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Article

The foundation of international competitiveness in the bioplastics sector: A comparative study of Brazil and China

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Abstract

This paper presents a comparative analysis of Brazil and China regarding the productive and competitive foundations of the biopolymer sector, drawing primarily on Michael Porter's theoretical framework. The study aims to discuss the elements that constitute the so-called "foundation for international competitors" in both countries, focusing on the formation of a potential biopolymer cluster and considering public policies, infrastructure, productive relationships, and the role of the state in fostering innovation and competitiveness. The methods used combine literature review with secondary data from official sources in Brazil and China. The findings highlight the importance of a strong, productive base and suggest that China's experience underscores the need to strengthen state involvement in fostering a dynamic environment for productivity and competitiveness.

Keywords: national competitiveness strategy, biopolymers, renewable raw materials, sustainability

1. Introduction

Michael Porter presents important discussions for analyzing the productive sector in general. One of the key takeaways from his approaches is that for an industry to be competitive, several conditions must be met. He refers to conditions as the foundation for productivity and competitiveness. Porter questions why certain nations become the base for international competitors and succeed in specific sectors. According to Porter, market dynamism is essential for all productive sectors and countries. He states: "No company and no country can afford to ignore the need to compete. Every company and every country must seek to understand and master competition" (Porter 1999a, 7).

The study by Escobar and Britz (2021) supports the justification for this study by showing that Brazil and China are currently the countries with the highest production of bioplastics, as will be detailed throughout the

paper. Their research indicates that Brazil is the world's leading bioplastics producer among the analyzed regions, while China ranks fourth, with half of Brazil's share. It was possible to interpret that although China leads the global market in traditional plastics, its bioplastics production is still proportionally low. In contrast, Brazil, with limited relevance in conventional plastics, stands out in this segment, highlighting a more advanced productive transition. In Brazil, nearly 2% of plastic production already consists of bioplastics - a significant figure compared to the global average - while in China, this figure is only 0.14%. Regarding costs, China allocates a larger portion to raw materials, suggesting higher costs or lower availability of resources. At the same time, Brazil concentrates its costs on primary factors such as land, labor, and capital. Additionally, the tax burden on inputs is higher in Brazil, which may affect the competitiveness of Brazilian bioplastics.

Given the complexity of competitiveness, several authors such as Porter, Sharma, and Nogueira (Porter 1998; Porter 1999a; Porter 1999b; Sharma et al. 2022; Nogueira et al. 2024) provide important insights for analyzing the productive sector in general. Throughout their approaches, especially Porter's, it becomes evident that competitiveness in an industry depends on multiple factors he terms the foundation for productivity and competitiveness, and he questions why some nations become home to successful international competitors in specific industries.

This study aims to assess the foundation provided by the Brazilian nation for the biopolymer sector and compare it, for example, with the existing foundation in China to problematize how both countries appear to foster - or not - a dynamic environment for this sector. Therefore, the paper will first discuss Michael Porter's elements of competitiveness. Second, it will provide an overview of Brazil's material base to support, or not, the development of a biopolymer cluster. Finally, some elements of China's material base for the sector will be outlined.

2. Methodology

This study analyzes the existence or absence of an emerging bioplastics cluster in Brazil and China. It draws on Michael Porter's literature, particularly his understanding of what constitutes a base for international competitors, to discuss the bioplastics sector in both countries (Table 1).

Table 1. Main themes, authors, and publication years used in the literature review.

Theme	**Authors**
Base for international competitors	Porter (1999a, 1999b)
Productive landscape of the bioplastics sector	Escobar and Britz (2021), Sharma et al. (2022), and European Bioplastics (2024)
Analysis of the bioplastics sector in Brazil	Pertussatti (2020), ANBA (Brazil-Arab News Agency) (2023), Godoi et al. (2023), Globo Rural (2024), Godoi (2024), Godoi et al. (2024)
Analysis of the bioplastics sector in China	Mou (2023); Godoi et al. (2024); The China Project (2022; European Bioplastics (2024)

Source: The authors

Thus, this is a qualitative, reflective exercise based on a review of literature and data regarding initiatives and actions by the public and private sectors in Brazil and China. It aims to assess how each country currently stands concerning factors such as business environment, input productivity, value-added capacity, adoption of advanced technologies, the existence (or lack) of an organized cluster, and whether the sector is concentrated in a few companies.

The study, therefore, adopts a sectoral comparative analysis methodology grounded in a literature review and secondary document analysis, guided by Michael Porter's theoretical model of national competitiveness. The

following section presents the core elements of Porter's theory for understanding the competitive base, followed by a discussion of bioplastics and the sector's development in Brazil and China.

The literature information, combined with secondary data, has been prepared and organized in tables to support the argumentation line we used throughout the paper. Finally, this reflective exercise allows us to consider some aspects of Porter's theoretical contributions while suggesting that new lines of questioning are necessary, such as the state's role in creating and steering this material base that generates dynamism.

3. The base for international competitors in a given sector, by Michael Porter

Michael Porter is a prominent figure in discussions of strategy and competitiveness. Based on his reflections on the dynamics of competition, this study analyzes the bioplastics sectors in Brazil and China as a reflective exercise informed by international competitors.

The expression "base for international competitiveness" comes from Michael Porter himself. In his book "The Competitive Advantage of Nations," Porter discusses factors essential to ensuring dynamism and competitiveness in sectors and nations.

The author begins his discussion by questioning the reasons why some nations succeed while others fail in international competition, noting that this has become one of the most frequently debated economic issues of the time and a central concern for governments and industries worldwide (Porter 1999b).

