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UMA ANÁLISE UTILIZANDO O MÉTODO DE CONTROLE SINTÉTICO**

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ABSTRACT

Economic groups are important arenas for increasing the competitiveness of products and exports through international trade. This paper aims to examine the impact of BRICS on non-coniferous wood exports between 1990 and 2021, considering Brazil's entry into the group in 2006. Methodologically, a database was constructed including 46 countries, using total cubic meters (m³) of non-coniferous wood exported. The Synthetic Control Method was employed, allowing for the creation of a counterfactual (synthetic) unit to assess the performance of the treated unit in the pre- and post-treatment periods. For treated Brazil, a 17.74% reduction in non-coniferous wood exports was observed, while synthetic Brazil experienced a 230% increase. For treated China, an increase of 14% was recorded, and for its synthetic counterpart, an increase of 125%. For treated Russia, exports increased by 1.59%, whereas synthetic Russia showed an increase of 4.24%. Finally, for treated India, growth was 3.62%, while its synthetic counterpart grew by 5.98%. It is concluded that, despite the formalization of the geopolitical bloc, Brazil exhibited significantly lower non-coniferous wood export performance compared to its synthetic counterfactual, suggesting that BRICS membership did not offset the sector's structural and environmental bottlenecks.

Keywords: Economic group. BRICS. Non-Coniferous Wood Exports.

RESUMO

Os grupos econômicos são espaços importantes para aumentar a competitividade dos produtos e das exportações via comércio mundial. Este artigo objetiva verificar qual o impacto do BRICS nas exportações de madeira não conífera entre 1990 e 2021, considerando a entrada do Brasil ao grupo no ano de 2006. Metodologicamente, construiu-se uma base de dados contendo 46 países, utilizando os totais de m³ exportados de madeira não conífera. Foi empregado o método de Controle Sintético, permitindo a criação de uma unidade contrafactual (sintética) para verificar o desempenho da unidade tratada no período antes e pós-tratamento. Para o Brasil tratado, verificou-se redução de 17,74% nas exportações de madeira não coníferas; enquanto para o Brasil sintético houve um aumento de 230%. Para a China tratada, registrou-se um aumento de 14%, e para sua sintética, um aumento de 125%. Para a Rússia tratada, as exportações aumentaram 1,59%, e para Rússia sintética o aumento foi de 4,24%. Por fim, para a Índia tratada o crescimento foi de 3,62%, e para sua sintética o crescimento foi de 5,98%. Conclui-se que, apesar da formalização do bloco, o Brasil apresentou um desempenho exportador de madeira não conífera significativamente inferior ao seu contrafactual sintético, sugerindo que a inserção no BRICS não compensou gargalos estruturais e ambientais do setor.

Palavras-chave: Grupo Econômico. BRICS. Exportação de Madeira Não Conífera.

1. INTRODUCTION

The current international environment presents increasing competition among global economies that seek to engage in transregional integration initiatives in order to reduce threats to the global economic order. Thus, emerging markets and developing countries are called upon to play an increasingly important role in the pursuit of greater cooperation (Duggan et al., 2022).

In this context, BRICS emerges as a grouping of emerging countries (Brazil, Russia, India, China, and South Africa) with growth potential and diplomatic engagement in the global economy. In 2006, BRICS evolved from an informal political-diplomatic group into a formal bloc with a high geopolitical capacity for intervention in the international economic arena. This occurred through active policies aimed at mobilizing resources, expanding trade policies, establishing public contracts, and providing financial support (Santiago, 2020), (Pinto, 2013).

Considering the relationships among the countries belonging to BRICS, Brazilian exports to China increased from 14% in 2009 to 27% in 2018. Imports also increased, rising from 13% to 23% between 2009 and 2018. Considering exports to Russia, approximately US\$ 8 billion in trade was conducted in 2008. Proportionally, Brazilian exports to Russia exceeded imports since 2001, shifting in 2011 and reversing again in 2018 (Lourenço, 2019), (Almeida et al., 2018).



Through BRICS, Brazilian exports to India accounted for 12% in 2009, declining to 5.5% in 2018, which was the lowest level of representation. Regarding imports, although 2009 began at 11%, the years 2011 and 2014 recorded approximately 14% participation of Brazilian exports. Considering the share of Brazilian exports to South Africa through BRICS in 2009, they accounted for 4.4%, declining to 1.92% in 2018 (Lourenço, 2019), (Almeida et al., 2018).

According to data from the Brazilian Forest Service (SFB) (2026-b) of the Ministry of the Environment, considering ten timber segments for the period between 2020 and 2023, revenues totaling R\$ 523.5 billion were generated. The segments analyzed range from the processing of wood into sawn wood, treated wood, pulp and paper, plywood and laminated wood, among others. For comparison purposes, considering Brazil's 2023 GDP and the revenues generated during the period, the sector accounts for 4.8% of national GDP.

In 2021, BRICS accounted for approximately 41% of the world's population, 24% of global GDP, and more than 16% of world trade. One of the areas that will receive special attention in this article is the wood and forest products sector, which represents a source of income and employment generation in the member countries. In the context of international trade, with particular emphasis on forest trade, this sector has developed as an important component of the global economy, fundamental to several countries (BRICS, 2021).

According to the International Tropical Timber Organization (ITTO, 2023), between 1997 and 2021, 12.5 million cubic meters (m³) of roundwood and 291.4 million cubic meters (m³) of sawnwood were traded, generating US\$ 872.4 million in revenue from roundwood and US\$ 14.8 billion from sawnwood. The Food and Agriculture Organization of the United Nations (FAO, 2023) highlights that 15 countries accounted for 78.84% of total sawnwood imports in 2021. In this context, China accounted for 29.67% of imports; the other 14 countries accounted for 20.21%; and the remaining countries for 50.12%.

In Brazil, growth in exports is observed between 2011 and 2021. The Brazilian Forest Service (SFB, 2023-a) reports a 45% increase in export revenue, rising from US\$ 9.6 billion in 2011 to US\$ 14 billion in 2021. Pulp generated revenues of US\$ 4.98 billion in 2011, increasing to US\$ 6.73 billion in 2021, a 35% increase. Sawnwood represents the highest financial export volumes, increasing from



US\$ 408 million to US\$ 944 million from 2011 to 2021, a 231.37% increase considering the quantity exported (1,037,730 m³ in 2011 to 3,880,865 m³ in 2021). Roundwood also experienced growth of 576.08% during the period between 2011 and 2021, increasing from US\$ 11.5 million to US\$ 222.1 million.

