Brazilian Reprimarization as a Process of Emissions Specialization in the 2010s[1]

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Abstract:
This paper analyzes the evolution of greenhouse gas emissions associated with Brazilian exports between 2010 and 2021 through a structural decomposition analysis based on an input–output model. The results indicate that the reprimarization of Brazilian foreign trade reinforced a process of emissions specialization, driven mainly by the expansion of exports to China and the growing concentration in agriculture, livestock, and resource-intensive industrial sectors. Sectorally, agriculture and livestock account for the largest increase in emissions, while industrial sectors contribute less overall, although they remain relevant in hard-to-abate activities. The decomposition results show that, between 2010 and 2014, compositional changes in the export basket played the dominant role in increasing emissions, whereas between 2015 and 2021 the expansion of export volumes and rising emissions intensity became the main drivers. By combining trade structure and environmental dimensions, the paper contributes to the debate on reprimarization, structural change, and the environmental implications of Brazil's insertion into the global economy.

Keywords:
Reprimarization; Exports; Greenhouse gas emissions; Input–output model

JEL Codes: F14; Q56; C67

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Introduction

Since the beginning of the 2010s, the Brazilian economy has experienced important structural transformations in its productive and commercial structure. In response to weak domestic demand, recurrent macroeconomic instability, and low economic growth, exports increasingly became one of the main mechanisms through which economic activity was sustained. This movement intensified the relevance of the external sector in the Brazilian growth strategy and reinforced the role of commodities in the country's international insertion.

At the same time, the growing participation of primary and resource-intensive sectors in Brazilian exports revived the debate surrounding the reprimarization of the export basket. The concept of reprimarization refers to a process in which the composition of exports shifts toward products with lower technological sophistication and greater dependence on natural resources, such as agricultural commodities, minerals, livestock products, and other primary goods. In the Brazilian case, this movement became particularly visible after the global commodity boom associated with the rapid industrialization and urbanization of China.

The expansion of trade relations with China significantly altered both the geographical and sectoral composition of Brazilian exports. While China became the country's main trading partner, Brazilian exports to the Chinese market became heavily concentrated in soybeans, iron ore, meat products, crude oil, and other commodity-intensive sectors. Simultaneously, the participation of technologically sophisticated manufacturing sectors declined in relative terms. As a result, the Brazilian productive structure became increasingly specialized in activities characterized by lower technological intensity and greater environmental pressure.

This transformation has important environmental implications. Several studies have shown that the export sector is among the components of final demand with the highest greenhouse gas emissions intensity in Brazil. The reason for this lies in the strong concentration of exports in sectors associated with land-use change, livestock production, agriculture, mining, and carbon-intensive industrial activities. Consequently, changes in the composition and destination of exports may substantially affect the trajectory of Brazilian greenhouse gas emissions.

This paper analyzes the evolution of greenhouse gas emissions associated with Brazilian exports between 2010 and 2021 using a structural decomposition analysis based on an input–output framework. The main objective is to understand how changes in export composition, destination markets, emissions intensity, production technology, and export scale contributed to the growth of emissions associated with the Brazilian external sector.

The paper argues that the reprimarization of Brazilian exports should also be understood as a process of emissions specialization. In other words, the growing concentration of exports in sectors intensive in natural resources simultaneously implies a greater concentration of emissions in the export structure. Therefore, reprimarization is not merely a commercial or productive phenomenon, but also an environmental transformation that reinforces the carbon-intensive character of Brazil's insertion into the global economy.

The study contributes to the literature in several ways. First, it combines the debates on structural change, reprimarization, and environmental sustainability within a unified

analytical framework. Second, it employs a detailed input–output model with 67 sectors, allowing for a more disaggregated analysis of agriculture, livestock, and industrial activities. Third, it incorporates a decomposition methodology capable of isolating the effects of export composition, trade destinations, emissions intensity, and export scale on the evolution of greenhouse gas emissions.

The results indicate that the growth of emissions associated with Brazilian exports between 2010 and 2021 was driven not only by the expansion of export volumes, but also by structural changes in the export basket. In particular, the increasing relevance of agriculture and livestock, combined with the strengthening of trade relations with China, contributed significantly to the increase in emissions. The findings therefore reinforce the existence of a structural process of emissions specialization in Brazil during the 2010s.

