When and Under What Conditions Does an Emission Trading Scheme Become Cost Effective?

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Finding the path for achieving the carbon neutral commitment with the lowest costs has become a significant challenge around the world. As a market-driven instrument, an emission trading scheme (ETS) is believed to relieve energy and environmental stress in a more cost-effective way. However, much less attention has focused on the cost dynamics attributed to ETS-induced efficiency changes. Power generation enterprises are expected to take the lead in carbon reduction efforts. Understanding the cost implications of the ETS pilot projects is important for addressing the financial stress of power plants and helping them to maintain a sustainable electricity supply while optimizing the economic costs of the carbon policy in general.

Our research question is twofold: when does the ETS affect the production cost and the associated cost efficiency of the thermal power plants, and are these effects different across the pilot provinces if the localized conditions vary? Based on unique plant-level panel data during 2006-2017 and the difference-in-differences strategy, we illustrate that the plants in the pilot provinces experienced an insignificant increase in total costs relative to the non-pilot plants during the announcement stage. When the pilot policy entered into force after 2013, we found a significant reduction in production costs for the treated group. We observed similar results for cost efficiency, as there was an insignificant downward adjustment of cost efficiency for the pilot power plants in the announcement stage but a significant increase in cost efficiency when the policy was formally implemented. It implies that the ETS announcement encouraged them to undertake actions to prepare for the change, and when the implementation stage starts officially, the plants are well prepared to cut emissions more cost-efficiently.

We address several challenges that may affect the validity of our results. First, we construct an event-study model to test and confirm the parallel trend trend before the shocks. Second, we employ the propensity score matching (PSM) before the DID estimation to address the potential endogeneity which may arise if the ETS pilot provinces were not randomly selected. Third, we considered other confounding policies, such as the SO_2 pilot policy and provincial CO_2 emission reduction targets in 12th and 13th Five-Year Plan. Fourth, we apply the Tobit model to address the data truncation for cost efficiency. All of these checks confirmed the robustness of our results.

We then uncover the condition through which power plants in one pilot province differ from those in other pilot provinces. Our results illustrate that the treatment effects of the ETS differed across pilot provinces. We found that localized conditions of a higher degree of marketization, stricter policy enforcement, and lower carbon dependence could expand ETS benefits. Therefore, the effectiveness of the ETS depends also on the external forces being exerted where the plant is located. An appropriate design of the ETS policy should consider these external factors to smooth the barriers that may mute the efficacy of the policy.

Finally, we employ the synthetic control method and quantify the cost savings attributed to the ETS. As the underlying effects of the ETS depend on the localized conditions, we estimate

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the effects by regions. The synthetic control results show that the carbon trading pilots resulted in improved efficiency in power plants in Shanghai, Guangdong, and Tianjin during the period 2013–2017, with an associated total cost saving of approximately 29.75 million RMB, accounting for 29.94% of the total cost in 2017. However, the effects are invisible for thermal power plants in Chongqing and Hubei.

Overall, this study makes several contributions. First, it adds to the discussion on the price versus quantity policy instrument for promoting carbon mitigation and a low-carbon economy. Our results shed light on the cost-effective advantage of a carbon ETS by proving the significant role of carbon trading in enhancing the cost efficiency of thermal power plants. This also provides a promising solution for the survival of thermal power plants. Second, it enhances our understanding of the policy process on regulating carbon mitigation in the policy-making stage framework by demonstrating firms' manifestations towards different policy stages (announcement and formal implementation stages). Finally, it also adds to the literature on the effectiveness of the ETS in different localized circumstances by highlighting the conditions that could effectively expand the benefits of the ETS for the cost performance of thermal power enterprises. Our findings therefore provide the theoretical inspiration for accelerating the carbon reduction process.