PERFORMANCE EVALUATION OF GOVERNMENT REGULATED ENERGY DISTRIBUTION UTILITIES : A STOCHASTIC FRONTIER APPROACH

Pavan Khetrapal[1], Tripta Thakur[2] and Alok Gupta[3]

[1]Department of Electrical Engineering, Maulana Azad National Institute of Technology, Bhopal, India.

[2]Department of Electrical Engineering, Maulana Azad National Institute of Technology, Bhopal, India.

[3]Madhya Pradesh Electricity Regulatory Commission, Bhopal, India.

ABSTRACT

The distribution network of the power system constitutes the vital link between the electricity generation and the end consumer. The efficiency of power sector is primarily judged on the basis of operational performance of distribution system. Almost 90% of India's power distribution operation comes under the ailing government regulated electricity distribution licensees. The power distribution system in Indian scenario is historically plagued by high transmission and distribution losses, inefficiency of collection, power theft, non-billing, inept planning etc., thereby resulting in the poor operational performance of the sector. Hence, achieving improvements in the overall operational performance of the government regulated electricity distribution licensees is of paramount importance and remains critical for the robust functioning and development of the Indian power sector. In recent years, a relative number of empirical studies and policy makers have applied benchmarking techniques to evaluate the technical efficiency and performance of electricity distribution licensees. In this paper we adopted Stochastic Frontier Approach (SFA) for estimating the technical efficiency of 37 government regulated electricity distribution licensees in India. The results indicate that the sampled electricity distribution licensees were not fully technically efficient. The mean technical efficiency is estimated as 82% indicating that there is an 18% allowance for improving efficiency of electricity distribution licensees. Based on the empirical findings from the present study, the inefficient distribution licensees can frame some strategic plans to improve efficiency in operations.

KEYWORDS

Technical Efficiency, Stochastic Frontier Analysis, Performance Evaluation, Cobb's-Douglas, Production Frontier, Energy Distribution Utilities.

1. INTRODUCTION

During the past two decades many countries including India have introduced regulatory reforms and incentive based regulation scheme in their electricity distribution sector so as to promote

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efficiency improvements in electricity networks and to ensure reliable electricity supply to consumers. The financial health of Indian state electricity distribution utilities has become a matter of grave concern considering that their losses have reached an alarming level of Rs.28,000 crores during 2010-11. Improvement in the financial and technical performance of electricity distribution sector in India continues to be an important issue for utility providers, policy makers and electricity customers in order to effectively utilize the results for future policy discussions [1]. In recent years, productivity measurement and efficiency analysis has become a very useful tool to estimate and assess the efficiency scores of electricity distribution sector, and to help distribution licensees and policy makers to understand the determinant factors of productivity [2]. With the introduction of incentive oriented regulation schemes, efficiency estimation (benchmarking) has been widely applied to electricity distribution licensees, both in policy framework as well as in academic studies. Internationally, benchmarking has been introduced as a significant tool for electricity regulators to compare the technical efficiencies of utilities and analyzing the energy policies of electricity distribution licensees [3], [4]. This study applies Cobb's-Douglas stochastic frontier model to estimate and compare the efficiency score of 37 government regulated energy distribution licensees in India utilizing the cross-sectional utility level data for the year 2010-11[1]. It is expected that this study will be immensely useful to distribution licensees themselves as they can compare their performance with other companies and implement some strategic plans and policies to improve their performance.

