The Effects of Multi-Target Policy on Green Productivity: Evidence from China's Fossil Fuel Power Plants

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In China, command-and-control regulatory constraints are effective policy tools to deal with environmental deterioration. However, driven by mandatory national targets, the adoption of the "one-size-fits-all" discontinuation and "campaign-style" mitigation has unintentionally triggered electricity restrictions and shortages, so the prospects are not promising. Improving green productivity is an effective solution to this dilemma, which maximizes outputs (e.g., electricity) while minimizing energy consumption and emissions (or other inputs) simultaneously. Therefore, examining the effect of environmental governance on green productivity of power plants is a significant strategic guide to advancing China's high-quality development.

This paper addresses two critical questions: firstly, which quality increase in production factors is driving green productivity? secondly, how do regulatory constraints (the 12th Five-Year Plan) affect green productivity, and through which channels? Based on unique plant-level panel data from 2005 to 2015, we use the non-parametric data envelopment analysis (DEA) method and difference-in-differences (DID) strategy to carry out our empirical research. Between 2005 and 2015, green productivity increased by an average of 0.95% per year, driven by the increase in technology leadership effects and generation efficiency. During the 12th Five-Year Plan period, the multi-targets, including energy-saving targets and SO_2 reduction targets, have contributed to green productivity growth. Specifically, a 1% increase in the average energy-saving target cumulatively increases green productivity by 0.50%, while a 1% increase in the average SO_2 reduction target cumulatively decreases that by 0.03%. In all channels of effects, the technology leadership effects and generation efficiency exhibit more sensitively. Differential effects of the multi-targets on state-owned versus non-state-owned plants reveal significant differences in observed production technology.

We overcome potential threats that affect the validity of our results. First, we develop a unified framework for green productivity measures, which addresses common issues in classical productivity indexes such as technology heterogeneity, slack variables, and linear programming infeasibility. Second, we control for pre-determined variables before estimating the DID method to address the potential endogeneity arising from the non-randomness of the constrained targets. Third, we exclude other confounding policies (e.g., carbon emissions trading scheme) or targets (e.g., CO_2 reduction targets). All of these checks confirmed the accuracy and robustness of our results.

The main contributions of our study are threefold. First, we propose a novel productivity index that complements the discussion on green productivity estimation in efficiency and productivity analysis. Our results also demonstrate that the omission of some potential threats can cause biased green productivity estimates. Second, we provide a complete decomposition of green productivity growth, thus opening up the "black-box" of productivity change. We are the first to fill the

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gap in productivity decomposition in China from a factor perspective. Third, we estimate the causal effects of multi-targets in the 12th Five-Year Plan on green productivity encompassing all channels of effects, identifying the effectiveness of different constrained targets in broad-based environmental governance. Our findings therefore provide the theoretical inspiration for balancing environmental governance and economic high-quality development.