Productivity and Efficiency Analysis of the Indian State Electricity Boards

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Abstract

This paper presents a framework for assessing the productivities of the Indian State Electricity boards (SEBs), the government owned and controlled entities, which have been mainly responsible for the generation, distribution and transmission of electricity in India. Data Envelopment Analysis (DEA) was employed to analyse the relative efficiencies of the SEBs, while the productivity performances of the twenty-six utilities was evaluated using the Malmquist index for the period 1996-97 to 2001-02. The total factor productivity was decomposed into the effects of technical change and pure efficiency change, and the results revealed that the SEBs have attained productivity progress from 1996-97 to 2001-02, but the technical progress has been rather subdued. The SEBs have reported productivity growths but have been unable to sustain their growths, their operations have also been relatively inefficient and need improvement. The analysis reveals that DEA analysis can reveal significant results of significant interest to various stakeholders comprising the policy-makers, regulators, government and the public at large.

Key words: Data Envelopment Analysis (DEA), Productivity, Malmquist index, State Electricity Boards

1. Introduction

Electricity Sector reforms are transforming the structure and operating environments of electricity industries across a host of developed and developing countries to introduce private capital and increase competition (David et al., 1999; Sardana, 2003). This has been accompanied by the introduction of new regulatory regimes (Glachant and Finon, 2005). The effects of such reforms in a number of the developed economies are now being documented, however, apart from a few case studies; the experience of developing countries remains much less researched. Nonetheless, this is important not just because such studies would reflect concerns that would affect millions of poor, but also because privatization, competition and the reforms of state regulation are the key themes in donor aid programmes, notably of the World Bank (Clive, 2003).

Power reform in developing countries have been necessitated by the pressing need for improvement in the existing power services as several of these countries are plagued by sub-optimal sector performances. Huge demand-supply gap is often a universal problem in developing countries and the distribution sectors are frequently financially crippled (Romeo and Elaine, 2002, Resende, 2002). Serious cash flow constraints result in palpable curtailment of much needed investment in expansion and maintenance of services, and ultimately manifest in poor sector performances. High distribution losses, poor management, low market densities, poor metering and billing practices and weak institutions are some of the common problems besieging the electricity sectors in the developing nations (Alberto, 2004).

Performance evaluation plays a crucial role in structural reforms in facilitating an understanding of the behaviour of electric utilities, and also in defining regulatory policies for both transmission and distribution. Benchmarking models for electricity distribution have been introduced in UK and US (Burns and Weyman-Jones, 1996; Pahwa, 2002), and have become common throughout Latin America (Estache et al., 2004) and Europe. In Europe, a number of studies have been reported which include those by Hjalmarsson and Veiderpass (1992) for Sweden, Foresund and Kittelsen (1998) for Norway; Filippini (1998) and Filippini and Wild (2001) for Switzerland; and Hirshchhausen and Kappeler (2004) for Germany. Outside Europe, the Australian electricity sector has been analysed by Abbott (2006), who has evaluated the improvements in the productivity and efficiency performances after sector reforms.

Comparative studies across developed nations have also been reported in the literature. For example, Hattori, Jamasb and Pollitt (2005) make use of both a Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) approach to analyse productivity growth in a sample of 23 Japanese and UK electricity distribution businesses over the period 1986-1998.

However, for developing countries few studies have so far been reported. For example, Romeo and Elanine (2002) have calculated the cost efficiencies for Philippines power sector. Philippines another benchmarking study using DEA and SFA was done Rouselle (2004). Chen (2002) compares the technical efficiency and cross efficiency of distribution sector in Taiwan's using DEA, which is the study of a monopolized and conventionally regulated utilities. Resende (2002) analyses relative efficiency measurement and prospects for yardstick competition in Brazilian electricity distribution.

However, to date, no detailed performance analysis has so far been reported for the Indian electric sector which has undergone reforms since 1991, and has further accelerated the process of change with the recently enacted Electricity Act, 2003 (Thakur et al, 2005). The current paper is amongst the first productivity analyses carried out for the SEBs, which are the vertically integrated utilities mainly responsible for generation, transmission and distribution of power in India[1].

