Abstract

A Study on Policy Interactions between Cap-and-trade and RPS in the South Korean Power Sector

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International interest in climate change is rising day by day. Greenhouse gases that cause climate change are a representative bad in economics. As with goods, efficient allocation of a bad is achieved through optimization behavior of market participants. However, this condition is met only on the premise that there are no external factors, such as externalities, and in areas where externalities cause market failure, such as climate change, the government can intervene in the market through policies such as regulation to improve social wellbeing.

Climate policies aim to ensure that production of greenhouse gases is determined at the point where social marginal costs and social marginal benefits meet. In reality, however, environmental externalities occur at various levels, and policies to address individual externalities affect each other. With policies to internalize the environmental externalities interacting, it is difficult to maximize social benefits if individual policies only take into account the social marginal costs of each market. Therefore, it is necessary to estimate the exact social marginal costs and benefits through qualitative and quantitative analyses of policy interactions.

As one of these efforts, this study performs an policy interaction analysis that have not been fully considered in the process of establishing environmental and energy policies. Specifically, the interaction of the cap-and-trade and RPS, which are representative policies for coping with climate change applied to the power wholesale sector, is analyzed. The wholesale power sector is suitable for analyzing the interaction of environmental and energy policies in that it is not only a field in which a large amount of greenhouse gases and environmental pollutants is emitted, but also greatly influenced by the government's policies. Although the study does not directly estimate social marginal costs or benefits, the results of the study show that it provides critical evidence for internalization of externalities.

This study first develops an analytical model that describes Korean wholesale power sector. The model consists of the objective function and the constraints. The objective function is described as minimizing the present value of the levelized cost of electricity over the period of 30 years that this study onsiders. Constraints consist of: (1) an equation of motion; (2) a capacity factor restriction; (3) a restriction on external loads; (4) market clearing conditions; (5) a restriction on planning reserve margin; (6) a cap-and-trade policy; (7) a restriction on RPS; (8) a restriction on renewable energy generation; (9) thermal constraints; and (10) a restriction on the exogenous generation capacity. The data used in the analysis were obtained through various sources including the "8th Basic Plan for Power Supply and Demand."

Although the model developed in this study tried to capture the most important characteristics of the Korean power wholesale market, it still has the following limitations and requires attention to the interpretation of the results. First, in this study, the generation levels

of baseloaders such as nuclear and coal may be higher than the real world, as the restriction on the ramping rates is not considered. Second, the cap-and-trade is applied to the overall industry including the power sector, but this study assumes that the cap-and-trade takes place only within the power generation sector. In addition, a power plant may convert its greenhouse gas reduction performance outside of the country into offset credits, which are not considered in the model either. Third, the domestic power wholesale market still has some characteristics of regulated market. It necessitates a way to model some unique components of the market such as adjustment factor and capacity price, but this study does not take this into account. However, it discusses the potential of the model by introducing the strategies necessary to reflect these characteristics in the model.

The model develped in this study is based on linear programming. But once one introduces MCP (Mixed Complementarity Problem) as we discuss in the paper, one can easily incorporate the adjustment factor, capacity prices, endogenous electricity demand, etc.

The results show that the model reflects important aspects of the 8th Basic Plan. In the benchmark, generation capacity is characterized by an increase in solar and wind, a decrease in nuclear and a slight increase in LNG. For generation by technology, the pattern is similar to the generation capacity, which is summarized as reduction of the share of coal, nuclear, oil generation, increase in solar, wind power and other renewable energy, and stable trends of LNG and pump.

Simulation based on four scenarios, including the standard balance, reveals that in the NOCAT scenario, coal power generation was increased while LNG and solar were reduced. In the NORPS scenario, where RPS constraint is removed, the proportion of coal and wind has decreased somewhat and the LNG has increased. And in the NOPOL

scenario, where neither policy exists, the share of solar, wind and other renewable generation has been greatly reduced, and it has been filled by coal power generation, the cheapest of the power sources. Electricity prices, greenhouse gas emissions and greenhouse gas production units are significantly affected by the ratio of coal power generation.

Based on the results of the scenario analysis, we calculate the extent to which policy interactions affect GHG emissions as well as renewable generation. Cap-and-trade has a greater impact on the reduction of GHG emissions in the power generation sector, and the interaction between the RPS and the cap-and-trade results in 755 MMTCO2E less GHG reductions. RPS is a more effective policy when it comes to promoting renewable generation. The policy interaction leads to a reduction in renewable energy generation by about 70 GW.

The price of emission permit increases about 30 percent when the RPS was not implemented. This can be interpreted as the result of increasing the amount of renewable energy generation for the RPS policy, which helped power generation businesses comply with cap-and-trade. REC prices are more affected by cap-and-trade. In scenarios without the cap-and-trade, REC prices are about four times higher than BMK's.

The results of the empirical analyses carried out in this study provide important policy implications. First of all, the results of the analysis can provide strategies for responding to the policy challenges facing Korea's power generation industry. The power generation industry is facing policy challenges as a major source of greenhouse gases in South Korea. The "Revisions to Roadmap to Reduce Greenhouse Gases" issued in July 2018 confirmed a reduction of about 24 million tons in the transition (power generation, collective energy) sector, but did not provide specific reduction plans for about

34 million tons. In other words, by 2030 the power generation industry will have to achieve a significant amount of additional greenhouse gas reductions.

The simulation analysis shows that cap-and-trade is more effective than the RPS to reduce greenhouse gas emissions. Therefore, it is inevitable to strengthen cap-and-trade for a large amount of additional cuts of 34 million tons. To this end, the strategies that the power generation industry can take include as follows:

First, it is necessary to establish low-carbon generation mix in the power generation industry. By expanding the use of high-calorie coal, we can expect to reduce greenhouse gas emissions by consuming fewer coal to produce the same amount of electricity. In addition, efforts are needed to replace coal power plants and build high-efficiency LNG power plants in the process to protect the power generation industry from an increase in fuel costs. Second, since the government is consistently pushing for the expansion of the supply of renewable energy, expansion of renewable energy can also be a major strategy. Third, securing offset emission rights by expanding domestic and international reduction projects is considered a valid strategy, and finally, expanding the use of CCUS technology can be considered.

Environmental and energy policy implications from a more general perspective derived from the results of this study are as follows: First, cap-and-trade and RPS are well realized in the power generation sector. However, since interaction analysis has shown that it is inefficient to implement multiple policies with similar objectives, it would be appropriate to pursue a few of the most efficient policies to achieve the goal. Second, cap-and-trade and the RPS are affecting each other to lower emission prices and REC prices. The drop in emission permit prices could lower incentives for companies to cut

greenhouse gas emissions through innovation, so future work needs to be done to more accurately estimate the impact of interaction on social wellbeing through a welfare analysis using a general equilibrium model.

The model developed in this study can help identify the differences in social welfare between regulated and deregulated Korean power wholesale sector. It can also provide a framework for quantitative analysis of the effects of various policies pursued for the dissemination of renewable energy. Further, the modeling endogenous electricity demand will allow one to analyze the impact of various environmental and energy policies on the manufacturing industry through the channel of changes in electricity prices.