Among the exported materials, plywood, roundwood, laminated wood, profiled wood, sawnwood, and others are considered the main forest products exported by Brazil, according to the results of the SFB (2026-a). As indicated by this source, a total of US\$ 320 million in timber products, excluding raw materials for paper, was traded with China, which stood out as a major trading partner of Brazil in 2021. India imported US\$ 53 million of these products from Brazil, while Russia traded US\$ 345 thousand in the same sector. It is observed that these countries, belonging to BRICS, play significant roles in the trade of forest products with Brazil.

In turn, BRICS increased its imports of non-coniferous wood by 35% between 2011 and 2021. FAO (2023) notes that non-coniferous wood is defined as all types of wood derived from trees classified as angiosperms located in tropical and temperate zones. Exports of this type of wood accounted for 27% of the volume traded during the highlighted period, with Chinese production representing 40% of exports and Brazilian production 19%. Russia reduced its imports by 48% and increased its exports by 65% during the period from 2011 to 2021, with domestic production increasing by approximately 13% annually, demonstrating that its focus is on the external market. India increased its imports by 59% and its exports by 348%, following the trend highlighted by Russia. South Africa, in contrast to the other countries, increased its imports by 125% and reduced its exports by 32%, aiming to supply the domestic market.

The forest-based sector is identified in the scientific literature as a relevant driver of regional development in Brazil, as it generates employment, income, and productive linkages in rural and peripheral regions, promoting multiplier effects on the local economy and contributing to the reduction of regional inequalities (Campoli et al., 2024; Silva et al., 2024; Silva e Rezende, 2021). Furthermore, studies indicate that current sustainable forest management practices, as well as the valorization of timber and non-timber forest products, support sustainable regional development strategies, reconciling economic growth, environmental conservation, and social inclusion, especially in areas such as the Legal Amazon (Morais et al., 2019; Andrade, Neto e Candido, 2021; Santos et al., 2022).



Para Bacha (2013), o sistema agroindustrial florestal brasileiro integra atividades a montante, produção florestal e transformação industrial, formando uma cadeia produtiva relevante para o crescimento econômico nacional. This sector contributes significantly to GDP, job creation, and trade balance surpluses, with emphasis on pulp, paper, wood, and furniture. The sector's export dynamism, even in contexts of currency appreciation, demonstrates its competitiveness and capacity to promote sustained economic development, especially through forest-based industrialization.

Abramovay (2012) emphasizes that labor-intensive activities, such as sustainable forest management and agroforestry systems, tend to distribute income more equitably than highly mechanized sectors. Regarding timber extraction, the Brazilian Forest Service (SFB, 2021) points out that legal forest exploitation and community-based forest management have strong potential to improve local income, reduce regional inequalities, and strengthen local economies, thereby contributing to environmental conservation and socioeconomic development.

Thus, within this framework, the research problem and the general objective of this article are presented. The research problem raises the following question: what is the impact of BRICS on non-coniferous wood exports between 1990 and 2022? It should be considered that the establishment of BRICS occurred in 2006. The general objective of the article is to analyze non-coniferous wood exports to BRICS during the period from 1990 to 2022.

Through the results, the study seeks to verify whether the inclusion of this product in Brazil's export basket to BRICS brought significant comparative and competitive advantages during the period analyzed. Methodologically, the article uses the Synthetic Control Method developed by Abadie and Gardeazabal (2003) and Abadie et al. (2010). This method seeks to assess, based on a shock (the creation of BRICS), the impact on non-coniferous wood exports to the member countries.

That said, the article is divided into five sections, including this introduction and problem statement (1). Subsequently, the description of the BRICS policy is presented (2); followed by the methodology (3); and the presentation of the data and analyses regarding the impact on exports and its explanatory mechanism (4). The final considerations conclude this study (5).



2. DESCRIPTION OF BRICS AND ITS POLICIES

The idea of forming BRICS originated from a study conducted in 2001 entitled “Building Better Global Economic BRICs,” carried out by Goldman Sachs and economist Jim O’Neill. The initial argument was based on an analysis of the economic-financial, business, academic, and media spheres. In 2006, with the evolution of this concept, the idea of a grouping was adopted and incorporated into the foreign policies of Brazil, Russia, India, and China. As a result of the Third Summit in 2011, South Africa joined the group of countries, and the final acronym became BRICS (Baumann, 2022; Baumann and Oliveira, 2014; Azevedo and Nascimento, 2016; BRICS, 2021).

During the period from 2001 to 2006, there was no significant coordination among the countries due to the absence of mechanisms that would enable greater cooperation. It was only at the 61st United Nations (UN) General Assembly that these countries adopted a different approach, resulting in their first joint action aimed at achieving a more prominent role on the international stage (Baumann, 2022; BRICS, 2021).

In 2009, the vertical institutionalization of BRICS took place, elevating it to a level of political interaction as seen at the Yekaterinburg Summit. The Second Summit, held in Brasília in 2010, reinforced this process, advancing further with the Third Summit held in Sanya in 2011. This reinforced the political direction of the exchanges among the countries, particularly BRICS’ position as a space for dialogue and engagement on the global stage. The focus was on important issues on the global agenda, including economic and financial matters and the pursuit of joint projects, particularly in key sectors of these countries’ economies, such as agriculture, energy, and science and technology. This trend was reinforced with the Fourth Summit in 2012 and the Fifth Summit in 2013 (Baumann, 2022; BRICS, 2021).

There was also horizontal institutionalization of BRICS in other areas, beginning with its origin, when the group sought to address issues related to the economic and financial sphere. In addition, issues such as food security, agriculture, and energy were addressed within the framework of the grouping. There were also advances in legal cooperation, along with progress in the academic and business spheres and in cooperative systems, including the signing of agreements among development banks (Baumann, 2022; BRICS, 2021).



