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The effect of regulatory governance on efficiency of thermal power generation in India: A stochastic frontier analysis

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HIGHLIGHTS

- The impact of regulatory governance on Indian generation efficiency is investigated.
- Stochastic frontier analysis (SFA) on a panel dataset covering pre and post reform era.
- Index of state-wise variation in regulation to explain inefficiency effects.
- Results show improved but not very high technical efficiencies.
- State-level regulation has positively impacted power plant performance.

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ABSTRACT

This paper investigates the impact of institutional quality – typified as regulatory governance – on the performance of thermal power plants in India. The Indian power sector was reformed in the early 1990s. However, reforms are effective only as much as the regulators are committed in ensuring that they are implemented. We hypothesize that higher the quality of regulation in a federal Indian state, higher is the efficiency of electric generation utilities. A translog stochastic frontier model is estimated using index of state-level independent regulation as one of the determinants of inefficiency. The dataset comprises a panel of 77 coal-based thermal power plants during the reform period covering over 70% of installed electricity generation capacity. The mean technical efficiency of 76.7% indicates there is wide scope for efficiency improvement in the sector. Results are robust to various model specifications and show that state-level regulators have positively impacted plant performance. Technical efficiency is sensitive to both unbundling of state utilities, and regulatory experience. The policy implication is that further reforms which empower independent regulators will have far reaching impacts on power sector performance.

1. Introduction

The impact of regulatory reforms on utility level efficiency in developing countries remains under investigated. One probable reason is that in several of these countries reforms have been enacted in piecemeal manner (Erdogdu, 2013), thereby testing for their effectiveness is inconclusive. Still a key inference from the process of reforms in these countries is that reforms are effective only as much as the regulators are effective in ensuring that they are implemented, which is about how committed they are (Dubash, 2008). This is an institutional issue and in recent times there has been an increasing interest on, and acceptance of, the role of institutional quality in determining the performance in the utilities sector (Cubbin and Stern, 2006; Erdogdu, 2013). While the earlier emphasis of the regulatory literature has been on incentives (Loeb and Magat, 1979; Laffont and Tirole, 1993), the new institutional economics is concerned with governance (Spiller and Tommasi, 2005). In distinguishing between incentives and governance, Levy and Spiller (1994) refer to *incentives* as the rules related to utility pricing, subsidies etc. and *governance* as the ways in which high credible commitments are generated. Unless there is a commitment against expropriation of rents, investments in high asset-specific electricity infrastructure does not take place (Ghosh and Kathuria, 2015). In liberalized electricity sectors this role of credible commitments is delegated to independent regulators. It is therefore important that the role of regulators in performance enhancement be tested empirically.

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India is a perfect laboratory for such analysis since it has a federal structure with all the states having some flexibility and individual responsibility for electricity reforms (Sen and Jamasb, 2010). In India a system of independent regulation in power sector began in 1998 with the passage of Electricity Regulatory Commissions Act, 1998. The Act resulted in constitution of the Central Electricity Regulatory Commission (CERC) which lays down the major guidelines and has jurisdiction over both-centrally-owned utilities and inter-state transmission and trade issues. Additionally, each federal state was mandated to have its own regulatory authority known as State Electricity Regulatory Commissions (SERCs) with regulatory oversight at the state-level. The establishment of independent regulation was followed by another set of regulatory reforms in the form of the Electricity Act, 2003 (Bhattacharya, 2005). Thus, compared to the regulated pre-reform era of 1990s by the middle of the decade of 2000s the institutional foundations for a liberalized power sector were clearly laid down. Some of the key changes brought in were the de-licensing of thermal generation and captive production allowing for private participation, license-free generation and distribution in rural areas, non-discriminatory open-access in transmission, a road-map for open access in distribution, provision for power trading and setting up of multi-year tariff principles (Singh, 2006). These were meant to usher in favorable environment for a competitive market and induce power plants to operate at higher efficiency levels. Additionally there were special measures to ensure that there is competition in the generation segment. Private investors were assured a fair rate-of-return and states were advised to unbundle their electricity boards into separate generation, transmission and distribution functions within the electricity supply chain (Dubash and Rao, 2008). There were clear regulatory guidelines instituted to compensate power plants based on their scheduled generation and operating heat rate. Provisions were made to compensate for the fixed costs (like interest on loans and return on equity) based on plant availability [2](load factor). On the input side, tariffs on coal imports were also reduced (Chikkatur et al., 2007; Malik et al., 2011).