The present study seeks to answer the following questions:

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[1] Electric distribution is still a monopoly of SEBs in India with a few private distribution utilities and two state Delhi and Orissa as an exception (Thakur, 2005).

1. What has been the trend in the growth of Total Factor Productivity (TFP) for electric power utilities (mainly the SEBs) of India?
2. Can we isolate the contributions of technical change and efficiency change in the productivity analysis?
3. Which of the SEBs have improved their productivities over time?
4. Which of the SEB are efficient in operation?
5. Which are the inefficient utilities? What is the extent of inefficiency in these utilities?

While attempting to answer these questions, this paper examines relative performance of SEBs between 1996-97 and 2001-02, applying the benchmarking techniques known as Data Envelopment Analysis (DEA). Further due to panel data, dynamics of efficiency are evaluated and Total Factor Productivity (TFP) is calculated based on the individual data using the Malmquist index for the periods 1996-2002.TFP growth is then decomposed into efficiency change and technical change. Productive cost benchmarking exercise provides valuable information on the speed at which the efficiency frontier has moved over recent years. This information will be useful in helping to determine, for providing incentive appropriate X factors based regulation scheme in future which is now being adopted by UK, Norway, Netherlands and Australia.

This paper is structured as follows: A brief introduction is provided in section 1which is followed by Section 2 that establishes the need for the analysis of the Indian electric utilities. Section 3 presents methodology adopted in this paper, while section 4 analyses the data used. Section 5 then presents the results of the cost benchmarking. Section 6 provides a brief conclusion to this paper.

2. Need For Productivity Analysis of Indian Electricity Utilities

India has commenced an era of reforms in 1991 by opening the electricity sector to independent power producers (IPPs). However, more than a decade and a half later, the contribution of IPPs remains insignificant, with the private sector contributing only 12.1%, 0.4% and 12% of the total share in generation, transmission and distribution respectively (MoP website). Thus, the major players in the Indian electricity sector continue to be the State Owned Electric Utilities (SOEUs), previously known as the State Electricity Boards (SEBs). These SEBs were established for the rationalization of power development at the state level (for Generation, Transmission and Distribution activities), and were statutorily required to function as autonomous corporations by the Electricity (Supply) Act of 1948. Due to overriding declared social objectives, the SEBs have never been viewed as commercial entities with an avowed objective of profit-making unlike the private sector[2]. The lack of professional management, lack of accountability, political interfernance, unscientific tariff structure and non-transparent practices and subsidies make them loss-making bodies. This approach has adversely affected their performance and currently no SEB earns profit (Thakur et al., 2007). Also adversely affected are the expansion schemes for meeting the growing demand[3]. There is therefore, a case for the review of the performances of these utilities, so that lessons from failures be taken note of, and effective steps be taken to mitigate shortcomings.

Such an analysis holds immense significance for India because presently the main focus of the Indian reforms programme is to make SEBs efficient and to commercialise the electric entities[4] (Task Force, 2004). Such an analysis of appraisal of existing SEBs is also warranted from the viewpoint of establishing crucial innovation in the reforms process that incorporates continuous review of newly evolved public-private mechanisms. Further, The ERC Act, 1998 has laid the foundation of the regulatory commission in India as a independent autonomous body[5]. Such an analysis will also be of interest to the regulators in deciding the tariff setting principles where the productivity element X plays a crucial role

[2] Fox (1999) argued that public sector managers do not have comparable control over the mix of services they provide, and so are constrained in their ability of allocate resources and services in an efficient manner.
[3] Presently the demand supply gap is alarming with peak deficit of 12.2% and energy deficit of 8% at the all India level in the year 2006, October (MoP, 2006).
[4] For any monopolistic electricity market, the usual market indicator of performance such as profitability or rate of return cannot be used to gauge the economic performance accurately. It is possible that these financial indicators will be more an indication of the distortions themselves, rather than of the performance of the industry in question. In these circumstances, indicators of the level and change of productivity and efficiency are more appropriate indicator of an industry's performance (Abbott, 2006).
[5] Central Electricity Regulating commission (CERC) at the central level and the State Electricity Regulating Commission (SERC) at the state level. The CERC is currently a functioning body, whereas twenty-two states have so far constituted the SERCs.

in addition to general price or cost increases[6]. Past productivity records therefore would also provide information for setting up of future targets. Also the learning from the past decade's experience would be an invaluable exercise for addressing similar sector problems common to most developing countries.