Later, he argues that although this question is commonly asked, it is not the most appropriate one for understanding the foundations of economic prosperity. Instead, he suggests focusing on why a particular nation becomes the home base for successful international competitors within specific industries (Porter 1999b).

In examining the post–World War II context, Porter highlights that Europe experienced a period of intense reinvestment directed toward reconstruction and industrial support. He observes that, although a lack of competition is often associated with developing economies, advanced nations also underwent profound transformations. According to him, the breakup of cartels and dominant business groups, along with rising competition, contributed significantly to the remarkable economic recovery of Germany and Japan after the war (Porter 1999a).

However, to grasp the dynamics of competition, it is essential to understand the factors that shape it. Porter explains that competition is influenced by the structure and evolution of industries, as well as by the mechanisms through which firms attain and maintain competitive advantage within their respective sectors (Porter 1999a).

Therefore, understanding the dynamics of relationships and the involved structures is essential to grasp the "base for competitors." Porter argues that most competitive approaches are rooted in macroeconomics and fail to capture the true nature of the business environment. He states the usual approach to competitiveness is generally based on two main points: (1) macroeconomic policies such as government budgets, monetary policy, market liberalization, and (2) comparative advantages originating from labor, natural resources, and capital. Porter proposed a different rationale in which the competitiveness of locations is supported by the structure of the business environment offered to firms. By itself, gaining access to labor, capital, and natural resources is not a prerequisite for prosperity, as long as these assets become increasingly available. The real competitiveness of a location comes from the productivity of the companies using these inputs to create highly valuable products and services. In short, productivity and prosperity in a location are contingent on the way firms compete, not necessarily dependent on differences such as high-tech and low-tech or between manufacturing and services, since high technology and qualified labor are available to all industries (Porter 1999a).

Thus, the foundation for competitiveness also requires spatial relationships, structured territories, and territories organized for production, which Porter (1999) identifies as a favorable business environment. Productivity in using inputs is essential, and mere access to these inputs is not enough. Porter (1999) also argues that an abundance of inputs alone does not guarantee competitiveness; conversely, it can become a dangerous problem by generating dependence on comparative advantage. Forms of competition are also determinants of prosperity, as is the capacity to add value to goods and services. Competition will also require this dynamic to be constantly nourished. Finally, adopting advanced technologies and high levels of qualification is indispensable to sustaining competition and ensuring the dynamism of firms, sectors, and localities.

Based on the interconnection of these factors, the author organizes the elements around his proposed diamond model. In the paper "The Competitive Advantage of Nations", Porter presented the results of location on competition by means of a model with four dimensions, also known as the "diamond model": factor conditions, demand conditions, strategy and rivalry of firms, and related and supporting industries. The Diamond Model became a reference in Porter's theory. Through another paper, "The Competitive Advantage of Nations", the author explained how the government can exert positive or negative influence on the diamond dimensions. Also, the author mentioned that the theory can be an instrument for managers as much as a tool for governments dealing with microeconomic policies approaching real competition (Porter 1999a).

Thus, the author highlights the microeconomic dimension as fundamental to analyzing the dynamics of competitiveness, explaining that the prosperity of firms and nations is closely linked to the characteristics of the local environment in which competition occurs (Porter 1999a).

In this context, it is necessary to consider the spatial and territorial dimensions of organized production territories, drawing on Porter's insights. He considers it essential to identify the national attributes that foster competitive advantage in specific industries (Porter 1999b).

Therefore, the following sections list national attributes that either stimulate or hinder competitive advantages in the bioplastics production sector, whether in Brazil or China.

4. The productive landscape of the bioplastics sector

Bioplastics still represent a small percentage of the total volume of plastics produced globally. Nevertheless, it is a promising market due to increasing pressure on the conventional plastics industry and the availability of raw materials derived from renewable sources.

The European Bioplastics Association publishes studies and reports on the market and various related variables annually. These data reinforce the growing role of bioplastics in the global bioeconomy (European Bioplastics, 2024).

In 2024, the Bioplastics Market Development Update 2024 report reinforces this understanding by reporting that bioplastics accounted for 0.5% of the nearly 414 million tons of plastics produced annually (European Bioplastics, 2024). It also presented a scenario of global growth in bioplastics production, which is expected to rise from 2.47 million tons to 5.73 million tons by 2029 (European Bioplastics, 2024).

Sharma et al. (2022) project that, despite the economic impacts of the post–COVID-19 period, the bioplastics market is expected to grow from approximately USD 4,000 million to about USD 5,643 million by 2028, reflecting a compound annual growth rate of 5.9%. Likewise, they estimate that the biocomposites market will expand to around USD 36.76 billion within the following two years.

The main products include bio-based and biodegradable polymers such as polylactic acid (PLA) and polyhydroxyalkanoates (PHA), as well as bio-based polyethylene (PE) and bio-based polypropylene (PP). These are used in various applications, including packaging, consumer goods, automotive and agricultural products. Packaging is currently the segment with the highest usage, accounting for 45%, as corroborated by Sharma et al. (2022).

Sharma et al. (2022) note that these materials are viewed not only as a promising solution to the current environmental crisis but also as highly versatile, making them a preferred choice across various industries. The authors further suggest that emerging smart and intelligent technologies represent a hopeful pathway toward a more sustainable and environmentally secure future.

It is therefore possible to observe the sector's global potential. Regarding Brazil and China, the study by Escobar and Britz (2021). identifies these as the leading producers of bioplastics today. The study uses analyses of native vegetation loss to derive quantitative indicators of bioplastic production from crops across the five main producing regions: Brazil, China, the European Union, the United States, and Thailand. The study presents the following scenario (Table 2).