2. CONCEPT OF EFFICIENCY

Efficiency measurement (or comparative efficiency analysis) has received considerable attention from both theoretical and applied economists and has been widely recognized as useful tool for benchmarking and incentive regulation. Measuring efficiency is an important aspect of firm's performance because this is the first step in a process that might lead to significant resource savings and these resource savings have important implications for both policy making and regulatory framework. Efficiency of a firm (or utility) refers to how best a firm produces the maximum possible output from a given set of inputs and thereby, indicates the success of the firm. The concept of efficiency measurement was first proposed in 1951 by Koopmans and Debreu [5]. Later in 1957, Farrell [6] extended the work initiated by Koopmans and Debreu and introduced a framework to quantify efficiency measures based on the concept of production frontier. A production frontier may be used to define the relationship between the amount of output and the inputs of production, given the current state of technology involved. Farrell laid the foundation of microeconomic efficiency measurement and productivity studies and proposed that the efficiency of any given firm consists of two components: technical efficiency and allocative (or price) efficiency. Technical efficiency refers to the ability of a firm to produce a maximum level outputs given a certain level of inputs, or the ability to minimize input use in the production of a given output vector. Alternatively, a firm (or producer) is technically efficient if an increase in an output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output. Allocative efficiency refers the ability of a firm to combine inputs and outputs in optimal proportions, given their respective prices and current state of production technology [7]. Put differently, allocative efficiency involves selecting the feasible combinations of inputs so as to produce the maximum possible outputs. These two measures, technical efficiency and allocative efficiency are then combined together to provide a measure of productive efficiency (or total economic efficiency). Figure 1 illustrates the Farrell's efficiency concept.

The diagram shows that a firm uses two inputs (x_1 *and* x_2) to produce a single output y at point A under the assumption constant returns to scale (where the relationship between output y and inputs (x_1 *and* x_2) does not change (or remains constant) as the input increases). The curve SS' represents the isoquant (showing various combinations of two inputs that firm employs to produce a unit of output) of fully efficient firm that allows the measurement of technical efficiency. Now, for a given firm using quantities of inputs (x_1*, x_2*) defined by point A(x_1*/y, x_2*/y) to produce a unit of output, y*, the ratio OB/OA measures the level of technical efficiency, or the ability of the firm (or production unit) to produce maximum outputs from a

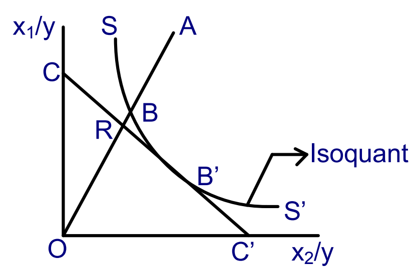

Figure 1. Farrell's efficiency indices

given level of inputs i.e. point B represents technically efficient firm using the two inputs (x_1 *and* x_2) in the same ratio as point A. Therefore, the ratio OB/OA measures the combination of inputs (x_1, x_2) actually used in producing y*. Thus (1- OB/OA), the technical inefficiency of the firm, measures the proportion by which the inputs (x_1*, x_2*) could be proportionally reduced, holding the input ratio (x_1/x_2) constant, without a reduction in output. Alternatively, firm A should have produced OA/OB times more output with the same input quantities. Technical Efficiency will take a value between zero and unity; a zero score when the technical inefficiency ratio is 1, and a unity score when the degree of inefficiency is zero, i.e., the firm is technically efficient with point A coinciding with point B on the isoquant [8].

If the input price ratio represented by the slope of isocost line CC' in Figure 1 is also known (showing the various combinations of inputs that require the same level of expenditure), a technically fully efficient firm would operate at point B'. Allocative efficiency can be calculated for the firm operating at point A by the ratio:

$$\text{Allocative Efficiency (AE)} = \frac{OR}{OB} \tag{1}$$

The distance RB represents the reduction in production costs that may occur if production achieved (or occurred) at the fully efficient (allocatively and technically efficient) point B', rather than B – technically efficient, but allocatively inefficient point.

Finally, if both technical and allocative efficiencies of firm A are considered, then its production efficiency or total economic efficiency (EE) is defined by the ratio:

$$\text{Economic Efficiency} = \frac{OR}{OA} \tag{2}$$

Accordingly, $1 - \left(\frac{OR}{OA}\right)$ represents total inefficiency of firm A. The cost reduction achievable is the distance RA which is obtained by moving from the observed point A to the cost minimizing point B'. Moreover, based on Farrell's concept, the overall economic efficiency $\left(\frac{OR}{OA}\right)$ is given by the product of technical (OB/OA) and allocative (OR/OB) efficiencies, i.e., EE = (OB/OA) x (OR/OB) = OR/OA [9].

