[Analysis of carbon tax effect on long-term low greenhouse gas emission strategies in Korea]

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Overview

Fifty countries submitted long-term low greenhouse gas emission development strategies (LT-LEDS) to UNFCCC as of 2021 following Article 4(19) of the Paris Agreement. It is important to understand the country's mitigation and macroeconomic effects when the strategies are implemented in this context. This study analyses the effect of the carbon tax on the adoption of LT-LEDS in the Korean manufacturing industry. In particular, the contrasting carbon tax effect between the two models is identified by comparing the stand-alone bottom-up (BU) and hybrid model, which combined BU and top-down (TD) computable general equilibrium (CGE) model. This study helps understand the two models' characteristics and explains emissions reduction options' environmental and economic impacts.

Methods

Energy system models are available tools to analyse carbon tax effects. This study develops eleven bottom-up energy system models for ten emission-intensive industries and the electricity sector. The CGE model describes the Korean economy and incorporates the hydrogen production sector. The main emission reduction options in the study include energy efficiency improvement, electrification, low emission fuels such as renewable energy, using hydrogen in steel-making, and carbon capture and storage(CCS). Carbon taxes linearly increase and achieve levels of KRW 50,000 (USD 41)/ton CO2eq, KRW 500,000 (USD 415)/ton CO2eq and KRW 1,000,000 (USD 830)/ton CO2eq in 2050.

Results

The hybrid model observes output change of the manufacturing sector which affects emissions reduction, technology mix, and costs by contrast to the BU model assumed given output. In the CTAX100 scenario, the manufacturing sector's output will decrease 6% by 2050. Heat and electricity emission coefficients fluctuating with energy prices result in different technology and energy mix in two models. More than KRW 500,000/ton CO2eq carbon tax induces a steep coefficient decline because the electricity sector introduces emissions reduction options. The hybrid model comprehensively interprets carbon tax effects because it observes macroeconomic changes. Although a carbon tax helps adopt CCS and hydrogen-based technologies and reduce emissions, it negatively affects the Korean economy.

Conclusions

This study provides opportunities to comprehensively interpret the results of energy system models by comparing BU and hybrid models. Carbon tax effects on emissions reduction are more prominent in the hybrid model because decreasing output due to carbon tax allows additional emissions reduction. The BU model reduces emissions through new efficient technology adoption, whereas the hybrid model introduces low-emission energy sources. Hydrogen is less dominant in the hybrid model because decreasing output reduces room for new hydrogen-based technology of the steel industry. Since the manufacturing sector includes emission reduction options, its output loss because of the carbon tax is 20% smaller.