

A structural decomposition of greenhouse-emissions embodied in Brazilian exports, 2010–2021, based on the input–output model

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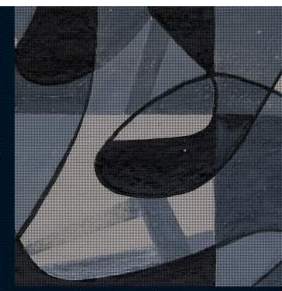
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Why look at exports and emissions?

Export-led growth, modest results

Brazilian goods exports grew 2.19% p.a. (2010–2021), but the 2010s still recorded the slowest decade of economic growth in 80 years (0.6% p.a., IBGE).

Exports are the most emission-intensive demand component

Exports carry higher average GHG intensity than other components of final demand, driven by commodity content - 40% of all exports in average is led by exports

A structural shift in trade geography

China's share of Brazilian exports rose from 14.9% (2010) to 30.3% (2021), alongside reprimarization of the export basket to other partners.

- Research question: how much of the growth in export-embodied emissions reflects reprimarization itself — versus scale, technology, or relative-price effects?
- Alvarenga (2024) shows 72% of the 2000–2019: process of “structural carbonization.”
- What’s new:
 - Disaggregates from 42 to 67 sectors, splitting agriculture from livestock — two activities with very different emission profiles that were previously merged.
 - Holds 2010 relative prices constant in a hybrid (physical + monetary) input–output model, isolating real compositional shifts from price-driven inflation of commodity shares — a refinement over Alvarenga's (2024) use of aggregate inflation only.

An emissions-augmented input–output model

$$\varepsilon = \hat{h} \times L \times T \times \psi \times e$$

emissions = (emission coefficients) × (Leontief inverse) × (sector mix) × (partner mix) × (export level)

Intensity

emissions per
unit of output
($\hat{h}$)

Technology

domestic
input
requirements
(Leontief, L)

Level

total volume
exported (e)

Product mix

sector
composition
of exports (T)

Partner mix

geographic
destination
shares (ψ)

Structural Decomposition Analysis (Dietzenbacher & Los, 1998 — average polar decomposition) attributes $\Delta\varepsilon$ between two years to each of these five factors.

Data sources

Input– output matrices	67 sectors / 126 products, constant 2010 prices (Alves- Passoni & Freitas, 2022)
Trade by partner	NCM exports by destination, harmonized to national accounts (MDIC/SECEX, 2024)
Emission vectors	67-sector GHG series incl. land-use change (Costa & Alvarenga, 2025; MapBiomass, 2025)

*Period: 2010–2021,
split into 2010–2014 and
2015–2021*

Six industrial groups (GIC/UFRJ typology)