According to the Ministry of Foreign Affairs (MRE, 2014), following the aforementioned summits, efforts were made in 2014 to strengthen economic activity and cooperation, which became evident in the actions developed at the Sixth Summit, particularly through the commitment to elevate intra-BRICS economic relations and cooperation to a new qualitative level. Furthermore, measures were formulated to promote economic, trade, and investment cooperation.

The 2008 financial crisis prompted significant reforms in emerging economies and developing countries. Discussions evolved toward the creation of the New Development Bank (NDB) and the stabilization fund known as the Contingent Reserve Arrangement (CRA) by the BRICS countries. The NDB was established to promote financial cooperation among the founding countries, as well as to serve as a collaborative instrument alongside other multilateral and regional institutions. A capital base of US\$ 100 billion was established to finance projects aimed at strengthening alliances among the group's countries and addressing infrastructure investment gaps (Acioly, 2019).

During the summit held in Ufa in 2015, according to Baumann (2022), concern was expressed over the slow and fragile global economic recovery. There was condemnation of policies imposing economic sanctions, with emphasis on adopting a comprehensive strategy for BRICS economic partnership. This strategy includes the expansion of trade and investment, as well as cooperation in areas such as energy, agriculture, industry, mineral processing, science, technology, innovation, financial cooperation, connectivity, and information and communication technologies. Furthermore, in the financial context, the potential for the use of national currencies in transactions among member countries was recognized, as well as the joint effort to improve competition policy (Baumann, 2022).

According to the Ministry of Foreign Affairs (MRE, 2017), at the summit held in Xiamen (2017), the BRICS countries emphasized economic cooperation, including trade facilitation, investment, connectivity, and policy sharing. Efforts were announced to develop Local Currency Bond Markets and to establish a BRICS Local Currency Bond Fund. In addition, the development banks adopted a local currency credit line and cooperated on credit rating initiatives. A joint task force for disaster risk management was established.

According to the Ministry of Foreign Affairs (MRE, 2018), the BRICS Ministers of Foreign Affairs discussed global issues in the political, security, economic-financial, and development spheres. They highlighted the results of intra-BRICS cooperation and the establishment of the BRICS Development Bank. In addition, initiatives such as the Strategy for BRICS Economic Partnership; the Action Agenda on Economic and Trade Cooperation; and the Agricultural Research Platform were mentioned. Economic cooperation, the fight against protectionism, and the defense of a rules-based, transparent, and non-discriminatory multilateral trading system were emphasized. They reaffirmed their commitment to free trade and opposition to unilateral measures that harm global trade and economic growth.

In addition, initiatives were highlighted for the creation of the BRICS Innovation Network (iBRICS), the adoption of the New Architecture in Science, Technology, and Innovation (STI), the establishment of the BRICS Local Currency Bond Fund, and cooperation in the fields of energy, health, and agriculture. There was also emphasis on the importance of cooperation among BRICS countries in international forums such as the World Trade Organization (WTO), the International Monetary Fund (IMF), and the United Nations (UN), as well as on the promotion of regional cooperation, including the creation of the BRICS Women's Business Alliance (WBA) and the strengthening of customs cooperation (MRE, 2018).

According to the Ministry of Foreign Affairs (MRE, 2021), the main economic actions of BRICS in 2020 included intergovernmental, economic, and financial cooperation. The countries reaffirmed their commitment to the recovery of global health and the global economy through multilateral cooperation and international efforts to address the current crisis and ensure economic growth. Fiscal, monetary, and financial stability targets were strengthened to support economic growth and ensure financial security. The countries committed to promoting macroeconomic policies to enhance economic resilience, strengthen social safety nets and health systems, increase public and private investment, and pursue integration into global supply chains for industrial and agricultural goods.

Currently, the movement to expand trade partners capable of adding a range of opportunities to this market is recognized. In August 2023, according to what was recorded in the Johannesburg Declaration (2023), invitations were extended to Saudi Arabia, Argentina, Egypt, Ethiopia, Iran, and the United Arab Emirates to join the group of emerging nations as of January 2024. At that meeting, it was announced that studies on the adoption of a BRICS reference currency for international trade would be conducted by the Central Banks and the Ministries of Finance and Economy of each country.

There is a strategic repositioning of BRICS within the international economic system, beyond the mere expansion of new countries into the bloc. The incorporation of new members as of 2024, many of which are major producers of energy, food, and strategic commodities, aims to strengthen the group's economic and geopolitical weight, expanding its capacity to influence global trade, financial, and energy flows. The move also signals an attempt to reduce dependence on traditional central economies (the United States and the European Union), diversifying partners and creating an economic space more aligned with the interests of the Global South (BRICS, 2023).

The debate surrounding the creation of a reference currency within BRICS is part of a broader strategy to reorganize the international monetary system, marked by the pursuit of greater financial autonomy and the reduction of the dollar's centrality in international trade. The literature indicates that, rather than the immediate creation of a common currency, the bloc's progress has occurred through strengthening the use of national currencies, alternative clearing mechanisms, and proprietary payment systems, reflecting a response to the asymmetries and vulnerabilities of the current global financial arrangement (Araripe, Peruffo, Cunha, 2025).

Despite the strategic potential of this agenda, studies highlight that macroeconomic heterogeneity, distinct monetary regimes, and institutional credibility challenges limit, in the short term, the feasibility of a fully integrated currency. Even so, the initiative has a strong geopolitical dimension, as it signals BRICS' intention to expand its influence in international economic governance and reduce exposure to external shocks and financial sanctions. This tends to generate reactions and tensions with the United States in the context of global financial hegemony (Coquidé, Lages, Shepelyansky, 2023).



3. METHODOLOGY

The Synthetic Control Method constitutes an appropriate empirical strategy for regional development analyses, as it allows for the construction of counterfactual scenarios that account for structural differences among territories. Its application makes it possible to assess the impacts of public policies and economic interventions on regional variables in an integrated manner, taking into account distinct trajectories of growth, income, and well-being. Thus, the method contributes to deepening causal analysis in regional studies, aligning with the contemporary approach to regional development based on robust empirical evidence (Abadie and Gardeazabal, 2003; Abadie, Diamond, and Hainmueller, 2014; Rodríguez-Pose, 2018).

