*ECONOMICALLY, DO ENVIRONMENTALLY REGULATED FIRMS PERFORM WORSE?: EVIDENCE FROM THE GERMAN MANUFACTURING SECTOR**

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Overview

A persistent concern in the literature on climate policy is that the emissions abatement, achieved through environmental regulation, in turn potentially adversely affects firms' economic performance. I investigate these issues in the context of the European Union Emissions Trading Scheme (EU ETS) and the German manufacturing sector based on twelve years of firm-level German production census data ("AFiD"), collected by the German Federal Statistical Office and the Statistical Offices of the German Federal States. The participation in the census is mandatory by law, and it includes all manufacturing firms with more than 20 employees. The longitudinal data is confidential and only accessible for scientific purposes and official government statistics.

The interplay between the EU ETS and the economic performance of regulated firms becomes apparent through various possibilities of complying with the regulation. Namely, a firm may surrender allowances to legitimate its emissions or sell the surplus on the market, in any case, there are opportunity costs of emissions. The firm can also abate emissions through the change in input choice (e.g. fuel switch) or adjust its production process (e.g. investment in energy efficiency, reduction of fuel usage). Alternatively, firms may develop less emission-intensive products or reduce their output. It is clear that all of the compliance options will either demand an investment, reduce revenues or increase costs for firms. Unfortunately, empirical evidence on this is scarce, which is why researchers have argued, that a better understanding of the relationship between the economic performance and the EU ETS is needed, not just to improve this specific climate policy but also other emerging cap-and-trade systems around the world.

This study is one response to this need. As a measure of economic performance, I estimate firm-level cost efficiency and its determinants. The vast heterogeneity of the German manufacturing sector requires a separate cost frontier estimation for narrowly defined industries, by means of the Stochastic Cost Frontier Analysis (SFA). In order to directly compare cost efficiency across industries and treatment groups (EU ETS and non-EU ETS firms), I employ Meta Frontier Analysis (MFA). The latter allows me to investigate cost efficiency in a dynamic, long-run setting and search for evidence of induced innovation of EU ETS firms, in line with the widely-known Porter Hypothesis. In a cost-minimizing framework, input allocation is optimal, if producers allocate inputs such that input price ratios equal ratio of their marginal products. In that case, actual cost differs from the optimal cost by the technical efficiency. If, however, the input allocation is sub-optimal, the cost will be higher due to both technical and allocative inefficiency. I use the Primal System Approach (PSA) to evaluate the impact of both sources of inefficiency on costs, through the decomposition of the cost efficiency. This means that in addition to examining whether, and by how much, a firm can reduce its costs, I identify how much of this cost reduction can be achieved through improvements in production technology and how much through an optimal mix of inputs. In order to provide causal impact evidence of the EU ETS on the cost efficiency of treated firms, I employ a Difference-in-Differences (DD) framework. Finally, I explore potential endogeneity issues in my SFA model.

The paper is structured as follows. After the introduction, in Section 2, some background to the EU ETS is provided. In Section 3, I describe the methodology used and outline my empirical strategy. Section 4 describes the German production census and additional data used. The results of my analysis are shown in Section 5. In Section 6, I conclude with a discussion.

Methods

Stochastic Frontier Analysis, Meta Frontier Analysis, Primal System Approach, Differences-in-Differences.

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Results

First, there is still potential to increase cost efficiency in most industries of the German manufacturing sector.

Second, the analysis of the cost efficiency drivers confirms that in most industries exporting firms are more cost-efficient than their counterparts. In contrast, innovating firms and firms, which are regulated by the EU ETS, are found to be less cost-efficient than non-regulated firms.

Third, meta-stochastic frontier analysis is successfully applied to enable direct comparisons of cost efficiency scores between different industries of the German manufacturing sector, and between differently regulated groups of firms (EU ETS firms and non-regulated firms) within a subsample of industries.

Fourth, a subsample DD analysis confirms that the EU ETS had no significant effect on the cost efficiency of treated firms.

Fifth, allocative inefficiency represents a much smaller source of higher costs than technical inefficiency in most of the narrowly defined industries of the German manufacturing sector.

Conclusions

This study is, to the best of my knowledge, the first comprehensive and systematic analysis of the relationship between firm-level cost efficiency and environmental regulation, comprising various methodologies that provide evidence on correlations, as well as causal impacts. My results suggest that there is potential to increase cost efficiency in all analysed industries of the German manufacturing sector, although cost efficiency scores are in general relatively high. The variety in the cost efficiency scores at the industry level reflects the heterogeneity of the German manufacturing sector and reiterates the need for meta-frontier analysis to facilitate the direct comparison of scores between industries. Furthermore, I show that heterogeneity persists also regarding the influence of the analysed drivers of cost efficiency. Exporting firms are in general more cost-efficient than non-exporting firms. Thus, I show that this measure is positively correlated to higher cost efficiency in almost all industries. While the analysis of cost efficiency drivers would suggest that EU ETS regulates less cost efficient firms, and/or that the price signal materialized in various ways across industries and types of firms, the DD analysis conclusively shows that the EU ETS did not significantly affect the cost efficiency of treated firms. My results are robust when using stochastic frontier models that account for potential endogeneity bias (simultaneity). The decomposition of cost efficiency revealed that technical inefficiency is the major source of extra cost in most industries, thus the time-varying cost efficiency might be increased by optimizing production processes through technological change (innovation). The recently introduced Innovation Fund in the EU ETS is, therefore, policy-wise, a step in the right direction.