

Reconciling Producer and Consumer Responsibilities: A Parameter-Free Shared Model Based on Production Layer Decomposition

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The existing United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol are predominantly grounded in the Producer Responsibility Principle. This carbon emission responsibility accounting system, built on the territorial principle, not only overlooks the cross-border flow of embodied carbon in international trade, but also leaves institutional loopholes for developed economies to achieve book-value emission reductions by relocating high-polluting enterprises to developing countries via foreign direct investment (FDI). Against this backdrop, the Consumer Responsibility Principle, which upholds the core notion of “who benefits, who bears responsibility”, has come to the fore. This principle mandates that all carbon emissions generated across the entire industrial chain be fully attributed to the final consuming country, yet it entirely exempts exporting countries from environmental constraints in the profit-making production process. In this context, the Shared Responsibility Principle has gradually emerged as a focal point of academic research. However, a comprehensive review of extant literature shows that most existing shared responsibility frameworks rely heavily on exogenously assigned empirical weight coefficients, lacking endogenous consideration of the topological structure of production processes within the supply chain and the depth of the industrial chain.

This study puts forward a novel theoretical scheme for shared emission responsibility: a new paradigm for carbon emission responsibility allocation based on structured production layer decomposition. Leveraging the power series expansion of the Leontief inverse matrix in the multi-regional input-output (MRIO) model, we disaggregate the total embodied carbon emissions in bilateral direct trade between any two countries by production layer. We explicitly define the concept of carbon emissions from the purchaser’s perspective at the first layer (final assembly and direct export), second layer (direct intermediate input), third layer (first-round indirect input) and higher layers, and integrate the metric of carbon emission intensity into this analytical framework. For empirical analysis, this study adopts the global MRIO tables and carbon footprint accounts spanning 1995 to 2022 released by the Organisation for Economic Co-operation and Development (OECD), the International Trade in Goods data published by Eurostat (the Statistical Office of the European Union), as well as the default Carbon Border Adjustment Mechanism (CBAM) values for products of various economies. Our empirical findings reveal that the default CBAM values for US products generally fall within the carbon emission intensity indicators of purchasers in the first two layers, while the default CBAM values for Chinese products are significantly higher than the carbon emission intensity indicator of purchasers at the third layer. We further conduct an empirical analysis of total carbon emissions from bilateral direct trade among core economies including China, India, the European Union and the United States. The results demonstrate that developing countries represented by China and India have long completed the transformation from a shallow processing trade model to an internalized full industrial chain model. In contrast, developed economies represented by the European Union and the United States show a clear trend of manufacturing hollowing-out and the outsourcing of high-carbon emission production links.