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Climate-Smart Goods in Brazil: Trends, Opportunities, and Trade Policy Implications

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ABSTRACT

This study analyzed Brazil's Climate-Smart Goods (CSG) trade from 2000 to 2023. While Brazil's overall trade expanded significantly, CSG trade, though growing, remains a small fraction. A persistent trade deficit in CSGs indicates a reliance on imported sustainable technologies and limited domestic production. Despite fluctuations, CSG trade has shown steady growth, suggesting a growing alignment with global sustainability goals. However, CSGs constitute a small portion of Brazil's overall exports, highlighting untapped potential in the domestic CSG sector. These findings suggest that Brazil can enhance its role in the global CSG market by implementing policies that foster domestic production and reduce import reliance. Such a shift would not only improve Brazil's trade balance but also contribute to its climate objectives and sustainable development goals.

INTRODUCTION

The urgency to combat climate change and environmental degradation has significantly reshaped global economic priorities, highlighting the need for sustainable development practices across diverse sectors (Begum, 2020). Within this framework, trade in climate-smart goods (CSGs)—products and technologies specifically designed to mitigate environmental impacts and enhance sustainability—has emerged as a pivotal aspect of international trade policy and economic strategy (Mathur, 2011). CSGs encompass a broad array of products, including renewable energy technologies, pollution management equipment, energy-efficient machinery, and sustainable agricultural inputs (Dinda, 2011). The expansion of CSG trade holds the potential to reduce carbon emissions while simultaneously driving economic growth through innovation and increased productivity (Saghaian *et al.*, 2020).

Brazil, as one of the world's largest emerging economies, occupies a unique position in this landscape due to its rich natural resources, vast biodiversity, and significant contributions to global greenhouse gas (GHG) emissions (Baer, 2008). Analyzing Brazil's CSG trade patterns is crucial for understanding the sector's capacity to support the nation's sustainable development efforts and align with international environmental objectives.

The trade structure and policy framework in Brazil are evolving amid an increasingly climate-conscious global economy (Nassif *et al.*, 2020). The country's energy matrix is notably sustainable, primarily reliant on hydroelectric power and expanding into renewable sources such as wind, solar, and bioenergy (Investment guide to Brasil, 2017). However, Brazil faces complex environmental challenges, including deforestation and high levels of industrial and agricultural GHG emissions (Ferraz *et al.*, 1999). Participation in global CSG trade represents a strategic opportunity for Brazil to mitigate these

environmental impacts, leveraging green technologies for both economic advancement and environmental preservation (Knoch *et al.*, 2020). Thus, CSG trade offers Brazil a dual opportunity: to diminish its carbon footprint while securing competitive advantages in the international market for sustainable goods.

The global demand for climate-smart goods has surged in recent years as nations adopt stringent environmental policies and commit to international agreements, such as the Paris Agreement (Crowford, 2011). CSG trade has rapidly grown, with countries seeking to reduce their reliance on traditional, carbon-intensive goods in favor of sustainable alternatives (Saghaian *et al.*, 2020). For Brazil, the promotion of CSGs is particularly relevant, as it seeks to diversify its export portfolio, reduce dependency on primary commodities, and bolster its position within the global green economy (Piao *et al.*, 2021). However, despite Brazil's potential as a key player in CSG trade, the existing literature reveals a limited exploration of the drivers and barriers influencing CSG trade growth. Furthermore, Brazil's trade policies and regulatory environment may facilitate or constrain its ability to fully capitalize on CSG opportunities, depending on their alignment with international standards and climate-related goals.