Table 2. Each region's share of the global bioplastic and total plastic markets (%) in the benchmark year, and associated cost shares (%) in bioplastic production. EU28: European Union.

Indicator	Brazil	China	EU-28	Thailand	United States
Bioplastics market share of world output (%)	33.33	16.22	28.23	2.7	19.52
Total plastics market share of world output (%)	3.54	23.99	25.6	1.12	16.02
Bioplastics as a share of total plastics output (%)	1.9	0.14	0.22	0.49	0.25
Raw material cost share (%)	17.1	35.0	18.8	17.0	17.1
Other intermediate inputs (%)	28.7	30.8	33.2	20.2	30.0
Primary factors (%)	50.4	33.7	39.8	62.1	47.9
Input taxes (%)	3.8	0.5	8.1	0.7	5.0

Source: Escobar and Britz (2021)

The study clearly shows that Brazil is the world's largest producer of bioplastics among these regions. China ranks fourth, with half of Brazil's share, indicating Brazilian leadership in this sector, likely linked to the use of renewable raw materials such as sugarcane. According to the data presented in the table, the ranking of the world's largest bioplastic producers, based on their share of the global bioplastic market, is led by Brazil with 33.33%, followed by the European Union (EU28) with 28.23%, the United States with 19.52%, China with 16.22%, and Thailand with 2.70%. This distribution highlights Brazil's leading role in global bioplastic production, with the EU28 and the United States also standing out as major contributors, while China and Thailand account for smaller but still significant shares.

It can be inferred that China leads the traditional plastics market but still has a relatively low share in bioplastics. Conversely, Brazil plays a minor role in conventional plastics but has a strong presence in bioplastics. This shows Brazil's transition to bioplastics is more advanced in terms of productive focus. Nearly 2% of Brazil's total plastic production is bioplastic, a significant figure given the still-low global average.

In China, only 0.14% of plastic production is bioplastic, revealing that the sector remains very small compared to its overall plastics market. Regarding raw materials, China spends proportionally much more on feedstocks (35% of costs), which may indicate that bioplastic feedstocks are more expensive or less available there. In contrast, Brazil seems to allocate more resources to primary factors (land, labor, and capital), perhaps reflecting a greater agricultural land use. As for input taxes, they are more significant in Brazil (3.8%) than in China (0.5%), which may affect price competitiveness.

In conclusion, we can observe the formation of global competition around an emerging market. The following sections will present elements of the Brazilian and Chinese markets to explore central aspects of competitiveness, based on Porter (1999a, 1999b).

5. The foundation for international competitors in the bioplastics sector in Brazil

In 2022, the then-president of the Brazilian Association of Compostable Biopolymers and Composting (ABICOM, 2024), Karina Daruich, assessed that the environment in Brazil was favorable to achieving a bioplastics production growth rate above the global average. The global estimate was that the bioplastics industry would more than triple its production capacity within the next five years, and she presented Brazil as a country with a promising future in bioplastics, citing easy access, abundance, and low input costs as potential factors for the sector's performance. She also stated: "The scenario improved after the implementation of reverse logistics and the National Solid Waste Policy, which began requiring the proper disposal of packaging after use" (ANBA, 2023).

Thayse Hernandes, a Brazilian researcher at the National Laboratory of Biorenewables (LNBR), highlighted in an article dedicated to exploring the bioplastics sector in Brazil the country's enormous potential to be highly productive in bioplastics, especially when using agricultural land to promote more circular value chains. According to this perspective, 35.6 million hectares could be dedicated to sugarcane cultivation, an excellent raw material for bioplastics. Of this total, 3.55 million hectares could be used to produce more than 30 million tons of bioplastics annually, equivalent to 35% of current global polyethylene demand, according to Globo Rural (2024).

The study published in Nature by Nogueira et al. (2024) examines Brazil's potential to sustainably expand bioplastics production to meet global demand by 2050. The authors argue that, under environmentally conservative land-use zoning, the country's available land for sugarcane cultivation would be sufficient to replace all fossil-based polyethylene (PE) with bio-based PE. This outcome, however, depends on the adoption of advanced recycling technologies, improvements in closed-loop efficiency across the PE value chain, and effective measures to prevent material leakage.

Brazil has several initiatives related to bioplastics. The study by Godoi et al. (2023) analyzed the formation of the Brazilian bioplastics cluster based on Michael Porter's (1999) ideas and identified opportunities and challenges for the sector in the country. Godoi et al. (2023) discuss the Brazilian context for bioplastics, highlighting the potential to produce biopolymers from national agricultural products within an agro-industrial context, as well as the implications of land use and its potential expansion. The authors also reflect on the organization of a productive sector in Brazil, considering the establishment of the first biopolymer industry in the country and in Latin America. For this analysis, they applied Michael Porter's (1999) concepts of competitiveness, notably the Diamond of Competitive Advantage, to identify both strengths and weaknesses of the biopolymer sector in relation to each component of the model.

The study's main findings indicate that Brazil holds significant potential in this field, primarily because of its abundant raw materials, especially large-scale crops such as corn and sugarcane. According to Godoi et al. (2023), although the country possesses a strong comparative advantage in this sector, achieving a true competitive advantage will require substantial investments in economic, social, political, environmental, and technological areas, among others.

