[*PAPER/POSTER TITLE*]
The Path of Green Transformation - The Impact of Fossil Fuel Sur-Charge and ETS in Japan Based on CGE Analysis

[Yayue, Xiao, Graduate School of Economics, Waseda University, Yayue21@akane.waseda.jp]
[Shiro, Takeda, Faculty of Economics, Kyoto Sangyo University, Shiro.takeda@gmail.com]
[T.H. Arimura, Faculty of Political Science and Economics, Waseda University, Arimura@waseda.jp]

Overview

The urgent need to combat climate change has driven global efforts under the Paris Agreement, prompting nations and economies to commit to ambitious emission reduction targets. Achieving these targets necessitates effective economic instruments, such as carbon pricing (CP), which internalizes the external environmental costs of emissions. CP mechanisms, including Emission Trading Schemes (ETS) and carbon taxes, assign costs to carbon emissions, incentivizing cleaner technologies and practices. Despite their theoretical effectiveness, CP implementation faces significant challenges, including potential economic impacts and concerns over increased tax burdens.

In Japan, efforts to introduce a national ETS before 2020 encountered strong industrial opposition. The Japanese government subsequently launched the Green Transformation (GX) initiative in 2020, aimed at transitioning the economy from fossil fuel dependence to green energy. The GX initiative incorporates CP mechanisms, such as ETS and fossil fuel surcharges, aligned with Japan Climate Transition Bonds to fund research and development (R&D) and innovation. By ensuring CP revenues meet bond requirements, this industry-friendly policy minimizes economic burdens and lowers the entry barriers for ETS participation. This study evaluates whether this approach effectively achieves mitigation goal.

Methods

This study employs a Japan Multi-Regional Computable General Equilibrium (CGE) model is used to conduct an ex-ante analysis of the GX policy impacts. The model incorporates 10 Japanese regions and 45 commodities. Electricity production is modeled using four generation technologies: fossil fuel, hydropower, nuclear power, and renewable energy. Three primary factors—labor, capital, and power plant capital—are considered, with labor and capital intersectorally mobile within a region but immobile between regions.

Production functions for non-electricity sectors follow a nested CES structure. At the top level, intermediate inputs and energy-labor-capital inputs are combined following a Leontief structure, implying no substitution between these components. Within energy-labor-capital inputs, substitution is possible between energy and labor-capital inputs.

For electricity generation, each technology has a technology-specific power plant capital. This power plant capital is substitutional for fossil fuel and renewable electricity generation, allowing these technologies to adjust output levels in response to price changes. Conversely, hydropower and nuclear power have fixed power plant capital, which determines their output levels and prevents substitution with other technologies. The model assumes no differentiation in the electricity produced by different generation technologies.

Emissions are linked in fixed proportions to the combustion of specific inputs, including “petroleum products,” “coal products,” “gas and heat,” and “coal, oil, and natural gas.” To align the simulation with the GX initiative, CP levels are internally determined based on revenue constraints. The model incorporates an approach to implement unit tax according to per CO_2 emissions rather than a fixed-rate tax to the price, ensuring consistency with policy requirements.

Policy scenarios are designed to explore the impact of different CP designs, including those targeting all sectors and those focused solely on the electricity sector. Additionally, different levels of technological advancement through R&D investments are incorporated to project future baselines and assess their influence on emissions and economic outcomes.

Results

The analysis reveals that under the benchmark scenario, reducing fossil fuel use in the electricity sector triggers a rebound effect, undermining mitigation efforts. Conversely, integrating R&D investments and energy innovation into CP policies significantly enhances emissions reduction potential. However, the relatively low CP levels required to satisfy revenue constraints limit the overall effectiveness of CP mechanisms.

Conclusions

The analysis reveals that a simple reduction in fossil fuel use within the electricity sector triggers a rebound effect, undermining overall mitigation efforts. Investments in renewable energy choices can help offset this rebound effect, highlighting the need for targeted measures to enhance the effectiveness of CP strategies.

The industry-friendly approach of aligning CP revenues with Climate Transition Bonds effectively lowers barriers to Emission Trading Scheme (ETS) adoption, fostering industry participation. However, this approach results in relatively low CP levels, limiting their ability to significantly reduce emissions and potentially falling short of achieving emissions reduction targets.

This study provides valuable insights into designing climate policies that balance environmental and economic considerations. To ensure meaningful mitigation outcomes, additional measures, such as innovation-driven policies are required. The findings contribute to the development of balanced strategies for achieving ambitious climate targets while minimizing economic disruptions.

References