This study aims to bridge these gaps by analyzing the trends and trade patterns of CSGs in Brazil, thereby providing a comprehensive understanding of the country's competitive positioning in the global CSG market. By examining import and export trends, sectoral contributions, and value chain dynamics, this research seeks to identify the sectors most engaged in CSG trade, the key markets for Brazilian CSG exports, and the primary sources of CSG imports. Understanding these patterns is vital for assessing Brazil's relative strengths and weaknesses in CSG trade and determining the alignment of its trade policies with sustainable development goals. Additionally, the study will analyze the regulatory and

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policy environment surrounding CSG trade in Brazil, evaluating whether current policies facilitate or inhibit CSG growth. International experiences indicate that regulatory frameworks can either promote the expansion of green technology markets or impose limitations due to restrictive tariffs, non-tariff barriers, or inadequate incentives. A key question for Brazil is the extent to which its policies align with its climate commitments, as this alignment could significantly influence the success of integrating CSG trade into its broader economic strategy. The motivation for this research is twofold. First, an analysis of CSG trade trends in Brazil contributes to the literature on sustainable trade by providing empirical insights into Brazil's role and potential within the CSG sector. Second, the findings will offer policymakers evidence-based insights regarding the ability of CSGs to bolster Brazil's economic resilience, environmental stewardship, and compliance with international climate standards. Given the increasing significance of sustainable trade in the global economy, this research presents timely insights that can inform Brazil's trade policy, promote technological innovation, and support the transition to a low-carbon economy.

Ultimately, this study seeks to enhance our understanding of how CSG trade can advance Brazil's sustainable development objectives, contribute to emissions reduction, and improve Brazil's positioning in the global green economy. By identifying the factors that drive or inhibit CSG trade growth, this research will illuminate strategic choices available to Brazilian policymakers, enabling them to leverage CSG trade as a vital instrument for sustainable economic development. This work will serve as a foundation for further research on the impacts of CSG trade on economic, environmental, and social outcomes, thereby contributing to Brazil's evolving narrative as a significant participant in the global movement toward a sustainable future.

LITERATURE REVIEW

Climate change has become one of the most pressing issues in contemporary discourse, both at national and international levels. Across most climate policy discussions, trade is increasingly recognized as a pivotal factor influencing climate change dynamics (Dellink *et al.*, 2017). While trade drives economic growth and prosperity, it also poses environmental challenges due to emissions generated in the production, transportation, and consumption of traded goods (Harris *et al.*, 2021). Many climate experts contend that a substantial portion of global CO₂ emissions, a key contributor to climate change, is attributable to trade-related activities. In 2019, China, the United States, India, Japan, and the Russian Federation alone accounted for nearly 70% of global CO₂ emissions (Schleicher *et al.*, 2018). However, the trade trends in climate-smart goods (CSGs) in major economies such as China and India reveal a shift towards more sustainable practices, potentially contributing to a reduction in emissions (Chowdhury *et al.*, 2018).

This dual role of trade—promoting economic growth while impacting the environment—has led many countries to grapple with balancing economic and environmental objectives (Grossman *et al.*, 1994). One solution to mitigate the negative environmental effects of trade while sustaining economic growth is to adopt environmentally sustainable trade practices (Zhong, 2023). Expanding the market for climate-smart goods (CSGs) can facilitate this balance, as CSGs encompass technologies and products that mitigate environmental impacts and enhance sustainability (Mathur, 2011). Market trends for CSGs suggest that trade in these goods is often regionally concentrated. For instance, in the Asia-Pacific region, CSG export and import volumes have increased significantly; in 2002, export and import growth rates in the region were 235% and 222%, respectively. In contrast, African regional economic communities such as COMESA, EAC, and SADC have seen comparatively lower growth rates in CSG trade, with higher import growth than export growth (UNESCAP, 2011). This trend indicates a greater reliance on imported CSGs. Similarly, in APEC countries, export growth of environmental goods has outpaced import growth, with an export rate of 13.3% compared to an 11.6% import rate (Kuriyama, 2012). Least developed countries (LDCs) have also demonstrated impressive growth in environmental goods trade, exceeding global growth rates; in 2007, the global growth rate for environmental goods was 13.58%, while LDCs experienced a growth rate of 22.80% (Khatun, 2012).