In a subsequent study, Godoi (2024) highlights prominent initiatives among the BRICS countries and discusses the existence of a Brazilian association dedicated to bringing together companies involved in the production and commercialization of bioplastics

Godoi (2024) points out that initiatives related to the Brazilian bioplastics sector include the role of the Brazilian Association of Compostable Biopolymers and Composting (ABICOM, 2024), the presence of industries with projects dedicated to bioplastics such as Braskem, ERT, and Bioelements, as well as supporting companies like Raízen. The author also notes that several firms engaged in commercialization and production are associated with ABICOM, among them Additiva, BASF, Bioreset, eeCoo Sustentabilidade, Romapack, Futamura, IMCD, Já Fui Mandioca, Mitsubishi Chemical Group, Moinho Produtos Sustentáveis, Nelxon, Oeko Bioplásticos, Polimex Bioplásticos, RevPack, Tamoios, and Wacker.

Beyond private-sector initiatives, aspects of the public sector can also be identified, such as laws, legislative bills, and policies that can serve as stimuli and structure for creating the environment, or foundation, for competitors.

Regarding environmental legislative bills in Brazilian cities, one can observe efforts to regulate the use of plastics, particularly in shopping and trash bags. Pertussatti (2020) notes that from 1995 to 2019, 135 legislative bills related to "plastic" were introduced in the National Congress. Godoi et al. (2023) observed that such laws emerged in 2008 and peaked in 2011. This may be associated with broader mobilization in the states, possibly in response to international debates or national guidelines on solid waste, as the National Solid Waste Policy was enacted in 2010.

Recently, from 2020 to 2022, a new wave of legislation began, possibly linked to social pressure for sustainability, international agreements, and the encouragement of the bioeconomy, especially due to the current federal government's role in broadening the debate on these topics. It is also evident that this is a decentralized effort, encompassing both state and municipal legislation, highlighting the reach and complexity of environmental concerns in Brazil and revealing the lack of a unified identity or general definitions on the matter at the national level.

Based on these elements, it is possible to identify the components that form the foundation for international competitors concerning Brazil (Table 3).

Table 3. Elements that make up the basis for international competitors in Brazil

Item	Possible Variations	Country Potential (Existing or Not Existing)	Source
Business environment	Although there are organized sectoral associations (such as ABICOM, 2024) and legal incentives (reverse logistics, National Policy on Solid Waste), the environment still requires institutional improvements, reduction of bureaucracy, and clearer incentives for the bioeconomy.	Partial	Godoi (2024); ANBA (2023)
An abundance of raw material	Brazil has abundant raw materials such as sugarcane and corn, which are widely cultivated for agroindustrial use and potentially for bioplastics.	Existing	Godoi et al. (2023)
Production and commercialization companies	The country has companies involved in production and commercialization, both national (Braskem, Bioelements, Mandioca, etc.) and multinational (Basf, Mitsubishi, Wacker, etc.), connected to ABICOM.	Existing	Godoi (2024)
Scientific production	There is an increasing national and international scientific output dedicated to evaluating Brazil's potential and strategies for bioplastics. However, investment in research and integration between academia and industry must be strengthened.	Partial	Nogueira et al. (2024); Godoi et al. (2023)
Public policy	Brazil has environmental laws and bills aimed at regulating the use of plastic. However, a lack of national coordination and standardization leads to a decentralized, fragmented system.	Partial	Pertussatti (2020); Godoi et al. (2023)
Social pressure and environmental awareness	There is growing public demand for sustainable practices and environmental education efforts, especially in urban centers, though this awareness is uneven across regions.	Existing	Godoi (2024)
Access to technology and innovation	Although companies like Braskem have developed cutting-edge technologies (e.g., green polyethylene), their diffusion across the sector remains limited. Greater investment is needed in technology transfer and incentives for innovation in smaller companies.	Partial	Godoi et al. (2023); ANBA (2023)
Infrastructure and logistics	Brazil faces structural challenges in logistics and distribution infrastructure, impacting competitiveness and the flow of inputs and final products.	Not fully existing	Godoi (2024)

Source: The authors

Brazil shows potential in bioplastics, including abundant raw materials, agricultural productivity, industrial experience in biopolymers, and ongoing sectoral coordination efforts. It is observed that the only item with high potential is related to the production of inputs, and this, as Porter (1999a; 1999b) argues, is only the initial part of the demands of a competitive cluster. In this sense, there are institutional challenges, low regulatory standardization, and a need to strengthen value aggregation and large-scale technological adoption. This requires integrated public policies and a long-term vision to transform comparative advantages into competitive global advantages.

The following section presents elements to consider as a foundation for Chinese competitors.

6. The foundation for international competitors in the bioplastics sector in China

China has been consolidating itself as a leader in production and competitiveness across various sectors and is already the second-largest bioplastics producer globally. Regarding new materials derived from renewable sources, such as bioplastics, both public- and private-sector initiatives can be identified in China. Official government documents show growing concern about productive transformations involving new materials, especially those derived from renewable sources.

In January 2020, as previously mentioned, the Ministry of Ecology and Environment, along with the National Development and Reform Commission, issued a communication entitled “Opinions on Further Strengthening the Control of Plastic Pollution”, which announced bans and restrictions on four types of single-use plastics in China over the next five years. To address challenges related to plastic products and stimulate the development of new materials, the government issued a document. According to Chinese central government guidelines, a new approach to the use of certain types of plastic will be adopted. The production of alternative, recyclable plastics will be encouraged. A management system for the production, circulation, use, recycling, and utilization of plastic products will also be improved, ensuring organized and effective control over plastic pollution.

The document further underscores the importance of concentrating efforts on key areas and advancing in a structured manner. It outlines a vision driven by innovation and supported by science and technology, aiming to develop and promote plastic products and alternatives that are both high-performing and environmentally friendly. Guided by principles of recyclability, ease of recycling, and biodegradability, the approach also seeks to encourage new business models that enable standardized recovery, recycling, and pollution reduction.