Reprimarization and Structural Change in Brazil

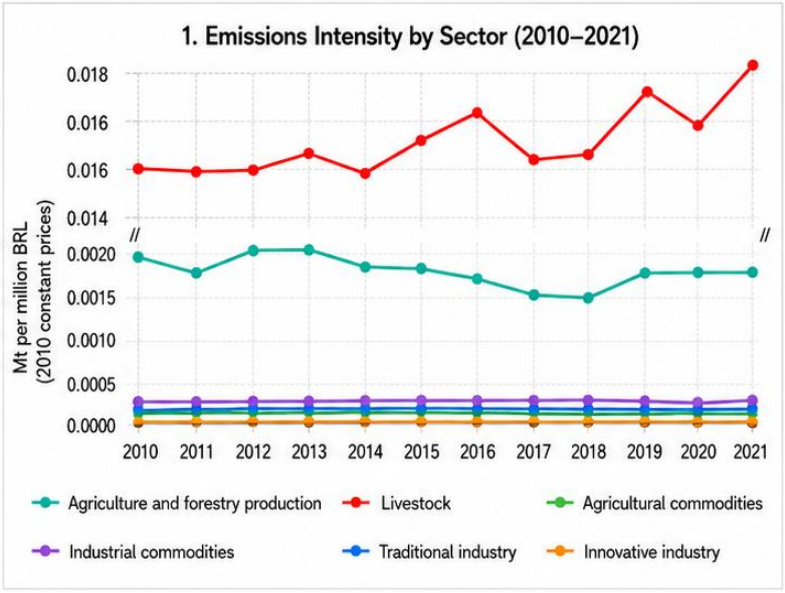
The debate regarding reprimarization in Brazil emerged strongly during the 2000s, particularly after the commodity boom that accompanied the rapid expansion of the Chinese economy (Bresser-Pereira & Marconi, 2010; Nassif & Castilho, 2020). Several authors argued that the Brazilian economy was undergoing a process of "regressive specialization," characterized by the growing importance of primary sectors and the relative decline of manufacturing activities with higher technological content.

This process was associated with both domestic and international factors. Domestically, trade liberalization, financial openness, exchange-rate appreciation, and high interest rates reduced the competitiveness of manufacturing sectors and stimulated imports of industrial goods (Coutinho, 1997). Internationally, the strong increase in global demand for commodities, especially from China, encouraged specialization in sectors in which Brazil already possessed comparative advantages (Hiratuka & Sarti, 2017).

As a consequence, the composition of Brazilian exports progressively shifted toward agricultural commodities, livestock products, mineral extraction, and other resource-based sectors. In contrast, the participation of manufacturing sectors with medium-high and high technological intensity declined substantially (Neves, 2013; Nassif & Castilho, 2020).

This transformation also altered the geographical structure of Brazilian trade. China's participation in Brazilian exports increased rapidly during the 2010s, while the relative importance of traditional industrial markets such as the European Union and the United States declined. Since Brazilian exports to China are particularly concentrated in commodities, the growing centrality of China reinforced the reprimarization process.

The environmental implications of this movement are considerable. Agriculture, livestock, mining, and land-use-intensive activities generally exhibit higher greenhouse gas emissions intensity than technologically sophisticated manufacturing sectors, as we see in Figure 1. In Brazil, livestock production is especially carbon-intensive due to methane emissions and deforestation associated with land-use change. Similarly, agricultural expansion and extractive activities are closely connected to environmental degradation and emissions growth (Young, 1996; Gramkow, 2011).



Source: Authors' elaboration based on data from Alves-Passoni and Freitas (2022), Costa and Alvarenga (2025), MapBiomas (2025), and SECEX (2024).

Thus, changes in the composition of exports toward more commodity-intensive sectors tend to increase the average emissions intensity of the export basket. Even relatively small increases in the participation of these sectors may substantially affect total emissions associated with exports.

The relationship between trade specialization and emissions is particularly relevant in developing countries characterized by strong dependence on natural-resource-based exports. In such economies, external demand may reinforce environmentally unsustainable specialization patterns and increase the vulnerability of growth trajectories to fluctuations in commodity markets.

The Brazilian case illustrates this dynamic clearly. Although exports grew throughout the decade, economic growth remained relatively weak, suggesting that commodity specialization generated limited productive spillovers and low dynamism for the domestic economy. Simultaneously, the expansion of exports contributed to higher greenhouse gas emissions and reinforced environmentally intensive growth patterns.

Therefore, understanding the interaction between reprimarization and emissions dynamics is essential for evaluating the sustainability of Brazil's development trajectory.

Methodology

The analysis is based on an environmentally extended input–output model combined with structural decomposition analysis (SDA). Input–output analysis provides a suitable framework for evaluating the direct and indirect environmental impacts associated with economic activity and final demand.

