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Benchmarking and regulation of power distribution companies in Pakistan

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ABSTRACT

Using stochastic frontier analysis the study examines the cost effectiveness of electricity distribution utilities in Pakistan. For this purpose cost (in)efficiency is calculated for 8 distribution utilities using data for the period 2003–2013. The findings reveal that on average there is 72.5% efficiency in the electricity distribution sector. It indicates that electricity distribution utilities in Pakistan are cost inefficient by 27.5%. It is also found that quality of service affects efficiency. The results imply that there is significant potential to improve efficiency of electricity distribution utilities and that quality of service should be incorporated as part of efficiency of the electricity distribution utilities in Pakistan.

Contents

1. Introduction . . . 1095
2. Analytical framework . . . 1096
   2.1. Stochastic frontier analysis . . . 1096
   2.2. Specification of models . . . 1097
   2.3. Economies of scale . . . 1097
   2.4. Econometric methodology . . . 1097
3. Data and estimation of models . . . 1097
   3.1. Data sources and construction of variables . . . 1097
   3.2. Estimation of models . . . 1097
   3.3. Cost efficiency . . . 1098
   3.4. Industry efficiency . . . 1099
   3.5. Economies of scale . . . 1099
4. Conclusion . . . 1099
References . . . 1099

1. Introduction

Electricity industry consists of generation, transmission and distribution activities in which generation sector is potentially competitive while transmission and distribution sectors are characterized as natural monopolies. Reforms and regulations play a pivotal role to bring competition in generation and supply activities and to improve efficiency in transmission and distribution sectors [1]. The traditional regulation reforms bring efficiency through privatization, price mechanism, revenue caps and rate of return [2,3]. An alternative to traditional regulatory reforms is benchmarking, which is a management tool and is being widely used to bring efficiency in the power sector.

In developing countries, transformation of power distribution utilities into market oriented and regulated entity is an important issue. Like many other developing countries, Pakistan also followed

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the policy of deregulation of its power sector. In this regard, generation sector was liberalized in 1994 while distribution sector was unbundled in 1997 and electricity area board was fragmented into 8 regional distribution companies. As a part of regulatory reforms and a step towards liberalization, an autonomous regulatory body, National Electric Power Regulatory Authority (NEPRA), was established in 1997. NEPRA is responsible to issue licenses, to set tariffs and to monitor the performance of distribution companies. The purpose of all these reforms was to make the distribution sector more efficient and to reduce fiscal burden of the government.

Quality of service also affects cost efficiency of electricity distribution utilities. Quality of service variables such as outages and distribution losses have increased the cost of distribution utilities which has led to high and unaffordable tariffs. Growitsch et al. [4] have suggested that incorporating quality dimensions in cost efficiency analysis have significant effect on estimated efficiency. Thus, to improve efficiency and performance of the power sector, there is need to regularize electricity distribution companies through benchmarking and regulation.

Empirically, several studies have shown that benchmarking analysis is an important tool for performance-based regulations [5–9]. In fact, previous studies differ in their results as they have used different variables and econometric models for benchmarking analysis to find the efficiency score [10,11]. Jamasb and Pollitt [7] document that selection of benchmarking model and variable specification can alter the efficiency scores. Moreover, Farsi and Filippini [12] and Kuosmanen et al. [13] have also shown that different benchmarking techniques have different results.

In South Asia Yadav et al. [14] have studied 29 Indian electricity distribution divisions to evaluate their performance by using DEA model and conclude that these divisions have technical and scale inefficiencies. In Pakistan, only one study has been conducted on benchmarking so far. Saleem [15] has studied the benchmarking and regulatory framework of electricity distribution sector in Pakistan. DEA technique is applied to calculate changes in efficiency scores in terms of productivity of 9 distribution utilities using data for the period 1998–2003. The study finds that 6 firms are operating on frontier and reports 92% efficiency of the power sector. The estimated results reveal that distribution sector reforms have not improved the performance of the sector and that inefficiency has increased. However, this study has not incorporated quality of service variables in benchmarking models.

