Environmental Input-Output Analyses of Global Supply Chain Restructuring

前野, 啓太郎

（様式３）

氏　　名　：前野　啓太郎

論 文 名　：Environmental Input-Output Analyses of Global Supply Chain Restructuring
（グローバルサプライチェーンの再構築の環境拡張型産業連関分析）

区　　分　：甲

論　文　内　容　の　要　旨

The expansion of global supply chain (GSC) structure in the world led to 4.2 times increase in CO_2 emission transfers from advanced countries to developing countries between 1990 and 2008, contributing to drastic increase of CO_2 emissions embodied in international trades which accounted for more than 25% of the world's total CO_2 emissions. Based on this fact, industries worldwide are required to reduce CO_2 emissions associated with not only their own production activities but also their GSCs for climate change mitigation. On the other hand, GSC restructuring has become a critical concern for industries due to recent global events which caused disruptions of their GSCs. In this situation, it is essential for industries to transition their existing GSCs into environmentally friendly GSCs which have a low-carbon structure (i.e., a low-carbon GSC restructuring). With this background, this thesis develops a novel analysis framework for investigating the relationship between GSC restructuring and CO_2 emissions. Through this process, this thesis sophisticates the scenario-based hypothetical extraction analysis rooted in the environmental extended input-output analysis. The presented framework can offer valuable insights for policymaking towards low-carbon GSC restructuring by providing useful evidence, which is changes in CO_2 emissions triggered by a structural change of GSC that relevant stakeholders might consider. This thesis comprises five chapters.

Chapter 1 briefly shows research background, research objectives, and contributions of this thesis. This chapter provides an overview of the current situation of CO_2 emissions in the world and describes a necessity to reduce CO_2 emissions from industrial production activities including those GSCs, considering CO_2 emission transfers. Furthermore, this chapter emphasizes a significance of transitioning GSCs towards a low-carbon structure based on the growing importance of GSC restructuring for industries worldwide.

Chapter 2 conducts a review of relevant existing articles, identifies the contributions and problems of the existing research, and describes the significance and objectives of the present study.

Chapter 3 develops an integrated analysis framework using four different input-output methods—unit structure analysis, cluster analysis, extended global extraction analysis and structural decomposition analysis. For a case study, this chapter used the latest 2014 World Input–Output Database: WIOD and modeled the GSC-CO_2 network structure triggered by the final demand for the Japanese automobile industry which induced significant CO_2 emissions from its GSC. The cluster analysis based on the GSC-CO_2 network data revealed CO_2 emission-intensive clusters existed in this network with overconcentrated CO_2 emissions

outside of Japan. From the results, this chapter also found that the restructuring of the Japanese automotive supply chain based on extracting the largest CO_2 emission cluster (i.e., CO_2 emission hotspot) reduces its global carbon footprint by 6.5% and identified the main factors contributing to these CO_2 reductions. Simultaneously, the restructuring increases CO_2 emissions in all countries other than a hotspot country, particularly in some important locations for the substitute production. This chapter concluded that Japan's current automotive supply chain can significantly reduce CO_2 emissions through structural reforms and discussed appropriate policies for restructuring green supply chains.

Chapter 4 develops a scenario-based hypothetical extraction method: HEM into a practical and flexible framework with a focus on the reasonable scale of relevant GSC restructuring by incorporating the revealed comparative advantage index into the HEM framework. As a case study, this chapter applied the practical HEM framework to the latest WIOD in 2014 and estimated the impacts of restructuring major automotive GSCs (the Japanese and German automotive GSCs in this chapter) on CO_2 emissions. Based on the results, this chapter identified the Chinese electrical equipment sector and the Russian basic metals sector, both included in the automotive GSCs as key sectors (i.e., key suppliers) for low-carbon GSC restructuring. These sectors exhibited the largest CO_2 reduction effects when targeted for relevant GSC restructuring. Additionally, this chapter highlighted the practical potential for CO_2 reduction based on a reasonable scale of relevant GSC restructuring. Finally, based on the findings, this chapter discussed how policymakers should formulate trade policies that prioritize intermediate products to promote GSC restructuring toward low-carbon practices and proposed an effective approach to utilize the results as benchmarks for setting CO_2 reduction targets or incentives in the context of GSC restructuring.

Chapter 5 summarizes the analysis results obtained from Chapters 3 and 4, and presents the conclusions of this thesis.