews conducted for this study confirm success stories in productivity, innovation, and access to foreign markets.

As noted in CINDES (2008), for South American economies: "Due to the characteristics of their productive and international specialization, South American economies were only partially and very heterogeneously affected by the process of international fragmentation of production. This does not mean, however, that they do not articulate with international value chains, nor can it be evaluated a priori as something that compromises its prospects for growth and international insertion."

While several authors (see Sturgeon and also the World Bank [WB] development report) do not consider this type of upstream integration as GVC participation, it should be noted (see IDB 2019, among others) that more and more the mechanization of agriculture and intense use of technology on natural resources exploration approximate these sectors to productive processes usually identified with manufacturing, with more intense use of coordination among sellers and buyers as well as contractual relationships. As pointed out in the IDB (2019) report: "Advanced genetics, precision agriculture, and the use of sensors and big data suggest that, at the frontier, farming has become a technology industry."

In fact, a significant competitive advantage of the Brazilian economy is the possibility of offering clean, secure, and reliable energy at a reasonable cost. Brazil is one of the few countries in the world with a power matrix predominantly based on hydropower, with a rapidly increasing participation of wind and solar energy.

In this section, we explore some opportunities and challenges in the main segments of the economy, starting with the energy sector, followed by agribusiness and mining, as well as the manufacturing and services sectors.

THE ENERGY SECTOR

In fact, a significant competitive advantage of the Brazilian economy is the possibility of offering clean, secure, and reliable energy at a reasonable cost. Brazil is one of the few countries in the world with a power matrix predominantly based on hydropower, with a rapidly increasing participation of wind and solar energy, as shown in Figure 12. The Brazilian energy matrix generates fewer emissions than OECD and BRICS countries, a feature that reduces the upfront costs of the transition.

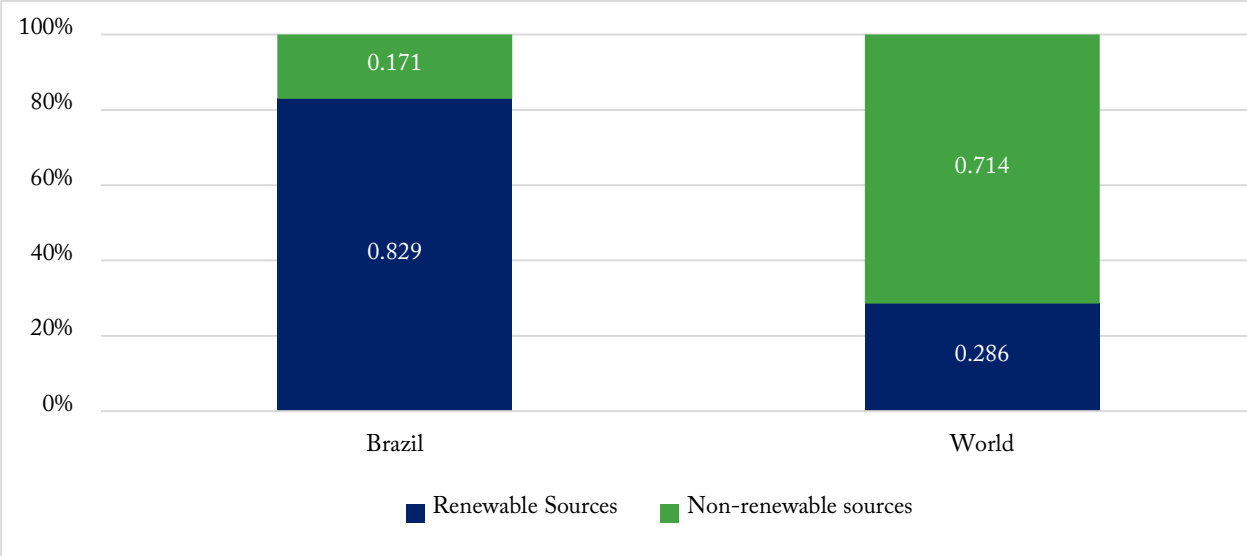
In 2021, the energy sector accounted for only 18% of Brazil's greenhouse gas (GHG) emissions. The resumption of sustained growth of the Brazilian economy should lead to an increase in per capita energy consumption in the country. Emissions should follow the same path. Although it is possible to advance the energy efficiency agenda through waste reduction and the modernization of production processes, it will be inevitable to increase the energy supply and use renewable sources.

According to the Energy Planning Enterprise (EPE [2022]), based on information from the International Energy Agency (IEA), each Brazilian producing and consuming energy in 2021 emitted on average 1.9 t CO2-eq, that is, the equivalent of 13% of an American, 32% of a citizen of the European Union, and 27% of a Chinese citizen. According to these sources, the carbon intensity in the Brazilian economy is equivalent to 32% of the Chinese economy, 57% of the American economy, and 95% of the European Union economy. For every toe (a ton of oil equivalent) made available, Brazil emits the equivalent of 89% of the emissions of the European Union, 65% of the United States, and 49% of China.

Wind and solar energy lead the country's electricity investments, corresponding to 82% of the supply of new projects by 2026 (PDE 2031)[16]. The first solar energy production projects went into operation in 2016, and the wind projects in 2010, with the most significant share of capacity occurring between 2020

16 Plano Decenal de Expansão de Energia 2031. Avaliable at https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2031.

Figure 12. Use of Renewable Sources for Power Generation in Brazil (2020)



Source: EPE - https://www.epe.gov.br/pt/abcdenergia/matriz-energetica-e-eletrica

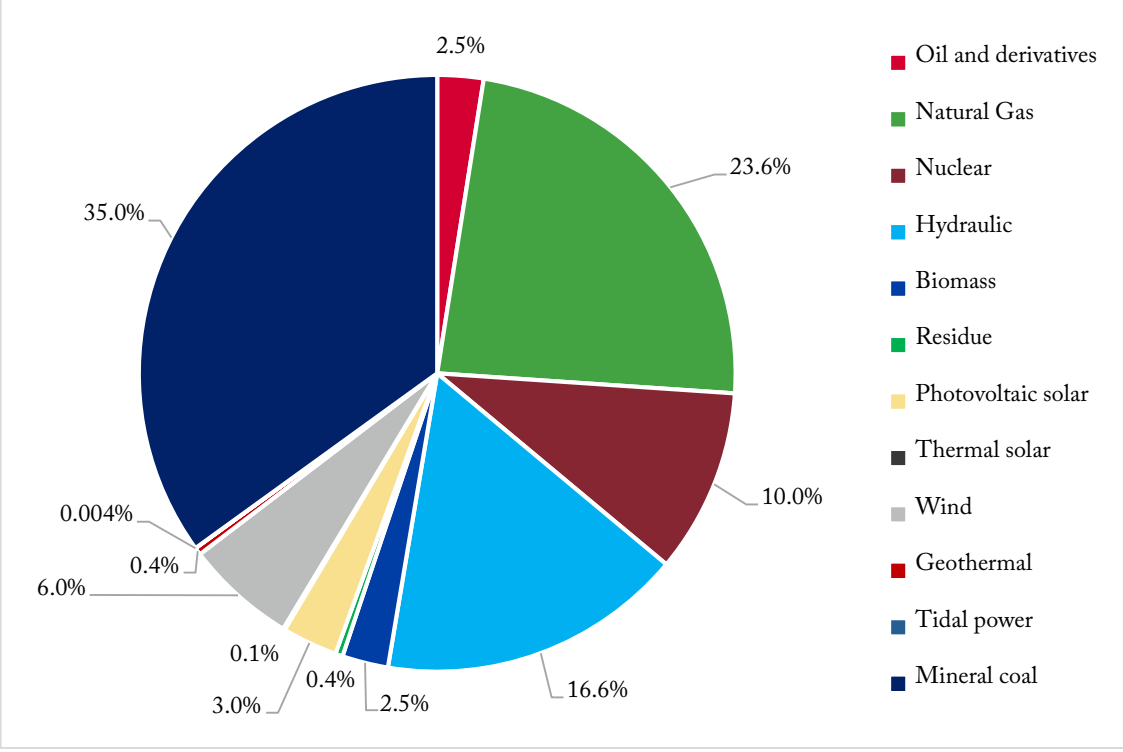
and 2023. A significant part of the renewable energy supply has been produced in the northeast, one of the country's least developed regions.

According to the Ten-Year Energy Expansion Plan (PDE) 2031,

> *"GHG emissions per unit of energy consumed in Brazil are small compared to other countries. However, as per capita energy consumption is expected to increase considerably by 2031, emissions from the sector will increase. As expected, the transport and industrial sectors remain over the horizon as the main drivers of emissions in the energy sector. Considering the Brazilian potential for producing electricity and fuels from renewable sources, the main strategy of the sector to mitigate GHG emissions is to keep these sources' participation in the matrix high, maintaining Brazil's prominence in producing energy with low emissions."*

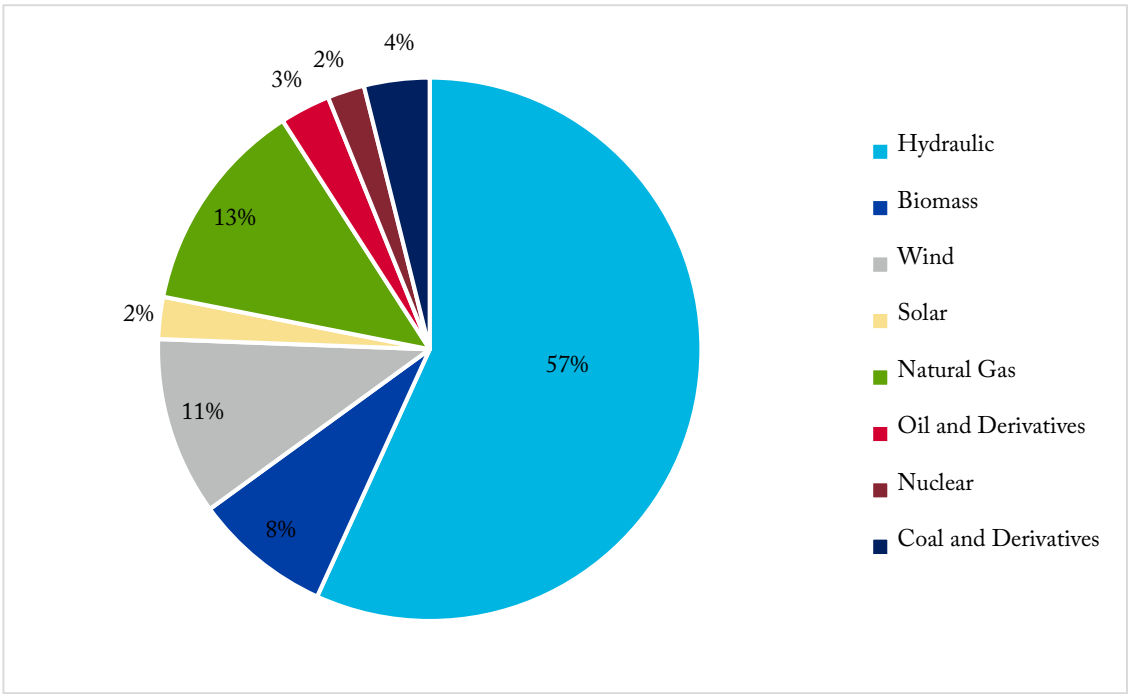
Historically, hydroelectricity has been the primary generation source in the Brazilian electricity system. It has already represented more than 80% of the installed capacity of the national generator park in the 1980s and 1990s and accounted for about 70% of the total in the last ten years. The reduction of the importance of hydroelectricity in the Brazilian energy matrix is related to the development of alternative energy sources, renewable and non-renewable. This evolution was driven, first, by the expansion of the thermoelectric park as a response to the impacts of energy rationing in 2001, then by the accelerated gains in competitiveness of non-hydro renewable sources, such as wind and solar photovoltaics, encouraged by government programs. This trend will likely continue over the next few years, leading hydroelectricity to represent, in 2031, 46% of the generation capacity of the Brazilian electricity system, against 40% of non-hydro renewable sources, according to EPE projections (EPE, 2022).

Figure 13. The World Electricity Matrix, 2020



Source: EPE - https://www.epe.gov.br/pt/abcdenergia/matriz-energetica-e-eletrica

Figure 14. Brazilian Electrical Matrix, 2021 (BEN, 2022)



Source: CCEE https://www.ccee.org.br/o/ccee/documentos/CCEE_1068101

The remarkable growth of intermittent generation sources in recent years has contributed significantly to the diversification of sources and the expansion of generation capacity. While they bring unequivocal gains, these expansion vectors also bring costs associated with the lower predictability of the system and the need for investments in the distribution network. If the winds decrease and solar radiation is insufficient, hydropower is the only source of clean energy that can quickly replace intermittent ones.