China's 14th Five-Year Plan (2021–2025) also encourages the development of new materials by establishing the creation of new biotechnologies and biomaterials as fundamental pillars of a new industrial system. The document states that China will focus on new-generation information technology, biotechnology, new energy, new materials, high-tech equipment, new-energy vehicles, environmental protection, aerospace research, maritime equipment, and other strategically important industries. Furthermore, innovation and the application of basic technologies in key sectors will be encouraged to improve the country's capacity to supply productive factors and stimulate new drivers of industrial development. The integration and innovation of biotechnology and information technology will also be promoted, as well as the acceleration of the development of biomedicine, biological breeding, biomaterials, bioenergy, and other industries, aiming to enhance the scale and strength of a bioeconomy.

In March 2025, Xi Jinping delivered a speech published on the official platform of the Communist Party of China's Central Committee, in which he addressed the progress of Chinese society and reaffirmed the country's commitment to becoming a scientific and technological power. In this publication, the Chinese president emphasized that innovation encourages high-quality development with discoveries in diverse areas such as integrated circuits, artificial intelligence, satellite launches, high-precision navigation systems, production of large aircraft in commercial operation, high-speed railways, electric vehicles in the global automotive industry, green technologies, biotechnology, and new medicines.

In addition to what can be observed in official government documents and statements from Chinese political leaders, regulatory developments reflect concern with transitioning from conventional plastics to bioplastics. In this regard, Mou (2023) notes that China has been reevaluating its policies regarding domestic plastics production. A major milestone was reached in 2008, when the first public policy regarding the plastics industry was adopted. This policy prohibited the manufacturing sector from producing plastic bags thinner than 0.025 mm and limited the use of plastics by citizens.

Godoi et al. (2024) analyze China's initiatives to boost bioplastics production and strengthen regulations to reduce plastic waste. The authors note that, in January 2020, the Ministry of Ecology and Environment and the National Development and Reform Commission released a policy document titled Opinions on Further Strengthening the Control of Plastic Pollution, which introduced a series of bans and restrictions on four types of single-use plastics to be implemented progressively over the following five years.

As for research centers, due to China's vast size, numerous institutions have research programs in chemistry, industrial engineering, and other fields related to bioplastics. However, one noteworthy example is Tsinghua University, where Professor George Guo-Qiang Chen is active. He is part of the scientific committee of the International Symposium on Biopolymers, which is held annually in different countries and was hosted in China in 2018.

Regarding production, China not only encourages the transition away from conventional plastics through public sector actions but also supports the use of bioplastics in specific sectors and regions. It has fostered the emergence of new bioplastics industries and supported existing plastics companies in developing products based on new materials and raw inputs.

According to the study by Mou (2023), "China is the world's largest producer of bioplastics: China is the biggest producer of biodegradable plastic with the market volume of 162,000 tons" (Mou 2023, 342).

Moreover, this dynamic, growing market seeks to meet the demand to reduce conventional plastic use and tackle the environmental challenges posed by plastic waste, both domestically and globally.

As Asia's most populous country, China is a major consumer of plastics, and biodegradable plastics are considered an effective way to address pollution from single-use plastic waste. China is experiencing rapid growth in the market value of biodegradable plastics, reaching an estimated RMB 23.072 billion in 2023 from RMB 4.056 billion in 2018. In 2021, China's trade in biodegradable plastic-related products saw significant growth. The country's exports reached 136,900 tons valued at 3.96 billion yuan ($591.90 million), with a 27.88% year-on-year increase. Additionally, imports amounted to 8,500 tons valued at 1.96 billion yuan ($293.04 million), showing a remarkable 64.87% year-on-year increase, resulting in a trade surplus of about 2 billion yuan (nearly $300 million) (Mou 2023, 340).

Mou (2023) points out that market data highlight China's performance, and the increase in exports exposes the competitiveness of Chinese products.

The China Project is an information platform focused on China, based in New York. In a feature article titled "The Rise of the Biodegradable Plastics Industry in China—Business and Technology," the platform details the types of bioplastics being industrialized and the companies that stand out in the sector. Regarding China, the article highlights Kingfa, with a high PLA production capacity; Red Avenue Materials, which invests in PBAT; CB Material; and Tidetron, which is dedicated to PBS.

In another article titled "Is the 'strictest plastic ban in history' working in China?", also published by The China Project, another industrial initiative is mentioned — a company called Kanghui New Material Technology, a subsidiary of Hengli Petrochemical, specialized in biodegradable materials intended to produce plastic bags, disposable utensils, plastic agricultural films, and delivery packaging. The article forecasts production of 2.5 million tons of biodegradable materials and a future market exceeding US$ 8.3 billion.

There is, however, ongoing debate about the actual implementation of these measures. The article Is the "strictest plastic ban in history" working in China? raises such concerns, noting that China's biodegradable plastics industry is still in its nascent phase. According to Che (2021), while demand for biodegradable plastics has increased sharply due to new restrictions, the sector remains relatively small and fragmented. Supply continues to lag behind demand, and significant challenges to large-scale production persist, including constraints related to the availability of raw materials.

This overview reveals China's efforts to stimulate the bioplastics market through both the productive sector, with globally relevant raw material producers and industries participating in European-focused forums and institutions, and the public sector, which is supporting this type of production not only for its future market potential but also due to concerns related to conventional plastic production.

Three companies represent China, and it is important to note that the institutions affiliated with European Bioplastics differ from the ones mentioned above, as the documents listed present the Chinese sector. Therefore, in Table 4, we have gathered all the companies cited in the article and the materials they claim to specialize in.