3. Analytical Framework

Improvement in the financial and technical performance of electricity distribution sector in India continues to be an important issue for utility providers, policy makers and electricity customers in order to effectively utilize the results for future policy discussions. In recent years, an increasing number of empirical studies have used the more advanced econometric and linear mathematical programming frontier efficiency measurement techniques to estimate and compare the technical efficiencies of electricity distribution licensees. Frontier techniques commonly used in practice are based on benchmarking that identify the "best practice" frontier to which all the companies are assessed and compared. The "best practice" frontier may be estimated using either the linear programming (non-parametric) approach or econometric (parametric) approach. Non-parametric or linear programming approach does not impose a functional form on the production function to estimate the best practice frontier. This approach is non-stochastic in nature; that is, that all the deviations from the frontier are a result of firm's inefficiency. Further, the mathematical programming approach cannot decompose the noise term and inefficiency component during the estimation of technical efficiency, and is less susceptible to specification errors or random disturbances. The two commonly used non-parametric approaches are DEA and free disposal hull (FDH). By contrast, the econometric or parametric frontier approach assumes an explicit functional form on the production, cost, revenue, or profit, and makes suitable assumptions about the data. The econometric approach is stochastic; firms can deviate from the frontier because of the (1) random errors (or measurement errors) that captures the random effects beyond the control of the firm and, (2) firm specific inefficiency. The most common parametric approaches include SFA and corrected ordinary least square (COLS) models [10], [11]. Since both non-parametric and parametric approaches have their own relative merits and the true level of efficiency is unknown, the choice of suitable estimation methodology has been quite controversial, with some researchers preferring the mathematical programming approach; and others the econometric approach. Coelli *et al.* [12] have attempted to provide some interesting and relevant discussion on the choice of particular frontier benchmarking technique for estimating productive efficiency. Figure 2 illustrates a general classification of efficiency measurement techniques.

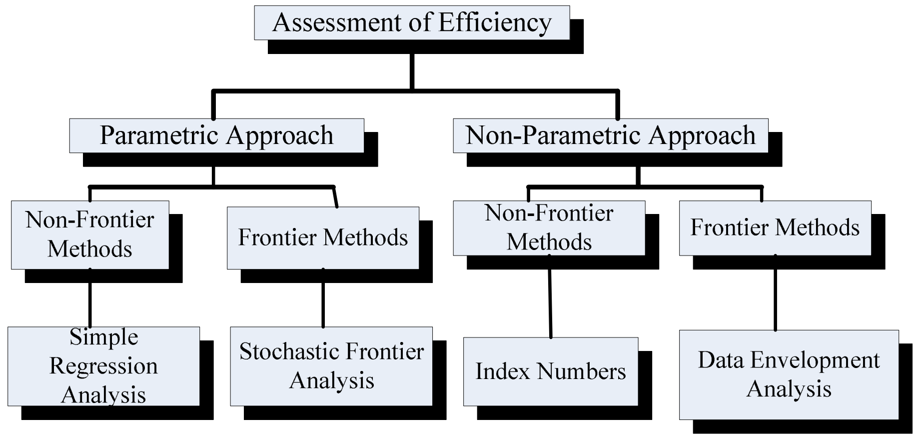

Figure 2. Taxonomy of Efficiency Measurement Techniques

The present study used the methodology of Aigner *et al*. [13] and Battese and Coelli [14] in a cross-sectional data context to assess and compare the efficiency scores for government-regulated electricity distribution licensees in India based on production frontier model.

The widely used econometric method, independently developed by Aigner *et al.* [13] and Meeusen and Broeck [15], is the stochastic frontier approach (SFA). The stochastic frontier approach (SFA) is a technique of frontier estimation that explicitly assumes a suitable functional form for the relationship between inputs and an output. With use of explicit assumptions about the inefficiency component's distribution, the stochastic frontier production model decomposes the error term into a two-sided random error component intended to capture the effects of statistical noise or random effects that are beyond the control of the firm and one sided error term representing technical efficiency [16].

