CO2 mitigation through global supply chain restructuring with consideration for the environmental efficiency of international shipping

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Author: Tomomi SHODA
Co-Authors: Keitaro Maeno, Shigemi KAGAWA, Taiga Shimotsuura

To tackle climate change and its negative impacts, the Paris Agreement was adopted in 2015, and more than 120 countries and regions have set a goal of â€œnet zero carbon dioxide emissionsâ€•. Decarbonization of all industries is essential for all countries to reach the goal. In particular, 23% of global CO2 emissions are embodied in traded goods through the global supply chain (GSC). Therefore, the reduction of CO2 emissions from the GSC has attracted great attention. According to Maeno et al. (2022), the restructuring of the GSC has the potential to significantly reduce the carbon footprint of production. However, it should be noted that the development of the GSC has caused the geographic separation of production areas and consumption areas, which makes the GSC highly dependent on international shipping. In other words, the restructuring of the GSC, accompanying the change of production areas, could lead to changes in the international shipping network. In other words, the restructuring of the GSC has a strong influence over the environmental efficiency of shipping network and the whole process of trade, including production, transportation, and consumption. This research starts from a simple question that if Japan should change importing destination from China to other countries when considering not only the CO2 emissions from production but also the CO2 emissions from transportation. Based on above, the purpose of this research is to simultaneously identify CO2 emission hotspots in the GSC (CO2 emission-intensive industry clusters in the supply chain network of industries) and CO2 emission hotspots in the international shipping network (ports and routes with high CO2 emissions from departing and arriving container ships) by combining the GSC network with international shipping network and to propose CO2 emission reduction strategies for the GSC that explicitly take into account the detailed shipping network.

In this research, we collected the data of movements of 8881 container ships owned by top 10 container ship companies from Sea-web Movements Database provided by the IHS Markit Ltd in 2018-2020, and calculated the CO2 emissions from these container ships in bottom-up methods. Then, we visualized the CO2 emissions network for more than 44 million shipping routes and identify environmentally-important routes and ports by using network centrality analysis and cluster analysis. Next, we calculated the share of ports and routes and combined the environmental consequences with WIOD database and broke down the importing destination into port level. The result shows that the port of Tokyo (Japan) is the hotspot in the international shipping network, and the supply chain of manufacturing industries is the hotspot in the GSC network of Japan. We suggest that the environmental policies which mitigate the CO2 emissions should focus on manufacturing industries and the port of Tokyo (Japan).

The novelty of this research is focusing on the strong connection between the GSC network and the shipping network during the process of international trade and combining the GSC network and the shipping network. Since â€œcarbon neutralityâ€• has been noticed, there are some researches focusing on the decarbonization of the GSC, such as Maeno et al. (2022), and also some researches focusing on the decarbonization of the shipping network, such as Guo et al. (2022). Definitely, it is important to decarbonize the production process of goods and services in production areas in order to mitigate CO2 emissions from the GSC, but it is also important to consider the decarbonization of the international shipping network at the same time. This research provides a new framework to comprehensively analyze the environmental consequences of international trade by treating production and transportation as a whole, without splitting them up.