Reliability in supply, political stability, and alignment with international values are attributes to which the availability and stability of low-emission energy sources are relevant factors for attracting foreign direct investment. Even trends that, at first glance, can be interpreted as new barriers to Brazilian exports, such as the introduction of mechanisms such as carbon adjustment rates at the border (CBAM) in Europe and eventually in the United States and other developed countries, may represent opportunities for Brazil. Brazilian exports of products that will be subject to this type of mechanism have as competitors companies located in countries that tend to have dirtier energy matrices than Brazil.

The military conflict in Ukraine has deepened concerns about energy security and the cost impacts of the energy transition. The renewable energy sources of intermittent generation certainly contribute to the complementation and diversification of energy matrices. However, it will be necessary to develop strategies for storage and diversification of suppliers.

To take advantage of the opportunities of powershoring, the energy sector in Brazil will need to combine renewable sources of intermittent generation (wind and solar) with those that can provide energy security, such as hydroelectric generation (reversible hydroelectric plants, for example), or other energy storage processes, such as those that use hydrogen or batteries. Several regulatory aspects in the power sector require change, as well as logistics challenges. However, it seems clear that if powershoring becomes a relevant factor for industrial plant relocation, Brazil stands out as a frontrunner in the race for attraction of firms.

Biofuels

In addition to wind and solar, biofuels are another area where the country faces many opportunities. According to the International Energy Agency[17], biofuel demand will nearly double toward net energy neutrality in 2025. This represents another export opportunity for countries in the region, such as Brazil, Argentina, and Colombia, which are already producing such fuels. According to the IDB, Brazil has an already established value chain in biofuels, with an annual production of over 50TWh/year in 2020[18], representing about 10% of world production. Therefore, it could be a major player in this market.

Brazil has extensive experience producing and using ethanol, biodiesel, and biogas. Proálcool, a program focused on producing and using ethanol, is over 50 years old and was created initially to face the oil crisis of the 1970s. Since 2005, Brazil has started producing biodiesel, adding this fuel to fossil fuel diesel, usually based on soybean oil. The first law on the subject is from 2008. By 2021, 10 laws had dealt with the matter. Brazil is one of the largest producers of biodiesel in the world—a mandatory blend of 27% of ethanol in gasoline and 11% biodiesel in diesel. Cars in Brazil can use different combinations of gasoline and ethanol.

Companies based in Brazil have different strategies for what to do [with ethanol], but they may also face competition from new companies that are transforming the sector.

The Brazilian experience in various biomass applications—by companies and consumers—is an asset to face the energy transition. On the one hand, it allows flexibility to make technological choices in a world with multiple technology routes under test[19]. On the other hand, it generates solutions adaptable to specific company situations, according to the needs of their processes, requirements for adaptation of the available infrastructure, and the availability of regional factors.

While ethanol production from sugarcane is already well established from a technological point of view, new challenges are associated with producing second-generation ethanol from bagasse, straw, and forest fragments. This route has two main advantages: waste and the ability to store the raw material, which does not happen with sugar. There are already technological solutions being developed: Raízen, a leading company in Brazil, announced the operation of 20 second-generation ethanol plants by 2030 or 2031, with a production capacity of 82 million liters per plant.

Ethanol has multiple uses: fuel for automobiles, electricity generation, kerosene for aviation, production of hydrogen (H2), and biofuel for ships (biobunkers). In the case of use in automobiles, decisions are more complex and dependent on the movements of value chains on a global scale. Companies based in Brazil have different strategies for what to do, but they may also face competition from new companies that are transforming the sector. At least four alternatives are being discussed: a) hybrid electric cars (ethanol could be one of the options); b) electric cars with external recharge; c) EVs; and d) electric cars powered by hydrogen fuel (probably limited to trucks and buses).

Sustainable aviation fuels (SAFs) are considered the most promising alternative to reduce aviation

17 IEA, Biofuel demand in the main case, accelerated case and Net Zero Scenario, 2018-2030, IEA, Paris https://www.iea.org/data-and-statistics/charts/biofuel-demand-in-the-main-case-accelerated-case-and-net-zero-scenario-2018-2030, IEA. License: CC BY 4.0.

18 IRENA (2022). Bioenergy & biofuels. https://www.irena.org/Energy-Transition/Technology/Bioenergy-and-biofuels

19 In aviation there are different technological routes under test: SAF fuels, electric and the H2 base. In the steel industry there are several paths being evaluated. The biggest concern of the various players is that public policies do not limit the technological options aimed at reducing emissions.

emissions and one of the great opportunities for Brazil. It has been the subject of several initiatives, in Brazil and worldwide, of research and testing among aviation companies, air transport regulatory agencies, and fuel producers. Seven technologies have already been approved, and six are under evaluation. Raízen already has a plant in the United States with alcohol-to-jet technology approved. In Brazil, there are projects focused on its production. The production of SAF uses a varied menu of inputs (waste vegetable oils, food, paper, textiles, animal fats, exhaust gases from steel mills, and alcohol) and different technological routes. The cost, however, is still high when compared to fossil fuels.[20] In 2021, more than 315,000 flights used SAF worldwide, using mixtures up to 50%. Boeing aims to be able to use 100% sustainable fuels by 2030 in all its planes.

Brazil's ability to expand the supply of renewables at competitive prices will be critical for its insertion in segments of global value chains.

This flexibility associated with using different sources of raw materials, various technologies, and fossil fuel infrastructure creates conditions for an energy transition with multiple routes and lower costs. The multi-product system that emanates from ethanol and biomass production is remarkable. The same input, subject to different technologies and temperature levels, generates diverse products and solutions.

The key issue for investments in the various energy sources will always be the economics of the project, and the final test will be the price for the consumer, both as a user and as a payer of any fiscal resources necessary to finance the transition. The multiplicity of challenges associated with reducing emissions-intensive sectors recommends an integrated vision that combines the assessment of technological risks, economics, and the pressure for fiscal and financing resources. The evaluation of the economics of the choices is decisive.

Oil and Gas

The role of the oil and gas sector in the energy transition cannot be underestimated. The energy crisis stemming from the invasion of Ukraine challenges perceptions about the existence of alternatives at scale to suppress the use of oil and gas in short time frames. Oil and gas production plays an important role for Brazil in the transition due to the low exploration costs and the lower CO2 intensity of its production, making its continuous exploration compatible with Brazil's nationally determined contributions (NDCs).

Strategic decisions about oil and gas investments are not trivial. As Yergin (2022) points out, this is a policy-driven transition—motivated by the goal of reducing emissions to address the consequences of global warming—and not exclusively by economic or technological factors. The ambition is to transform the entire energy base in 25 years, impacting all production processes.

Unlike other energy transitions—characterized by long periods between discovery and massification of use, coexistence of sources, differentiated use according to efficiency of use and regional availability—in this one, there will be a tipping point, a moment, depending on the evolution of technologies and the costs of alternatives, in which there will be no need for new investments in oil and gas.

In this scenario, the incentive will be aimed at maximizing the exploration of current opportunities. The central differential is the cost and quality of oil and gas produced in the country, the possibilities of using natural gas with a positive impact on the industry's emissions level, and the tendency to reduce the

20 Airlines face long haul to reach sustainable fuel goals, *Financial Times (FT)*, October 27, 2021, and Boeing CEO warn climate friendly biofuels will "never achieve the price of jet fuel", *FT*, May 23, 2023.

production of the most inefficient fields on a global scale. The offshore exploration in the Pre-Sal area, the largest production area in Brazil, emits fewer greenhouse gases (measured in CO2 equivalent, CO2e) for each barrel produced than the world average: 17 kg CO2e per barrel produced in the world, compared to 10 kg in the Pre-Sal. [21]

The oil and gas industry will also have to develop projects aimed at producing these inputs with fewer emissions and using new low-carbon technologies throughout the value chain. The ability of companies in these segments to expand positions in GVCs will depend on using technologies that reduce carbon emissions.

The permanence of industrial and transport processes that are not amenable to efficient substitution in the medium term generates a demand for the production, at competitive costs, of fossil fuels with lower emissions. Between 2015 and 2022, Petrobras, the leading Brazilian company, reduced its emissions by 39%. The continuity of this movement is largely dependent on the capture, use, and storage of CO2, the electrification of processes, energy efficiency, consolidation, and modernization of platforms and new technologies, such as Hi-SEP that separates CO2-rich gas from oil still under the soil and investments in renewable energies.[22]

The Challenges of the Energy Sector

Brazil's ability to expand the supply of renewables at competitive prices will be critical for its insertion in segments of global value chains, both as an exporter of renewable energy and as a platform for the export of energy and electro-intensive products in which it already has comparative advantages, which have been eroded in recent years due to the increase in tariffs and energy supply problems.

To reap the benefits of this competitive edge, the country has three main challenges: the first, to ensure the evolution toward a cleaner matrix; the second, to create conditions for supply growth; and the third, the ability to create a regulatory environment that encourages competitive prices. The scale of these challenges should not be minimized.

To face these challenges[23], Brazil has some assets: a) An interconnected electric system[24] in a continental country, subject to different climatic regimes and sources of supply of renewables, which allows flexibility of operation and less need for investments; b) Experience in auctions of power generation and distribution offer; and c) The hydropower base and the possibility of reversible hydroelectric plants. The potential for the use of biomass and the more intense application of demand management methods—dependent on regulation and the application of predictive models and digital technologies—are a pillar for a more efficient management of the intermittency derived from the greater presence of wind and solar energy. The full use of this asset depends, however, on regulations that come to recognize the "battery" function of hydroelectric plants.

The energy transition requires intensive regulatory activism. The interviews conducted for this study reinforced the importance of defining regulatory frameworks to attract investments (such as offshore wind, hydrogen, SAF, the role of hydroelectric plants, and mining) and the need to update the general frameworks that guide the power sector.

21 See Petrobras, Fatos e Dados, March 2022.

22 Petrobras (2022), Fatos e Dados.

23 For an examination of the problems and opportunities of the energy transition in Brazil see CEBEDS/PCR, Roadmap: the paths of the Brazilian business sector in the energy transition, 2023.

24 The United States has three systems—West, East, and Texas—with few connection points for sharing. There are conflicting interests and high difficulty in building transmission lines. See Why the U.S. Electric Grid isn't ready for the energy transition, *New York Times*, June 12, 2023.

The abundant supply of renewables—wind, solar, the vast array of biofuels—means that Brazil will have to make choices regarding the transition to low carbon.

The interviewees considered the availability of renewable energy at competitive prices as one of the country's competitive differentials and one of the assets with the greatest capacity to act as a factor to attract investments and change Brazil's role in GVCs. However, an institutional agenda needs to be developed to ensure that the structural energy surplus is not lost and ends up not contributing to structural transformation. There are two main challenges: first, to organize the electricity sector with governance capable of planning, correcting deviations, eliminating distortions of burdens, and contributing to the development of energy opportunities; second, to ensure a clean energy matrix, without which opportunities to capture investments aimed at the foreign market are lost, and the contribution to the elimination of emissions is reduced.

As of 2023, Brazil faces a comfortable situation from the point of view of energy supply. Despite the comfortable situation in terms of supply, the current energy pricing system is characterized by strong market segmentation and complexity in the formation of energy tariffs. Since 2001, when Brazil suffered an energy blackout, Brazilian energy policy has adopted a series of interventions that accumulate and result in distortions in the formation of tariffs. Following the creation of the Energy Development Account (CDE) in that year, several social and sectoral programs have been created, including subsidies to new energy sources and specific population segments. As a result, there are currently 16 sectoral charges, which go into the formation of energy tariffs and to which are added the taxes levied on the tariffs, accounting for about 40% of the total electricity costs.

In addition, there is a growing fragmentation of the energy market, which is basically composed of two major regimes: the Regulated Environment (ACR), formed by captive consumers who can only buy electricity from the concessionaire responsible for distribution in their region, and the Free Contracting Environment (ACL), also known as the Free Energy Market. In this trading environment, consumers negotiate the conditions for the purchase of electricity directly with the generators or traders.

