

Structural Analysis of Air Pollutant Emissions and Its Attributed Mortality in Asia

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(アジアにおける大気汚染物質排出とその排出に伴う死亡者数の構造分析)

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論 文 内 容 の 要 旨

Asia produces almost half of all global manufactured goods and plays a vital role as a global production powerhouse. As the industrial production of the region continues to rise, so do concerns about the adverse environmental and health impacts associated with production activities. Among these, fine particulate matter ≤ 2.5 micrometers in aerodynamic diameter ($PM_{2.5}$) has been one of the most controversial environmental and human health issues in this region in recent years. It has been estimated that both per-capita and total mortality attributable to $PM_{2.5}$ are highest in the Asian domain, amounting to 63 deaths per 100,000 population and 2.3 million total deaths, respectively, in 2010. With this background, this thesis develops a supply-chain network analysis that is fully linked consumer demand via supply chains to primary emitters, and then linked those emitters via atmospheric transport to fate and health impact. This thesis also extends the Miyazawa's augmented input-output analysis. By using the provided analysis frameworks, this thesis identifies environmentally-important supply-chain paths, linkages and key sectors for the Asian economies and the Chinese provinces and discusses effective mitigation policies of the $PM_{2.5}$ emissions in Asia. This thesis comprises five chapters.

Chapter 1 briefly provides research background, research objectives, and contributions of this thesis. This chapter illustrates $PM_{2.5}$ emissions at globe and total mortality attributable to the $PM_{2.5}$ emissions and points out an importance of mitigating $PM_{2.5}$ in the Asian domain. This chapter also argues how the consumption-based accounting can be useful in providing environmental information on life-cycle $PM_{2.5}$ emissions associated with global supply-chains and making effective policies on the air pollutant mitigation.

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 applied consumption-based accounting to identify the key sectors responsible for primary carbonaceous $PM_{2.5}$ mortality and combined an input-output model with an atmospheric transport model and fully links consumer demand to final pollutant fate and health impact. This chapter used the $PM_{2.5}$ emission inventory database from previous studies and the Asian International Input-Output Table for 2005 covering 10 countries and regions (Indonesia, Malaysia, the Philippines, Singapore, Thailand, China, Taiwan, South Korea, Japan, and the United States). This study found the following: (1) considering atmospheric transport changes the distribution of demand-induced impact as compared to conventional emissions footprinting, (2)

the supply chain paths with the greatest impact on PM_{2.5}-induced human health problems in the region are centered around agricultural technologies in China, and (3) the transportation sector of China plays a major role in the supply chain paths that generate relatively large impacts on human health. This chapter concluded that Japan is responsible for PM_{2.5} mortality in Asia and should take leadership in changing key high-priority technologies and critical supply chain paths into greener ones.

Consumption-based approach has provided beneficial information for understanding the key industries driving the huge life-cycle PM_{2.5} emissions. However, the residential sector, which is the largest emitter of carbonaceous aerosols in China, has been treated exogenously and neglected in the context of consumption-based thinking. Therefore, chapter 4 extends the augmented input-output system by incorporating residential PM_{2.5} emissions in China into the consumption → production → income process. This chapter used the multi-regional input-output table for 30 regions in China in 2007 and the data on residential PM_{2.5} emissions by each province. This chapter found that households engaged in high income industries such as “other services”, “agriculture” and “construction” in Sichuan, Shangdong, Guangxi and Anhui mainly contributed their own residential PM_{2.5} emissions. Furthermore, the final demand of urban areas for construction, transport equipment and agriculture drove rural areas' residential emissions through production of commodities such as nonmetal products, coal mining, agriculture, and metallurgy.

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