The model estimates the greenhouse gas emissions embodied in Brazilian exports between 2010 and 2021. Emissions are calculated by combining sectoral emissions coefficients, the Leontief inverse matrix, and export vectors.

The environmentally extended input–output model can be expressed as:

$$\boldsymbol{E = \hat{h}(I - A)^{-1}f}$$

where **E** represents total emissions associated with exports, **h** is the vector of sectoral emissions coefficients, A is the matrix of domestic technical coefficients, $\boldsymbol{(I - A)^{-1}}$ is the Leontief inverse matrix, and f represents exports.

The emissions coefficients capture the amount of greenhouse gas emissions generated per unit of gross output in each sector. These coefficients incorporate emissions associated with industrial processes, energy use, agriculture, livestock, and land-use change.

The study uses a 67-sector input–output database for Brazil estimated at constant relative prices. The use of constant relative prices is particularly important because commodity prices experienced substantial fluctuations during the period analyzed. Without proper price adjustments, changes in relative prices could artificially inflate the participation of commodity sectors in exports and emissions.

To facilitate interpretation, sectors are grouped into six categories:

1. Agriculture and forestry production
2. Livestock
3. Agricultural commodities
4. Industrial commodities
5. Traditional industry
6. Innovative industry

This classification allows the analysis to distinguish between sectors with different technological characteristics and emissions intensities.

The geographical decomposition focuses on Brazil's main trading partners during the period:

- China
- United States
- European Union
- Argentina
- Rest of the World

Structural decomposition analysis is employed to identify the factors responsible for changes in emissions over time. The decomposition separates emissions growth into five main effects:

1. Emissions intensity effect: changes in emissions per unit of output
2. Technological effect: changes in domestic input requirements and production linkages
3. Export level effect: contribution of changes in the total volume of exports
4. Product composition effect: changes in the sectoral composition of exports affected emissions

5. Destination composition effect: changes in the geographical distribution of exports influenced emissions.

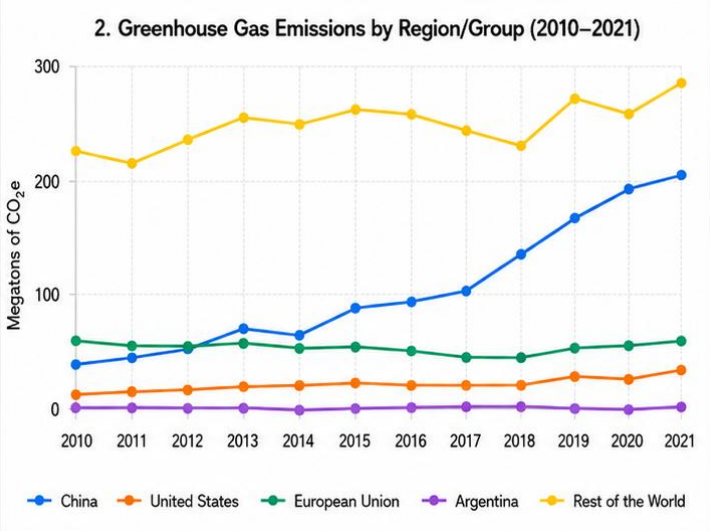
The decomposition is performed for three periods:

- 2010–2014
- 2015–2021
- 2010–2021

This division allows the identification of distinct phases in the evolution of Brazilian exports and emissions.

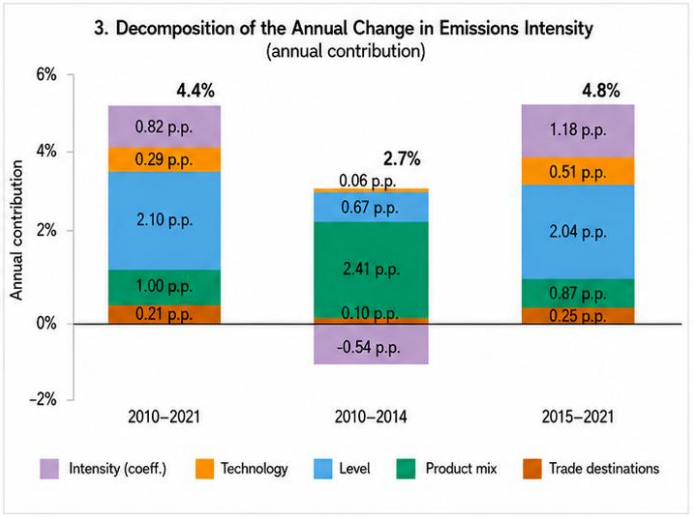
Results

The results indicate that greenhouse gas emissions associated with Brazilian exports increased substantially between 2010 and 2021. Total emissions embodied in exports grew by more than 65% during the period, reflecting both the expansion of export volumes and structural transformations in the export basket, as we see in Figure 2.