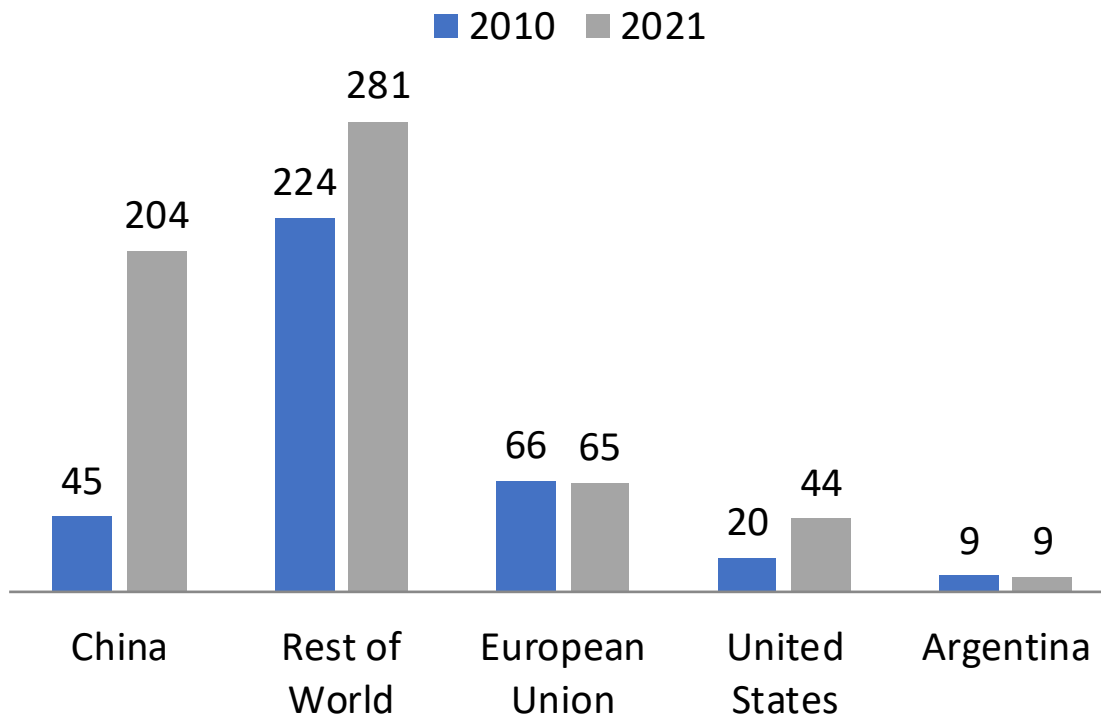
- Agriculture & forestry
- Livedstock
- Processed agri-
commodities
- Industrial
commodities
- Traditional industry
- Innovative industry

Trading partners

- China
- United States
- European Union
- Argentina
- Rest of World (residual)

*These four partners account for >50% of
Brazilian exports throughout the period.*

Where did the new emissions go?



China:

from 12.3% to 33.8%
of total export emissions
— by far the fastest-
growing destination, at
14.7% p.a.

EU & Argentina: flat or falling

Both show slightly negative growth
($\approx -0.2\%$ p.a.) in embodied
emissions over the period.