Table 4. Chinese industries and bioplastic raw materials produced or used

Chinese Company	**Material**
Kingfa	PLA
Red Avenue Materials	PBAT
CB Material	Not Found
Tidetron	PBS
Kanghui New Material Technology	Not Found
Jinhui Zhaolong High Tech	PBAT
Pha Builder Zhejiang	PHA
Hisun Biomaterials	PLA, PBS

Source: European Bioplastics (2024)

The role of the Chinese state, therefore, appears to be active in driving policies both to encourage the introduction of new materials and to restrict the use of plastics in the production of certain products, such as plastic bags, cutlery, and packaging, which are gradually being phased out in favor of bioplastics, among other alternatives.

It was possible to conclude that China is actively moving towards the adoption of bioplastics, both from a production and regulatory perspective. While challenges persist, such as expanding production capacity, state policy is aligned with the search for sustainable alternatives.

Therefore, China could play a crucial role in shaping the future of the global bioplastics industry, given its influence and active participation in this growing market. Based on these findings, elements that may serve as a basis for Chinese competitors in the bioplastics sector can be analyzed (Table 5).

Table 5. Elements that form the basis for international competitors in China

Item	Possible Variations
Country's Potential (Existing or Not Existing)	High – China has strong state governance, regulatory support, and alignment between companies and public policies.
Business Environment	The Chinese state directly shapes the business environment through five-year plans, market control, innovation encouragement, restrictions on plastic waste imports, and regulatory standards for biodegradable materials.
Productivity in Inputs	China stands out not only for its access to biomass and labor but also for its increasingly productive use of these resources. Moderate or Medium—Despite its scale, China is still dependent on the importation of some enzymes and catalysts, and costs remain high compared to fossil-based inputs.
Value-Adding Capacity	Incentives for producing packaging, utensils, and finished goods with bioplastics, not just basic raw material production. Companies like Kingfa, Red Avenue Materials, and CB Material focus on specific biopolymers (PLA, PBAT, PBS), indicating market specialization and differentiation. Medium - There is ongoing development of eco-labeling and standards that add perceived value for consumers.
Adoption of Advanced Technologies	Adoption of technologies is embedded in the five-year plans, focusing on bioeconomy, biotechnology, bioenergy, and biomedicine. Public investments and R&D in biodegradation processes, new enzymes, and catalysis. High - Leadership in the number of patents, state-run laboratories, and coordination between research and industry.
Existence of an Organized Cluster	An emerging cluster is identified with industries, research centers, and productive specializations, leading to participation in international associations such as European Bioplastics and export of specific raw materials and finished products for the packaging sector. However, there is still a need for further development of more complex, high-value-added products and differentiation between companies. Medium to High - There is still regional inequality in cluster development, but specific public policies are in place to foster it.
Business Concentration	China seems to host a large number of companies in an emerging sector, encourages new players, and supports large companies like Kingfa, Red Avenue, and Hisun, offering concessions and subsidies for larger enterprises. Moderate to High – The structure is dominated by large companies with high-scale capacity, which accelerates productivity but may reduce diversity.

Source: The authors

Thus, it can be affirmed that China is consolidating its position as a major player in the bioplastics sector through government incentives and investments in innovation (Wu et al. 2023).

7. Comparative study of Brazil and China

After presenting the elements that form the basis for international competitors in Brazil and China, we can make some comparisons, summarized in Table 6.

Table 6. Summary of elements that form the basis for international competitors in Brazil and China

Item	Brazil	China	Source
Country's Potential (Existing or Not Existing)	Existing - strong agricultural base	Existing - strong government support and innovation	Wu et al. (2023), Globo Rural (2024)
Business Environment	Improving, but still bureaucratic	Strong state incentives and a competitive environment	ANBA (2023), Wu et al. (2023)
Productivity in Inputs	High agricultural availability	High investment in technology and efficiency	Wu et al. (2023), Nogueira et al. (2024)
Value-Added Capacity	Developing, focused on bioenergy	Established in high technology and biotechnology	Sharma et al. (2022), Nogueira et al. (2024)
Adoption of Advanced Technologies	Growing but unequal	Accelerated with strong innovation support	Sharma et al. (2022), Wu et al. (2023)
Existence of an Organized Cluster	Emerging	Already consolidated in industrial regions like Zhejiang	Wu et al. (2023)
Business Concentration	Fragmented market	Concentration in large conglomerates and state partnerships	Wu et al. (2023)

Source: The authors

Considering the comparison between Brazil and China shown in Table 6, starting with the item "Country's Potential," it is evident that Brazil has significant potential to be highly productive in bioplastics, especially given its use of arable land, aiming to promote a circular value chain. The country has a large amount of land available for sugarcane cultivation, which can constitute excellent raw material for bioplastics. China, on the other hand, has strong governance potential, effective regulatory support, and a strong alignment between companies and public policies.

Regarding the “Business Environment”, although Brazil has good sectoral organizations such as the Brazilian Association of Compostable Biopolymers (ABICOM), as well as legal incentives like the National Policy on Solid Waste, there is still a need for institutional improvements, a reduction in bureaucracy, and greater transparency in incentives for the bioeconomy. In this sense, China acts directly in the business environment through a five-year plan, controlling the market and encouraging innovation, seeking to restrict the import of plastic waste and establishing standards for biodegradable materials.

Given "Productivity in Inputs," Brazil has abundant raw materials, such as sugarcane and corn, widely cultivated for the agro-industry and for potential use in bioplastics. Furthermore, it is a country with a very promising future in bioplastics, as it has easy access to low-cost inputs, which is a key factor in the sector's high potential. China, on the other hand, stands out for its access to and use of biomass and its availability of labor, but it is still quite dependent on the import of certain enzymes and catalysts, which makes its costs higher than those of fossil raw materials.