The literature has widely debated the question of trade liberalization in environmental goods. Several studies emphasize that liberalizing trade policy for environmental goods could significantly expand these markets, thereby benefiting environmental conditions in developing countries by promoting cleaner technologies (Zhang, 2011; Antweiler *et al.*, 2001; Dean, 1999). This perspective aligns with the Environmental Kuznets Curve hypothesis, which posits that economic growth initially leads to environmental degradation, but beyond a certain income level, cleaner technologies and stronger regulations begin to improve environmental quality (Mishra, 2020). Proponents of this view argue that policies should both support environmental goods and prohibit environmentally harmful goods. Conversely, some studies highlight that trade liberalization does not always yield positive environmental outcomes, aligning instead with the pollution haven hypothesis, which suggests that trade liberalization can lead to the relocation of polluting industries to countries with weaker environmental regulations (Duy, 2010).

The majority of existing research has focused on global and regional CSG trade trends, with studies examining trade dynamics in China, India, and other major economies. While the literature on trade trends and patterns in Brazil is substantial, to the best of the researcher's knowledge, no study has specifically addressed the trend and trade patterns of CSGs in Brazil. Therefore, this study aims

to fill this gap by analyzing Brazil's CSG trade trends and patterns. This research is expected to provide a deeper understanding of Brazil's role in sustainable trade and its potential contribution to global emissions reduction through the expansion of CSG markets.

MATERIALS AND METHODS

This study relies on data reflecting Brazil's trade performance, specifically focusing on total trade value, total export value, and total import value, as well as the trade of climate-smart goods (CSGs) in Brazil, including CSG export and import values. The primary sources for these data were the UN Comtrade, UNCTAD, and World Bank databases. All data observations were recorded on an annual basis and measured in thousands of U.S. dollars, ensuring consistency and comparability over time. Climate-smart goods were identified at the HS 6-digit level, with relevant data for these goods extracted from the World Integrated Trade Solution (WITS) database. To analyze the trade trends of CSGs in Brazil, the study employed descriptive statistical tools, which are well-suited for summarizing and visualizing large datasets. Various

statistical techniques, including tabulation, graphical representations, percentages, and ratio analyses, were applied to examine the annual changes and comparative performance in Brazil's trade. These techniques facilitated a clear understanding of the extent and composition of CSG trade between Brazil and its global trade partners. Ultimately, this analytical approach aims to illuminate Brazil's positioning within the CSG market and its alignment with global trends in sustainable trade.

RESULTS AND DISCUSSION

Trends of Trade in Climate Smart Goods in Brazil with the Rest of the World

Brazil, with strong agricultural, manufacturing, and mining sectors, became a prominent player in international trade after liberalizing its economy in 1988. This shift led to significant export growth across most sectors, boosting Brazil's trade balance and enhancing its economic integration. The table below highlights trends in Brazil's total trade and climate-smart goods trade from 2000 to 2023, reflecting the country's growing role in sustainable trade alongside traditional sectors.

Table 1: Total Trade and Trade in Climate-Smart Goods in Brazil (million, USD)

Year	Total trade (million,USD)	Total CSGs trade (million,USD)	Percentage Share of CSGs in Brazil's Total Trade
2000	113762.00	2193671.04	1.92829859
2001	116669.00	2302158.53	1.97323927
2002	110162.00	2838707.97	2.57684861
2003	124084.00	2896213.86	2.33407519
2004	163111.00	2719779.35	1.66744079
2005	196157.00	3123048.64	1.59211684
2006	234630.00	3945725.33	1.6816798
2007	287927.00	6023259.59	2.09193983
2008	379686.00	6677086.31	1.75858112
2009	287170.00	3815619.07	1.32869696
2010	393618.00	3460914.60	0.8792572
2011	492372.00	4589350.17	0.93209
2012	475357.00	5942439.52	1.25010035
2013	484826.00	4525499.72	0.9334276
2014	461686.00	4273107.12	0.92554401
2015	367242.00	3733315.83	1.01658193
2016	324774.00	6787453.57	2.08990054
2017	380843.00	9196147.14	2.41468194
2018	424730.00	7431957.43	1.74980751
2019	414289.00	8122633.73	1.96062018
2020	375516.00	7983918.31	2.12611934
2021	515505.00	11729434.01	2.27532885
2022	626381.00	13505410.29	2.15610152
2023	592406.00	13864941.39	2.34044581