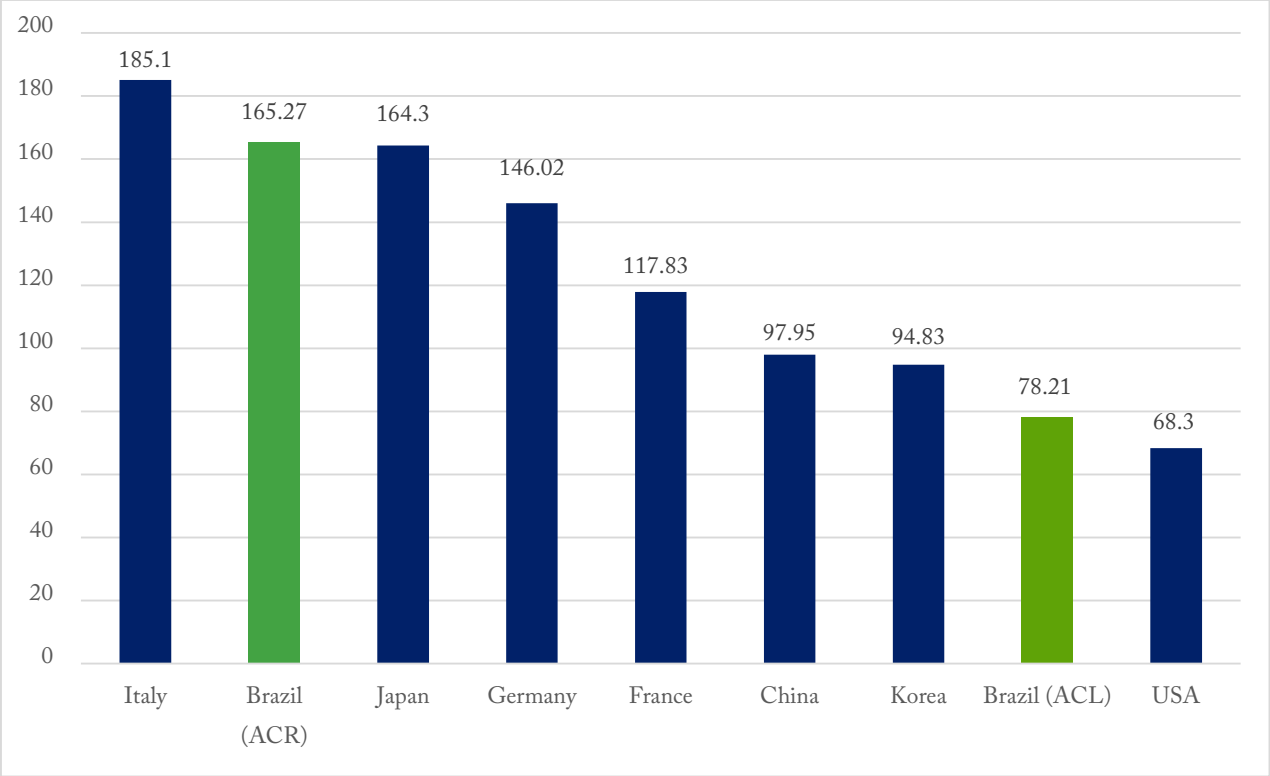
Currently, only companies connected at high voltage and meeting the requirement of contracted demand above 500kW can participate in the ACL. These companies can opt for alternative energy sources, negotiate values and amounts of energy directly with the supplier, write the contractual conditions that best fit their business, and have the possibility to work the contracted amount optimally to your business. From January 1, 2024, all high-voltage connected companies will be able to migrate to the ACL.

As can be seen in Figure 15, there is a significant difference between energy costs in the two environments. The international comparison, carried out by the National Confederation of Industry, with energy prices as of 2019 in the main exporting countries to Brazil shows that the prices paid by Brazilian companies in the ACL were quite competitive, only higher than those paid by North American companies. On the other hand, the resulting tariffs in the ACR are uncompetitive, being surpassed only by those in force in Italy.

Figure 16 highlights the portion of the energy tariff that corresponds to the charges and taxes for the countries for which it was possible to obtain this information.

The distortions in the mechanisms of formation of energy tariffs in Brazil, the overlapping of institutional

Figure 15. Electricity Price for Industrial Consumers in 2019, Including Taxes (USD/MWh) – Brazil and Selected Countries



Source: Prepared by CNI (National Confederation of Industry), using Aneel data (2021b), CEIC (2021a), Dcide, IEA (2021b) and PSR.

Note: In Brazil, there are two different prices: the Regulated Contracting Environment (ACR) and the Free Contracting Environment (ACL).

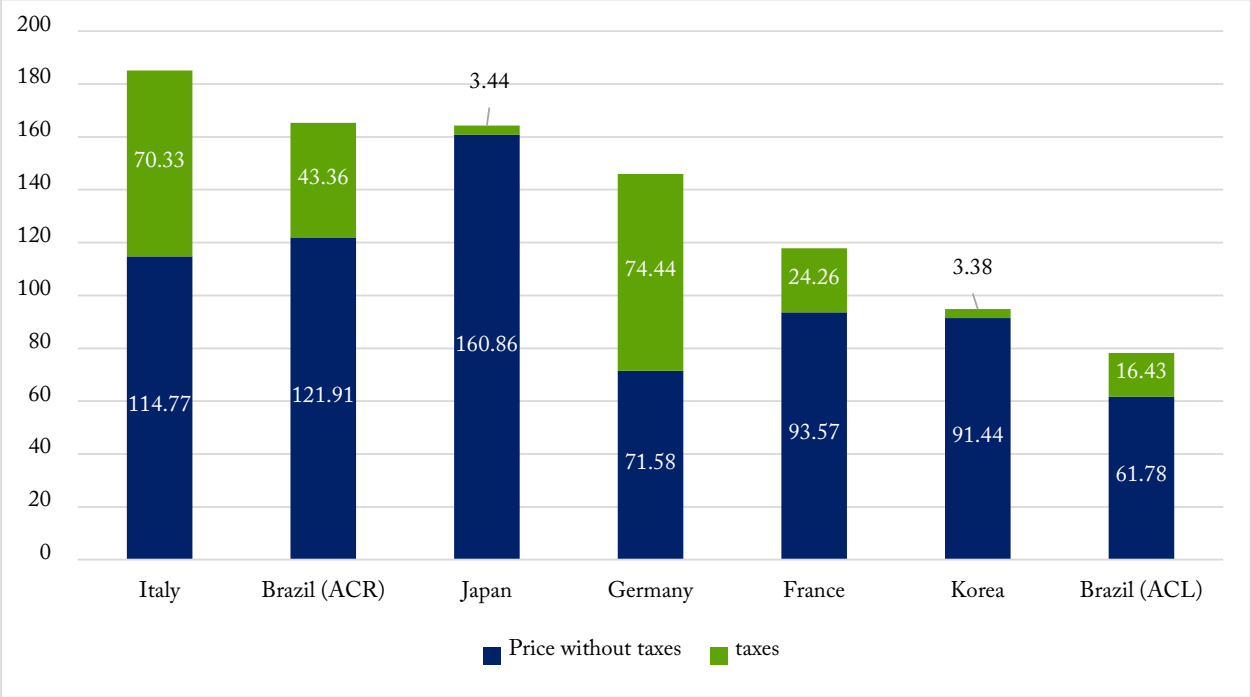
functions, and the regulatory problems hinder the more efficient allocation of resources and constitute some of the existent obstacles to the country acting on opportunities that arise with the global agenda of decarbonization.

It will be essential to review the process of formation of energy tariffs, reducing the impacts of the various taxes and cross-subsidies that affect energy tariffs and giving transparency to the price formation. In addition to prioritizing lower tariff levels in the definition of pricing mechanisms, it is key to eliminate unnecessary subsidies as well as transfer charges that are not directly linked to the generation of energy to the federal budget so that the energy tariffs end up reflecting the costs and services provided by the various sources that make up the Brazilian electricity matrix.

Currently, the storage services provided by hydroelectric plants are not adequately remunerated. It will also be relevant to ensure remuneration that is compatible with the ancillary services provided by the different sources to the energy matrix. In addition, it will be necessary to have a regulatory framework that provides predictability and legal certainty to investors.

The abundant supply of renewables—wind, solar, the vast array of biofuels—means that Brazil will have to make choices regarding the transition to low carbon. However, Brazil's relative effort will not be as intense as the effort most countries will face in seeking to reduce emissions from energy sources. This allows for an energy transition with lower costs and increases the country's flexibility and ability to make technological choices over time.

Figure 16. Electricity Price for Industrial Consumers in 2019, Highlighting Taxes (USD/MWh) – Brazil and Selected Countries



Source: Prepared by CNI, using Aneel data (2021b), CEIC (2021a), Dcide, IEA (2021b) and PSR.

Note: In Brazil, there are two different prices: the Regulated Contracting Environment (ACR) and the Free Contracting Environment (ACL).

For a country with well-known fiscal constraints, it is critical that regulatory and capital market issues do not become obstacles. There is a need for an intense focus on the regulatory quality of the energy complex. Many issues extend beyond the domestic level and suggest a high priority for monitoring regulatory trends in other countries and regions. The potential repercussion of these regulations on domestic opportunities suggests that energy and climate diplomacy is one of the areas that deserves greater attention from Brazil's foreign policy.

Green Hydrogen

Green hydrogen (GH2) is considered by many experts as an effective alternative for the decarbonization of the world economy, with conditions to become the energy vector of the coming decades. Among the most promising possibilities to produce sustainable hydrogen is green hydrogen, obtained by water electrolysis using renewable energy sources. GH2 can play the role of green fuel for heavy vehicles or maritime transport, decentralized energy storage and generation, or decarbonizing the production process of sectors that struggle to be electrified—particularly petrochemicals, iron and steel, and fertilizers.

Latin America is generally well positioned in the potential to produce green hydrogen. According to the IDB, Chile and Brazil stand out among Latin American countries due to the competitiveness of their renewable energy industries, already existing infrastructure, and the expected costs (see IDB 2023).

With abundant wind and solar power and an integrated low-carbon electrical system, Brazil hopes to

Box 3. Transmission Lines: Main Challenges Ahead

Brazil's electricity distribution relies on a complex net of transmission lines covering 179,000 km of operating lines, integrated through the Interlinked National System (SIN). SIN is a multisource system (mainly hydroelectricity, thermal, wind, and solar photovoltaic), integrating four subsystems: South, Southeast/Center west, Northeast, and part of the North Region. It hosts the second longest transmission line in the world, linking Belo Monte, a hydroelectric plant in Para (North Region), to Rio de Janeiro (Southeast Region), with an extension of 2,500 km.

SIN is operated by the National Operator of the Electric System (ONS, in its Portuguese acronym) – a non-profit institution created in 1998 to coordinate and control the operations of the generation plants and transmission lines integrated into the system. The ONS is supervised by ANEEL (National Agency of Electrical Energy), and its membership comprises companies working on the generation, transmission, distribution, importation, and exportation of electricity and consumers in the free market.

The fast growth of renewable energy sources (wind and solar) in the SIN's matrix in recent years has added new challenges to the system's operation. There is a remarkable mismatch in the length of time required for the implementation of new generation operations of renewable sources (up to three years) and the projects for the corresponding expansion of transmission lines (up to seven years, depending on the complexity of the situation).

To cope with the challenges foreseen for the next years, the Energy Research Office (EPE), responsible for supporting the Brazilian Ministry of Mines and Energy policies with studies and research on energy planning covering electricity, estimates an expansion of 17,700 km of new transmission lines until 2037, with investment amounting to R$44.6 billion (US$9 billion, approximately). To strengthen the operational capacity and avoid blackouts and other problems in the distribution system, EPE proposes an investment of R$32.7 billion (US$6.5 billion) in electric power substations in the same period.

The New Growth Acceleration Program (Novo PAC), launched by the Brazilian government in mid-2023, is even more ambitious than EPE's recommendations. It foresees total investment of R$69.8 billion (US$14 billion) in electricity transmission until 2026 and R$18 billion (US$3.6 billion) after 2026, adding 28,000 km to the Brazilian transmission net.

In the short run, there are specific gaps in the transmission systems, particularly in Northeast Brazil, where renewable sources have grown faster in recent years, which demands optimization in the allocation of resources.

become one of the world's leading producers of GH2. The total investments are in the order of US$15 to 20 billion in 2040, with most of this potential to serve the domestic market, and US$4 to 6 billion are expected to come from exports of GH2 and its derivatives to Europe, Asia, and the United States.

Given the characteristics of the Brazilian electricity matrix and the current energy oversupply, Brazil is well-positioned to participate in this chain. Energy availability scenarios developed for Brazil indicate that the country will have a structural surplus of renewable energy for the next five years, with a marginal

Box 4. Electricity Integration with Neighboring Countries

Electricity integration is weak in the Southern Cone (Argentina, Brazil, Chile, Paraguay, and Uruguay). Despite existing large binational infrastructures, the region lacks a regional electricity market. Binational electricity trade responds to 5% of total demand in the five countries of the zone, but there are opportunities to increase efficiency and supply of electricity. A regional market would promote the utilization of the excess renewable energy available during some periods and allow the exploitation of complementarity of different sources.

Besides Itaipu, the large binational hydropower plant deployed by Brazil and Paraguay on their frontier, there is some integration between Brazil and Argentina and Brazil and Uruguay. Nevertheless, there is a need to improve existing binational infrastructures and to integrate the different facilities.

Another area of potential integration is the North Arch (ARCONORTE), which includes Brazil, Guyana, French Guyana, and Suriname. This is a region with abundant conventional and non-conventional resources. Energy integration could provide economies of scale to the needed investment and energy security for the area.