Therefore, the choice of the Synthetic Control Method (SCM) is grounded in international trade and regional development theory, as it allows for isolating the specific effect of an institutional change—in this case, accession to BRICS—by creating a counterfactual that simulates the trajectory of Brazilian exports in the absence of this event, thereby ensuring the rigor necessary for the intended regional impact analysis.

Thus, in order to assess the impact resulting from the establishment of BRICS and non-coniferous wood exports, a panel dataset was constructed comprising 48 countries that maintain trade relations in products included in Brazil's forest export basket between 1995 and 2021. The criteria considered for this construction were economic similarity, similarity in the wood sector, and data availability.

Based on the identification of the criteria for defining the group of countries to be used in the research, Table 1 highlights the variables to be considered in estimating the impact of BRICS on non-coniferous wood exports.

Table 1 | Description of Variables and Data Sources Collected

Description of Variable	Data Source
Export Value (US\$ 1,000)	ITTO
Import Value (US\$ 1,000)	ITTO
Product Quantity (m ³)	ITTO
GDP (US\$)	THE WORLD BANK
Distance (km)	GOOGLE EARTH

Source: prepared by the authors (2023).



3.1 THE SYNTHETIC CONTROL MODEL

The Synthetic Control Method, developed by Abadie and Gardeazabal (2003), involves estimating the effects of an event, such as a political or economic intervention, on a specific geographic area designated as the “treated region”. To this end, groups of regions that serve as controls are selected based on similar characteristics during the pre-intervention period. Each of these regions contributes a weight to the formation of the “synthetic” region, which seeks to replicate the characteristics of the country that was not subjected to the treatment prior to the intervention.

The synthetic country is a statistical construct that represents what the outcomes in the treated region would have been in the absence of the intervention. It is formed by a weighted combination of other regions that were not directly affected by the event but share similar characteristics with the treated region prior to the intervention. Subsequently, these weights are used to construct a trajectory of the synthetic outcome, reflecting counterfactual data and estimating the result that would have occurred in the treated region in the absence of the intervention (Abadie and Gardeazabal, 2003).

According to Abadie and Gardeazabal (2003), considering $J + 1$ countries where only one country is treated, the remaining j countries serve as potential controls that did not undergo the policy intervention. Let Y_{it}^N denote the outcome that would be observed for country i in period t in the absence of the intervention, for regions $i = 1, \dots, J + 1$ over periods $t = 1, \dots, T$. T_0 is defined as the number of pre-intervention periods, where $1 \leq T_0 < T$. Let Y_{it}^I denote the outcome that would be observed for country i in period t when it is exposed to the policy intervention during periods $T_0 + 1$ e T .

The usual assumptions are that there are no intervention effects in the pre-treatment period, that is, for $t \in \{1, \dots, T_0\}$ and for $i \in \{1, \dots, J+1\}$, so that $Y_{it}^I = Y_{it}^N$, and that the intervention does not affect other units. The effect of the intervention on the variable in region i in period t , which is to be estimated, is written as:

$$\alpha_{it} = Y_{it}^I - Y_{it}^N(1)$$

...



In this sense, let D_{it} be a dummy variable that takes the value 1 if region i was exposed to the intervention in period t , and 0 otherwise. The observed outcome for country i in period t , defined as Y_{it} , can be rewritten as:

$$Y_{it} = Y_{it}^N + \alpha_{it} D_{it} \quad (2)$$

Suppose that Y_{it}^N is given by the following factor model:

$$Y_{it}^N = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \varepsilon_{it} \quad (3)$$

Where:

δ_t = common time shock for all regions (time fixed effect);

θ_t = a $(1 \times r)$ vector of unknown parameters;

Z_i = an $(r \times 1)$ vector of observable characteristics for region i (not affected by the intervention);

λ_t = a $(1 \times F)$ vector of common factors;

μ_i = an $(F \times 1)$ vector of unobservable variables for region i ;

ε_{it} = transitory random shocks, unobserved at the regional level, with zero mean.

The next objective is to determine the weight vector $(J \times 1)$, which allows the combination of the J donor units in the synthetic control group. Thus, a *weight vector* $W = (w_2, \dots, w_{j+1})'$ is defined such that $0 \leq w_j \leq 1, j = 2, \dots, J + 1$, and $\sum_{j=2}^{J+1} w_j = 1$. Given that each W represents a possible synthetic control group, and based on the observed data for Y and Z from the donor units and on the data-generating process of the outcome variable proposed in (2), the following expression is obtained:

$$\sum_{j=2}^{J+1} w_j Y_{it} = \delta_t + \theta_t \sum_{j=2}^{J+1} w_j Z_i + \lambda_t \sum_{j=2}^{J+1} w_j \mu_i + \sum_{j=2}^{J+1} w_j \varepsilon_{it}$$

Suppose there exists a weight vector $W^* = (w_{2}^*, \dots, w_{j+1}^*)'$ that forms a weighted combination of the countries not subjected to the intervention and corresponds to the synthetic control of region i under intervention, such that the following conditions hold: $\sum_{j=2}^{J+1} w_j^* Y_{j1} = Y_{i1}, \dots, \sum_{j=2}^{J+1} w_j^* Y_{jT0} = Y_{iT0}$ and $\sum_{j=2}^{J+1} w_j^* Z_j = Z_i$. Then, Abadie et al. (2010) demonstrate that the following equation holds:

$$\sum_{j=2}^{J+1} w_j^* Y_{j1} = Y_{11}, \quad \sum_{j=2}^{J+1} w_j^* Y_{j2} = Y_{12}, \quad \sum_{j=2}^{J+1} w_j^* Y_{jT_0} = Y_{1T_0}, \quad \sum_{j=2}^{J+1} w_j^* Z_j = Z_1$$

Therefore:

$$Y_{1t}^N - \sum_{j=2}^{J+1} w_j^* Y_{jt} = \sum_{j=2}^{J+1} w_j \sum_{s=1}^{T_0} \lambda_t \left(\sum_{n=1}^{T_0} \lambda'_n \lambda_n \right)^{-1} \lambda'_s (\varepsilon_{js} - \varepsilon_{1s}) - \sum_{j=2}^{J+1} w_j^* (\varepsilon_{js} \varepsilon_{1t})$$