This paper adopted the model specification of Battese and Coelli [14] who outlined a time-varying model for the technical inefficiency effects in the stochastic frontier production function for (unbalanced) panel data which has firm effects which are assumed to be distributed as truncated normal random variables. The general form of a stochastic frontier production model for (unbalanced) panel data may be expressed as:

$$y_{it} = x_{it}\beta + (v_{it} - u_{it}) \quad i = 1, 2, ...N, \quad t = 1, 2, ...T \tag{3}$$

where, y_{it} is the logarithm of the production of the i^{th} firm in the t^{th} time period, x_{it} is a vector of input quantities of the i^{th} firm in the t^{th} time period and β is a vector of unknown parameters. The composed error term comprises two parts. The term v_{it} is a two-sided ($-\infty < v_{it} < \infty$) normally distributed random error that captures the stochastic effects outside the firm's control, measurement errors, and other statistical noise. Aigner *et al.* [13] assumed that $v_{it}s$ were independently and identically distributed as ($v_{it}s$ ~ N [0, σ_v^2]), independent of the $u_{it}s$.

The term u_{it} is a one-sided ($u_{it} \geq 0$) efficiency component that captures the technical inefficiency of the firm, which is assumed to be independently and identically distributed and truncations (at zero) of the normal distribution with mean, μ , and variance, σ_u^2 - (u_{it}~N [μ ,σ_u^2]). Additionally, the other distributional assumptions of the inefficiency component (u_i) have also been proposed such as a half-normal distribution [13], an exponential distribution [15], a truncated normal distribution [17] and a two-parameter gamma distribution [18] , and there is no a priori justification that suggests that one of distribution is superior to another, although different specifications yield different levels of technical efficiency. However, the advocates of econometric approach believed that the truncated normal distribution is a more general specification.

The technical inefficiency effects are assumed to be defined by [14]

$$u_{it} = \{\exp[-\eta(t-T)]\}u_i \quad i = 1,2,...,N; t = 1,2,...,T \tag{4}$$

where, η is an unknown scalar parameter to be estimated, which determines whether inefficiencies are time-varying or time invariant. If η is positive, then $-\eta(t-T) \equiv \eta(T-t)$ is positive for $t < T$ and so $\exp[-\eta(t-T)] > 1$, which implies that the technical inefficiencies of industries decline over time. However, if η is negative, then $-\eta(t-T) < 0$ and thus technical inefficiencies increases over time [19].

The ratio of the observed output for the i^{th} firm to the maximum feasible output, defined by the frontier function, given the available technology and input vector, x_{it}, is used to define the technical efficiency of the i^{th} firm in the t^{th} time period:

$$TE_{it} = \frac{y_{it}}{(x_{it}\ \beta)} = \frac{(x_{it}\beta - u_i)}{(x_{it}\beta)} = \exp(-u_{it}) \tag{5}$$

Since the term u_{it} is a non-negative random variable, the measure of technical efficiency takes a value between zero and one. A unity value indicates that the firm is technically efficient and achieves its maximum feasible value of (x_{it}, β), while TE_i<1 indicates that i^{th} firm is technically inefficient and thus, provides a measure of the shortfall of the observed output from maximum feasible output in an environment characterized by $\exp(v_i)$, which is allowed to vary across firms [20], [21].

4. Empirical Modelling

In order to estimate the stochastic production function, we need to specify an explicit functional form of the production function. As far as the functional form of the stochastic production function is concerned, a range of functional forms for the stochastic production function frontier are available that can be used to specify (or model) the production frontier. Since the cross sectional data is used in present study and the sample number is not very high, we select the