3. Methodology

The concept of introducing efficiency ensures (a) input procurement at least costs, and (b) improved management and higher efficiency as there are quantifiable goals to be achieved. The two are related since greater efficiency results in cost savings and allows greater availability of funds for investment; and also results in improved management results due to performance benchmarks. Thus performance appraisal of utilities is a primary step in the direction of ensuring sustenance in the power services. It is possible to carry out such appraisals with the help of techniques that include the Data Envelop Analysis (DEA).

In the recent times, DEA is receiving increasing importance as a tool for evaluating and improving the performance of manufacturing and service operations. DEA is a multi-factor productivity analysis for measuring the relative efficiencies of a homogenous set of decision-making units (DMUs) that perform similar tasks by consuming multiple inputs to produce multiple outputs. Most studies of productivity change are aggregate in character, in the sense that in most cases, an entire production sector is treated as a unit. However, in order to understand productivity developments, it is necessary to carry out the analyses at disaggregate levels because of the efficiency differences across the operating units. The productivity change for firms can be thought of as the net effect of changes in efficiency with respect to a common frontier technology (Forsund, 1996). A piecewise linear technology is calculated through the non-parametric approach of solving linear programming problems. The productivity changes are subsequently measured by the Malmquist index (Malmquist, 1953).

[6] The change in maximal price or allowable costs over time could be based on an 'RPI-X' formula, where RPI is the retail price index and X is the regulators' target for productivity improvement. UK and other countries are already adopting this formula.

3.1 DEA

In DEA, the data are enveloped by a piecewise linear frontier in such a way that radial distances to the frontier are minimized. The basic model of DEA, the CCR model, was proposed by Charnes, Cooper and Rhodes (1978). The CCR model was formulated as a linear programming (LP) problem concerned with, say, n decision making units (DMUs), electric utilities in the present analysis, which use varying quantities and combination of inputs X_i (i=1,…s) to produce varying quantities and combinations of outputs Y_j (j=1,…m).The most common form of measurement of efficiency in case of a single output and single input framework is the ratio output/input. In case of multiple outputs and inputs, it is a weighted combination of outputs to weighted combination of inputs, known as virtual outputs and virtual inputs, where the weights are derived from data instead of being fixed in advance. Efficiency of each DMU is measured and hence n optimization exercises are carried out. The following problem is solved to obtain the values of input weights (v_i) and output weights (u_r) as variables:

$$\max \qquad \vartheta_o = \frac{\sum_r \{u_r y_{ro}\}}{\sum_i \{v_i x_{io}\}}$$

$$\text{s.t.} \qquad \frac{u_1 y_{1j} + ... + u_s y_{sj}}{v_1 x_{1j} + ... + v_m x_{mj}} \leq 1$$

where j=1,…,n

$v_1, v_2, ... v_m \geq 0,$

$u_1, u_2, ... u_s \geq 0,$

The constraints imply that the ratio of “virtual output” to “virtual input” should not exceed 1 for every DMU. The objective is to obtain weights v_i and u_r that maximize the ratio for DMU_o. The optimal objective value θ^* is at most 1. However, multiple solutions might exist for the above problem. Hence it is transformed into a linear programming problem using transformation developed by Charnes and Cooper (1962). The problem can be considered as an input minimization problem by normalizing the linear combination of inputs consumed by the concerned DMU as:

$$\max_{u\ v} \quad \sum u_r y_{ro}$$

$$\text{s.t.} \quad \sum v_i x_{io} = 1$$

$$\sum_r y_{rj} - \sum v_i x_{ij} \le 0 \qquad \forall j = 1,\ldots,n$$

The maximum value of the objective function is 1, when the DMU is efficient. This is also called the multiplier problem as the aim is to derive the optimal multipliers v_i^*s and u_r^*s. The dual to the above problem is called the envelopment problem, which is easier to solve with lesser number of constraints. The envelopment problem is

$$\min. \quad \vartheta_o$$

$$\text{s.t.}$$

$$\sum_j \lambda_j x_{ij} \le \vartheta_o x_{io}$$

$$\sum \lambda_j y_{ij} \ge y_{io}$$

$$\lambda_i \ge 0$$

Here θ_o signifies the extent to which the inputs need to be reduced to bring them on the best practice frontier. The λ_js are the intensity variables to indicate the intensity with which the DMU being scored is related to the DMUs in the efficient facet. The output-oriented problem can be formulated similarly by normalizing the linear combination of outputs.