Source: Authors' elaboration based on data from Alves-Passoni and Freitas (2022), Costa and Alvarenga (2025), MapBiomas (2025), and SECEX (2024).

The decomposition analysis reveals in Figure 3 that the export level effect was the largest contributor to emissions growth over the full period. In other words, the increase in total export volumes played a central role in explaining emissions expansion.

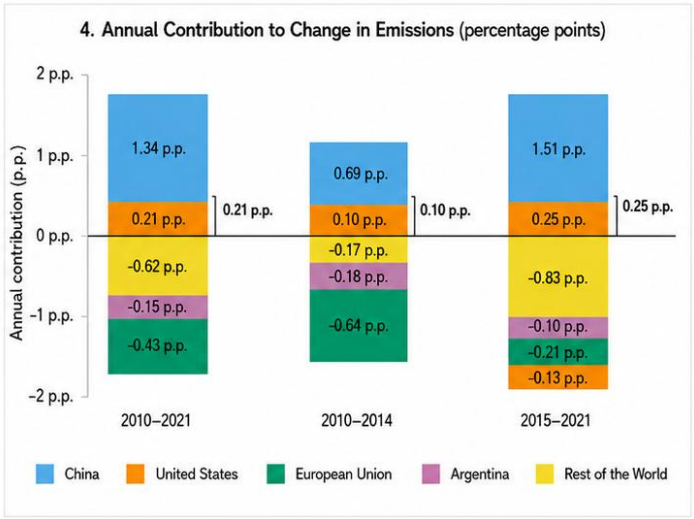


Source: Authors' elaboration based on data from Alves-Passoni and Freitas (2022), Costa and Alvarenga (2025), MapBiomas (2025), and SECEX (2024).

However, structural factors also played a highly significant role. The product composition effect contributed positively to emissions growth, indicating that Brazilian exports became increasingly concentrated in sectors with higher emissions intensity.

This result confirms the existence of a reprimarization process characterized by the growing participation of agriculture, livestock, and resource-intensive activities in exports.

The destination composition effect, detailed in Figure 4 was also positive and important. This reflects the increasing relevance of China as a destination market for Brazilian exports. Since exports to China are heavily concentrated in commodities, the growing participation of China increased the average emissions intensity of Brazilian exports.



Source: Authors' elaboration based on data from Alves-Passoni and Freitas (2022), Costa and Alvarenga (2025), MapBiomas (2025), and SECEX (2024).

The emissions intensity effect also contributed positively to emissions growth. This indicates that production associated with exports became more emissions-intensive over time. Several factors may explain this result, including rising deforestation rates, expansion of land-use-intensive activities, and greater use of fossil-fuel-based electricity generation.

The technological effect was positive but relatively modest. This suggests that production chains associated with exports became somewhat more input-intensive over time.

Subperiod Analysis

The decomposition by subperiod reveals important differences between the first and second halves of the decade.

Between 2010 and 2014, emissions growth was primarily driven by the product composition effect. During this period, changes in the composition of exports toward more emissions-intensive sectors represented the main driver of emissions expansion.

This phase can therefore be interpreted as an initial stage of reprimarization, characterized mainly by changes in export composition.

Between 2015 and 2021, the pattern changed significantly. During this second phase, emissions growth became increasingly associated with the export level effect and the emissions intensity effect.

This suggests that reprimarization had already become consolidated by this point. Rather than changes in export composition alone, emissions growth increasingly reflected the expansion of the scale of commodity exports and the intensification of environmentally intensive production patterns.

Destination Effects

The geographical decomposition highlights the dominant role of China in driving emissions growth.

China exhibited the largest positive contribution among all trading partners. The rapid increase in China's participation in Brazilian exports was accompanied by strong growth in emissions embodied in exports to the Chinese market.

This result reflects the sectoral composition of bilateral trade. Brazilian exports to China are highly concentrated in agriculture, livestock, mining, and industrial commodities, all of which display relatively high emissions intensity.

In contrast, the European Union exhibited a negative contribution to emissions growth. The declining participation of the European market reduced the relative importance of less emissions-intensive manufacturing exports.

The United States showed a relatively small positive contribution, while Argentina displayed a negative contribution due to its declining participation in Brazilian exports.

The Rest of the World also contributed negatively overall, suggesting that emissions growth was concentrated in a limited number of trading partners rather than being generalized across all export destinations.