Regarding the "Value-Added Capacity" aspect, Brazil currently has a constantly evolving national and international scientific production, which contributes to the development of the bioplastics area. China, in turn, has many incentives to produce various bioplastic products, such as packaging, household utensils, and finished goods. Companies such as Kingfa, Red Avenue Materials, and CB Material focus on specific biopolymers, including PLA, PBAT, and PBS.

About "Adoption of Advanced Technology", Brazil faces significant challenges, including low regulatory standardization, a strong need to strengthen value creation, and the necessity of adopting technology on a large scale. For this to happen, integrated public policies must be established, and a long-term vision is needed to transform comparative advantages into competitive advantages. In China, the adoption of new technologies is embedded in its five-year plans, focusing on bioeconomy, biotechnology, bioenergy, and biomedicine. There are also investments in research and development in biodegradable processes, new enzymes, and catalysts. This is further complemented by an increase in the number of patents, state-owned laboratories, and coordination between research and industry.

Regarding the items "Existence of an Organized Cluster" and "Business Concentration," Brazil presents interesting dynamics in the formation of bioplastics clusters, with reference to the ideas of Michael Porter (1999a, 1999b). Godoi et al. (2023), based on Porter's Diamond Model of Competitive Advantage, discussed the Brazilian environment for bioplastics production, highlighting the potential for national output based on the country's existing agro-industrial base. It would be the first bioplastics cluster in Latin America. The most likely areas in the country for the formation of a first cluster are the Central-West and Southern regions, where agribusiness is strong. China, in turn, has an emerging bioplastics cluster, with an international presence and connection to European Bioplastics, exporting specific materials and finished products to the packaging sector. However, there is a need to develop more complex products with higher added value. Although the country faces regional inequalities in cluster development, China has public policies underway to address them.

This study shows that countries with large production capacities, even with abundant raw material supplies, do not necessarily succeed in developing a cluster based on raw material abundance, as discussed in various countries and studies. It is important to highlight the need for future, more in-depth discussions about the role of countries and national policies, and the state's role in fostering and creating bases for international competitors. In China, the productive and organizational dynamics highlight the importance of state power in creating the foundation for clusters and competitiveness. In contrast, Brazil demonstrates that it takes more than raw material production and a few competitive companies to form and stimulate a cluster.

8. Final considerations

This article develops a comparative analysis of the biopolymer sector in Brazil and China, grounded in Michael Porter’s theories on competitiveness, particularly The Competitive Advantage of Nations and Competitive Strategy: Essential Concepts. According to Porter, national competitiveness depends on the capacity to create dynamic business environments shaped by productivity, industrial structure, efficient resource use, and technological innovation. The study applies these concepts to examine how both countries are fostering the development of potential biopolymer clusters, with attention to public policies, infrastructure, productive relations, and the state's role in promoting innovation and competitiveness.

The analysis draws on data from sources such as European Bioplastics, e.g., its Bioplastics Market Development Update 2024, as well as recent academic studies. It explores the material foundations and institutional frameworks that influence the sector in both Brazil and China. The findings show that while Brazil possesses a strong agricultural base and availability of raw materials, the country still faces bureaucratic challenges and fragmented industrial structures that limit the consolidation of a cohesive biopolymer cluster.

China, in contrast, has consolidated itself as a global leader in industrial competitiveness and is currently the world’s fourth-largest producer of bioplastics. State-led initiatives, reinforced by the 14th Five-Year Plan (2021–2025) and specific regulations such as the 2020 Opinions on Further Strengthening the Control of Plastic Pollution, demonstrate a clear strategy to reduce single-use plastics, foster renewable-based materials, and stimulate industrial innovation. These policies are complemented by significant R&D investment, regulatory reforms, and integration between universities, industries, and international forums, resulting in an emerging bioplastics cluster concentrated in regions such as Zhejiang.

Data also indicate that China’s biodegradable plastics market has expanded rapidly, reaching RMB 23.072 billion in 2023, up from RMB 4.056 billion in 2018, and exports of 136,900 tons in 2021 valued at nearly $600 million. Major companies such as Kingfa, Red Avenue Materials, and Hisun Biomaterials illustrate the country’s capacity for specialization in PLA, PBAT, and PBS production. Although demand still exceeds supply and

challenges persist in scaling up advanced materials, the combination of state policies, industrial capacity, and innovation support highlights China's competitive advantage.

When comparing the two contexts, Brazil demonstrates potential but remains largely at an emerging stage, while China shows an advanced capacity to integrate policy, production, and innovation. The study concludes that abundant raw materials alone do not guarantee the formation of an internationally competitive cluster. In Brazil, structural reforms and innovation-oriented policies are still necessary. In contrast, in China, the decisive role of the state has accelerated the transition from conventional plastics to bioplastics, positioning the country as a central actor in the future of the global bioplastics industry.

This study is limited by its reliance on secondary data, such as reports, government documents, and industry publications, which may not fully capture the latest developments in the rapidly evolving bioplastics sector. Moreover, the comparative approach focuses primarily on Brazil and China, leaving out other important actors in the global bioplastics industry, such as the European Union and the United States, which could provide further insights into different models of competitiveness and innovation. Another limitation concerns the difficulty of accessing reliable, comparable data on production volumes, trade flows, and market structures, as much of the available information is fragmented or comes from industry-driven sources that may be biased.

