CO2 Reduction Potentials through Productive Efficiency Improvement in Manufacturing Sectors

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（製造業の生産効率性の改善に伴う二酸化炭素削減ポテンシャルの分析）

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論　文　内　容　の　要　旨

Human-induced warming has already reached about 1°C above pre-industrial levels, and mitigating GHG emissions such as CO_2 is urgent issue for our society. Global CO_2 emissions from fuel combustion has dramatically increased from 20.5Gt to 32.8Gt between 1990 and 2017. In 2017, the manufacturing industry accounts for 19.0 percent of the global direct CO_2 emissions, and the manufacturing industry needs to reduce its CO_2 emissions through various efforts such as demand and technology policy for climate change mitigation. It is useful to evaluate production technology of manufacturing sectors of countries, and estimate CO_2 reduction potentials through production technology improvement in discussing technology investment policy. With this background, this thesis develops a new analysis framework for CO_2 reduction potential estimation by incorporating input-output analysis, data envelopment analysis, and index decomposition analysis. By using the proposed analysis framework, this thesis analyzes productive efficiency and quantifies CO_2 reduction potentials through efficiency improvement in global manufacturing sectors. Based on the empirical results, this thesis discusses effective CO_2 mitigation strategy in manufacturing sectors of countries. This thesis comprises five chapters.

Chapter 1 briefly provide research background, objectives, and contribution of this thesis. This chapter illustrates global CO_2 emissions from manufacturing sectors and points out an importance of mitigating CO_2 emissions through productive efficiency improvement in manufacturing sectors. This chapter also argues how CO_2 reduction potential estimation can be useful in providing effective CO_2 mitigation policy of each manufacturing sector and country.

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 developed a new framework for estimating scope 1, 2, and 3 CO_2 reduction potential through efficiency improvement by combining data envelopment analysis and input-output analysis. This chapter used multi-regional input-output table (EXIOBASE 2) to construct input-output dataset of 14 metal sectors (e.g., iron and steel, aluminium, copper sector) in 40 countries in 2007, and the dataset is applied to the developed framework for CO_2 reduction potential estimation. This chapter found the followings: (1) there exists large technology gaps between metal sectors in developed countries and developing countries, (2) significant amount of CO_2 would be reduced (17.2 percent of the metal sectors) by improving production technology, and (3) input structure and production technology differ by sector and country, thus effective CO_2 mitigation policy also differ by sector and country. This chapter proposes efficiency improvement schemes, which considers input structure and production technology, to each sector of country for effectively reducing CO_2 emissions.

Chapter 4 extends the analysis framework developed in chapter 3 in terms of time series analysis. Previous literatures of CO_2 reduction potential estimation are based on static analysis and incapable of identifying driving factors of CO_2 reduction potentials. To discuss efficiency improvement priority, it is important to identify driving factors of CO_2 reduction potentials. In this chapter, a new framework for evaluating CO_2 reduction potential is proposed by combining data envelopment analysis and index decomposition analysis. World Input-Output Database is used to make input output dataset for four manufacturing sectors (chemical, metal, non-metallic mineral, and paper sector) in 26 countries during 2008 and 2014. Empirical analysis revealed that significant CO_2 reduction potentials exist in all four manufacturing sectors across 26 countries in 2014: 1139Mt-CO_2, 1096Mt-CO_2, 171Mt-CO_2, and 322Mt-CO_2, respectively. The decomposition results show that carbon factor and energy intensity effect decreased the CO_2 reduction potential, whereas energy saving potential ratio effect increased the potential during the study period. This chapter discuss the efficiency improvement priority for CO_2 mitigation from two perspectives: the size of the potential and the transition of each contributory factor to the potential over time.

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