In which the right-hand side will take values close to zero (0) if the number of pre-intervention periods is much greater than the magnitude of the transitory shocks. This means that $Y_{1t}^N = \sum_{j=2}^{J+1} w_j^* Y_{jt}$, which implies the following estimator for the vector α :

$$\hat{\alpha}_{1t} = Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt}$$

Thus, the vector W^* provides the possibility of creating a weighted average based on the observed outcome variable in the donor units in order to estimate the approximate counterfactual value of the treated unit for period t , for the analysis of the effects caused by the policies. In this context, by applying the weighted average, an unbiased estimate of the impact observed in period t is obtained: $\hat{\alpha}_{1t} = Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt}$. It should be noted that a situation may arise in which it is not possible to find a weight vector capable of making this difference practically zero, because absolute counterfactuals may not exist.

Thus, in order to obtain the optimal weight vector W^* let $X_1 = (Z_1', Y_{11}, \dots, Y_{1T_0})'$, which contains the pre-intervention characteristics for the treated state. Accordingly, X_0 will be the matrix containing the same variables for the untreated states, such that the j -th column of X_0 is $(Z_j', Y_{ij}, \dots, Y_{jT_0})'$. Then, W^* is chosen to minimize the distance between X_1 and $X_0 W$, $\|X_1 - X_0 W\|_V = \sqrt{(X_1 - X_0 W)' V (X_1 - X_0 W)}$, subject to $w_j \geq 0$ for $j = 2, \dots, J+1$ and $w_2 + \dots + w_{J+1} = 1$, where V is a symmetric and positive matrix selected to ensure that the evolution of the variable of interest in the synthetic control approximates, as closely as possible, the evolution of that same variable for the affected state in the pre-intervention periods.

The choice of the matrix V influences the mean squared error of the estimator. Therefore, a procedure is adopted that prioritizes the selection of V among positive diagonal matrices in order to minimize the error of the variable of interest in the pre-intervention period. Moreover, the Synthetic Control Model allows the relaxation of the assumption that factors are time-invariant (fixed effects) or share a common trend, since the effects of unobserved factors are flexible and may vary over time (Abadie; Diamond; Hainmueller, 2010).

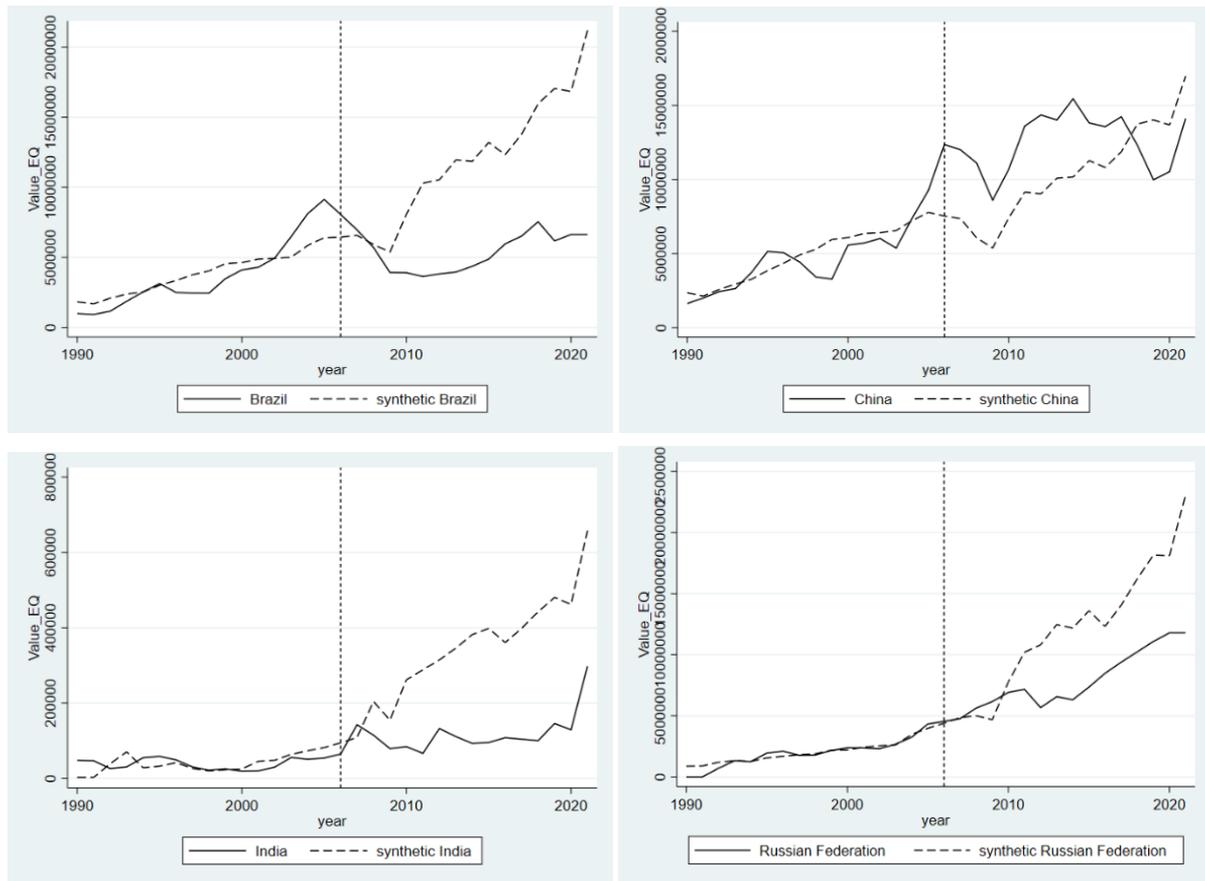
The placebo test will be used under the assumption that each country in the pool of potential controls received the same treatment applied to the BRICS countries, estimating a placebo for each country. If the results show differences of similar magnitude to those of the unit analyzed, it is concluded that there is no significant evidence. Therefore, if the estimated difference for the treated country is significantly greater compared to the differences obtained in the placebo experiments, then the analysis suggests that the treatment affected the outcome of interest (Abadie; Diamond; Hainmueller, 2010).

