Reallocating Emission Responsibility in Maritime Decarbonization: A Shared-Responsibility MRIO Analysis of Global Shipbuilding Supply Chains

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International shipping accounts for more than 80% of global trade and contributes approximately 2â€“3% of global COâ„‚ emissions, making it both economically and environmentally significant. Accordingly, decarbonizing this sector is essential to achieving international climate goals. In its revised 2023 GHG Strategy, the International Maritime Organization (IMO) set a target of reaching net-zero greenhouse gas emissions from international shipping by around 2050. This strategy goes beyond conventional technical measures and includes market-based mechanisms. As a result, emission governance in international shipping is shifting from ship-level efficiency standards toward managing the sectorâ€™s total annual emissions along the pathways outlined in the 2023 GHG Strategy.

One implication of this transition is the acceleration of fleet renewal. For example, the International Chamber of Shipping (ICS) has proposed the International Maritime Research and Development Board (IMRB), which would fund the development of zero-emission vessels through contributions linked to fuel consumption of shipping companies. Such mechanisms are designed to incentivize fuel-efficiency improvements and support the deployment of zero-emission technologies. However, because zero-emission vessels (e.g., those powered by ammonia or hydrogen) are difficult to introduce solely through retrofitting, they are likely to be deployed primarily via newbuildings. Consequently, although fleet renewal may reduce operational emissions, it may also lead to increased emissions from the shipbuilding sector and its upstream supply chains due to the expansion of new ship construction.

This structural shift creates a separation between emission-generating actors and beneficiaries. The adoption of zero-emission vessels reduces future operational emissions, benefiting the global shipping network and final demand sectors (e.g., automotive and apparel sectors) that seek to reduce their Scope 3 emissions. In contrast, the additional emissions embodied in ship construction are recorded in shipbuilding countries. Given this structural disconnect, an important question arises: in the decarbonization of international shipping, how should emissions from the shipbuilding and operational stagesâ€”and the associated mitigation costsâ€”be allocated among actors along the supply chain?

To address this issue, this study takes a first step by focusing on shipbuilding supply chains. Specifically, it aims to establish a fair allocation of mitigation responsibilities among upstream suppliers, shipyards, and ship operators using a shared-responsibility framework. The analysis focuses on the three largest shipbuilding countries in terms of global market share (i.e., China, South Korea, and Japan), which together account for more than 90% of global shipbuilding capacity.

To outline the key methodological approach and data sources, emission responsibilities are allocated among upstream suppliers and shipyards according to sectoral value added, and between shipyards and ship operators based on sectoral capital formation. For this purpose, we employ the OECD Inter-Country Inputâ€“Output tables, as they provide a distinct shipbuilding sector, which is essential for our analysis. To perform the environmentally extended inputâ€“output analysis, we utilize the GLORIA database to define the CO2 emission coefficient vector.

The results of the preliminary analysis reveal clear structural differences among the three leading shipbuilding countries. In terms of consumption-based emissions, China recorded the highest CO2 emissions in 2022, amounting to 35 Mt-CO2, followed by South Korea (9.2 Mt-CO2) and Japan (4.2 Mt-CO2). The share of domestic emissions exceeded 90% in China and was approximately 70% in Japan. In contrast, South Korea exhibited a more globally distributed emission structure, with domestic emissions accounting for around 50% of the total.

Direct emissions from shipyards were relatively small in all three countries, accounting for 6%, 5%, and 5% of total emissions in China, South Korea, and Japan, respectively. These findings highlight the strong upstream dependence of the shipbuilding sectorâ€”particularly on electricity generation and basic iron and steel productionâ€”thereby stressing the importance of applying a shared-responsibility framework in emission accounting.

This study offers two main novel contributions. First, it examines the potential for carbon leakage resulting from differences in regulatory treatment between operational and shipbuilding emissions. Specifically, it clarifies how operation-centered IMO policies associated with fleet renewal generate environmental impacts across the shipbuilding supply chain. Second, it develops a shared-responsibility model that links shipbuilding and shipping actors, explicitly proposing criteria to evaluate the fairness of mitigation cost allocation in the decarbonization of international shipping.