Cobb-Douglas stochastic frontier production model with the distributional assumption to estimate the technical efficiency of government regulated electricity distribution licensees in India. Furthermore, the Cobb-Douglas production function is widely used because it is a flexible functional form and can handle multiple inputs in its generalized form. The basic specification of parametric Cobb-Douglas frontier production model with the error term is empirically defined as:

$$\ln y_i = \beta_0 + \sum_{j=1}^{k} \beta_j \ln x_{ji} + v_i - u_i \tag{6}$$

In this model:

subscript i represent the i^{th} distribution company.
y_i is the output of i^{th} distribution company.
x_{ji} is the corresponding level of input j of i^{th} distribution company.
ln refers to the natural logarithm.
β is a vector of unknown parameters to be estimated.
v_i is a two sided random error term which is assumed to be independently and identically distributed as (N $[0, \sigma_v{}^2]$).
u_i is one sided random error term that captures the technical inefficiency of the firm.

The parameters of the stochastic frontier production function are estimated using maximum likelihood estimation (MLE) technique which is superior to other estimation techniques in computing measures of technical efficiency, such as ordinary least squares (OLS) technique and COLS technique. More specifically, MLE technique is consistent and asymptotically more efficient than the COLS technique [14], [16]. A drawback of the COLS method is that the estimated parameters may not make engineering sense. Also, the technique makes no assumption for stochastic errors and actively relies on the position of the single fully efficient distribution company. Aigner *et al.* [13] parameterized the log likelihood function in terms of the variance parameters, $\lambda = \left(\frac{\sigma_u}{\sigma_v}\right)$ and $\sigma^2 = \left(\sigma_u{}^2 + \sigma_v{}^2\right)$ .Using the parameterization as suggested by Battese and Corra [21] we replace $\sigma_v{}^2$ and $\sigma_u{}^2$ with $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \frac{\sigma_u{}^2}{\sigma^2}$. The parameter, γ, must have a value between 0 and 1 and this interval range can be searched for a suitable starting value for the use in iterative maximization algorithm involved.

5. Data Set

The choice of input and output variables is the most important step in the process of performance assessment and efficiency estimation while using SFA. In the review of benchmarking studies, Jamasb [8] pointed out that there is no firm consensus on which input and output variables best describe the operation of distribution licensees. The most widely used inputs are number of employees, operation and maintenance cost, distribution transformer capacity and network line length. The most commonly used output variables are number of consumers, units of electricity sold and the size of service area. The variables selected for our model includes:

Inputs:

x_1: Total Operating Expenditure (TOTEX) (Rs Crores).
x_2: Total distribution network line length (km).
x_3: Total number of distribution transformers.
x_4: Distribution energy loss (%).

Output:

y_1: Electricity delivered to end consumers (MU's)

Our data series involves annual operational data on 37 government-regulated electricity distribution licensees in India for year 2010-11. All data used in this paper were retrieved from Annual Revenue Requirement (ARR) reports and Tariff petitions submitted by the distribution licensees; Power Finance Corporation report; All India Electricity Statistics and various online reports published by Government of India, Ministry of Power [23], [24]. The description of the quantitative variables and summary statistics for the data set is contained in Table 1.

Table 1: Descriptive statistics of the variables, 2010-11

	Variable	**Maximum**	**Minimum**	**Mean**	**Standard Deviation**
INPUTS	TOTEX (Rs Crores)	35441	453	6267.03	1027.26
	Network Length (km)	833470.29	3806	202257.79	164845.05
	Distribution Transformers (Nos)	472307	3760	135580	109868.62
	Energy Loss (%)	60.99	7	24.20	9.977
OUTPUT	Total electricity sold (MU's)	71280	568.84	13225.41	14495.67

6. Results And Discussions

The maximum likelihood estimates of the frontier production model (Equation 6) are estimated by using a computer programme, FRONTIER Version 4.1[25]. FRONTIER provides the estimates of β, σ^2, γ and computes specific technical efficiency of each firm as well as overall mean technical efficiency score. In addition, FRONTIER 4.1 offers the possibility to incorporate both half-normal and truncated normal distributional assumptions for the random error term. The results of the OLS estimates and maximum likelihood estimates for half-normal model for u_i are shown in table 2.