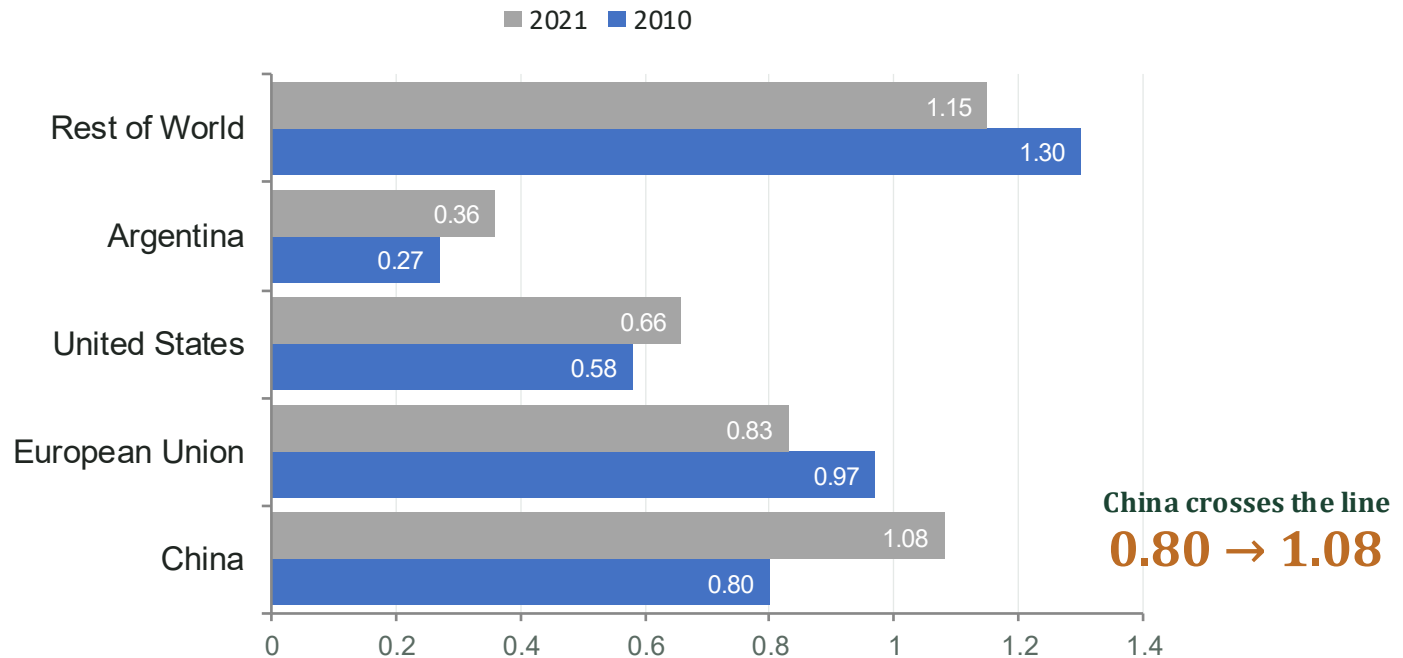
In Mega Tons of CO₂eq

China: more emissions than its trade share implies

Ratio = 1 means a destination's share of emissions matches its share of export value.

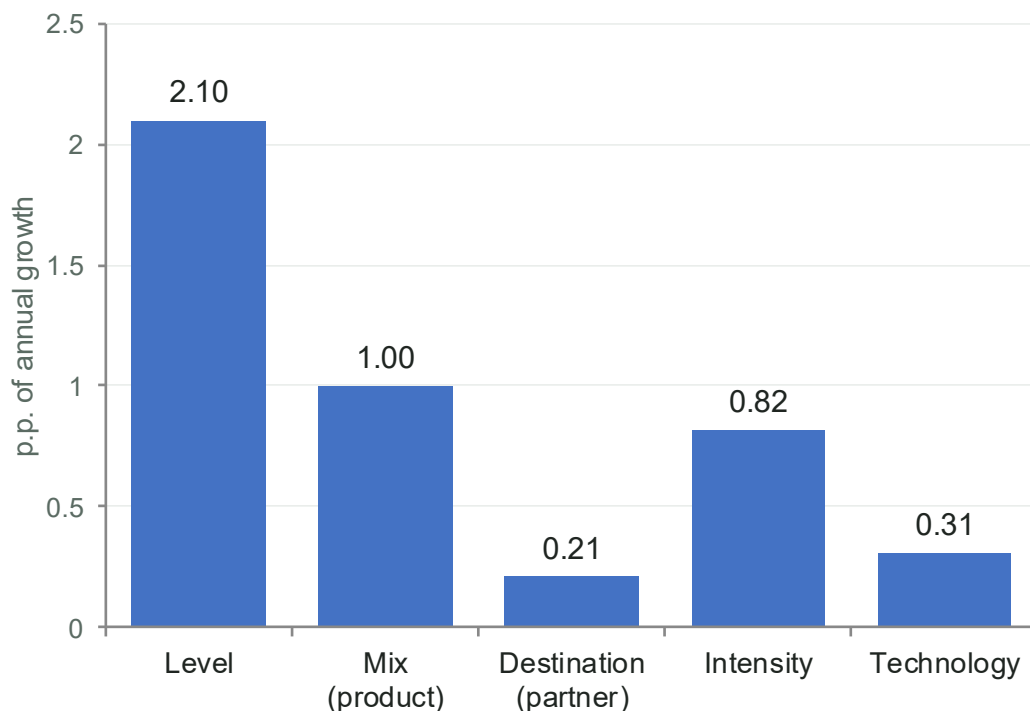


Ratio of emission share to export share by destination (2010 vs 2021)



China moved from under-weight to over-weight in emissions relative to its commercial footprint — the clearest sign that its growing trade share is reshaping Brazil's emissions profile, not just its export value.