The IDB has already identified some projects in its Integración Eléctrica del Continente Americano (IECA) to strengthen the link between Brazil and its neighbors. However, the regulation for implementing regional markets is missing.

The commercialization of electric energy in Brazil is subject to specific authorization from the Ministry of Mining and Energy. Traditionally, the energy exchange with neighboring countries was subject to the return of the volume exported when power was available in the partner country. The government oriented these operations through political decisions to mitigate energy shortages in the neighboring countries.

Recently, the Brazilian government issued new regulations setting guidelines for the stoppable exportation of electric energy by authorized agents resulting from the excess generation of electricity by hydropower plants. The National Operator of the Electric System (ONS) oversees licensing the operations when the electricity generated is transmissible and not placeable in the SIN. The new regulation defines conditions for the commercialization, without requirement of return, to Argentina and Uruguay and is valid until December 2026.

The setting of these new regulations was favored by the context of hydrologic abundance in Brazil since 2022, after a period of drought and scarcity of hydroelectric power. This initiative contributed to avoiding the waste of energy generated by the hydroelectric plants in Brazil and to lower the price of electric power to consumers. The bulk of the operations took place in the first half of 2023. From July on, no new operation was authorized.

Having seized the benefits of the new regulations, some of the big energy companies in Brazil are pressing the government to allow the operations to be permanent, independent of the existence of excess water in the system.

cost of production of the cheapest in the world (see EPE 2022). This situation gives Brazil a clear comparative advantage since 70% of the cost of GH2 production is related to electricity. In addition to the cyclical oversupply, the country has a decisive structural advantage: it has one of the cleanest electricity matrices in the world, in which renewable sources represented, in 2022, about 85% of electricity generation.

In accordance with the consulting firm Roland Berger[25],

> *"The demand of these sectors and other potential off-takers gives green hydrogen enormous potential: the value pool arising from growth in the production of green hydrogen through 2030 is expected to be in the region of EUR 500 billion."*

The same company estimates that

> *"Brazil has the potential to become the world's largest producer of green hydrogen, with annual revenues of R$150 billion by 2050 – of which R$100 billion will come from exports."*[26]

In the current situation, the availability of an electric matrix with a strong and growing predominance of renewable sources and the excess of supply over the projected demand for the coming years make it possible for the Levelized Cost of Green Hydrogen (LCOH) of GH2 in Brazil to reach in 2030 to about US$1.50 /kg, in line with the most competitive countries such as the United States, Australia, Spain, and Saudi Arabia. [27]

The potential uses of green hydrogen are currently being debated in Brazil. Will the country produce to export or direct the production to the domestic market to support the decarbonization of sectors with greater difficulty in reducing CO2 emissions? McKinsey estimates that Brazil could export between $1 billion and $2 billion in 2030 and somewhere between $4 to 6 billion in 2040. However, the domestic market size could be significantly larger, reaching $10 to 12 billion by 2040.

In the domestic market, the most promising GH2 applications appear to be:

- As an input for the iron and steel industries, particularly for the production of green hot briquetted iron (HBI), combining Brazilian competitiveness in iron ore and GH2 to export low-carbon iron;
- As green ammonia in the production of fertilizers, with a lower carbon footprint;
- For long-distance rail freight transport, replacing diesel;
- As methanol or ammonia in the international maritime transport of cargo;
- In heavy cargo road transport, particularly mining haul trucks, replacing diesel;
- In the generation of heat in the industrial processes of pulp and paper, cement and steel;
- Combined with gas in turbines for power generation.

25 See Berger (2023)

26 See Berger (2023)

27 Experts interviewed for this project estimate that, currently, the LCOH in Brazil is around US$ 3.5 (without taxes), with a cost for placement in Rotterdam of US$ 5.5. These costs suppose a very competitive wind and/or solar plant and the tax incentives of a Special Processing Zone (ZPE). Just for comparison, in the United States the Inflation Reduction Act (IRA) introduced a subsidy of up to US$3.0 per kg of hydrogen produced from projects with a CO2 intensity of less than 0.45 kg/kg of hydrogen (kg CO2e/kg H2). As the cost of production in the country reaches US$5.0/kg, that subsidy means a market price of $2.0. It should be noted that the US adopts the concept of sustainable hydrogen, which is different from the European concept of GH2, premised on the production of hydrogen from the use of renewable sources.

Brazil's evident comparative advantages in producing green hydrogen have attracted the interest of several public and private actors, both Brazilian and foreign. Several ongoing initiatives focus on the analysis of projects, the celebration of partnerships, consortiums, and other forms of association. Most of these initiatives are still in the economic feasibility study phase.

The Challenges for Green Hydrogen

There is no shortage of challenges ahead in the development of hydrogen, starting with a worldwide challenge to develop a market for this product. In Brazil, there are uncertainties and barriers regarding the evolution of demand (prices and quantities), regulation, and high investment capital expenditure (CAPEX).

Hydrogen poses very specific and substantial regulatory challenges. There are issues related to the institutional organization, given the multiplicity of bodies and actors (in the executive and legislative branches of government) that tend to intervene in the regulation, the structuring of the regulation of production and end use of GH2, and the definition of technical regulations, for example, those aimed at the transport and storage of the product.

Brazil is lagging in constructing a regulatory and institutional framework for the production and final use of green hydrogen that provides security for investments and is convergent with international practices. A new bill is under discussion in the House of Representatives, but it has a long way to go until the regulation is approved and implemented (see Annex 4 for details). In addition to building its regulation, the country urgently needs to identify its priorities in relation to GH2 production routes to act in international fora that discuss certification criteria.

The debate in Brazil about the future of green hydrogen is not yet mature. There are varied and sometimes divergent views on the desirability of prioritizing the exploitation of GH2 vis-à-vis the incorporation of other sources, such as natural gas, biomass, and biofuels, into the Brazilian energy matrix. This perception is reinforced by the risks still associated with green hydrogen generation and the requirements of capital and scale demand subsidies and procurement commitments secured by public agencies that require fiscal resources that the country may be unable to provide.

Some classify as "poor" a strategy of focusing efforts on GH2 exports to Europe when value could be added in Brazil, allocating its production to support the decarbonization of industrial processes in the country. The options on the sources of electricity to be used in the production process and the certification schemes may also vary depending on the strategies chosen for the commercialization of the product.

Exporting will likely require that production in Brazil meets the certification requirements set in the destination markets[28]. Europe is the most relevant market for GH2 and the one that is more advanced in regulation setting. The regulation proposed by the European Commission to the Parliament and the Council foresees that, as a rule, the share of renewables produced is equal to the average share of renewable electricity on the electricity network of the country where the hydrogen/fuel production facility is located. By way of derogation from this default rule, the hydrogen produced can be counted as fully renewable in the following two scenarios (i.e., the subject of the Delegated Act):

28 On 10 February 2023, the European Commission adopted the Additionality Delegated Act, which outlines conditions under which hydrogen, hydrogen-based fuels, or other synthetic fuels can be considered as renewable fuels of non-biological origin (RFNBOs). Once these Delegated Acts have been sent to the European Parliament and the Council, both institutions will have two months (potentially extended by another two months) to approve or veto the Delegated Acts. See: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_594

- The direct line setup, where the hydrogen production facility is connected directly to a new renewable electricity installation and does not use grid electricity.
- The grid connection setup, where the hydrogen production facility is connected to the grid, but the electricity used is demonstrably renewable. In this case, the production facility could be located in a country or region where the electricity grids contain at least 90% of renewables.

While off-grid production is feasible, with yet untapped opportunities for on-shore wind and solar generation, such an option requires additional investments in transmission infrastructure. Furthermore, this option still depends on the regulation of offshore generation itself, which is still lagging in the country. Adding to the need for connection infrastructure, it is an opportunity for the longer term.

Although Brazil is lagging in constructing the regulatory framework and establishing GH2 certification schemes, some steps have been taken recently. The National Energy Plan 2050 (PNE), published in 2020, highlights hydrogen as a disruptive technology, drawing attention to regulation challenges to enable its use, transport, and storage. The document also provides recommendations for regulatory improvements related to hydrogen's quality, safety, transportation infrastructure, storage, and end-use.

In June 2022, the National Council of Energy Policy (CNPE) published a resolution establishing the National Hydrogen Program (PNH2) and setting the program's governance structure. Among the guidelines of the PNH2 are to take advantage of the national natural gas reserves, with capture and storage of CO2 to produce blue hydrogen; stimulate the competitiveness of renewable energies for GH2; and take advantage of the possibilities brought by biofuels, such as ethanol and biogas.

At the end of 2022, the Electric Energy Trading Chamber (CCEE) launched the first Brazilian certification of low-carbon hydrogen. The goal is to attest that H2 comes from clean or low-carbon energy sources. The preliminary version of the certification was built from the consultation with several value chain representatives based on the requirements of the main potential customer—Europe—and the characteristics of the Brazilian power matrix.[29]

The GH2 Development Agenda

Several initiatives are needed to enable the country's opportunities related to the development of GH2. Below are some of them presented schematically:

- Develop the National Hydrogen Program, which has already been created but is still in its early stages;
- Create an institutional structure in the country capable of ensuring that national actors act in a coordinated manner for the development of a regulatory framework compatible with taking advantage of the opportunities that are envisaged in the GH2 market;
- Actively participate in international negotiations of GH2 certification schemes;
- Implement the carbon market in the country in order to establish carbon pricing criteria;
- Support research and development (R&D) initiatives using regulated funds and other existing mechanisms;

29 Influencing the international certification schemes in gestation is also important. CCEE will participate in the work of the International Committee for the Production and Transmission of Electric Energy (CIGRE) for studies on the certification of GH2 production. Recently, the World Bank invited Brazil to participate in a working group to facilitate the recognition of certified hydrogen.

- Support the development of talents and researchers in the country, focused on research in energy and green fuels.
- Advance in the definition of technical regulations necessary for the different end uses of GH2 produced in the country.

AGRIBUSINESS

The transformation of Brazilian agribusiness in the last decades has been impressive[30]:

- Exports increased five-fold in 20 years, from US$20 billion in 2000 to US$110 billion in 2021;
- Today, Brazil is the largest exporter of five products (sugar, coffee, soybeans, poultry, and orange juice). Overall, Brazil is the third largest exporter of agricultural products in the world;
- Market diversification has been impressive: Brazilian exports to China jumped from US$1 billion in 2000 to US$36 billion in 2020, while Europe and the United States reduced their combined share in Brazilian agricultural exports from 59% in 2000 to 23% in 2020 in Brazilian agricultural exports in 2020.
- Total factor productivity increased continuously, at an annual average growth rate of 3.2% between 2000 and 2019, according to IPEA, well above estimates for the world average (1.7% annually in the same period).

Recent global trends that have impacted global value chains have also impacted Brazilian agribusiness, posed new challenges, and opened new opportunities. These trends include geopolitical tensions[31], worldwide concerns with food insecurity (recently aggravated by the Russian invasion of Ukraine), and continuous changes in consumer preferences toward cleaner and sustainable supply chains.

These global movements trigger strategic reactions from the affected countries. The combination of all these factors stimulates Brazil's repositioning to the direction of:

1. Consolidate its position as a source of global food security by increasing its competitiveness and ability to ensure the quality, traceability, and health safety of products;
2. Prioritize trade liberalization agreements that allow better navigation in an environment of greater competition and increasing tendency to use phytosanitary barriers;
3. Capture opportunities not yet fully exploited by offering products tailored to the preferences of consumers in high-income markets (e.g., organic, traceable, certified, sustainable);
4. Strengthen the sustainability of the value chain in order to avoid restrictions on consumer markets and reputational risks and favor the expansion of markets;
5. Find nobler areas of the value chain, such as product differentiation, greater influence in distribution chains, and brand consolidation;

30 Information based on Cabral and Jank (2021); Jank et al. (2023); Gasques et al. (2022), and EMBRAPA (2022).

31 Martins Jorge (2022) shows that the trade war between the United States and China has had a positive and relevant impact on soybean export premiums in Brazil, estimated at 37.46 USD/ton (2.25 USD/bag), or approximately 102 cents/bushel, with an overall impact of US$1 billion in the product exports.

6. Strengthen the technological base with support to ecosystem initiatives supporting biotechnologies, automation, application of technologies in operational and management areas, territorial management, and genetic improvement. The challenge here is for research institutions, universities, and companies to have the ability and flexibility to adapt to support the development of a more decentralized and open system of innovation and support for startups.

There are, therefore, old and new challenges for Brazilian agribusiness. The old challenges relate to diversifying markets and products, capturing value in the value chain, maintaining phytosanitary standards, and further market liberalization. The new challenges are linked to the effects of sustainability policies and the direct impacts of climate change on agricultural supply. The requirements of sustainability policies are increasingly present in regulatory standards, trade agreements, and public and private standards. There are also challenges associated with mitigating and adapting to the potential impacts of climate change on agricultural production.