However, there is no conclusive evidence so far to suggest that regulators have been successful in implementing these regulatory changes thereby impacting the performance of the power sector. This paper fills the gap by investigating the impact of regulators on the technical efficiency of thermal power plants (which is almost entirely coal-based) in India.[3] We estimate a single stage inefficiency effects model, which accounts for both the technical change and time-varying inefficiency effects in a single equation and avoids the problem of inconsistency often encountered in the two-stage approach (Battese and Coelli, 1995; See and Coelli, 2012). Dynamic technical efficiency is calculated using a stochastic frontier method for a panel of 77 coal-based power plants in India for the period 1994–95 to 2010–11. An index of state-level regulation is computed to be then used as a variable explaining the thermal power plant's inefficiency. The index captures governance and is an aggregation of sub-indexes like tariff setting, transmission and distributions gains, age of regulatory commission, unbundling and regulatory commission composition. It covers 11 year period from 2000–01 to 2010–11 and is constructed for 14 major Indian states. It is hypothesized that the efficiency level of a generation utility in a state is positively impacted by the quality of regulation in that federal state.

The paper improves on existing literature in several ways: first, an index of state-level regulation is constructed which helps measure the impact of how regulators govern the sector. The index includes institutional aspects which have been often neglected in the literature dealing with utility level performance. The use of the index also reflects a sense of reality in terms of the relative policy importance of the indicators and facilitates a sensitivity analysis. Second, the study covers the period from 2000 to 01 onwards when regulatory reforms were initiated in India and regulatory agencies were established. This gives the advantage of using federal state level regulatory variances to explain technical inefficiencies. Besides, a recently developed method of a single stage inefficiency effects model is applied. Lastly, instead of the standard Cobb–Douglas production function as used in the studies before, a flexible translog production function is used. The rest of the paper is structured as follows: Section 2 reviews the literature on efficiency analysis of Indian thermal power plants, the determinants of technical inefficiency and the role of regulatory factors on utility performance. Section 3 describes the stochastic frontier analysis (SFA) method that incorporates exogenous influences on efficiency. Section 4 details the empirical strategy by specifying the stochastic frontier model and describing the data. The section explains how the composite regulatory index is constructed and the data sources for the key indicators. It then presents the results from the estimation of model parameters. Section 5 provides explanations for the observed results on the determinants of technical inefficiency, especially the regulatory factors. Section 6 summarizes the paper and concludes with potential policy outcomes.

2. Literature review

The literature on impacts of regulation on utility level efficiency, specifically in the Indian context, is classified into three strands in this section. Since the focus is on Indian power plant performance, we begin by discussing the relevant literature available on Indian thermal efficiency. As will be revealed subsequently, there is not much information on the possible factors behind inefficiency in the Indian context. There has been some on plant level factors but hardly any on the regulatory determinants. Therefore, the literature on how plant level factors affect utility performance is discussed followed by the regulatory determinants of inefficiency in the international context. The purpose of this review is to help situate the study around the developments in this field and also to locate the gaps which need to be filled. Moreover, the discussion on regulatory determinants lays down the theoretical frame which emphasizes the need to assess the role of the institutional quality of regulation through the governance aspect.

The earliest study of Indian thermal power efficiency was conducted by Singh (1991). It used plant level data for the year 1986–87 to estimate a deterministic frontier production function and calculate technical efficiencies. The results showed that the efficiency of a power plant was positively influenced by its size and capacity utilization. However, efficiency was not associated with its location. Khanna and Zilberman (1999) measured the efficiency of 63 coal-based power plants prior to the reforms i.e., from the period 1987-1988 to 1990–91. They found that efficiency improved with 'high-heat content' coal, private ownership and better management practices. Inefficient operation, lack of coal washing facilities and high imported coal tariffs reduced efficiency of thermal plants. Khanna et al. (1999) estimated a stochastic frontier cost function for 66 thermal power plants in India for the period 1987–88 to 1990–91. They found that publicly owned power plants were less efficient than private plants. Plant age did not have a significant effect on efficiency while capacity utilization

[2] An availability based tariff (ABT) controls power supply to the grid where a tariff is imposed upon any deviation from scheduled generation metered by system frequency.

[3] Our focus is on coal based power production as it is the backbone of Indian electricity system comprising nearly 70% of total electricity generated (Shrivastava et al., 2012).