Decomposing the 4.4% annual growth rate



Two forces

Mix effect (1.00 p.p.): exports reoriented toward more emission-intensive products.

Destination effect (0.21 p.p.): trade reoriented toward a partner (China) whose import basket is itself commodity-heavy.

1.21 p.p. = 27.5%

of total emissions growth in 2010–2021

A two-phase story: composition, then scale

2010–2014

COMPOSITIONAL PHASE

2.7%

p.a.

- Growth dominated by the product-mix effect: 2.41 p.p. of the period's growth
- Export volumes and emission intensity play a secondary role
- Geographic reallocation already under way: China +0.69 p.p., U.S. +0.40 p.p., while the EU contributes –0.64 p.p.

2015–2021

SCALE & INTENSITY PHASE

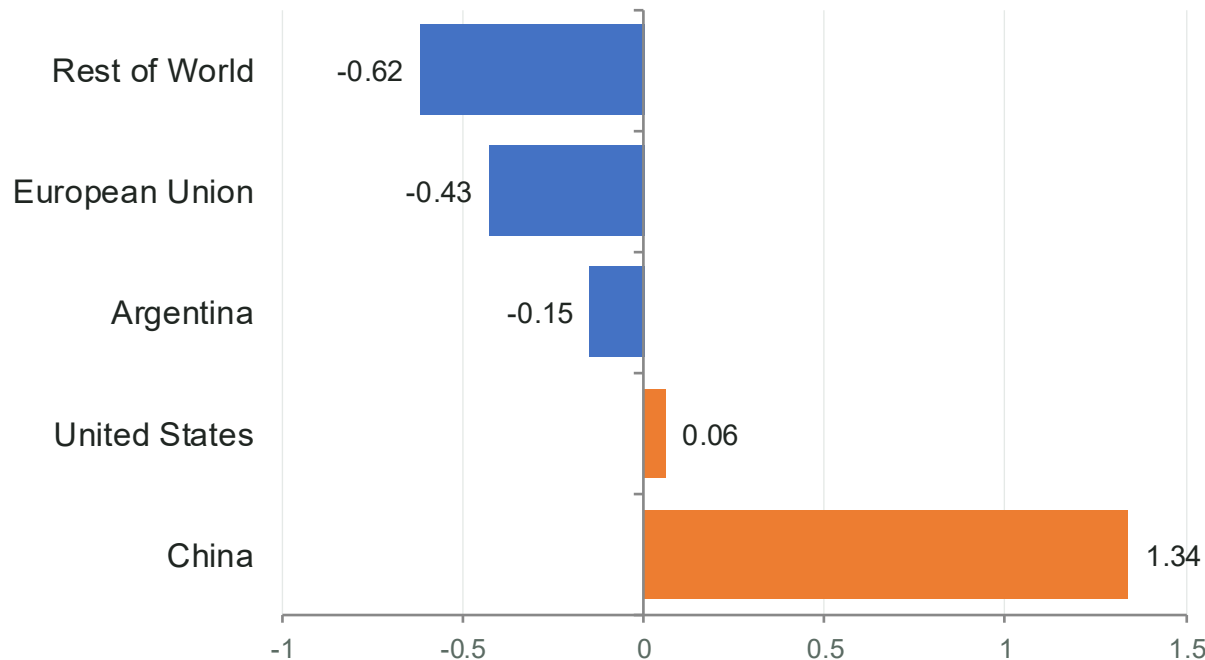
4.8%

p.a.