In addition to strengthening the institutions capable of guaranteeing food security, the country needs to overcome the difficulty of responding to environmental and climate regulatory demands[32]. Inaction here can reduce the ability to access agricultural markets with more demanding standards and affect the intensive industrial export performance in the use of agricultural and bioenergy inputs. Climate change, with effects on temperature and the regularity and intensity of rainfall[33], generates impacts on agricultural supply and transport corridors, as well as changing the geography of production, favoring the expansion of production in temperate countries. These are topics relevant to the assessments of the agribusiness scenarios.

The expansion of new rules tends to create conditionalities for participants in the value chain. The ability to ensure the expansion of production without using uncultivated land or at the expense of other uses for food production is at the heart of regulatory discussions, as indicated by the directives emanating from the European Union. The effects of these regulations extend beyond agricultural products and have indirect effects on the supply of non-agricultural commodities. Industrial products using bioenergy will be restricted if inputs do not meet regulatory requirements. Box 5 reveals Brazil's potential capacity to meet these criteria by pointing out the possibility of expanding ethanol production in Brazil by reducing the area used.

The country's ability to meet these conditions is relevant to Brazil's participation in markets with higher levels of regulation. Naidin et al. (2020) highlight the difficulties the Brazilian agro-export sector faces in forming a strategy beyond actions on image and complaints about "murky protectionism." The difficulty of forming a common position is exacerbated by recent and future sources of demand expansion in regions less active in defining sustainability standards[34]. The share of agricultural livestock exports to the EU decreased from 41% in 2000 to 17% in 2022, while the share of China and Hong Kong, in the same period, increased from 5% to 33%. The extent of this transformation is illustrated by

In addition to strengthening the institutions capable of guaranteeing food security, the country needs to overcome the difficulty of responding to environmental and climate regulatory demands

32 Standards related to environment, climate, and sustainable business correspond to 57% of the 338 standards identified by the ITC Standards Map APP.

33 Embrapa (2022) identifies risks to the Brazilian production model and cites that weather events are currently responsible for 25-35% of the fluctuations in agricultural prices.

34 Naidin et al. (2020)

Box 5. Technology, Productivity, and Sustainability: An Example

Centro de Tecnologia Canavieira (CTC) is a listed company focused on genetic improvement, biotechnology, and innovation. Its revenue derives from the royalties collected from the developed cultivars. It has a laboratory in Saint Louis, Missouri, for advancing knowledge of disruptive technologies associated with sugarcane genetics.

According to the CTC, the average sugarcane productivity in Brazil is expected to increase by 33% by 2040 based on genetic improvement, biotechnology, and new planting forms. The main effects include a reduction of the need to expand the area (estimated at 3 million hectares, or 36% of the area utilized in the country) and more sustainable production due to a reduction in the use of diesel, fertilizers, and chemical products.

Technology, productivity, and environmental policy management will be key to ensuring production compliance with three criteria: zero deforestation, compliance with legal requirements of the Forest Code, and compliance with agricultural zoning.

the fact that 69% of Brazilian exports are to China (33%), the rest of Asia (12%), Middle East and North Africa (13%), and Africa (11%), markets with less demanding standards than the EU[35].

To navigate this regulatory environment, Brazil has three main challenges: to monitor the regulatory centers of the major markets, to have the ability to contribute and influence international regulations, and to implement environmental policies capable of ensuring standards in accordance with the regulations of consumer markets.

Another aspect that deserves attention is related to the effects of climate change on agricultural supply. FAO (2018) and Assunção and Chein (2016) studies point to the potential effects of climate change on Brazil's agricultural production growth and the geography of global production. The study conducted by FAO presents two basic scenarios: in the first one, with no climate change effects, maintaining the positive effects of technological changes, and without the incorporation of new lands, Brazilian agriculture output would grow 40% between 2011 and 2050, slightly above the global output expansion of 38%; in the second scenario, incorporating climate change impacts, both global and Brazilian agricultural production would decrease 1.1% between 2011 and 2050. The primary beneficiaries of this scenario would be the United States, Canada, Russia, and Eastern European countries. The assessment developed by Assunção and Chein (2016) estimates a drop in productivity for Brazilian agriculture of 18% between 2030 and 2049, considering the forecast of temperature increase of 1.43°C and rainfall reduction of 1.44%.

In dealing with the challenges posed by climate change, in addition to the capacity to implement environmental policies, a key aspect is the ability to develop adaptive technologies. Akin to its role in developing agriculture in the *cerrado*, climate change imposes new challenges associated with production techniques and seed types adapted to water restriction, recovery of damaged ecosystems, and maintenance of the biome.

35 INSPER AGRO GLOBAL, 2023

The digitization of agriculture could have productivity impacts like the expansion phase of agricultural mechanization and relevant effects on environmental management. According to Embrapa (2022),

> *"The agriculture sector becomes digital as task management inside and outside the farm focuses on different types of data obtained using sensors, machines, drones, and satellites to monitor, control and act on the soil, water, animals, and humans. Planning, supplying, producing, storing, processing, and marketing in the production chains will be a set of increasingly digitized and interconnected activities."*

The prospects of Brazilian agribusiness are positive despite the new challenges. Brazil will remain one of the largest net exporters in the world. It will, however, face new competitors, demographic changes in consumer markets, stricter regulatory requirements, and the need to adapt and mitigate the impacts of climate change. Sound management and use of technology—essential ingredients for the take-off of Brazilian agribusiness—will remain the divider for the ability to face the challenges of this new stage. Moreover, permanent topics on the agenda, such as transport, ports, and storage capacity, have their role even more pronounced. The search for productivity growth will remain at the center of the agenda in the context of increasing environmental constraints, rising climate risks, and high fertilizer prices. This challenge cannot be ignored in light of the success of the recent past.

MINING AND CRITICAL MINERALS

The decarbonization of the world economy and the search for security in the supply of critical minerals generate opportunities, reinforcing the premium the country already has associated with the quality of its iron ore and opening opportunities for ores to be used in products and processes aimed at decarbonization. Brazil has only 3% of its geological potential mapped. Overcoming the knowledge deficit is one of the challenges.

The iron ore extracted in Brazilian mines, with a high concentration of iron and low slag value, reduces steel emissions and favors the migration to electric arc furnaces, which have lower emissions. [36] Quality generates a premium reflected in the price of ore, as buyers avoid the impacts of carbon pricing and adjustment measures (CBAM), such as those announced by the European Union.

Another opportunity for Brazil arises from the increased demand for copper, nickel, lithium, graphite, and rare minerals, among others, in the transition to low-carbon economies. These minerals are vital to producing batteries, wind turbines, and solar panels, to name a few. For graphite, in particular, Brazil is one of the few producers in the LAC region and has one of the world's largest reserves.[37]

Here, there is undoubtedly a nearshoring opportunity. As pointed out by AmCham,

> *"The United States Department of Defense, along with North American Congress, allowed the granting of financial support for the creation of supply chains in critical minerals with allied countries. Considering the wide availability of natural resources in Brazil and the existence of already established supply networks between the two countries, Brazil and the United States can explore opportunities to expand the production and supply from Brazil."*

36 Vale (2021)

37 Global graphite reserves by leading country 2022 | Statista

Many of these ores will require the transformation of the various stages of the value chain—extraction of ores, processing, and definition of parts to be produced in the area of extraction, industrialization, and commercial network—and are associated with security and resilience issues—concentration in countries and firms—that mobilize the ongoing transformations in international trade. It should be noted that the nature of the technologies to be employed—both in iron ore and in ores that are still underexplored—have significant impacts on the location of the processing, whether near the mine or downstream.

The nature of mineral project exploration—high CAPEX, environmental and social impact management, environmental permits, stakeholder reaction, logistics dependence, long-term discovery, and exploration—demands governance and sophisticated policies capable of contributing to the efficient development of these projects. It is an agenda that is intensive in institutional construction. It begins with the increase of geological research and the modernization of mining policies, marked by inefficient regulation, fragmentation, overlapping of activities, and absence of strategic vision for these new challenges. A sensitive issue accompanying these projects is mineral exploration's environmental and social impact, especially in the Amazon region. This entails a double challenge: high environmental, social, and governance (ESG) mineral exploration standards and a rational licensing system that can minimize risks and ensure investments.

Box 6. Climbing the Value Ladder

One of the challenges of Brazilian agribusiness is to capture the highest value links in the chain and diversify markets. One of the companies interviewed has developed a strategy to become a global player in natural juices based on the following:

- Comparative advantages—world's lowest production cost in producing orange juice; varied fruit portfolio; already structured efficient logistics chain (unpacked juices) and container routes to large consumption areas.
- Value capture—Brazilian companies mostly export juices unpacked on ships. The company estimates a capture value three times greater than that of the product exported in bulk.
- Attention to market trends—natural, sugar-free, functional products with traceability of origin and ESG production patterns.
- Innovation—use of production technologies aimed at pasteurization with the ability to eliminate flavor differences in relation to natural juice, generate a product fresher than global brands with eight months of shelf life, which facilitates the placement of products in the Asian market, further away from the production area. In-house product development with impact on reducing time to market.

Companies seeking strategies to climb the value ladder rely on efficient management, access to modern technologies, and the ability to innovate in processes, products, and business models. There are also challenges associated with the business environment in which the absence of trade agreements stands out. Packaged juices may face tariffs five times higher than bulk juices. The same applies to soy products and other products. This pattern of import tariffs applies to many natural resources.

Addressing some of these problems will likely generate opportunities to develop support networks for the mining value chain in mineral research, technology development, process digitization, equipment production, specialized consultancies, and environmental and social services. These challenges are facilitated by the presence of leading international and national companies and by a diversified network of companies providing products and services. It is a production network that generates externalities for other sectors of the economy. The mining complex in Brazil has contributed to the development of a broad base of machinery and equipment companies, consultancies, and service providers that have expanded beyond the original activity of supporting the sector and that has been internationalized.

The development of these activities explains the presence of Brazilian companies with growing international participation, such as Visagio, Ambipar, and OceanPact. Visagio, a company born on the Federal University of Rio de Janeiro campus, is today one of the largest consulting companies in the country. Initial projects in the mining area have accredited it to have a presence in Australia with other mining companies and to expand its scope of action to different sectors of the economy and countries. In many of these companies, data analytics and artificial intelligence were crucial for increasing operational efficiency and reducing emissions. It is an application that will continue to play a critical role in the sector's development.

THE MANUFACTURING SECTOR: ARE THE SUCCESS CASES SCALABLE?

Brazil's industrial sector grew rapidly in the 1960s and 1970s of the twentieth century, stimulated by high protective measures, but the country has been witnessing a very rapid process of deindustrialization. Even in the presence of high levels of protection, the share of the manufacturing sector in GDP in Brazil has been experiencing a steady decline in the last four decades, from 24% of GDP at its peak in the 1980s to around 10% of GDP in recent years (Pessoa, 2023). This process has led to gloomy views about the future of the manufacturing sector in Brazil (Considera, 2022).

Brazil's industrial sector has developed in the pre-GVC era and is not well equipped to compete in a world where the global manufacturing sector is organized around regional and global production networks. As previously shown, the emphasis on protection and policies to substitute imports is still prevalent, limiting participation in GVCs to a handful of sectors and companies.

Despite the high level of trade costs and protection in Brazil, there are successful cases of manufacturing companies integrating into the world. Some of these cases are highlighted by Mendonça de Barros and Gomes de Oliveira (2021), who show that this success is based on integration into the world economy (not only through the commercial channel), financial deepening, and the focus on obtaining high levels of productivity. Fernandes (2022) reinforces this point of view, pointing out another driver of change in the industrial sector worldwide: digitalization, which can significantly impact how some of the leading industrial segments operate. He notes that changes in the country's environment that facilitate the absorption and development of new technologies, such as transformations in the venture capital and startup industry, have already occurred.

Brazil's industrial sector grew rapidly in the 1960s and 1970s of the twentieth century, stimulated by high protective measures, but the country has been witnessing a very rapid process of deindustrialization.

The interviews conducted for this study and the examination of cases of internationalization of Brazilian companies reinforce the potential of opportunities that derive from digital transformation. There are signs of transformation in companies and sectors. The challenge is to scale up these limited changes. The main challenges are the improvement of the business environment, the policies that connect Brazil with the world, and the capacity of the educational and research system to provide the resources and an adequate environment for companies to flourish.

To seize these opportunities, the country must address the obstacles and foster the development of abilities identified throughout this report. Decarbonization and digital transformation reinforce the importance of these requirements.

In the last four years, [Brazil] has stood out among the five countries that have advanced the most in the innovation ranking and has taken the lead in Latin America for the first time.