Table 2: Results from Ordinary Least Square and Maximum Likelihood Estimation

Variable	**Parameter**	**Ordinary Least Square Estimation**			**Maximum Likelihood Estimation**		
		Coefficient	**Standard Error**	**t-value**	**Coefficient**	**Standard Error**	**t-value**
Constant	β_0	0.899	0.503	1.785	1.075	.992	1.083
$\ln X_1$	β_1	1.100	0.077	14.11	1.172	0.495	2.366***

$\ln X_2$	β_2	0.047	0.069	0.683	0.050	0.744	0.068@
$\ln X_3$	β_3	-0.090	0.081	-1.11	-0.151	0.648	-0.233*
$\ln X_4$	β_4	-0.193	0.079	-2.43	-0.165	0.329	-0.502*
Diagnosis Statistics							
R-Squared	R^2	0.9428					
Sigma Squared	σ^2	0.034			0.073	0.119	0.612**
Gamma	γ				0.935	0.831	1.124**
Mu	μ	--			Restricted to be zero		
Eta	η	--			Restricted to be zero		
Log likelihood Function		12.57			14.12		
LR test of the one sided error					6.810		
Mean Technical Efficiency	**0.818**						

***, ** and * = Significant at 1%, 5% and 10%. @ = insignificant

The OLS estimation ensures that the frontier production function passes through the most efficient utility and bounds the other utilities. The parameters of the Cobb's-Douglas frontier production function can be directly interpreted as production elasticities of inputs in the production process. The coefficient of determination (i.e. R^2) tells us the proportion of variation in independent variable (y) that is explained by the explanatory variable (x). The value of R^2 ranges between 0 and 1. The coefficient R^2 as shown in table 2 is equal to 0.9428 which indicates that independent variable (x) explains 94.28% of total variation in dependent variable (y). In sum, high values of R^2 indicate a good fit and low value a poor fit [26], [27].

The estimated elasticity of mean output with respect to TOTEX input is positive and statistically significant at 1% level of significance. The 1.172 elasticity of TOTEX implies that a 1% increase in total operating expenditure, ceteris paribus, would lead to an increase of 1.172% in the electricity sold to end consumers. This suggests that TOTEX is a significant factor associated with changes in electricity sold. The estimated coefficient of input variable distribution line length is found to be positive but insignificant. This implies that distribution line length does not significantly affect the electricity sold to consumers. The magnitude of coefficient of total number of distribution transformers is estimated to be negative (-0.151) and significant at 10% level of significance. It means that the electricity distribution licensees are improperly using distribution transformers. The improper utilization of distribution transformers will not only affect the amount of electricity sold but it could also affect the quality of electricity delivered to the end consumers. The coefficient for distribution energy loss is negative and statistically significant at 5% probability level; indicating that 1% increase in distribution loss will decrease the electricity sold by .165%. The estimated coefficient of sigma squared (σ^2) is positive (.073) and significantly different from zero at 10% level of significance. This shows that the observed output differs from the frontier output owing to the factors which are within the control of distribution licensees in the sample under study. The maximum likelihood estimates of gamma (γ) parameter is 0.935 and highly significant at 5% level of significance. This implies that 93.5% of the discrepancies between the observed output and frontier output are due to technical inefficiency and 6.5% is due to stochastic random error.

6.1. Test of Hypothesis

There is growing interest to test the null hypothesis that the technical inefficiency effects are not present in the model and the coefficients of the variables in the frontier production model for the inefficiency effects are zero. Coelli *et al.* [16] suggested that a standard test being the one-sided generalized likelihood ratio (LR) test should be conducted in almost every empirical study involving the maximum likelihood estimation because this test has significantly the correct size. The generalized likelihood ratio test involves the estimation of production model under both the null hypothesis and alternative hypothesis. Under the null hypothesis, $H_0 : \gamma = 0$, the frontier production model is equivalent to the traditional average response function without the technical inefficiency effect term, u_i; implying that that distribution licensees are fully efficient. The generalized likelihood-ratio statistic is calculated as

