DISTRIBUTED GENERATION AND COST EFFICIENCY OF GERMAN ELECTRICITY DISTRIBUTION NETWORK OPERATORS

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Overview

In this paper, we use a comprehensive and unique data set of financial, technical and structural characteristics of German distribution network operators from 2011 to 2017 to estimate both the transient and persistent cost efficiency of German distribution network operators. In addition, we analyze the effect of an increasing capacity of distributed generation from renewable energy sources on the total costs of distribution network operators. Our results indicate an average cost reduction potential of approximately 12 percent in the short term and approximately 18 percent in the long term for German electricity distribution network operators. Furthermore, we find that distributed generation from renewable energy sources is a significant cost driver in the production process of network operators. Our study thus contributes to the ongoing debate on incentive regulation and efficiency benchmarking in electricity distribution industries and provides valuable insights for policymakers and regulators.

Methods

We employ state-of-the-art stochastic frontier panel data models to investigate the influence of different model specifications on the estimated individual cost efficiency targets of a large number of German electricity distribution network operators. In particular, we focus on the performance of recently developed SFA models that account for both transient and persistent inefficiency (Colombi et al., 2014; Tsionas and Kumbhakar, 2014; Filippini and Greene, 2016), as opposed to the widely used conventional SFA models that focus only on one source of inefficiency.

A distinction between transient and persistent inefficiency is important for regulatory purposes, as policy implications for improving persistent and transient efficiency are different. Transient inefficiency, for example induced by short-term managerial misbehavior, could be addressed relatively easily by implementing appropriate incentives in the existing regulatory framework. In contrast, persistent inefficiencies indicate structural problems that may require a general adjustment of the regulatory approach (Kumbhakar and Lien, 2017; Filippini et al., 2018).

In this paper, we use a unique and comprehensive panel data set of the financial, technical and structural characteristics of German distribution network operators from 2011 to 2017 that allows us to estimate both persistent and transient cost efficiency for a large segment of German electricity distribution network operators. Such an analysis is particularly interesting for two reasons: First, with around 900 electricity distribution network operators, Germany has a high number of heterogeneous network operators. Second, over the last two decades, there has been a significant and dynamic increase in distributed generation from renewable energy sources. As the major share of distributed generation is connected to the distribution network and given that network operators are legally obliged to connect and preferably dispatch distributed generation, it is likely that they will be financially affected by an increase of distributed generation. In the short term, the stochastic nature of decentralized generation makes it difficult to ensure safe and reliable grid operation, which increases the need for active intervention by the operator. In the long term, network expansion, modernization and innovation are essential.

In this context, our study is the first to use a large panel data set to analyze the impact of a large amount of distributed generation from renewable energy sources on the total costs of German electricity distribution network operators. Second, we analyze how different model specifications in terms of assumptions regarding the underlying functional form and the sources of inefficiency influence the estimated cost function parameters and both transient and persistent cost efficiency estimates. As electricity generation from renewable energy sources is increasing worldwide and electricity network regulation is becoming increasingly complex, our results are of high interest for not only German policy makers but also electricity network regulators globally.

Results

Our results indicate an average cost reduction potential of about 12 percent in the short term and about 18 percent in the long term when both sources of inefficiency are accounted forin a single model. These results are robust to the choice of a Cobb-Douglas or translog functional form. However, the comparison with econometric models that account for either only transient or only persistent efficiency shows significant differences in terms of efficiency

estimates and suggests that ignoring one or the other source of inefficiency can lead to false efficiency targets in incentive regulation. In accordance with Filippini et al. (2018) and Kumbhakar et al. (2020), we therefore conclude that the German regulator should consider both transient and persistent cost efficiency in its regulatory approach and use different measures to address inefficiencies resulting from both short-term management mistakes and from long-term structural problems.

Due to the significant and dynamic increase in decentralized generation from renewable energy sources in Germany over the last two decades, we were also interested in the effects of an increasing capacity of distributed generation on the total costs of distribution network operators. As expected, we find that distributed generation is a significant cost driver in the production process of German electricity distribution network operators. Our results indicate that a 10 percent increase in distributed generation capacity leads to a total costs increase of about 1.6 to 2.3 percent. In terms of cost efficiency, however, we did not find any significant differences among network operators with high and low installed distributed generation capacity in transient efficiency. These results indicate that distributed generation has no impact on cost efficiency, at least in Germany. However, it is important, particularly in contexts with a high share of distributed generation, to take distributed generation into account in the cost function and thus in the regulatory approach.

Conclusions

We conclude that the distinction between transient and persistent efficiency is highly relevant for German electricity distribution companies. Transient and persistent inefficiency have different causes and different policy implications in terms of improving efficiency. Furthermore, generally speaking, regulatory approaches globally and not just in Germany should be constantly adapted to novel circumstances, such as the increasing expansion of renewable energies. Electricity distribution network operators worldwide are facing major challenges in transforming power supply systems towards a sustainable energy supply. Not only on the generation side, the increase in the use of new technologies will necessarily lead to adjustments and thus to different cost structures. Increased electric mobility or the use of heat pumps and electricity storage systems will also have an impact. Such future developments must be taken into account in further research and regulation and thus also in the efficiency comparison of electricity distribution network operators.

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