- Reprimarization is now consolidated; growth shifts to the level effect: 2.04 p.p.
- Emission intensity becomes a major driver: 1.18 p.p. (rising deforestation, fossil thermal power)
- China's pull intensifies to 1.51 p.p. while every other partner turns negative

China drives the destination effect

Country contribution to the trading-partner composition effect, 2010–2021
(p.p. of annual emissions growth)



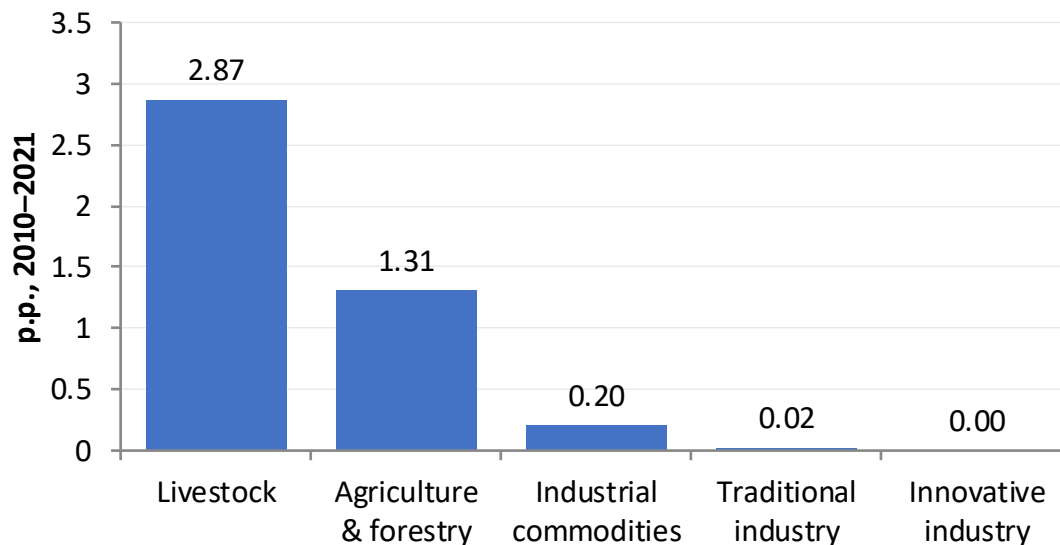
Why China dominates

China's import basket from Brazil is heavily concentrated in agriculture, livestock and industrial commodities — 60% of industrial-commodity exports went to China in 2010, still over 50% in 2021.

As China's share of total exports rises, every additional dollar exported carries more commodities — and more emissions — with it.

Livestock and agriculture lead the increase

Sectoral contribution to average annual growth of export-embodied emissions



Emission intensity, relative to innovative industry (=1×)

2,900× Livestock

300× Agriculture & forestry

35× Processed agri-commodities

8× Industrial commodities

Because intensities are so heterogeneous, even small basket shifts toward agropecuária translate into large emission effects.

Reprimarization as emissions specialization

- Export-embodied emissions are not just a story of growing trade volumes — they reflect a structural reorganization of what Brazil exports, and to whom.
- Reprimarization and geographic reorientation toward China are two faces of the same process: an across-countries reprimarization effect (Alvarenga, 2024) that this paper confirms net of relative-price distortions.
- The mechanism shifted over time — from compositional change (2010–2014) to scale and rising intensity (2015–2021) — but its direction did not reverse.

Deforestation control first

Land-use change linked to livestock expansion is the fastest, least costly lever for cutting export-embodied emissions in the short run.

Diversify, deliberately

A dual mandate: shift toward more complex products while simultaneously lowering the emission intensity of the economy — not one at the expense of the other.

A structural trade-off

Export-led growth anchored in primary commodities creates a persistent tension between trade performance and climate goals in emission-heterogeneous economies like Brazil's.

Questions & discussion welcome

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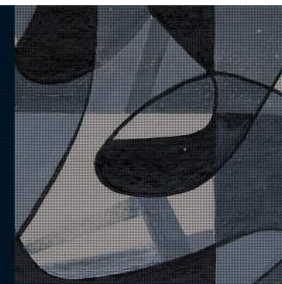
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