# *Will the tariff reform bridge cost efficiency gap between state branch and local grid firms ?*

Bai-Chen Xie, Tianjin University, Phone: +86-13312188917, E-mail: xiebaichen@tju.edu.cn
Tao Zhang*, Tianjin University, Phone: +86-16622808148, E-mail: zhangtaocome@tju.edu.cn
Yong-Heng Shi, Tianjin University, Phone: +86-16622537608, E-mail: shiyongheng@tju.edu.cn

## Overview

A lot of researches have proved that forwarding market-oriented reform is an effective approach to meet the objectives of decarbonisation, energy supply security and renewable energy development. The regulators have impacted the network cost efficiency by introducing tariffs and increasing confidence to reform process. Research on reforms in the electricity sector attracted more attention than any others as it is a typical sector facing institutional environment changes. Most of the literature devoted to exploring the impact of reform on the efficiency of electric utilities from a national perspective. However, the discrepancies among either regions or firms in reform effect may also shed light on efficiency changes, which provide an opportunity to investigate the impact of tariff reform on grid firms' cost efficiency.

A country as vast as China results in potential environmental heterogeneities among power grid firms, especially between state branch and local firms, which affects the effect of tariff reform and cost efficiency of grid firms. This study constructs a theoretical model to demonstrate the relationship between China's tariff reform and cost efficiency of grid firms, which is the first effort to use the data of 42 state branch and local grid firms in China from 2010 to 2019 for empirical research. The results are of great significance to schedule the grid sector development and to forward scientific reform policies.

## Methods

The research on cost efficiency of grid firms often proves the effect of the reform empirically, without illustrating the effect of tariff reform and the underlying mechanism. It is a matter of determining whether the reforms have similar effects for different types of grid firms, and whether it can improve the efficiency of underperformed firms. We develop a theoretical model in order to obtain some answers. It's main hypotheses and results are based on the cost efficiency of state branch and local grid firms in the early stage of reform and the regulation cycle of tariff prices.

In most empirical studies, cost efficiency is frequently measured by either nonparametric (i.e., data envelopment analysis, or DEA) or parametric methods (i.e., stochastic frontier analysis, or SFA). However, DEA takes no account of statistical noise, whereas SFA is more flexible and can eliminate the influence of statistical noise in benchmark analysis. SFA is suitable for dealing with heterogeneity because it can decompose random items. Although several SFA models can separate firm heterogeneity from time-varying inefficiency, they do not consider persistent inefficiency. To overcome these limitations of models, this study constructs a four component SFA model to estimate the potential heterogeneity, time-varying inefficiency, time-invariant inefficiency and uncontrollable random noise of firms. This paper estimates the cost function by a Cobb-Douglas function and a translogarithmic function separately that can be expressed as follows:

$$\ln cost_{Kit} = \alpha_0 + \sum_{m=1}^{M} \alpha_m \ln y_{mit} + \sum_{k=1}^{K} \beta_k \ln x_{kit} + \theta_t t + \mu_i + \eta_i + v_{it} + u_{it},$$

$$\ln cost_{Kit} = \alpha_0 + \sum_{m=1}^{M} \alpha_m \ln y_{mit} + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{N} \alpha_{mn} \ln y_{mit} \ln y_{nit} + \sum_{k=1}^{K} \beta_k \ln x_{kit} + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \beta_{kl} \ln x_{kit} \ln x_{lit}$$
$$+ \sum_{k=1}^{K}\sum_{m=1}^{M} \gamma_{km} \ln x_{kit} \ln y_{mit} + \theta_t t + \frac{1}{2}\theta_{tt} t^2 + \sum_{k=1}^{K} \lambda_k \ln x_{kit} t + \sum_{m=1}^{M} \varphi_m \ln y_{mit} t + \mu_i + \eta_i + v_{it} + u_{it},$$

$$\text{where } \mu_i \sim N\left(0, \sigma_\mu^2\right),$$
$$\eta_i \sim N^+\left(\delta_\eta^0 + z_i^{'}\delta_\eta, \sigma_\eta^2\right),$$
$$v_{it} \sim N\left(0, \sigma_v^2\right),$$
$$u_{it} \sim N^+\left(\delta_u^0 + z_{it}^{'}\delta_u, \sigma_u^2\right).$$

where $\alpha$, $\beta$, $\psi$, $\varphi$, $\theta$, and $\eta$ are the parameters to be estimated and $x$ is the input producing the output ($y$). $\eta_i$ and $u_{it}$ are time-invariant and time-varying inefficiency. $\mu_i$ and $v_{it}$ are firms' potential heterogeneity and random noise, respectively.