The comparison between subperiods reveals that the role of China intensified over time. Between 2015 and 2021, China became the dominant driver of emissions growth associated with exports.

Sectoral Effects

The sectoral decomposition demonstrates that livestock represented the single largest contributor to emissions growth.

This result is particularly important because livestock production displays extremely high emissions intensity, mainly due to methane emissions and land-use change. Even moderate increases in exports therefore generate substantial environmental impacts.

Agriculture and forestry production also contributed strongly to emissions growth. The expansion of agricultural exports, especially toward China, reinforced the environmentally intensive character of Brazilian trade specialization.

Industrial commodities contributed positively as well, although their contribution was smaller than that of primary sectors.

Traditional and innovative manufacturing industries exhibited only marginal contributions to emissions growth. This reflects both their declining participation in exports and their relatively lower emissions intensity.

The comparison between subperiods reveals an important transformation. During the first subperiod, emissions growth in agriculture and livestock was primarily driven by changes in export composition. During the second subperiod, however, growth increasingly reflected rising export volumes and greater emissions intensity.

This indicates that the reprimarization process evolved from a compositional transformation into a broader expansion of environmentally intensive production structures.

Discussion

The findings of this study have important implications for debates regarding development, industrial policy, and environmental sustainability in Brazil.

First, the results suggest that the Brazilian export model during the 2010s reinforced a pattern of environmentally intensive specialization. The growing dependence on commodities and primary sectors increased the carbon content of exports and strengthened the connection between external demand and emissions growth.

Second, the results highlight the importance of considering the environmental dimension of structural change. Reprimarization should not be interpreted solely as a productive or technological phenomenon. It also represents a transformation in the environmental profile of economic activity.

Third, the study demonstrates the central role of international trade patterns in shaping emissions trajectories. Changes in destination markets may substantially affect emissions even when total export volumes remain relatively stable.

The increasing concentration of exports toward China played a decisive role in reinforcing emissions specialization. Since China’s demand is heavily concentrated in primary products, the strengthening of trade relations with China intensified the environmental pressure associated with Brazilian exports.

Fourth, the findings suggest that commodity-led growth strategies may generate important environmental trade-offs. Although commodity exports contribute to foreign

exchange generation and trade surpluses, they may simultaneously reinforce environmentally unsustainable development patterns.

This issue is particularly relevant in the context of global climate change and increasing international pressure for decarbonization. Countries highly specialized in emissions-intensive exports may face growing difficulties in adapting to low-carbon transitions.

The Brazilian case therefore raises broader questions regarding the compatibility between export-led commodity specialization and sustainable development.

Policies aimed at diversifying exports, strengthening technologically sophisticated manufacturing sectors, and promoting green industrialization may be necessary to reduce the environmental intensity of Brazil's external insertion.

Similarly, policies designed to reduce deforestation, improve agricultural productivity, and decarbonize industrial processes are essential for mitigating emissions associated with exports.

The results also reinforce the importance of integrating environmental objectives into trade and industrial policies.

Conclusion

This paper analyzed the evolution of greenhouse gas emissions associated with Brazilian exports between 2010 and 2021 using an environmentally extended input–output model combined with structural decomposition analysis.

The results demonstrate that the reprimarization of Brazilian exports during the 2010s should also be understood as a process of emissions specialization. The growing concentration of exports in agriculture, livestock, and resource-intensive sectors substantially increased the emissions associated with Brazil's external sector.

The decomposition analysis showed that emissions growth was driven not only by the expansion of export volumes, but also by structural changes in the composition and geographical distribution of exports.

The product composition effect and the destination composition effect both played significant roles in increasing emissions. In particular, the growing importance of China as a destination market reinforced the concentration of exports in highly emissions-intensive sectors.

The sectoral decomposition revealed that livestock and agriculture were the main contributors to emissions growth, while technologically sophisticated manufacturing sectors played only a marginal role.

The comparison between subperiods demonstrated an important transformation in the dynamics of emissions growth. During the first half of the decade, emissions expansion was mainly associated with changes in export composition. During the second half, growth increasingly reflected the expansion of export scale and rising emissions intensity.

Overall, the findings highlight the strong interaction between structural change, trade specialization, and environmental sustainability in Brazil.

The study therefore contributes to broader debates regarding development strategies, industrial policy, and climate change in developing economies.

Future research may expand the analysis by incorporating global value chains, consumption-based emissions, and international comparisons. Additional studies could also investigate the social and regional implications of emissions specialization in Brazil.

Finally, the results suggest that reducing the environmental intensity of Brazilian exports will require not only technological improvements, but also structural transformations in the country's productive and commercial specialization patterns.

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