$$LR = -2[\ln\{L(H_0)\} - \ln\{L(H_1)\}] \tag{7}$$

where $L(H_0)$ and $L(H_1)$ are the values of the log-likelihood function under the null hypothesis, $H_0 : \gamma = 0$ and alternative hypothesis, $H_0 : \gamma > 1$, respectively. The value of log likelihood function for the full stochastic frontier model is calculated to be 14.12 and the value for the OLS fit of the production function is 12.57, which is less than that for the full stochastic frontier model. This implies that the one-sided generalized likelihood ratio (LR) test for testing the absence of technical inefficiency effects from the stochastic frontier model is calculated to be $LR = -2[12.57 - (14.12)] = 3.10$, which is estimated by the FRONTIER 4.1 and indicated as "LR test of the one-sided error". The value of likelihood-ratio (LR) test is significant, because it exceeds 5% critical value of 2.706, tabulated from Kodde and Palm for the degrees of freedom equal to 1. Hence the null hypothesis of no technical inefficiency effects in the performance of government-regulated electricity distribution licensees in India is rejected. The null hypothesis and the test results are presented in table 4.

Table 3: Generalized Likelihood-Ratio Test of Hypothesis Involving Parameters of the Cobb's Douglas Stochastic Frontier Production for State-owned electricity distribution companies in India in 2010-11

Null hypothesis	**Log likelihood**	**No of restrictions**	χ^2 **statistic**	**Critical Value**	**Decision**
$H_0 : \gamma = 0$	14.12	1	3.102	2.706	Rejected

The estimated technical efficiencies for the government-regulated electricity distribution licensees in this study range considerably from 0.575 to 0.964, with a mean technical efficiency of 0.818.

This implies that the sampled Indian electricity distribution licensees could produce the same level of output by reducing all given inputs equi-proportionately by 18.2%. Alternatively, there is a scope for the electricity distribution licensees to increase the energy sold output by 18.2% by adopting the techniques and technology used by the best performers [29], [30]. The frequency distribution of estimated technical efficiencies among the electricity distribution companies is shown in figure 3.

The majority of electricity distribution licensees, 12 in total (or 32.43%), have a technical efficiency index between .81 to .90, 12 (32.43%) distribution licensees have an index greater than 0.9, 4 (10.81%) lie in the range from 0.71 to 0.80, 7 (18.91%) from 0.60 to 0.70 and 2 (5.4%) distribution licensees have a technical efficiency index of less than 0.60. Figure 4 illustrates the predicted technical efficiencies for each government-regulated electricity distribution company in India for the year 2010-11.

