



## **Does environmental heterogeneity affect the productive efficiency of grid utilities in China?**

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In recent years efficiency analysis has been widely used in designing reforms and benchmarking the performance of grid utilities. China implemented the unbundling reform of separating power plants from grids in 2002 with the aim of improving the service quality and promoting competition. This study has adopted alternative stochastic frontier models to investigate the impact of observed heterogeneity, in terms of weather and geographic factors, and unobserved heterogeneity on the performance of grid utilities before and after the unbundling reform. We do this using provincial data on the performance of 29 of China's transmission and distribution systems over the period 1993–2014.

Both the observed and unobserved environmental heterogeneities need to be taken into account in measuring the efficiency of the grid industry. We first apply the conventional Battese and Coelli (1995) and true random effects (TRE) models, which capture observed and unobserved heterogeneity, respectively. By combining these two features, two additional models (labelled as TREH1 and TREH2) are estimated with different assumptions about the inefficiency term. In another version of the extended model – generalized true random effects (GTRE) – the inefficiency consists of two parts: time-varying and time-invariant parts. These results indicate that the estimated efficiencies are sensitive to model specification, and the models considering both observed and unobserved heterogeneity (TREH1 and TREH2) have a larger divergence than the others. The efficiency rank orders are quite different among the different models; thus, an efficiency-based regulation scheme should consider the role of benchmarking carefully. The lack of convergence in efficiency illustrates the necessity of taking firm-specific heterogeneity into consideration.



In addition, whatever model is selected, the number of customers and the network length are demonstrated to have positive impacts on the utilities' efficiency, and the effects of these two factors and power delivered is also positive. This is because the marginal inputs required to support the growth of customers, the extension of the network are limited, and economies of scale exist in China's grid industry. In general, regardless of whether observed or unobserved heterogeneity is included or not, the results from the alternative models all indicate the existence of economies of scale. This may be explained by the industry's natural monopoly, which calls for sustained public intervention and incentive-based monopoly regulation. As a result, further unbundling reform to introduce competitiveness and adjust the firms to proper scale will be a long-term project for the grid industry. Though we note that our sample bundles transmission and distribution, which may have different optimal scales (e.g. larger for transmission than distribution). It also ignores lower voltages which may also have a different – smaller - optimal scale. The results also indicate that adverse weather and geographic conditions are indeed obstacles to be overcome on the path towards the efficient operation of China's grid utilities.

Finally, we suggest that there is still room to improve China's grid system's relative performance, and more management effort and more effective policies should be put into practice to address apparent provincial under-performance. With regard to the unbundling reform of 2002, this study has found no evidence of significant improvements in efficiency (though we do not focus on the different but related issue of general productivity effects), although large differences in efficiency have been found among companies. The differences may have arisen because of the drive to meet investment targets and demand requirements and/or from China's strong intervention in the grid industry. Our in-depth analysis of the regional efficiency differences shows that the Northeast and Northwest China Power Grids show higher efficiencies, but the China Southern Power Grid witnesses a significant decrease after the unbundling reform. Thus, the independently operating China Southern Power Grid Corporation needs to consider the reasons behind its relative decline in performance since 2002. One of the practical ways is to implement regional specific policy reforms or pilot projects in a few provinces, so that lessons for national policy can be learned and regulatory decisions can be made more scientifically.

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