The recently published Global Innovation Index (GII), 2023, from World Intellectual Property Organization (WIPO), provides a backdrop for the evidence captured in interviews and case studies. Brazil has entered the list of the top 50 countries in the ranking and has improved its position in a group of 132 countries for the third consecutive year. In the last four years, it has stood out among the five countries that have advanced the most in the innovation ranking and has taken the lead in Latin America for the first time.

This performance occurs in a region with 11 out of the 37 countries performing below expectations. Brazil's forty-ninth position represents a gain of five positions compared to the previous report. It is Brazil's best result since 2011, when it was ranked forty-seventh. The worst result was recorded in 2015, seventieth.

A comparison of Brazil's results with those for a selected group of middle-income countries—Chile, India, Mexico, and Turkey—reveals the relative positions and the main strengths and weaknesses of a selected set of indicators. Here are some insights from GII 2023 (see Annex 6):

- **In the overall innovation indicator, Brazil's position (49) is lower than Turkey (39) and India (40)** but ahead of Chile (52) and Mexico (58). Between 2020 and 2023, Brazil's progress in the ranking is the most significant in this selection of countries.
- **In the macro indicators, Brazil's weakest performance is in institutions (99), capturing indicators related to the quality of the business environment.** Brazil is accompanied by Turkey (105) and Mexico (111). Chile (49) and India (56) have better positions.
- **In human capital and research, the position differences are relatively small among the selected countries.** Brazil (56) has a higher position than Chile (58) and Mexico (63) but is lower than Turkey (41) and India (48). Brazil's relative underperformance is in tertiary education.
- **In infrastructure, Brazil's position (58) is better than India (84) and Mexico (63)** but worse than Turkey (50) and Chile (52). Brazil's indicator is affected by a low rate of fixed capital formation. In the sub-indicator of information and communication technologies, Brazil leads among the countries in the group.

- **In market sophistication, Brazil's position (50) is superior to Mexico (57) and Chile (47)** but inferior to Turkey (36) and India (20). Brazil's position is negatively affected by sub-indicators of credit (80) and import tariff levels (107). Brazil has better positions in market scale (8) and economic diversification (39).
- **In business sophistication, Brazil's thirty-ninth position is ahead of the other countries in the group.** Turkey has the second relative position (46), followed by Chile (56), India (57), and Mexico (79). The position is consistent across all sub-indicators of business sophistication: knowledge workers, innovation linkages, and knowledge absorption. In the knowledge absorption sub-indicator, Brazil (32) is ahead of all countries in the group, a result not reflected in the tariff indicator, in which the country has a particularly unfavorable position (107). Brazil has the second position in the group in intellectual property payments/trade, imports of high-tech products/trade, ICT services/trade, and direct investment/GDP. However, it has the worst performance in research/business in the group.
- **In knowledge and technology products, Brazil's position (52nd) is lower than Turkey (44th) and India (22nd) but higher than Chile (58th) and Mexico (57th).** In the sub-indicators of this group, Brazil excels in the value of unicorns/GDP (22nd position, second only to India in the group, 9th overall), in intellectual property revenue on trade (41st, the best in the group), and in companies with ISO 9001 (second in the group).
- **In creative products, Brazil's position (46) follows the pattern of knowledge and technology products, and the position is only superior to the Latin American countries in the group.** Brazil has a relatively good performance in two sub-indicators: intangibles (31) and online creativity (52), but it has the worst position in creative goods and services (85).

The GII 2023 indicators in which Brazil has unfavorable positions confirm the results of the interviews regarding the constraints that Brazil faces in capturing movements of global value chain reorganization. Some of the main obstacles are associated with indicators of institutions (e.g., business environment), education, general infrastructure, credit, and import tariffs. The combination of these obstacles is reflected in the low growth of labor productivity, one of Brazil's indicators with the worst relative performance in the GII.

However, the exclusive examination of these constraints fails to capture the country's assets and changes in the economic environment that can be observed from other performance indicators and the comparison with company interviews.

From this assessment, it is possible to identify some critical points for examining opportunities for Brazil to attract segments of value chains:

- **Market size, scale, diversification, and complexity:** The market size generates scale, diversification, and investment attraction opportunities. Brazil's ability to attract foreign direct investment[17] is not accompanied by greater integration into value chains. The domestic diversification of Brazil's industry is higher than that of Latin American countries, but it does not project into the complexity of production and exports. Combining policies and seizing opportunities in decarbonization, digitalization, and the characteristics of the market and the country (for example health, biodiversity)[38] can enhance the power of these assets. The examination of the four leading companies that invest the most in R&D, according to the GII 2023, indicates a diverse profile

38 For example, the Brazilian Unified Health System (SUS) serves as a significant foundation for the implementation of digital solutions and artificial intelligence (AI) applications, as well as for innovation policies addressing local issues.

covering sectors such as aerospace and defense, oil and gas, software, and industrial engineering. Interviews identified several spillovers from these segments.

- **Access to knowledge and capital:** Despite high import tariffs on goods[39] and high taxation on service imports, the indicators point to a relatively favorable position for Brazil regarding knowledge absorption compared to other countries in the group. Brazil has a high share of foreign direct investment (FDI) flows, second only to Chile. Brazil's position in high-technology imports as a percentage of total trade (19) is only inferior to Mexico. In information, communication, and techology (ICT) services imports/total trade, Brazil is on par with India and much higher than the other countries. Brazil leads the group in payments for intellectual property as a percentage of trade, ranking seventeenth. Chile is seventieth, India is twenty-fifth, Mexico is one hundred fourth, and Turkey is sixtieth.

- **Scientific and technological foundation:** There is a scientific and technological base that can be enhanced and become a more relevant link for attracting investments. Brazil's position (34) in gross R&D expenditure as a percentage of GDP is higher than that of Chile (72), Mexico (75), India (54), and Turkey (35). The QS University TOP 3 indicator places Brazil (30) in line with Chile (31), better than Turkey (45), and worse than Mexico (26) and India (22). Collaboration between universities and industry is equivalent between Brazil (78), Chile (83), and Mexico (80). India (66) and Turkey (76) lead the group.[40]

- **Participation in the digital economy:** There are significant transformations, both in the business and government sectors, in Brazil's adaptation to the challenges and opportunities of digitization. Brazil's position (22) in the unicorn valuation to GDP indicator places it in the top group of the 132 leading countries in GII 2023. Brazil's position in the venture capital received indicator reflects the potential for developing digitally based companies, well ahead of all countries except India. The total value of the three top Brazilian unicorns, two fintechs and a real estate rental company surpasses, that of other countries in the group, except India. The cluster indicator ranks Brazil in the 50th position, only behind Mexico (42). Brazil's position in software expenditure as a percentage of GDP indicator (44) is higher than Mexico (76) and India (56) and lower than Chile and Turkey (23). Brazil's position in ICT exports as a percentage of total trade (86) is lower than India's (5) and higher than that of all countries. Another indicator related to Brazil's leadership position is the government's online service (14) and e-participation (11), which are ahead of all countries in the group.

The role of digital technologies as a catalyst for innovations in industry, agriculture, finance, education, health care, trade, resource exploration, and as a source of new forms of Brazil's participation in value chains deserves special attention.

39 The ex-tariff regime, which involves the temporary reduction of import duties on capital goods, information technology, and telecommunications equipment without domestic production, may account for Brazil's indicators in high-technology goods, despite the high import tariffs.

40 According to the OECD, in 2022, Brazil was the third-largest recipient of foreign direct investment flows, following the United States and China. https://www.oecd.org/daf/inv/investment-policy/FDI-in-Figures-April-2023.pdf

These results show that Brazil has significant assets—market, business ecosystem, business sophistication, connections with knowledge absorption sources, and scientific and technological potential—capable of supporting the capture of value chain reorganization movements. Opportunities should be examined in a broader context, considering the increasing reduction of intersectoral boundaries. The role of digital technologies as a catalyst for innovations in industry, agriculture, finance, education, health care, trade, resource exploration, and as a source of new forms of Brazil's participation in value chains deserves special attention.

THE INTERNATIONALIZATION OF THE SERVICES SECTOR

Software companies, service providers, and specialized consultancies have increased their international presence. Services have become an important link connecting Brazil to the international economy. The interviews and evaluations of this study highlighted the role of exports and direct investments in services. **The interviews pointed out the following:**

- **Cases of exports and direct investments of consulting companies and provision of services,** software, e-commerce, financial and environmental services, and applications directed to automation and use of AI and analytics;
- **Cases in which industrial companies have development centers in Brazil integrated with the provision of services to other companies** in different regions of the world;
- **Examples of the dilution of the boundary between industry-services and identification of opportunities for integration with GVCs,** such as the development of software for grid management.

The rapid transformation in Brazil's trade in services reinforces the evidence presented in the OECD Digital Trade Review of Brazil (2022):

- **Exports of digitally delivered services, which include ICT and financial services, consulting, and audio-visual services, grew their share of total service exports from 46% in 2005 to 65% in 2020.** This segment accounted for 50% of service exports in 2018, with exports of information technology services accounting for 14% of total service exports;
- **Exports of ICT services are less regionally concentrated than commodity exports and less dependent on the Asian market.** In 2018, the United States was the largest market with 39% of exports, followed by Chile (18%), Canada (17%), Ireland (4%), the Netherlands (3%), and Singapore (3%);
- **Brazil is more specialized in exports of professional and technical services, consulting, and engineering than the other countries in the region, India, and South Africa.** In this group of services, the United States represents 45.8% of the exports of Brazil, the Netherlands (7.9%), and Chile (7.2%).

These are signs that Brazil can better exploit these opportunities and develop more complex forms of integration into value chains. It requires an agenda that addresses human resource training, R&D, regulatory quality, ICT infrastructure, and lower restrictions on ICT trade in ICT goods and services.

CONCLUSION: THE POLICY AGENDA

As we have shown in this report, the very high levels of protection and the high trade costs faced by firms in Brazil act as severe limitations for them to engage in GVC trade. Brazil has a sophisticated landscape of industrial firms, including the most important multinationals in the world. However, the size of the trade costs faced by firms in the country suggests that it will be very difficult to think of Brazil as an immediate option for the relocation of GVCs' industrial segments. Interviews conducted for this paper reinforce the view that most multinationals still see access to the Brazilian domestic market as the main reason to operate in the country.

Despite all this, there are reasons to consider Brazil as an alternative for industrial relocation, given the assets the country has to offer. These are associated with the ongoing changes in the productive processes throughout the world, chiefly among them the transition to a low-carbon economy and, secondarily, the huge technological changes led by digitalization. As shown in the previous sections, Brazil's productive sector is well-positioned to benefit from these transitions. This encompasses the whole spectrum of the productive sector, from the natural resources-based sub-sectors to manufacturing and services.

The country's comparative advantages in natural resources and its clean energy matrix position Brazil as a frontrunner if the search for a clean, secure, and affordable energy supply becomes a key driver for firms' relocation. In addition, Brazil boasts immense potential to produce green hydrogen—widely considered an effective alternative for the decarbonization of the world economy—**both for export and domestic use.** With abundant wind and solar power and an integrated low-carbon electrical system, Brazil hopes to become one of the world's leading producers of GH2. **The powershoring—or perhaps, more generally, the greenshoring—story can effectively offer immense opportunities for the country.**

However, the country must pursue reforms and policy actions to address challenges and remove key obstacles to benefit from these transitions. Some of these actions involve the energy sector and are required to guarantee that the country can provide clean, reliable, and affordable energy in the future. Energy costs in Brazil are low, but energy prices to consumers, including industrial firms, are not. As we have shown, several sector-specific charges enter the formation of energy tariffs, adding the taxes levied on the tariffs, accounting for about 40% of the total electricity costs to consumers.

It will be essential to review the process of the formation of energy tariffs, reducing the harmful impacts of the various taxes and cross-subsidies that affect energy tariffs and giving transparency to the formation of prices. It will be key to eliminate unnecessary subsidies and transfer charges not directly linked to power generation to the public sector budget so that energy tariffs reflect the costs and services provided by the various sources that make up the Brazilian electricity matrix.

In addition to the distortions in the mechanisms of energy tariff formation, the overlapping of institutional functions and regulatory problems hinder the more efficient allocation of resources and are obstacles for Brazil to capture the numerous opportunities open for the country with the global decarbonization agenda. The interviews conducted for this study confirmed the importance of defining regulatory frameworks to attract investments (for example offshore wind, SAF, the role of hydroelectric plants, mining) and the need to update the general frameworks that guide the electricity sector. The two challenges are to organize the electricity sector with institutional governance capable of planning, correcting deviations, eliminating distortions, and contributing to the development of energy opportunities and to ensure that a clean energy matrix is in place, which is essential to capture investments aimed at the foreign market and to contribute to the elimination of emissions.

