Decomposing Export-Related Emissions in Global Production Networks: Structural Drivers and Uncertainty Assessment

Topic: Sustainable Strategies for Reducing COâ‚‚ and non-COâ‚‚ Greenhouse Gas Emissions (I)
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The increasing fragmentation of production across borders has heightened the significance of greenhouse gas (GHG) emissions embodied in exports as countries integrate more deeply into global value chains (GVCs). As territorial-based accounting becomes insufficient for capturing the environmental pressures generated by internationally dispersed production systems, the measurement and interpretation of trade-related emissions have become central to climate policy debates. This paper provides a comprehensive analysis of changes in GHG emissions embodied in exports using a global multiâ€‘regional input-output (MRIO) framework grounded in the OECD Interâ€‘Country Inputâ€‘Output (ICIO) tables and the OECD Greenhouse Gas Footprint (GHG FP) indicators. By linking harmonized economic accounts with an environmentally extended database aligned with the System of Environmentalâ€‘Economic Accounting, the study delivers a robust assessment of how export-related emissions evolve and which structural mechanisms drive these changes.

A Structural Decomposition Analysis (SDA) is employed to isolate the effects of (i) changes in emission coefficients, reflecting shifts in GHG intensities and technological improvements; (ii) changes in domestic and international input structures, capturing transformations in the organization of production and sourcing patterns; and (iii) changes in the scale of gross exports, representing the impact of expanding or contracting trade volumes. This methodological approach allows us to determine whether exportâ€‘related emission trends are primarily driven by cleaner production, changes in supply-chain interdependencies, or simply export growth. The analysis examines both long-term dynamics and more recent developments to provide a nuanced understanding of how structural forces evolve over time.

Beyond the decomposition exercise, the paper addresses a critical methodological challenge in input-output modelling: uncertainty in coefficient estimates and multipliers. Inputâ€“output indicators can exhibit substantial volatility due to data assumptions, aggregation choices, and the propagation of errors through MRIO systems. As recent literature highlights, the credibility of footprint indicators and decomposition results depends increasingly on quantifying this uncertainty. Building on recent advances in the field, the study examines the statistical dispersion of multipliers and evaluates how coefficient variability affects the robustness of SDA findings. This dual focus-combining structural drivers with an explicit uncertainty assessment provides a more transparent and policyâ€‘relevant interpretation of tradeâ€‘related emission trajectories.

Several insights emerge from the application of this framework. Over longer horizons (2002-2022), changes in export volumes, emission intensities, and input structures can each play meaningful roles in shaping exportâ€‘embodied emissions, although their relative importance differs across regions, sectors, and time periods. Industrial sectors typically remain central to global emission patterns due to their upstream and energyâ€‘intensive nature, while services and agriculture play more regionally dependent roles. In more recent years (2017-2022), the balance between efficiency improvements, structural reconfiguration, and shifts in trade volumes has become more sensitive to short-term economic fluctuations and evolving global supplyâ€‘chain dynamics. These patterns highlight the value of SDA as a diagnostic tool capable of disentangling multiple overlapping drivers without relying on fixed assumptions about technological or trade evolution.

Overall, the paper contributes new analytical insights into the determinants of emissions embodied in trade while advancing methodological understanding of uncertainty in inputâ€‘outputâ€‘based environmental indicators. The findings emphasize the need for climate policies that simultaneously target production efficiency, supplyâ€‘chain composition, and the carbon intensity of traded

intermediates. By integrating decomposition and uncertainty analysis, the study provides policymakers, researchers, and international organizations with a more reliable framework for interpreting GHG footprints in an increasingly interconnected global economy.