Future research should include primary data collection through interviews, surveys, or case studies with companies, policymakers, and research institutions involved in the bioplastics sector, in order to complement secondary data with first-hand insights. Comparative analyses could also be expanded to include other countries or regions, particularly the EU, which has developed a strong regulatory and institutional framework for bioplastics. Another promising avenue would be the examination of the environmental and social impacts of bioplastics in both Brazil and China, focusing on issues such as land use, food security, integration into the circular economy, and waste management practices. Finally, longitudinal studies could provide a clearer picture of how public policies, technological advancements, and market dynamics evolve, helping assess whether the observed trajectories will result in sustainable, internationally competitive biopolymer clusters.

References

ABICOM - Associação Brasileira de Biopolímeros Compostáveis e Compostagem [Brazilian Association of Compostation and Compostable Biopolymers]. (2024). Apresentação institucional [Institutional Presentation], https://abicom.org.br/ApresentacaoInstitucional06_24.pdf

ANBA - Agência de Notícias Brasil-Árabe [Brazil-Arabic News Agency]. (2023). Brasil aposta em futuro promissor para bioplástico [Brazil believes in a promising future for bioplastics]. https://anba.com.br/en/brasil-aposta-em-futuro-promissor-para-bioplastico/

Che, C. (2021). Is the "strictest plastic ban in history' working in China? https://thechinaproject.com/2021/04/06/is-the-strictest-plastic-ban-in-history-working-in-china/

Escobar, N., & Britz, W. (2021). Metrics on the sustainability of region-specific bioplastics production, considering global land use change effects. *Resources, Conservation & Recycling*, 167, 105345. https://doi.org/10.1016/j.resconrec.2020.105345

European Bioplastics. (2024). Bioplastics market data 2024. https://docs.european-bioplastics.org/publications/market_data/2024/EUBP_Market_Data_Report_2024.pdf

Globo Rural. (2024). Brasil pode liderar a produção de bioplásticos [Brazil could lead the production of bioplastics]. https://globorural.globo.com/google/amp/especiais/um-so-planeta/noticia/2024/11/brasil-pode-liderar-a-producao-de-bioplasticos.ghtml

Godoi, C. (2024). Bioplásticos nos BRICS: análise das iniciativas nacionais e propostas para uma colaboração internacional [Bioplastics in the BRICS: analysis of national initiatives and proposals for international collaboration]. *ENTRE-LUGAR*, 15(30), 180–202. https://doi.org/10.30612/rel.v15i30.18792

Godoi, C. N., Cascades, O. & Espíndola, C. J. (2024). O setor produtivo de bioplásticos no Brasil: cenários, possibilidades e desafios [The bioplastics production sector in Brazil: scenarios, possibilities and challenges]. In Seminário Nacional de Gestão Estratégica Social (SENGES) [National Seminar on Strategic Social Management (SENGES)]. Território das Ideias [Territory of Ideas].

Godoi, C. N., Espíndola, C. J., & Bazzanella, S. L. (2023). Sistema nacional de inovação: uma discussão conceitual da planificação estatal chinesa [National Innovation System: A Conceptual Discussion of Chinese State Planning]. *Desenvolvimento Regional em Perspectiva*, 4(1), 1–15. https://doi.org/10.70612/drpes.v4.729

Godoi, C. N., Montanha, O. C., & Espíndola, C. J. (2024). A adoção de biopolímeros na China: uma análise de aspectos produtivos e regulatórios [The adoption of biopolymers in China: an analysis of productive and regulatory aspects]. In Bioplastics Brazil. São Paulo.

Godoi, N. C., Wander, A. E., Ladvocat, M., & Dias, R. H. M. (2023). Renewable resources are the future: The role of sustainable raw materials and the potential of biopolymers in Brazil. *Finnish Business Review*, 9, 33-55. https://verkkolehdet.jamk.fi/finnish-business-review/wp-content/blogs.dir/16/files/2023/07/FBR2023-Article-2.pdf.

Mou, K. (2023). Application and research of biodegradable plastics in China and the United States. *Highlights in Business, Economics and Management,* 23, 339-344. https://drpress.org/ojs/index.php/HBEM/article/view/16787/16291

Nogueira, G.P., Petrielli, G.P., Chagas, M.F., et al. (2024). Sustainability synergies and trade-offs considering circularity and land availability for bioplastics production in Brazil. *Nature Communications*, 15, 8836. https://doi.org/10.1038/s41467-024-53201-9

Pertussatti, C. A. (2020). Gestão ambiental de resíduos plásticos no Brasil: subsídios para uma diretriz nacional [Environmental management of plastic waste in Brazil: subsidies for a national guideline].

Porter, M. E. (1998). Clusters and the New Economics of Competition. *Harvard Business Review*, 76(6), 77-90.

Porter, M. E. (1999a). *A vantagem competitiva das nações* [The competitive Advantage of nations] (6ª ed.). Rio de Janeiro: Campus.

Porter, M. E. (1999b). *Competição: estratégias competitivas essenciais* [Competition: essential competitive strategies] (2ª ed.). Rio de Janeiro: Campus.

Sharma, V. P., Singh, A., Srivastava, N., Srivastava, P., & Inamuddin. (2022). Bioplastics, biocomposites, and biobased polymers—applications and innovative approaches for sustainability. In Inamuddin & Altalhi, T. (Eds.), Bioplastics, Biocomposites and Biobased Polymers (pp. 619-628). Wiley. https://doi.org/10.1002/9781119160182.ch29

The China Project. (2022). The rise of China's biodegradable plastics industry, https://thechinaproject.com/2022/06/27/the-rise-of-chinas-biodegradable-plastics-industry/

Wu, Y., Mo, D. , Liu, J., Li, Z., Chen, X. & Xie, L. (2023). Public perception of microplastics on a popular Chinese social media platform. *Journal of Cleaner Production*, 414 (2023) 137688. https://doi.org/10.1016/j.jclepro.2023.137688