Hydrogen poses particular regulatory challenges. There are issues related to institutional governance, questions related to the production and end-use of GH2, the definition of technical standards, and those aimed at transporting and storing the product. Brazil is lagging in the buildup of a regulatory and institutional framework for the production and final use of green hydrogen that provides security for investments and is concurrent with international practices. In addition to building its regulation, the country needs to identify its priorities regarding GH2 production routes to act in international fora that discuss certification criteria.

The final central area of reform is to persevere in reducing the high trade costs faced by firms located in Brazil. This extensively studied topic continues to be an indispensable policy agenda for Brazil. While energy and decarbonization can be essential drivers of industrial firms' relocation, it is clear, as previously discussed, that multiple variables affect firms' decisions. It is imperative, thus, to continue to pursue improvements in the business environment and on variables that affect firms' productivity.

The interviews conducted for this study confirmed the perception of high trade costs. The main obstacle mentioned is the current tax system because of its anti-export bias (withholding of tax credits, imperfect relief, and litigation) and its impacts on investments. Several cases were reported on how the tax system discourages the attraction of links in the value chain to Brazil. References were also made to the labor relations regime, high import tariffs, the cost of capital, and legal uncertainty.

While the list of components of the high production costs in Brazil—the so-called "custo Brasil"—is long, it is essential to recognize that significant changes have occurred in recent years. The recent approval by the Congress of a broad reform of consumption taxes is a major step in reducing trade costs in Brazil (Annex 5 summarizes the main changes proposed in this ongoing reform).

The tax reform is an essential step in a cycle of relevant reforms carried out since 2016, confirmed by many of the interviews conducted for this report. For instance, the quality of the ports and logistics received positive references in the interviews. There is a set of ports in various regions of the country that have undergone a relevant transformation in search of increased efficiency. The interviews pointed to the existence of more structured ports to attract links in the value chains, such as the offshore ports of Pecém and Açu. These ports have been developing strategies to attract investments based on logistics, storage, draft, areas for industrial expansion, access to renewable energy, and, in the case of Pecém, availability of an export processing zone. They seek to attract investments in energy, hydrogen, energy-intensive industries (such as steel mills, fertilizers), refineries of renewable fuels for ships, companies producing equipment, and other industrial activities.

The trade agenda is the main missing piece after the approval of the tax reform. There were very limited changes in trade policy in Brazil, which is still characterized, as discussed in the third section, by high levels of protection, making Brazil an outlier compared to most developing countries. The rationale invoked by such policies is the protection of domestic industry. But by ignoring the profound transformation in the international organization of production and the network of preferential agreements woven in recent decades, the policies adopted have not produced the intended effects, proving innocuous in their efforts to reverse the deindustrialization of the Brazilian economy.

The conclusion of the negotiations for a free trade agreement between Mercosur and the European Union is an opportunity for a major step forward. The European Union is a major destination for "green products" and has been leading the rules setting related to the decarbonization agenda. The block has been setting unilateral regulations that affect Brazilian interests in areas such as consumption of deforestation-free products, imposition of carbon border adjustment measures (CBAM) on energy-intensive products, and definition of green energy and green hydrogen, among others.

The agreement in principle reached by the two blocks in July 2019 includes a chapter on trade and sustainable development that tackles many issues related to the green agenda. An additional instrument presented by the EU to Mercosur is under consideration. This document aims to interpret and deepen commitments to the environmental agenda. Negotiating this document and closing the deal could be an opportunity for Brazil to include cooperation commitments that would mitigate the burden of the EU unilateral regulation that affects trade in areas where the country has natural comparative advantages. Furthermore, it would provide the needed predictability for developing businesses that require high investments (CAPEX).

Looking beyond this short-term opportunity, broader trade reforms, including a reform of the Brazilian tariff structure—which should include the adherence to the WTO Plurilateral Agreement on Information Technology (ITA) and the promotion of an accelerated tariff reduction for environmental capital goods, a significant reduction of non-tariff measures, liberalization of trade in services, and an engagement in the negotiation of other trade agreements—are key steps that the country needs to consider to seize the opportunities associated with relocation of industrial firms.

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ANNEX

Annex 1. Firms and Institutions interviewed

Firm/Association	Sector	Exporter?
WEG	Machines and equipment	Y
EMBRAER	Aerospace	Y
Siemens Energy	Energy equipment	Y
Nestle	Food	Y
Natura	Cosmetics	Y
Johnson & Johnson	Pharmaceuticals, medical devices	Y
Arcelor Mittal Brasil	Steel, mineral extraction	Y
Natural One	Fruit juices	Y
Ericsson	Telecom	
Whirpool	Appliances	
Eurofarma	Pharmaceuticals	Y
Unicase Moveis	Furniture	Y
Visagio	Management and logistic services	
Ambipar	Environment management	
Porto de Açu	Port	
PECEM	Port	
Porto de Santos	Port	
SENAI	National training agency	
Abrace	Association of energy consumers	
ICC – International Chamber of Commerce	Business association	
AMCHAM Brasil	Business association	

Annex 2. Expansion of Startups and Corporate Venture Capital

Growth of startups and venture capital in Brazil has been remarkable in recent years. The country has benefited from the global trends that have driven the technological transformations led by these companies and the fall in the global interest rate. In addition to the action of venture capital managers, a growing number of companies, industrial and non-industrial, have been investing in development, support, or acquisition of startups, as are the cases of Ambev, Embraer, Eurofarma, Globo, Mercedes Benz, Gerdau, Natura, Furnas, Petrobras, Itaú and Bradesco and WEG.

This movement of the companies has several motivations: identification of new business opportunities—for example WEG incorporates several startups, such as BirminD, focused on the application of AI in the industry—capturing solutions to problems (testing, experimenting with solutions, and contracting the solution), and generating tools for the development of the value chain.

The case of Embraer is emblematic. It illustrates the role of domestic innovation with access to global sources, the anticipation of disruptive opportunities, and the potential to generate new business that is born from complex value chains. The presence in California, including via venture capital funds, was important in capturing trends toward electric takeoff car (EvTOL), developing the new flying car business, and creating EVE in the United States, focused on integrated mobility, air information systems, and urban air traffic management. EVE is a spin-off of Embraer-X, an incubator dedicated to innovation.

The company has been exploring new expansion frontiers, connected to its core business, through various channels. In addition to the acquisition of a stake in a drone company, Embraer, via a multi-corporate venture capital (CVC), has a stake in Automni, a company dedicated to the performance of robots and logistics robotization (software and hardware), which was born in the Polytechnic School of the University of São Paulo with newly graduated engineers. Another case, Visiona Espacial, a joint venture with Embraer, is an integrator of space systems with the use of nano satellites and projects focused on remote sensing and satellite telecommunications. Embraer now has a majority stake in Tempest, a cybersecurity company from the digital port of Recife (see Box 7).

Digitalization impacts established industries and creates new frontiers of expansion. The combination of trained human resources, reduced investment requirements, and the ability to integrate the network of companies demanding solutions generates a potential for the development of new economic activities

Box 7. The Porto Digital Experience

Porto Digital, located in an old, degraded port area of the city of Recife, is a remarkable case of creating a district of innovation and urban transformation in Brazil. It originates from the perception of IT professors of the Federal University of Pernambuco about the difficulties graduates had finding work in the city, forcing them to migrate. Porto Digital, an institution with private governance created in the year 2000, has developed an innovation hub with more than 350 companies, 750 doctors, 6 incubators, 7 institutes of technology, its own faculty (Cesar School, focusing on computer science, design, and IT management, with undergraduate, executive training, master's, and doctoral courses) and about 14,700 professionals and entrepreneurs. Both the state and the municipality participate in its board and support it with selected and directed tax exemptions.

It is a place that unites education, technology, and business. The institution acts as a facilitator for companies through physical spaces, training of human resources, interaction/exchange of knowledge, and connection with investors.

Whereas its origin is associated with the formation of a pole for the development of software and applications for mobile devices, it has been evolving in other directions. There are cases of success, such as an artificial intelligence company, Neurotech, acquired by the B3 stock exchange, and a cybersecurity company, Tempest, acquired by Embraer. A new focus of attention is aimed at attracting companies from traditional sectors that may demand ecosystem services, such as the installation of technology centers from Accenture, Deloitte, NTT Data (Japan), Samsung, Fiat Chrysler, and Baterias Moura. There is an internationalization attempt, through the creation of a hub in Aveiro, Portugal, aiming at exploring the European market, with a focus on Germany.

Source: Presentation by Pierre Lucena, May 2023, and Porto Digital Website

and support networks for the more efficient management of companies. This potential is exemplified by the Next Innovative Therapeutics (NINTX) case. Comparative advantages—access to biodiversity—and the existence of skilled human resources create opportunities in a knowledge-intensive area. NINTX is a biotechnology company that conducts research in the human gut microbiome by testing the interaction of plant compounds with the microorganisms that inhabit the human organism. This research, using data science and analytics, seeks to produce solutions for the pharmaceutical and food industries.[41]

Many of these companies are born with connections to international systems to support venture capital and startups. International and even some Brazilian managers do prospect on a global scale. Brazilian managers such as Futurum Capital and Lanx Capital screen opportunities in the national and international markets and focus on globally scalable investments. The same is true of CVC investments. Brazilian companies make international investments and multinational companies, even with a reduced presence in the Brazilian market, start to make local investments. [42]

The ease of startups scaling encourages them to overcome domestic limitations via two moves: one, to quickly turn to outside operations; another, to seek a more favorable business environment and already settle, from the beginning, in another country, stimulated by environments less hostile to business that offer access to knowledge and broader public and private financial support networks. The profile of ABVCAP's Brazilian startups indicates that 15.4% of startups already have an international presence and 61.5% plan to have one.

Another source of international connection is the installation of research units, laboratories, the participation in venture capital funds and in projects of universities and specialized research centers. There are a variety of motivations that emerge from interviews and case evaluations: preparing for technological disruptions, access to frontier technologies, access to financial resources, and increased intellectual property security.[43]

Annex 3. The Expansion of Natural Resources-based Industrial and Services Segments

On top of its natural resource endowments, Brazil has been developing a network of companies, research institutions, and supporting ecosystems that has contributed to productivity gains and generation of opportunities for more complex forms of integration into value chains.

In agribusiness, the role of the leading public research agency, Embrapa, as well as the role of input suppliers, machines and equipment producers, and, increasingly, the AgTechs that operate both in management and financing solutions and in supporting the operation, is well known. These are relevant channels for increasing productivity and exporting new products and services.

An example is the production of drones. XMobots is the largest Latin American drone production company, and Embraer acquired a minority stake in this company in 2022. One of its products, the Arator, is an agricultural drone with operation adapted to Brazilian meteorology, the need for simplicity for use, and aimed at precision agriculture—mapping, crop protection, and spraying activities. From the agricultural sector, the company is expanding its products into security and defense, logistics, and drone air traffic management. It uses a business model that reduces the CAPEX of the agricultural operator by stimulating the "Drone as a Service" system, which facilitates and generates greater security in the

41 O avanço da NINTX na busca por medicamentos baseados na biodiversidade brasileira, NeoFeed, 23/05/23, https://nintx.com.br/pt/index.php.

42 This is the case of Brazilian companies such as Vale, Suzano, Eurofarma, Embraer and foreign companies in the areas of urban mobility and health. Jaguar executive justifies investments in CVC in Brazil: "finding technologies in the country that can be developed abroad", Neo Feed, 14/06/23

43 Among the cases that illustrate this tendency there are large Brazilian firms, such as Embraer, Vale, Gerdau, CTC, ToTVs and Eurofarma.

selection of service providers.

Another company, MSW Capital, invests in startups in an integrated way that supports the innovation strategy of the companies that participate in the funding. The focus is on startups that apply aerospace technology in cargo transportation, logistics, and agribusiness. This is another example of how comparative advantages and local problems mobilize solutions and scale the business in multiple directions.

The opportunities for integrating agribusiness in global value chains go beyond the export of agricultural or livestock products. There are opportunities associated with agricultural research, carbon-neutral production, precision agriculture software, drones, robotics and automation of machinery and equipment, and new products, such as alternative proteins. Climate change, due to its effects on the frequency and intensity of droughts and rains, demands new technological solutions for inputs, equipment, and services. Similarly, consumer behaviors and/or regulatory issues derived from trade agreements (for example Mercosur/EU) increases the demand for product traceability, which also creates opportunities for the value chain.

In the area of oil and gas, Brazil is a leader in the development of deepwater exploration projects. Cenpes—Petrobras' research center—and research centers in universities and companies in the sector have a relevant role in R&D, anchored in a system of compulsory resources for R&D, which deserves an evaluation of its impacts and ways to increase its effectiveness.