Source: Author's compilation based on World Development Indicators (WDI) of the World Bank and UN Comtrade data (2010), extracted from the World Integrated Trade Solution (WITS) database, accessed in August 2024

Table 1 offers a detailed analysis of Brazil's total trade and trade in climate-smart goods (CSGs) from 2000 to 2023, emphasizing the absolute figures and the percentage share of CSGs within Brazil's trade portfolio. It illustrates Brazil's increasing alignment with global trends in sustainable trade, evidenced by the tripling of total trade volume from USD 113.7 billion in 2000 to over USD 626 billion in 2022 and a parallel rise in CSG trade, peaking at USD 13.86 billion in 2023.

The CSG share as a percentage of total trade, despite some fluctuation, generally trends upward, surpassing

2% in recent years. Notably, increases in the CSG share during economic downturns (e.g., 2020) and peaks in 2021 and 2023 may indicate Brazil's strategic shift toward sustainable sectors amid global climate initiatives. These trends suggest that external economic conditions and policy shifts are influencing Brazil's CSG trade dynamics, aligning national trade with broader environmental objectives. This table, therefore, provides insight into the evolution of Brazil's trade structure, reflecting the growing yet variable role of CSGs as part of the country's response to global sustainability goals.

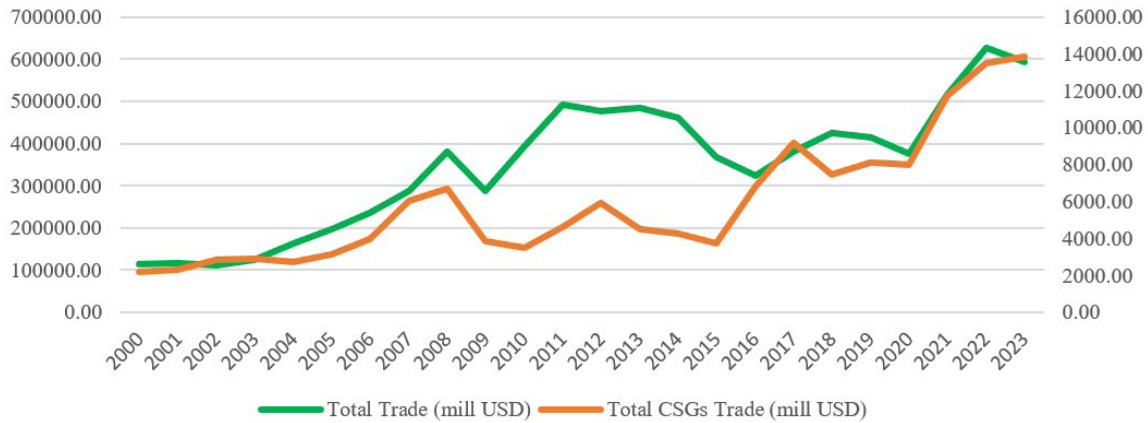


Figure 1: Total Trade & Total CSGs Trade in Brazil (million, USD) for the Study Period

Source: Author's compilation based on World Development Indicators (WDI) of the World Bank and UN Comtrade data (2010), extracted from the World Integrated Trade Solution (WITS) database, accessed in August 2024