To allow for variable returns to scale Banker, Charnes and Cooper (1984) added the convexity constraint to the optimization problem in (3), by restricting the summation of the intensity variables to 1. The LP problem now becomes:

min. ϑ_o

s.t.

$$\sum_j \lambda_j x_{ij} \leq \vartheta_o x_{io}$$

$$\sum \lambda_j y_{ij} \geq y_{io}$$

$$\sum_j \lambda_i = 1,$$

$$\lambda_i \geq 0 \qquad \forall j = 1,.....,n$$

In solving the CCR and the BCC models, optimal weights in the multiplier problem can attain the value zero. In the envelopment problem also, slacks may exist. Hence the non-archimedean ε is introduced in the problem, by restricting the multipliers to take values greater than ε in the multiplier problem and in the envelopment problem, it is included in the objective function as:

min. $\vartheta_o - \varepsilon(\sum_i S_i^- + \sum_{ir} S_r^+)$

s.t. $\vartheta_o x_{io} - \sum_j \lambda_j x_{ij} - S_i^- = 0$

$$\sum_r \lambda_j y_{ij} - S_r^+ = y_{ro}$$

$$\sum_j \lambda_j = 1, \quad \lambda_j, S_i^-, S_r^+ \geq 0$$

3.2 Malmquist Productivity Index

The DEA techniques can be used to calculate Malmquist Index of productivity change over time, assuming the underlying technology is constant returns to scale (CRS) (Coelli et al., 1998). The Malmquist total factor productivity (TFP) index measures the TFP change between two data points by calculating the ratio of the distances of each point relative to a common technology. The distance function in terms of the above analysis can be defined as $\{D^t(x^t,y^t)\}^{-1} = \theta^t$

Following Fare et al. (1994), the Malmquist input oriented TFP change index between period s and period t is given by:

$$m_i(y_s, x_s, y_t, x_t) = \left[\frac{d_i^s(y_t, x_t)}{d_i^s(y_s, x_s)} \times \frac{d_i^t(y_t, x_t)}{d_i^t(y_s, x_s)}\right]^{1/2}$$

An equivalent way of writing this index is:

$$m_i(y_s, x_s, y_t, x_t) = \frac{d_i^t(y_t, x_t)}{d_i^s(y_s, x_s)}\left[\frac{d_i^s(y_t, x_t)}{d_i^t(y_t, x_t)} \times \frac{d_i^s(y_s, x_s)}{d_i^t(y_s, x_s)}\right]^{1/2}$$

where the first ratio on the right hand side measured change in efficiency between periods s and t. The remaining part of the index in the equation measures technical change, so that

and tfpch = effch × techch

$$effch = \frac{d_i^t(y_t, x_t)}{d_i^s(y_s, x_s)}$$

$$techch = \left[\frac{d_i^s(y_t, x_t)}{d_i^t(y_t, x_t)} \times \frac{d_i^s(y_s, x_s)}{d_i^t(y_s, x_s)}\right]^{1/2}$$

where, *tfpch* signifies change in total productivity, which is caused by the joint influence of effch, i.e. the change in efficiency from period s to t and *techch*, the geometric mean of the shift in technology between the two periods, evaluated at x_t and also at x_s. The value of the indices greater than one signifies increase in productivity.

4. Data Analysis

4.1 Data source

The Planning Commission of the Government of India publishes annual performance reports for the SEBs on yearly basis (Annual Report). The data used in this paper has been derived mainly from these annual reports. The data availability was limited to year 1996-97 onwards as it was from this year onwards that the Planning Commission of India started inclusion of the data pertaining to the electricity departments and Union Territories like Arunachal Pradesh, Goa, Manipur, Mizoram, Nagaland, Pondicherry, Sikkim and Tripura. The choice for the cut-off year 2002 was again limited as subsequent to this year the Planning Commission and other data publishing government and non-government agencies have suspended the data publication work[7] due to the changing structure of Indian power utilities in the wake of SEBs having unbundled their structures. The physical data for various states were obtained from the General Reviews published by the Central Electricity Authority, Government of India on yearly basis.