As in the case of agribusiness, the development of a network of companies that participate in the exploration process has been a characteristic of the sector. One of the comparative advantages of leading companies lies in coordinating and mobilizing the specialized work of the different network participants. This network is mobilized to provide specialized services and to generate solutions to new problems and challenges of companies. Examples are companies specialized in emergency services and support to the operations of companies in the sector, such as Ambipar and OceanPact, which generate learning and experiences that qualify them, through acquisitions, to increase their participation as a supplier of solutions for companies in other countries and regions.

The accumulated expertise in the production and provision of services in areas where Brazil has comparative advantages allows the formation of a network of companies that develop, from adjacent opportunities, and that expand beyond the original sector. The internationalization process of these companies is usually associated with a demand to accompany the client—national or foreign—in their international operations.[44]

The expansion of companies in the industries examined and their ecosystem suggests that the focus of innovation moves away from disruptive movements and toward non-disruptive strategies. The stories emanating from the interviews conducted for this document indicate that entrepreneurs seek inspiration in other industries, in leading companies, in the network of suppliers and buyers, in the offer of complementary services, and in the reaction of consumers.

The possibilities derived from digitalization applied to these businesses create corridors of transformation. In all these sectors there is the growth of CVCs and startup networks. This movement is observed in companies such as Vale, Petrobras, and in the numerous independent projects of startups that seek to generate solutions to market problems.

44 This is the case of the companies interviewed in this project and the experience of the main software companies in Brazil that have gone international, such as Stefanini and ToTVs.

Agribusiness, mining, and oil and gas will have their development marked by value chain solutions supported by digitalization and decarbonization. In agribusiness, digitized irrigation allows drip on the foot of plants, reducing water and energy consumption. Digitally connected tractors and harvesters assess the soil and tailor actions to weather forecasts. The tracking of agricultural operations is an action that tends to become indispensable to ensure the absence of connections with deforestation and ensure the sanitary quality of products.

The mining and oil and gas sectors face the most acute challenges of decarbonization. Companies will have to move on a delicate line between investments to reduce emissions from oil and gas operations and investments focused on renewable energy.

Annex 4. GH2: Recent Developments in Brazil

The investments announced for the construction of GH2-producing plants in Brazil already amount to more than US$30 billion, most of them concentrated in ports—Pecém, in Ceará; Suape, in Pernambuco; and Açu, in Rio de Janeiro. These port complexes combine several strategic factors for the development of the new GH2 chain, such as logistics for export, proximity to industrial hubs, and renewable energy sources used in electrolysis for GH2 synthesis.

There are many memoranda of understanding announced, signed by these and other ports, as well as companies installed in Brazil, with international partners, most of which in terms still quite vague. The first industrial-scale GH2 project in Brazil is installed in Bahia, at the Camaçari Petrochemical Complex, by the company Unigel, the largest producer of nitrogen fertilizers in the country. Recently, Unigel has been facing financial constraints and is looking for a business partner to carry out the project.

The company White Martins, responsible for installing the first plant capable of producing GH2 on a large scale in South America, located in Pernambuco, fulfilled all the steps to also be the first company in the country to produce GH2 with certification. The company hired the German certifier TÜV Rheinland, a world reference in the sector, and, after a rigorous audit process, received the "Green hydrogen certification" seal.[45]

In October 2022, ArcelorMittal bought a steel mill in Pecém, Ceará, with the aim of capitalizing the significant amount of investment foreseen by third parties to deploy a hub of clean electricity and green hydrogen at the port[46]. One year later, the CEO announced that the company would buy the GH2 produced in Pecém, what was interpreted by the press as a commitment to buy the whole production of the gas.[47] In any case, the interest demonstrated by ArcelorMittal in the GH2 produced at the hub of Pecém shows that the project, originally devised to have the external markets as the main destination, is attracting plants that can use it to decarbonize its domestic production.

Brazil is expected to have the first electrolyzer factory in Latin America, from the expansion of a compressor unit of a German company installed in Minas Gerais, according to an announcement made by the company. There is also a memorandum of understanding between another German company and a Brazilian company producing wind and solar energy to develop the project of an electrolyzer plant at the Camaçari Complex in Bahia.[48]

45 https://www.GH2erdebrasil.com.br/noticia/principais-iniciativas-e-desafios-para-a-certificacao-do-hidrogenio/
https://valor.globo.com/brasil/noticia/2023/04/28/hidrogenio-verde-desponta-como-o-combustivel-da-proxima-decada.ghtml

46 https://brasil.arcelormittal.com/sala-imprensa/noticias/brasil/arcelormittal-assina-acordo-de-aquisicao-da-csp-no-brasil

47 https://exame.com/esg/o-ceara-nem-comecou-a-produzir-hidrogenio-verde-e-ja-vendeu-tudo/

48 https://valor.globo.com/brasil/noticia/2023/04/28/hidrogenio-verde-desponta-como-o-combustivel-da-proxima-decada.ghtml

Another asset developed in Brazil in recent years and that positions the country to take advantage of opportunities in the generation of GH2 are the research centers housed in universities, with laboratories of international standard to develop technologies adaptable to the national reality. The research centers are spread throughout several states of the country, with greater concentration in the southeast and northeast regions (34% each).

There is a bill under analysis at the House of the Representatives proposing a legal framework for the low carbon hydrogen. This framework includes the setting of The National Policy for the Low Carbon Hydrogen and the Development Program of the Low Carbon Hydrogen (LCH2).

It is interesting to note that the proposed regulation refers to LCH2, instead of Green Hydrogen (GH2), encompassing different technological routes. It defines LCH2 as hydrogen fuel or industrial input, collected or obtained from sources other than the production process, and which emits greenhouse gases (GHG), according to life cycle analysis, with an initial value less than or equal to four kilograms of carbon dioxide equivalent per kilogram of hydrogen produced (4 kgCO2eq/kgH2). It defines renewable hydrogen as hydrogen fuel or industrial input, collected or obtained from renewable sources, including solar, wind, hydro, biomass, biogas, biomethane, landfill, geothermal, tidal, and ocean gases.

Despite the broad definition, the scope of the framework and the policy instruments proposed seem to be oriented to the production of the GH2, including generation of energy and the infrastructure of transportation, storage, ports etc.

The bill includes a set of regulatory definitions that are basically in line with international regulations: additionality, temporality, decarbonization of inputs or the use of renewables etc. It defines that the H2 will be considered green if the production facility is connected to a subsystem of the existing grid (a subsystem of the SIN, in the case of Brazil) that had produced electricity in the previous year using at least 80% of low carbon emission sources. This percentage should gradually increase to 90% until 2030.

The framework includes provisions for the certification process, risk assessment, risk management, life cycle, and institutional governance, among other factors.

The most polemic aspect of the proposal lies in the creation of Rehidro—a special incentives regime to produce low carbon hydrogen. Rehidro incorporates a myriad of subsidies and incentives, including tax rebates and exemptions, tariff discounts, quotas for electricity bids, etc, which might deepen the many problems already identified in the current energy policy in Brazil.

Besides the considerable risks of creating new distortions to the energy policy, there are the impacts on the fiscal accounts, resulting from the several tax exemptions and rebates, which face resistance from the Ministry of Finance.

Annex 5. VAT Reform is Critical for Brazil's Trade Integration

Brazil has an imperfect consumption taxation system characterized by a very high level of cumulative taxes. This feature not only reduces productivity but also creates economic distortions that adversely affect Brazil's capacity to attract export-oriented investments. To address these problems, a tax reform bill is in final stage for approval by the Brazilian Congress.

Below are the main problems of the current system and their connection to trade integration obstacles:

1. Limits to expenses recognition: The use of the physical credit criteria instead of financial credit reduces the value of credits received by companies and their competitiveness. Administrative,

marketing, transportation, and research and development expenses are not creditable. For instance, energy expenses used in production entitle a company to credits, but not energy office expenses.

2. Delays in credit balance returns: These delays can be significant and may take several years, particularly in the case of investments. They have a notable impact on working capital, profitability, investments, and participation in export activities. In many instances, the delay in credit returns is tantamount to a denial of tax credits.

3. Administrative and compliance costs: Some of these costs arise from limits on credit expenses recognition and differences in state and municipal tax legislations. A common issue is the conflict regarding the definition of non-utility services, which are taxed by municipalities and do not generate tax credits for firms. These expenses constitute an increasing share of a firm's total expenses.

4. Lack of standards and rules: State and federal tax authorities have issued protocols that restrict the use of credits, limit the non-cumulation principle, and impede the use and transfer of accumulated balances. Besides the costs, this adds to a high level of bureaucracy burdens.

5. Tax litigation: These tax issues lead to judicial and administrative demands. Export companies invoke the constitutional precept of not taxing exports and file petitions with courts and administrative bodies to claim expenses recognition by tax authorities. INSPER estimates that federal tax litigations amount to 15% of GDP, whereas the median for OECD countries is 0.28%. The total amount of litigations at all federation levels reaches 75% of GDP.

In summary, the complex tax system in Brazil:

- Reduces the profitability of the export sector and Brazil's capacity to be part of global value chains, due to restrictions on the nature of credit rights and delays in receiving credits. Companies base their export planning on the volume of credits they expect to receive.
- Increases legal uncertainty and tax litigation.
- Distorts competition with imported products that do not face the same tax burdens, and in some cases, benefit from ICMS deferments due to state policies aimed at attracting investments.
- Diminishes companies' ability to respond to pressures for structural transformation due to non-recoverable investment taxes and restrictions on the use of credits in the operational stage.
- Lastly, it fuels protectionist measures and demands for fiscal incentives, all of which impact trade policies and the efficient allocation of resources.

Annex 6. GII 2023 Selected Ranking Indicators: Brazil, Chile, India, Mexico, and Turkey

Index	Brazil	China	India	Mexico	Turkey
Gross expenditure on R&D % GDP	34	72	54	75	35
Global corporate R&D investors top 3	34	40	13	32	35
QS University ranking, top 3	30	31	22	26	45
Market capitalization, % GDP	30	21	19	45	51
VC investors, deals/bn PPP$ GDP	53	49	6	40	34
Venture capital received, value, % GDP	29	44	6	40	34
Gross expenditure on R&D financed by business, %	39	55	41	69	32
Applied tariff rate, weighted average, %	107	5	97	13	71
High tech imports, % total trade	19	38	37	11	66
High tech exports, % total trade	58	70	41	9	60
ICT services exports, % total trade	86	99	5	131	89
ICT services imports, % total trade	34	90	32	131	87
Cultural and creative services exports, % total trade	53	70	18	110	71
Software spending, % GDP	44	21	56	76	23
FDI net inflows, % GDP	45	25	77	60	94
High tech manufacturing, %	33	55	35	16	36
Production and export complexity	59	75	46	20	41
Unicorn valuation, % GDP	22	36	9	31	30
State of cluster development	50	80	98	42	57
University-industry R&D collaboration	78	83	66	80	76
Citable documents H-index	23	38	20	33	33
Research talents, % in business	50	48	43	29	7
Global brand value, top 5	39	41	31	34	51
Patents by origin/bn PPP$ GDP	49	68	28	83	25
Intellectual property receipts, % total trade	41	70	45	102	60
ISO 9001 quality/bn PPP$ GDP	56	52	69	72	71
Labor productivity growth, %	100	37	43	123	21

ABOUT THE AUTHORS

José Guilherme Reis is an associated researcher with CINDES in Rio de Janeiro, Brazil. He was the executive director for Brazil at the Inter-American Development Bank from 2018 to 2022. Prior to this position, he spent 14 years at the World Bank, where he held several positions, the last one being practice manager for global trade and competition. Before joining the Bank in 2004, Reis occupied the positions of secretary for economic policy in the Ministry of Finance in Brazil (2001- 2002) and chief of economic advisors with the Ministry of Planning and Budget (1999-2001).

Sandra Rios is a director of the Center for Integration and Development Studies (Cindes), an independent think tank in Rio de Janeiro. Her areas of expertise include trade negotiations and trade policy. She has taught trade policy at the Pontifical Catholic University of Rio de Janeiro (PUC-Rio) and worked as a researcher at the Institute for Applied Economic Research (Ipea). For ten years, she was the head of the Trade Department of the Brazilian National Confederation of Industry (CNI).

José Augusto C. Fernandes is an associated researcher with CINDES in Rio de Janeiro. He was the policy and strategy director of the Brazilian National Confederation of Industry, ex-director of ICC Brazil and ex-president of FUNCEX, a trade policy think tank. He is a former member of the Global Agenda Council Latin América at the World Economic Forum.

Pedro da Motta Veiga is a director of CINDES in Rio de Janeiro. He has been Director at FINAME/BNDES and President's Chief of Staff in BNDES (1995 – 96) and Executive Diretor at the Foreign Trade Studies' Center – FUNCEX (1988-1995). He has acted as consultant to international organizations, such as IADB, OECD Development Centre and The World Bank. He is also, since 1997, a managing partner at EcoStrat, a consulting firm in Rio.

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