The objective of the present study is to analyze the cost and scale efficiency of 8 power distribution companies in Pakistan using data for the period 2003–2013. Further, performance of electricity distribution utilities will also be compared. For this purpose Stochastic Frontier Analysis (SFA) will be employed for efficiency analysis. Quality of service variables will also be incorporated in the analysis as they also affect the overall performance of power distribution sector.

The rest of the paper is organized as follows. Section 2 explains analytical framework. Section 3 provides the estimated results along with their discussions. Final section concludes the paper.

2. Analytical framework

The benchmarking methods are broadly classified as the average and frontier oriented approaches [7]. Average based approach compares firm's performance against some average performance, while frontier approach estimates utilities' performance against an efficient frontier. To close larger efficiency gaps, frontier-oriented approach is best suited in regulatory reforms. Broadly used frontier benchmarking approaches in efficiency analysis of power sector are Data Envelopment Analysis (DEA), Corrected Ordinary Least Square (COLS) and Stochastic Frontier Analysis (SFA).

DEA is a non-parametric benchmarking analysis approach as it does not imply any specific functional form for efficiency calculations. It involves piece wise linear programming to calculate (rather than estimate) the best and least practice efficiency frontier. Thus, the impact of input factors on the efficiency cannot be determined successfully using this approach. Another drawback of this approach is that it does not measure the absolute efficiency of the firm. To overcome these problems COLS model is used. Specification of functional form (cost or production function) is required in this technique. COLS model can calculate the efficiency scores of multi inputs and outputs by estimating their distance functions. As the name indicates COLS uses ordinary least square (OLS) technique for estimation. However, COLS model does not take into account the unobserved factors such as possible stochastic errors (noise and outliers) that have influence on results and attributes the residual as inefficiency. Therefore, to overcome this shortcoming this study will apply SFA approach that takes into account part of unobserved factors.

2.1. Stochastic frontier analysis

Stochastic frontier analysis (SFA) is a widely used parametric benchmarking approach for efficiency analysis [16,17]. It divides the residual into two components i.e. inefficiency and random noise components. It requires specification of functional form (production or cost function) and requires assumptions of (production or cost) technologies. The general model of stochastic frontier say for cost function is defined as follows;

$$Y_i = X_i^{'}\beta + (\upsilon_i + \mu_i) \tag{1}$$

In a more compact form, after taking log, stochastic frontier model can be expressed as follows:

$$y_i = \underbrace{\beta_0 + \beta_1 x_i}_{Deterministic} + \underbrace{\upsilon_i}_{Noise} + \underbrace{\mu_i}_{Inefficiency} \tag{2}$$

where y_i is cost of the i^{th} firm, $x_i = k * 1$ is vector of input prices of the i^{th}firm, β's are parameters to be estimated, υ_i is $iid \sim N\left(0, \delta_\upsilon^2\right)$ random error term, which captures the effect of noise, it could be positive or negative and is independent of μ_i. μ_i is non-negative technical inefficiency usually assumed to be half normal distributed and it is $iid \sim \left|N\left(0, \delta_\mu^2\right)\right|$.

SFA is used to find technical/cost efficiency (EF) of the firms as ratio of experiential cost to the stochastic frontier cost [11]. Mathematically

$$EF = \frac{\exp(x_i^{'}\beta + \upsilon_i - \mu_i)}{\exp(x_i^{'}\beta + \upsilon_i)} = \exp(-\mu_i) \tag{3}$$

Efficiency score ranges between zero and one. The value closer to zero indicates that firm is inefficient whereas the value close to 1 suggests that firm is efficient and is operating on efficient frontier. The efficiency estimate indicates the cost of the i^{th} firm with respect to the cost produced by an efficient frontier using the similar inputs. In simple words, cost efficiency is obtained as the ratio of actual cost to the least cost level. Thus, the first step in the prediction of efficiency score is the estimation of parameters of the SFA model explained by Eq. (1).

Industrial efficiency (IEF) score can be calculated as the average of the efficiency scores of all firms (N) in an industry [11]. Mathematically,

$$IEF = \frac{1}{N}\sum_{i=1}^{N} EF_i \tag{4}$$