4. RESULTS AND DISCUSSION

International trade plays a fundamental role in the global economic landscape and in the formation of blocs and economic groups. In addition to the member countries, the database was composed of 46 other countries, referred to as counterfactual countries. With respect to exports, and through the estimations conducted using the Synthetic Control Method, the aim was to verify possible divergences between the trajectories of the treated country and its synthetic counterpart in the post-policy period, thereby characterizing the impact of BRICS on Brazilian non-coniferous wood exports. In the pre-policy period, no impacts on exports are expected, that is, indicating the absence of unobserved fixed effects during the period of analysis.



Figure 1 | The Impact of BRICS on Non-Coniferous Wood Exports of Member Countries from 1990 to 2021



Source: prepared by the authors (2023).

In general, after the establishment of BRICS, a reduction in non-coniferous wood exports was observed in the member countries, except for the Russian Federation (Figure 1). However, over the years, an upward trend became noticeable, although no country achieved a full recovery relative to its synthetic outcome. For China, positive results were recorded after 2006 compared to its synthetic counterpart; however, a reduction was observed, influenced by the effects of COVID-19.

For India, performance was lower than that of its synthetic counterpart, showing a difference as significant as that observed for Brazil. Regarding Brazil, in the post-treatment period, non-coniferous wood exports decreased by 17.74%, while for synthetic Brazil they increased by 230% over the same period. For South Africa, the data were not considered due to the results obtained, which were not significant; therefore, only China, Russia, India, and Brazil were analyzed, in accordance with Jiang and Dai (2023).

Considering only Brazil's participation in the international market, it depends on various factors ranging from product competitiveness to compliance with effective demand requirements related to environmental issues, as well as the decline in the availability of roundwood of Amazonian origin. It is noteworthy that, although legal deforestation mechanisms are mandatory, such as forest management regulated by public policies and the issuance of licenses for the conversion of forest areas, the volume of illegal timber remains high, hindering greater participation of Brazilian exports (Imazon, 2023; Martins and Nonnenberg, 2020).

However, conventional unassisted extraction continues to occur due to enforcement failures, insufficient information related to forest resources, and impunity regarding environmental violations, in addition to the increased demand for cheap timber. With a downward trend since 2004, a different pattern was observed after 2018, with a 9.5% increase in deforested area between 2019 and 2020 (Imazon, 2023; Martins and Nonnenberg, 2020).

Tian et al. (2017) emphasize that incentives for the regularization of timber trade and the containment of deforestation in several countries have affected the global market for forest products. An annual increase of 7.66% in wood production was observed between 1981 and 1990; 3.62% between 1991 and 2000; and 4.3% between 2001 and 2010, indicating periods of fluctuation in production. In a study involving 176 nations, it was found that the more developed countries meet their needs through the exploitation of resources from countries with lower per capita GDP, while simultaneously playing an active role in promoting the preservation of their own forests.

The study by Tian et al. (2017) finds that wood production is directly linked to global consumption and forest conservation. The incentive for preservation began in 1972, with the United Nations Conference in Stockholm, when guidelines were formulated based on the Stockholm Declaration, composed of 26 principles. Similarly, the Rio 1992 Conference, the Kyoto Protocol, and COP 21 took place, which later gave rise to the Paris Agreement.

For China, observing its production before joining BRICS, an increase of 27.63% is noted between 1990 and 2005, followed by a 105.97% increase up to 2021. It was observed that domestic consumption has increased to meet the needs of other sectors, such as construction, which grew by 604% relative to GDP in the post-policy period, according to the National Bureau of Statistics of China (2023).



In the post-policy period (2006–2021), treated China showed a 14% increase in exports following the establishment of BRICS, while synthetic China experienced a 125% increase in the same post-policy period. Prior to that, in the period between 1990 and 2005, the increase was 465.64%. After 2006, the growth of Chinese exports gradually declined, showing fluctuations until 2014, reaching 51.87% above the counterfactual, according to Li, Mei, and Juvenal (2023). From 2015 onward, growth became more stable, remaining positive, but at lower rates. In the post-treatment period, China followed the approach described by Tian et al. (2017), importing wood from other countries and exporting it with added value, while simultaneously making intensive investments in forest plantations to meet its own demand and future exports.

The Russian Federation has reduced non-coniferous wood production by 25.56% since the 1990s. In this period, after the establishment of BRICS, Russia's non-coniferous wood exports increased by 1.59%, while synthetic Russia experienced a 4.24% increase. However, it can be seen that exports continued on an upward trajectory, reaching an increase of 159.46% after the policy's implementation, according to FAO data (2023). Between 2006 and 2021, the Russian Federation's exports remained below the synthetic Russia scenario, ranging from -3.22% in 2006 to -49.00% in 2021. This situation indicates that the treated country exported significantly less non-coniferous wood than expected in its counterfactual scenario. These values suggest that, despite positive growth after 2006, the outcome was below what was expected in the hypothetical scenario.

The Russian Federation has nearly half of its territory covered by forests. In 2025, the forest area (including planted forests) of the Russian Federation totaled 8,326,299 km², representing an increase of 0.101% compared to 2024, when it was 8,317,904 km². Forest growth in the country has been occurring for 33 consecutive years. According to FAOSTAT data, since 1992 the forest area has increased by 1.03 times. The smallest recorded forest area was in 1992, with 8,118,021 km². The maximum forest area in the Russian Federation was reached in 2025, with 8,326,299 km². Lands predominantly used for agriculture or urban purposes are excluded (STATBASE, 2025).

Considering treated India, from 2006 onward, its exports grew by 3.62%, while synthetic India experienced growth of 5.98%. This indicates that, after 2006, treated India experienced slower growth in its non-coniferous wood exports compared to synthetic India. However, from 2014 onward, India



began to show a downward trend in its exports, with negative differences compared to its synthetic counterpart. This trend continued until 2021, with a difference of -54.71% in its exports, according to Kant and Nautiyal (2023).