This line graph depicts the trends in total trade and climate-smart goods (CSGs) trade from 2000 to 2023, measured in millions of USD. The green line, representing total trade, shows a general upward trend with fluctuations, indicating variability in trade volumes. Notably, a sharp increase occurs around 2020, peaking in 2022, which may reflect broader economic or policy influences on trade in recent years. The orange line, indicating CSG trade, follows a similar growth trend but remains at a lower level throughout the period. CSG trade demonstrates more

consistent growth after 2008, suggesting an increase in the prioritization of climate-smart products, with a marked rise in recent years possibly driven by rising demand for sustainable goods or supportive policy changes. Overall, while both total trade and CSG trade have expanded significantly, CSG trade remains a smaller portion of total trade, highlighting the gradual yet limited incorporation of climate-smart goods into the broader trade framework and underscoring potential areas for policy intervention and market growth.

Table 2: Brazil's Trade Balance with Rest of the World (million, USD)

Year	Overall Trade Balance (million USD)			CSGs Trade Balance (million USD)		
	Export	Import	Trade balance	Export	Import	Trade balance
2000	55119	58643	-3524	455.172158	1738.49889	-1283.3267
2001	58287	58382	-95	565.589774	1736.56875	-1170.979
2002	60439	49723	10716	474.588398	2364.11957	-1889.5312
2003	73203	50881	22322	633.964255	2262.2496	-1628.2853
2004	96678	66433	30245	912.335865	1807.44348	-895.10762
2005	118529	77628	40901	1133.46813	1989.58051	-856.11237
2006	137581	97049	40532	1527.73055	2417.99477	-890.26422
2007	159816	128111	31705	2814.27889	3208.9807	-394.70181
2008	195765	183921	11844	2197.5014	4479.58491	-2282.0835
2009	151792	135378	16414	1911.66063	1903.95844	7.702198
2010	200434	193184	7250	1735.33934	1725.57526	9.764082
2011	253666	238706	14960	2290.32593	2299.02424	-8.698308

2012	239953	235404	4549	2950.8943	2991.54522	-40.650915
2013	232544	252282	-19738	2244.27738	2281.22235	-36.94497
2014	220923	240763	-19840	2139.3841	2133.72302	5.661078
2015	186782	180460	6322	1897.09024	1836.22559	60.864659
2016	179526	145248	34278	1951.02891	4836.42467	-2885.3958
2017	214988	165855	49133	4413.50737	4782.63977	-369.1324
2018	231890	192840	39050	1856.34144	5575.61599	-3719.2746
2019	221127	193162	27965	1811.91425	6310.71948	-4498.8052
2020	209180	166336	42844	1559.1732	6424.74511	-4865.5719
2021	280815	234690	46125	2038.13579	9691.29822	-7653.1624
2022	334136	292245	41891	1781.56839	11723.8419	-9942.2735
2023	339696	252710	86986	2046.11749	11818.8239	-9772.7064

Source: Author's compilation based on World Development Indicators (WDI) of the World Bank and UN Comtrade data (2010), extracted from the World Integrated Trade Solution (WITS) database, accessed in August 2024

This table 2 outlines Brazil's trade balance with the global market from 2000 to 2023, focusing on total trade and climate-smart goods (CSGs), measured in millions of USD. It details annual exports, imports, and the resultant trade balance, calculated as exports minus imports. A positive trade balance denotes a surplus, while a negative balance reflects a deficit.

From 2002 to 2023, Brazil generally maintained a positive overall trade balance, with notable surpluses from 2015 onwards, reaching a peak in 2023. In contrast, the trade

balance for CSGs consistently shows a deficit throughout the period, indicating that Brazil's imports of CSGs exceeded exports annually. This deficit has notably increased in recent years, exceeding \$9 billion in both 2022 and 2023, suggesting a growing dependence on CSG imports.

In summary, while Brazil's overall trade remains positive, its persistent CSG trade deficit highlights a reliance on imported climate-smart goods and underscores potential opportunities to strengthen domestic production in this sector.