4.2 Input/output selection

Selecting the appropriate inputs and outputs constitute the most important task of evaluating the performances. The choice of variables depends on not just the choice of methodology and technical requirements of the chosen model, but also on data availability and its quality, as well as on countries' own socio-economic structure. No universally applicable rational template is available for selection of variables. However, in general, the inputs must reflect the resources used and the outputs must reflect the service levels of the utility and the degree to which the utility is meeting its objective of supplying electricity to consumers. A study of standard literature reveals significant insights into the choice of variables. Jamasb and Pollitt (2001) outline the most widely used variables based on international experience.

The input/output selection for the present study was made in view of those parameters that directly affect the consumers in terms of cost of electricity supply. The choice of variables was also based on the study of available literature to sort out the right indicators from a potential group of parameters suggested in the survey by Jamasb et al., (2005). The variables were finalized with the help and advice from experts from educational institutes, industry, corporate sector and government whose opinions were also considered. Generally, for productivity analysis the inputs are fuel, labour and capital, which are combined in the above analysis and reflect in the term Total cost (Totex), which represents the cost incurred by the utility to supply electricity to the ultimate consumers. The components considered for calculating the total cost are: cost of the fuel, operating and maintenance cost (O&M), administrative and general cost (A&G), interest payment

[7] By the year 2001-02, four SEBs had unbundled their operation. For the unbundled SEBs the total cost was computed by combining the cost components of the unbundled entities within the state to maintain uniformity for comparison.

liability, depreciation and the cost of power purchase. In this study three outputs, namely, the energy sold, consumer numbers and length of distribution network, are employed in line with their common usage in the available literature and because these are able to represent the activity levels of the utilities and have a bearing on the cost (Thakur et al., 2007)

Table 1 shows the average output and input values and corresponding change for the year 1996-97 to 2001-02.

It is clear from the Table 1 that change in the input total cost from 1996 to 2002 is 143.46%, while the changes in output parameters are relatively less and amount to 28.62%, 21.89% and 24.89% for Number of Customers, Distribution line length and Energy sold respectively. The relatively larger change in input costs may have arisen due to either the inefficiencies of the SEBs in its reflection in being unable to manage increasing input costs or may have accrued from factors beyond the immediate control of the management such as hike in fuel prices. However, the fact that similar input increases have been experienced across a large number of states with varying proportion of thermal, hydro and other generation resources points out that the increase in inputs may have more to do with the inefficiencies. This is substantiated by the fact that the government owned and controlled entities have accumulated huge financial losses over time[8] (IT Task Force, 2003) and have not endeavoured to be cost-effective forcing the policy documents to focus on fostering efficiencies and diluting subsidies[9].

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[8] Over time, these SEBs have accumulated gross financial losses. Apparently, the financial losses have reached an estimated Rs. 260 thousand millions (Rupees 47=US $1) per year (IT Task Force, 2003) and no SEB currently recovers the full cost of power supplied. These financial losses cannot be made good from State budgets, as the states are themselves under severe financial strain; the result is that the SEBs are starved of resources to fund required expansion and typically end up neglecting even the essential maintenance. This has led to an undermined infrastructure base and inefficiencies in the system.

[9] The roadmap for the Tenth Plan (Planning Commission, 2001) explicitly lays the following as the reform objectives: “Reflecting the cost of service in the tariffs and transferring all subsidies explicitly to state budgets” and “Improving efficiency in all the three segments viz. generation, transmission and distribution..”.

5. Results and Discussions

5.1 Overall Results

The results of Malmquist indices for the electricity utilities in each state are reported in Table 2. Estimations for annual performance of all SEBs during the period of 1996-97 and 2001-02 are also presented in Table 2 and plotted in Figs.1, 2 and 3. Table 2 shows the multiplicative decomposition of the Malmquist productivity index into technical efficiency change, that is movement towards the production frontier (which Forsund, (1996) termed as the 'catching up' effect) and the pure technological change for the period 1996-97 to 2001-02. Since technologies cannot be forgotten, technological shift can be thought to be always greater than 1 (Atkinson and Stiglitz, 1969). However, as Forsund (1996) points out, the frontier concept being an empirical one, a change to a less productive technology might involve the effect of management practice and would be interesting to exhibit.