Wood consumption in India is expected to increase until 2030, widening the gap between production, demand, and dependence on imports, according to ITTO (2021). By 2030, the Indian wood market is expected to demand approximately 14.6 million m³ for the construction sector. Although forest cover has increased, domestic production does not meet demand, resulting in higher imports, which reached 1.4 million m³ between 2006 and 2021. As India is dependent on imports and is expanding its forests through planting, this explains the reduction in its exports to BRICS during the period analyzed. Regarding the countries serving as counterfactuals for the BRICS members, the Synthetic Control Method itself, when performing the estimation, selects the countries to form the counterfactual group — that is, countries that, in the analysis, resemble the treated country prior to its entry into the economic group. Many of them were assigned a weight of zero and thus discarded, with Table 2 showing only those countries, among the 46, that have weights greater than zero.

Table 2 | Weights of Countries in the Synthetic Control for Brazil, China, India, and the Russian Federation

	Counterfactual Countries	Weight
Treated Country Brazil	Canada	29.30%
	United States	4.69%
	Vietnam	66.10%
	Counterfactual Countries	Weight
Treated Country China	Canada	39.10%
	Japan	7.90%
	United States	5.49%
	Vietnam	47.60%
	Counterfactual Countries	Weight
Treated Country India	Argentina	3.70%
	Egypt	53.69%
	United Arab Emirates	40.70%
	Vietnam	2%
	Counterfactual Countries	Weight
Treated Country Russia	Canada	8.60%
	France	8.89%
	United States	2.40%
	Vietnam	80.30%

Source: prepared by the authors (2023).



Table 2 aims to describe the main factors of some of these countries in relation to the treated countries, using as a criterion their role as exporters of non-coniferous wood, specifically Vietnam, Canada, and the United States.

Vietnam increased its wood production by 93.8% between 1990 and 2021, and by 77.18% in the period from 2006 to 2021, according to FAO (2023). The country has become a leader in forest planting, aligning with the global shift in domestic wood supply over the past decades. It consolidated its position as the largest exporter in the sector, reaching US\$ 16.69 billion in 2016 and 2017 (Cuong, 2020). Between 2001 and 2016, the exported volume grew by 17.68%. During the same period, imports also increased significantly, with a focus on re-exporting. The value of imports increased 13.2-fold, with an average annual growth rate of 15.8% (Vu, 2020).

Canada accounts for 40.13% of the world's certified forest areas, totaling approximately 54.5 million hectares. Between 1990 and 2005, the country exported 16.2 million m³ of non-coniferous wood. Between 2006 and 2021, this volume decreased to 8.87 million m³. This decline represents a 45.25% reduction over the analyzed period. Regarding coniferous wood, the country maintained a prominent global position. A total of 574.9 million m³ was traded between 1990 and 2005. In the period from 2006 to 2021, the volume was 531.3 million m³, a reduction of 7.58% (FAO, 2023).

In 2021, Canadian wood exports generated US\$ 13.3 billion, making the country the world's largest exporter of sawnwood (ITTO, 2023; OEC, 2023). Wood ranked as the 5th most exported product in the Canadian economy. Between 2019 and 2021, the main destinations were the United States, Japan, India, and China. The Philippines, Taiwan, Vietnam, and Portugal also stand out as significant importers. In the global ranking, Canada held the 16th position as an importer of sawnwood. Its main trading partners were the United States, Guyana, Germany, Brazil, and China. The country has approximately 350 million hectares of forests available for exploitation.

The United States exported 42.5 million m³ of non-coniferous wood between 1990 and 2005. In the following period, between 2006 and 2021, the exported volume reached 53.3 million m³. This growth represents an increase of 25.41%. At the same time, the country has led international initiatives aimed at reducing illegal timber harvesting. It has also sought to combat



forest degradation and deforestation, with notable initiatives such as the European Union's Forest Law Enforcement, Governance and Trade Action Plan (FLEGT). In addition, the Lacey Act has been used as a central regulatory instrument (FAO, 2023).

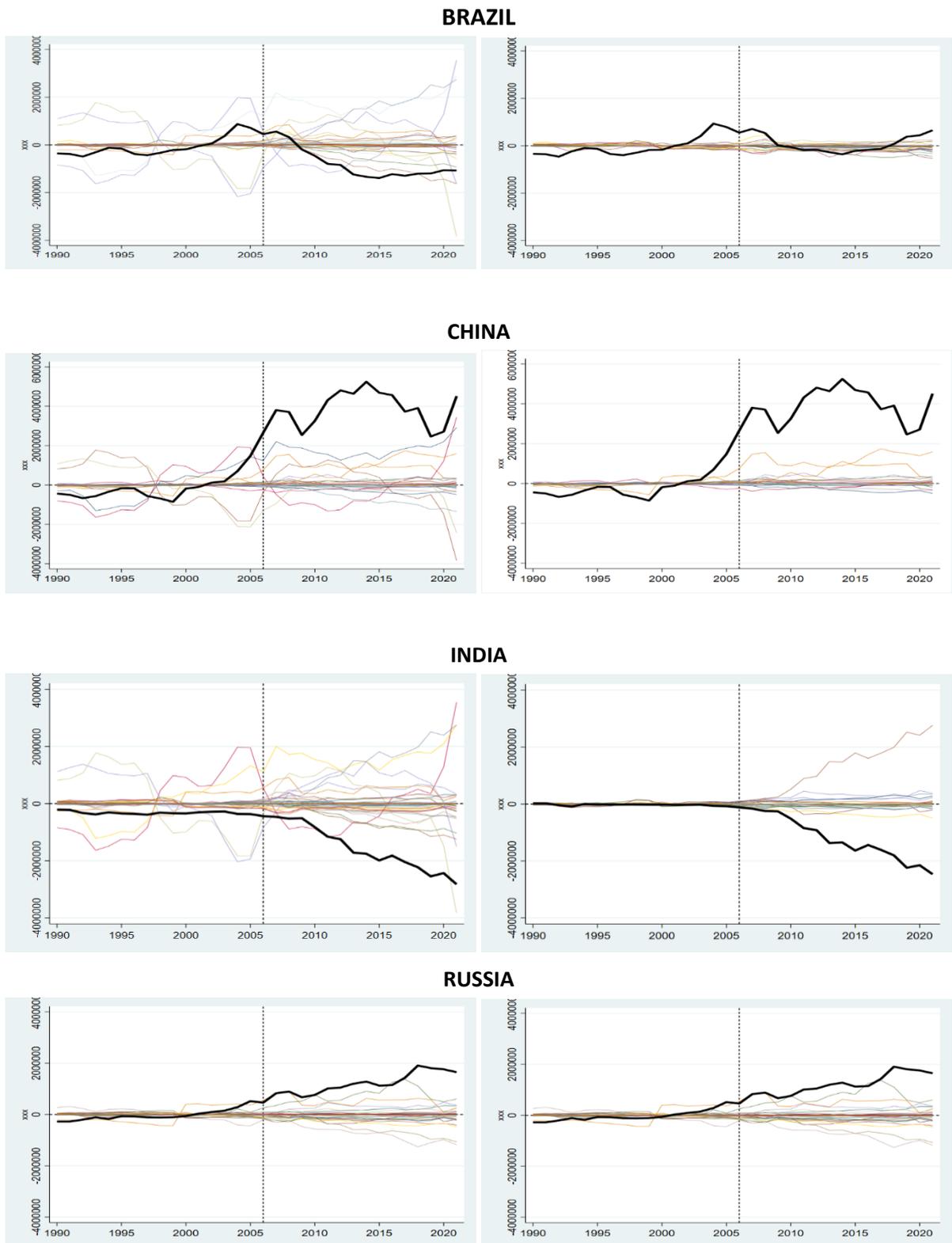
FLEGT aims to impose barriers on imports of timber with undeclared origin. The policy seeks to favor producers and exporters who operate legally. Despite institutional advances, difficulties persist in identifying the legal origin of timber. The distinction between legal and illegal products remains limited. Another challenge relates to the effective compliance of producing countries with legal requirements. In many cases, compliance with the regulations is insufficient or nonexistent. This is compounded by the weakness of national legal frameworks. As a result, monitoring systems show low effectiveness in detecting fraud (FAO, 2023).