Figure 2: Brazil's Export Values to the Rest of the World (million USD)

Source: Author's compilation based on World Development Indicators (WDI) of the World Bank and UN Comtrade data (2010), extracted from the World Integrated Trade Solution (WITS) database, accessed in August 2024

This line graph compares Brazil's total exports and exports of climate-smart goods (CSGs) from 2000 to 2023, in millions of USD.

The green line, representing total exports, shows a general upward trend with fluctuations, highlighting growth in Brazil's overall exports. Notable peaks appear in 2011, 2014, and 2023, reflecting significant increases in export activity. The orange line, representing CSG exports, follows a similar pattern but remains consistently

lower. Despite fluctuations, including a substantial spike in 2017, CSG exports have shown moderate growth in recent years.

In summary, both total exports and CSG exports have expanded, though CSGs remain a smaller portion of overall exports. This suggests an increasing but still limited role for climate-smart goods in Brazil's export portfolio, with CSG exports influenced by varying demand or supply conditions over time.

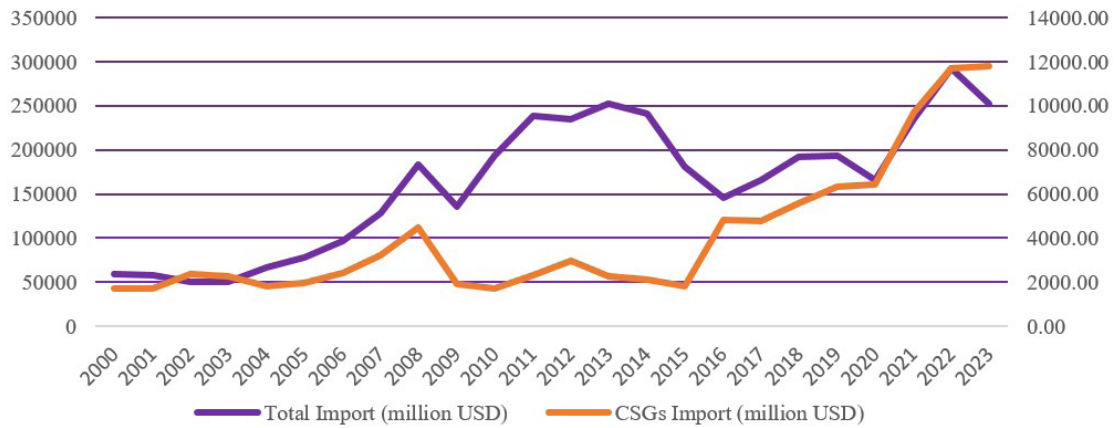


Figure 3: Brazil's Import Values with the Rest of the World (million USD)

Source: Author's compilation based on World Development Indicators (WDI) of the World Bank and UN Comtrade data (2010), extracted from the World Integrated Trade Solution (WITS) database, accessed in August 2024.

This line graph illustrates trends in Brazil's total imports and climate-smart goods (CSGs) imports from 2000 to 2023, in millions of USD.

The purple line, representing total imports, displays an overall upward trend with some fluctuations. Notably, imports increased between 2005 and 2013, showed variability thereafter, and rose sharply from 2020, peaking in 2022. The orange line, showing CSG imports,

consistently remains lower than total imports but follows a steady growth pattern. A significant rise begins around 2015, continuing through 2023, indicating an increased demand for climate-smart goods.

In sum, both total imports and CSG imports have expanded, with CSG imports representing a smaller but gradually increasing share, reflecting Brazil's growing focus on sustainable goods within its import portfolio.

