Key Sectors and Linkages in the Complex Global Supply Chain Network

時任, 翔平

https://doi.org/10.15017/2534376

（様式３）

氏　　名　：時任 翔平

論 文 名　：Key Sectors and Linkages in the Complex Global Supply Chain Network
（複雑なグローバルサプライチェーンネットワークにおける主要な部門と産業連関）

区　　分　：甲

論 文 内 容 の 要 旨

Although developed countries such as those included in the Kyoto Protocol Annex I have been striving to reduce territorial CO_2 emissions, the emissions arising from international trade have been rapidly increasing in countries with lax environmental regulations with the expansion of trade and the international fragmentation of production. Peters *et al*. (2011) demonstrated that CO_2 emissions associated with international trade have increased from 4.3 Gt in 1990 to 7.8 Gt in 2008. In reducing the global CO_2 emissions, developed countries need to consider trade-induced emissions and effective cooperation between developed and developing countries is crucial in reducing CO_2 emissions through supply chain engagement. In particular, in recent decades, a large part of the value chains associated with the automotive industry in developed countries such as Germany, has been shifted overseas and thus automotive supply-chains have contributed to the world economy. Thus, it can be said that the automotive industry supply chain network is complex and global. The manufacture of transport equipment uses more indirect energy to produce chemical products, metal products, and electricity across its supply chain than directly onsite. The shift from conventional gasoline-powered cars to the next generation of more fuel-efficient vehicles, such as hybrid, electric and hydrogen vehicles, will reduce CO_2 emissions from the driving phase. On the other hand, this shift will increase CO_2 emissions in the production phase. Therefore, detecting key ‘upstream’ sectors and inter-industry linkages is crucial for reducing CO_2 emissions associated with the automotive life-cycle. To the best of our knowledge, there are few studies analyzing the life-cycle of CO_2 emissions that focus on global automotive supply chains. This thesis focused on the supply chain associated with final demand for production in the “Transport Equipment” sector. Identifying both the key sectors and linkages in supply chain networks is important to advance negotiations for climate mitigation, as it can help inform policy makers about issues such as the transfer of greener technologies and greener material procurement. Identifying key sectors and linkages is nontrivial because of the complexity of the global supply chain network. This thesis develops methodologies for easily identifying key sectors and the linkages of supply chains and identified key sectors and clusters for effective reduction in CO_2 emission from the supply chain of transport equipment and discussed the need for international coordination in the relevant supply chains. This thesis comprises five chapters.

Chapter 1 briefly provides research background, research objectives, and contributions of this thesis. This chapter illustrates how industries can reduce CO_2 emissions through the global supply chain engagements. In

particular, this chapter points out that the automotive industry constructs a dense and complex supply-chain network associated with many upstream industries. It is difficult to not only identify environmentally-important sectors, supply chain paths, and clusters for the global supply chain management but visualize those key supply chain structures. The network approach enables the detection of key sectors and clusters and their links within a short computation time from large network databases, which should provide useful information for informing CO_2 mitigation policy from the lifecycle perspective.

Chapter 2 provides a comprehensive 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 focused on two analysis frameworks of hypothetical extraction method (HEM) and betweenness analysis to identify environmentally important sectors and transactions in supply chain complexity. This chapter derived an analytic expression for the relationship between hypothetical extraction analysis and betweenness centrality analysis. Second, using two widely used multi-regional input-output databases, Eora and WIOD, this chapter also analyzed how different the "important" sectors detected by two similar approaches, hypothetical extraction analysis and betweenness centrality analysis, are. The results show that the two approaches yield similar results, and the both methods have different advantages. This chapter suggests firstly estimating betweenness centrality indicators that are not only less computationally-expensive but meaningful for understanding positions in the global supply-chains network. Then the hypothetical extraction indicators can be easily computed by using the betweenness centrality indicators using the mathematical relationship developed in this study.

Chapter 4 combined the input-output clustering analysis and structural path betweenness analysis, and identified critical sectors belonging to important emission clusters with stronger linkages in the global supply chain networks associated with final demand of transport equipment in five countries (United States, China, Germany, Japan, and France). Clustering analysis can divide the groups constructing the strong connecting supply chain with large emissions from the global supply chain network, and structural path betweenness represents how much CO_2 emissions from the supply chain paths a sector has in global supply chain network. This chapter applied the combined method to the EORA database which covers 189 countries and focused on the whole global supply chain networks in detail. The results demonstrate that the global supply chain networks of transport equipment were well separated into emission clusters with higher emissions that consist of sectors with higher structural path betweenness. Chinese emission clusters were identified from the global supply chain networks for the five countries in question and the betweenness of Chinese sectors tend to be higher values in the supply chain networks. This study suggested supply chain management of high priority sectors in China for a reduction in CO_2 emissions of transport equipment in the producing countries.

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