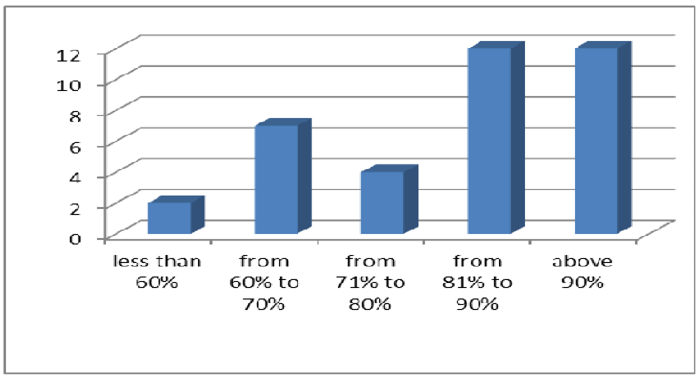

Figure 3. Frequency distribution of technical efficiencies

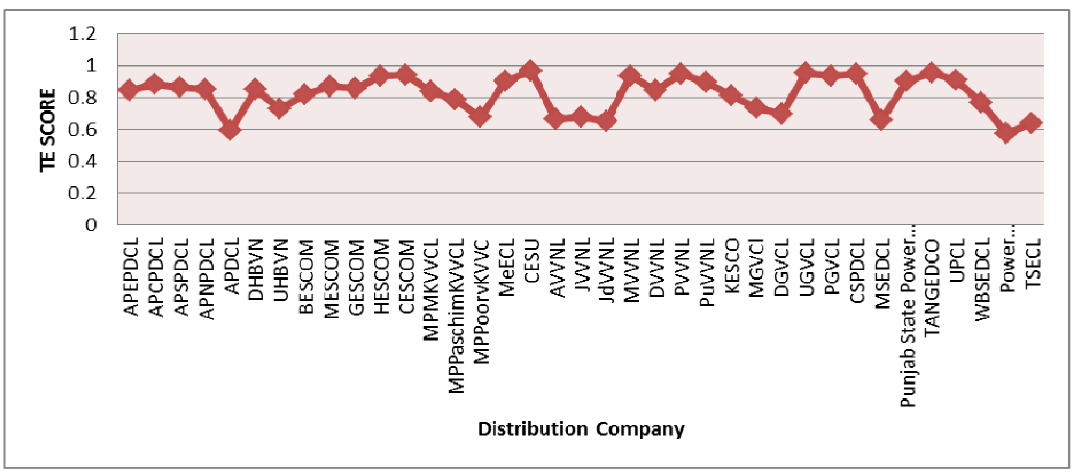

Figure 4. Technical efficiency score of sampled utilities during the observed period 2010-11

7. CONCLUSIONS

In this study, SFA was applied on 37 government-regulated electricity distribution licensees in India in order to estimate their relative technical efficiency score during the period 2010-11. Only 37 distribution licensees have been taken excluding privatized distribution licensees such as Tata Power Delhi Distribution Limited in Delhi where achievement is much more as compared to government-regulated government companies. This gives a reasonable analysis to arrive at comparative technical efficiency scores of government distribution licensees and among them The Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO) has achieved highest technical efficiency score because the Tamil Nadu's per capita consumption has reached the India's target of 1000 units by 2012 in 2007-08 itself, which is more than the national growth of 635 units. As per 2001 census, the population is 6.24 crores, which includes 1.46 crores households located in towns and villages of Tamil Nadu. TANGEDCO has a consumer base of about 223.44 lakh consumers and100% rural electrification has been achieved. Uttar Gujarat Vij Company Limited (UGVCL) has retained its position among first five companies because of drastic reduction in Aggregate Technical & Commercial Losses below 10%. The empirical findings obtained from SFA reveals that the technical efficiency performance of sampled electricity distribution licensees is relatively high, with a mean technical efficiency score of 0.818(or 81.8%). This implies that if the efficiency of input usage is increased by 18.2% (1-0.818), the electricity distribution licensees under the study will be operating on the production frontier. Furthermore, the findings of this study suggest the provision of robust, evidence-based policy implications and recommendations for use by policy makers and state electricity regulatory commissions, aimed at enhancing their technical efficiency and competitiveness. Meanwhile the results obtained in the present study can be used for reference of policy-making in electricity distribution sector.

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Authors

Pavan Khetrapal was born in India in 1974. He received his B.E. degree from MPCT, Gwalior, M.P. in 2001, India and M.Tech degree from GNDEC, Ludhiana, Punjab, India in 2009. Currently, he is pursuing PhD from Maulana Azad National Institute of Technology, Bhopal, M.P., India. He has published several papers in various journals and conferences. His main research area includes performance benchmarking, electric distribution regulation, power system deregulation.

Tripta Thakur received the M.Tech degree from Indian Institute of Technology, Kanpur, India in 1995 and a PhD degree from Indian Institute of Technology, Delhi, India in 2007. Currently, she is Professor in the Department of Electrical Engineering at Maulana Azad National Institute of Technology, Bhopal, M.P., India. Her research interest focuses on efficiency and industry best-practice analysis for electricity distribution companies; distribution sector reforms, incentive regulation in electricity networks.

Alok Gupta received the B.E degree from University of Roorkee, India in 1974 and an MBA degree from IGNOU, Delhi, India in 1994. Currently, he is working as a Member at Madhya Pradesh Regulatory Commission, Bhopal, M.P., India. His research interest focuses distribution sector reforms, incentive regulation in electricity networks.