## Results

It is possible to identify excessive investment under current tariff reforms by analysing the theory and statistical differences among grid firms. State branch firms have stronger incentives to over-invest assets in the early stage of reform, which intend to acquire a profitable tariff price by increasing costs.

In general, cost efficiency of grid firms improves significantly over the study period, and the tariff reform has a significant positive impact on cost efficiency. However, the effect of the reform is heterogeneous across state branch and local grid firms. At the beginning of the reform, the efficiency growth of state branch grid firms slowed down, while that of local grid firms sped up on the contrary. This resulted to a brief narrowing of the cost efficiency gap between state branch and local grid firms. But the gap still tended to widen along with the advancement of reform.

Cost efficiency is also related to economic development, geographical environment and weather of the region where the grid firm is located. We detected differences of grid firms' efficiency between the basic SFA and the transient-persistent SFA models by way of including exogenous factors. Heterogeneity factors affect not only time-invariant inefficiency but also time-varying inefficiency.

## Conclusions

The cost efficiency estimates fundamentally differ among grid firms due to the variety in tariff reforms, economic development and types of businesses as well as weather heterogeneity and geography, thus motivating us to study the cost efficiency of grid firms in China.

The different effect of tariff reforms for state branch and local grid firms offers a good theoretical and empirical evidence to justify the importance of reform adapting to circumstances and help improve tariff regulation to alleviate the distortion of resource allocation. Tariff reform policies need to take into account allowed costs plus reasonable returns under the flexible regulation in order to promote the development of state branch and local grid firms. The motivation of local grid firms is to serve remote customers in the early stage of establishment which leads to natural gap between state branch and local grid firms. The tariff pricing mechanism under the flexible regulation can help local grid firms rationalize the part of reasonable cost which cannot be included in the tariff price compared with the state branch grid firms. And it is conducive to optimize the resource allocation of state branch grid firms that allowed costs plus reasonable returns are fine-tuned to suit the regulation cycle of tariff prices. Balanced reform policies contribute to the coordinated development of state branch and local grid firms, so as to improve the cost efficiency of the power grid sector.

## References


Abate, A.G., Riccardi, R. and Ruiz, C. (2021). "Contracts in electricity markets under EU ETS: A stochastic programming approach." *Energy Economics* 99: 105309.

Anaya, K.L. and Pollitt, M.G. (2017). "Using stochastic frontier analysis to measure the impact of weather on the efficiency of electricity distribution businesses in developing economies." *European Journal of Operational Research* 263 (3): 1078-1094.

Arocena, P., Kühn, K.-U. and Regibeau, P. (1999). "Regulatory reform in the Spanish electricity industry: a missed opportunity for competition." *Energy Policy* 27 (7): 387-399.

Averch, H. and Johnson, L.L. (1962). "Behavior of the firm under regulatory constraint." *The American Economic Review* 52 (5): 1052-1069.

Kumbhakar, S.C., Lien, G. and Hardaker, J.B. (2014). "Technical efficiency in competing panel data models: a study of Norwegian grain farming." *Journal of Productivity Analysis* 41 (2): 321-337.

Li, H.-Z., Kopsakangas-Savolainen, M., Xiao, X.-Z. and Lau, S.-Y. (2017). "Have regulatory reforms improved the efficiency levels of the Japanese electricity distribution sector? A cost metafrontier-based analysis." *Energy Policy* 108: 606-616.

Liu, X.-Y., Pollitt, M.G., Xie, B.-C. and Liu, L.-Q. (2019). "Does environmental heterogeneity affect the productive efficiency of grid utilities in China?" *Energy Economics* 83: 333-344.

Orea, L., Álvarez, I.C. and Jamasb, T. (2018). "A spatial stochastic frontier model with omitted variables: Electricity distribution in Norway." *The Energy Journal* 39 (3): 93-116.

Sen, A., Nepal, R. and Jamasb, T. (2018). "Have model, will reform: Assessing the outcomes of electricity reforms in non-OECD Asia." *The Energy Journal* 39 (4): 181-209.

Zheng, X., Menezes, F. and Nepal, R. (2021). "In between the state and the market: An empirical assessment of the early achievements of China's 2015 electricity reform." *Energy Economics* 93: 105003.