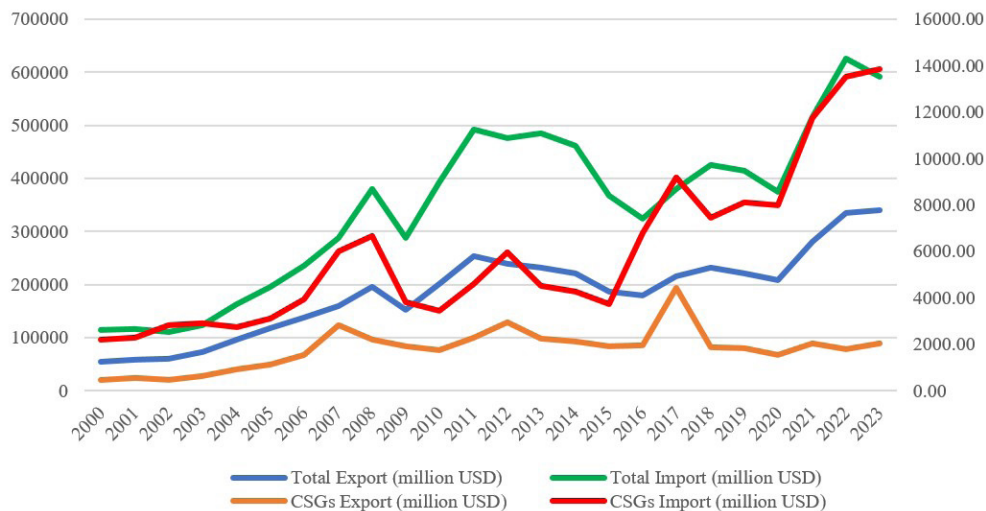


Figure 4: Comparison between Total EX-IM & Total CSGs EX-IM in Brazil (million USD) for the Study Period

Source: Author's compilation based on World Development Indicators (WDI) of the World Bank and UN Comtrade data (2010), extracted from the World Integrated Trade Solution (WITS) database, accessed in August 2024

A line graph comparing Brazil's total exports and imports (EX-IM) with trade in climate-smart goods (CSGs) from 2000 to 2023 would highlight trends in Brazil's overall and sustainable trade sectors. The Total EX-IM line reflects fluctuations in general trade, influenced by global economic cycles, exchange rates, and trade policies, with notable dips during events like the 2008–2009 financial crisis and the 2020 COVID-19 pandemic. The Total CSGs EX-IM line captures trade in green technologies, such as renewable energy and low-carbon products, influenced by domestic environmental policies,

international agreements, and growing global demand for sustainable goods.

If Total EX-IM outpaces CSG EX-IM, it suggests that while Brazil's overall trade expands, CSGs remain a smaller segment. Conversely, a narrowing gap indicates a shift towards a more sustainable trade portfolio. Sudden increases in CSG trade may reflect specific policies or international collaborations fostering green industries. This graph offers insight into Brazil's evolving engagement with sustainable trade practices in response to global environmental initiatives and economic incentives.

CONCLUSION

Brazil's trade in climate-smart goods (CSGs) reflects a growing, yet underdeveloped, engagement with sustainable trade practices. From 2000 to 2023, Brazil's total trade expanded significantly, with CSG trade following a generally upward trend, though consistently representing a small fraction of overall trade. The persistent trade deficit in CSGs underscores Brazil's dependence on imports for sustainable technologies, which suggests that the domestic CSG production sector has not kept pace with the rising demand. Despite this, the steady growth of CSG imports and exports highlights Brazil's increasing alignment with global sustainability goals, spurred by the global demand for environmentally friendly goods and Brazil's commitments to international climate accords.

However, CSG trade remains relatively limited within Brazil's broader export portfolio, signaling an area of untapped potential. The current trade pattern reflects Brazil's substantial import reliance and emphasizes the need for policies that can strengthen local production capabilities. Addressing this will be essential for Brazil to not only reduce its CSG trade deficit but also position itself as a competitive supplier in the global green market. This alignment could yield economic benefits while also supporting Brazil's climate objectives, making sustainable trade a dual engine for economic growth and environmental stewardship.

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