The Lacey Act has been in effect in the United States since the 1990s. Initially, its regulatory focus was limited to the trade of wildlife. In 2008, the legislation was amended and expanded with the support of the Legal Timber Protection Act (LTPA). Following this change, wood and paper products were included, and the law explicitly prohibited the importation of illegally harvested timber. It also prohibits the entry of processed products derived from illegally harvested logs. This milestone strengthened the regulation of international trade in forest products (USDA, 2023).

After estimates and analyses, a placebo test was conducted based on the assumption that the treatment previously applied to the group countries by the creation of BRICS was also replicated for the other countries, previously considered as counterfactuals for each treated country. The effect of this test is presented in Figure 2.



Figure 2 | Placebo Test and the Application of RMSPE for Brazil, China, India, the Russian Federation, and South Africa from 1990 to 2020



Source: prepared by the authors (2023).



The test presented in Figure 2 considers the hypothetical scenario in which all countries previously considered as counterfactuals join BRICS. It is observed that many of the countries show divergent results in non-coniferous wood exports after their hypothetical inclusion in the economic group. To eliminate such outliers, it was necessary to use the Root Mean Square Percentage Error (RMSPE) for the BRICS member countries in order to exclude the countries that poorly replicated the effects on wood exports. By excluding these countries, it is noted that, for the treated countries (Brazil, India, the Russian Federation, China, and South Africa), the results — considering the impact on non-coniferous wood exports — remain unchanged.

For Brazil, the RMSPE was applied by removing eight countries from the analysis to mitigate the wide variation in results, which exceeded the dispersion levels compared to Brazilian values. Similarly, the same procedure was applied to China, excluding five countries from the sample. In the case of India, eight countries were removed; for the Russian Federation, the database was adjusted by eliminating five countries.

5. CONCLUDING REMARKS

With respect to the research objective and problem, it is noteworthy that both were achieved. In the face of increasing globalization and interconnected economies, the grouping of countries constitutes an important process in commercial development among nations, boosting their economies. BRICS, through various outcomes, has stood out as a group that has become attractive to many developing economies.

Throughout the article, it was observed that, for the non-coniferous wood export market, there is no positive influence from membership in BRICS, according to the estimations performed using the Synthetic Control Method. Highlighting the results, it is noted that China was the BRICS country with the best performance in non-coniferous wood exports during the analyzed period compared to the others. For most of the post-policy period, China performed above expectations, unlike the other countries, where, even though exports grew, they remained below their synthetic counterparts.



In this context, Brazil and India achieved results below their synthetic counterparts, showing an increase only near the end of the expected period. This result can be explained by the global movement toward environmental protection that has developed over the past decades, which has slowed the non-coniferous wood export market. However, India has demand in the construction sector that can influence the outcomes of its imports. The Russian Federation has a larger market for coniferous wood; however, its non-coniferous wood market grew, albeit below its synthetic outcome.

Based on the results, Vietnam was the most frequent counterfactual country, showing significant outcomes in production and exports due to its substantial investment in tropical timber forestry. Next, Canada and the United States stand out as globally important countries in wood production.

Furthermore, the results highlight the importance of advanced statistical techniques, such as the placebo test and the use of RMSPE, in assessing the actual impact of trade policies. By excluding countries that did not adequately replicate BRICS membership, the consistency of the conclusions regarding the impact on exports to member countries was confirmed. These findings have valuable implications for policymakers and trade strategists, providing a solid foundation for promoting trade partnerships and developing export strategies in a constantly evolving global environment.

From the perspective of Regional Management and Development, this study contributes by showing that integration into global economic blocs does not, on its own, guarantee the strengthening of local resource-based productive sectors. In the case of Brazil, performance below the synthetic counterfactual indicates that structural bottlenecks and regional environmental pressures can offset the theoretical advantages of new trade agreements. Therefore, the management of the forestry sector should be accompanied by territorial competitiveness strategies that take into account the specific characteristics of producing regions in the face of changes in global economic governance.

As a suggestion for future studies, it is important to advance research using other methodologies, whether quantitative or qualitative, expanding the scope to include not only BRICS countries but also other economic blocs. These studies could encompass not only non-coniferous wood exports but also other products relevant to the context of international trade.



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