The result in Table 2 clearly shows the positive change in the overall electricity sector. Numbers greater than one indicate productivity growth, while the numbers smaller than one show regress and all SEBs shows progress as all of them has productivity index more than one. This shows that the overall the electric utilities in India have improved productivities since 1996-97, and investments in this industry took place with technical progress.

Fig.1 describes mean annual total factor productivity growth (TFP) for this model for each SEB between 1996-97 and 2001-2002. The SEBs attained average TFP growth of 192%, the average contribution from efficiency change is 110% and from frontier shift is 176%, this shows that the contribution from overall frontier shift is more on the TFP growth of SEBs in India. However, there are large variations within the SEB. The results indicate a rapid increase in TFP productivity for all the SEBs, however the growth is not persistent at the same rate to the all the SEB. The large maximal growth of Himachal Pradesh (Hydro generating state) is striking, indicating improvement of 338% of total productivity, with catching up improvement of 184% and frontier change of 183% (Table 2). Thus the growth reported is due to the contribution of both technical change and frontier change in almost equal measures. Other 9 best performing SEBs having growth index more than 2 are all big states. The less performing states are small states mainly union territories and electricity departments except the big state Bihar.[10]

Productivity growth can be distinguished between innovation and diffusion of technology and best practice. In Fig 2, Malmquist index is decomposed into technical efficiency change, and frontier change and the figure shows that the productivity growth is mainly due to improvement in frontier shift. This indicates that the industry as a whole is responding to the technical efficiency change, an inference that is especially predominant in the period 1997-99.

5.2 Productivity distributions

Although Fig. 1 illustrates the annual productivity growth, how does the TFP index vary over this period? Getting individual information of productivity development has its own advantages, and hence Fig 3 shows the distribution of total productivity growth from 1996-97 to 2001-02. Year 2000-01 has been significant as almost all the SEBs performed well with positive growths and demonstrated M-index values exceeding one. This may have occurred due to a wide array of factors such as:

- Spillover and trickling down of the impact of the overall improved national economy: The overall performance of the Indian economy started significant improvements since 1998-99. The Gross Domestic Product (GDP) in 1998-99 recorded a growth of 6.8 percent as against the growth rate of 5 percent during 1997-98. The increase in the rate of economic growth was mainly due to higher growth in agriculture, electricity and trade. After a negative growth of 1.9 percent in 1997-98, the agricultural GDP registered a growth of 7.2 per cent in 1998-99. 'Electricity, gas & water supply' recorded higher growths at 7.9 percent during 1998-99. The growth however marginally declined during the subsequent years 1999-2000 (6.4%) and during 2000-

[10] The state of Bihar lies in the fertile Gangetic plains, and is widely infamous for its poor governanace, corruption, a decadent political and education system, poverty, law & order problems, and a wide array of social conflicts. Bihar is among the least developed of the states of India and has a per capita annual income of $94 against India's average of $255. A total of 42.6% of its population lives below the poverty line, as against India's average of 26.1% (Wikipedia Encyclopedia, 2006)

01(5.2%), but these growth figures were rather significant as these were estimated over the last year values, and hence a 6.4% growth over and above the 7.9% in the previous year represented a quantum jump. (Annual Report, (2002), Planning Commission, (2001).

- Plant Load Factor of Thermal Power Stations in the country improved during the Ninth Plan[11](1997-2002). It increased from a level of 64.4% in 1996-97 to 69% in 2000-01 (Annual Report, 2002).

- The Electricity sector as a whole was under a process of reforms. The Electricity Regulatory Commission Act, 1998 (ERC Act 1998) was significantly introduced with proposal to distance the Government's role from regulatory acts such as tariff determination. Also there emerged a common consensus amongst the Indian states to initiate unbundling operations for the SEBs (MoP, 2001).

It is clear from the yearly distribution of the TFP indices that the SEBs are having wide fluctuations from 1996-97 to 2001-02 duration, although overall they have been able to increase their productivity but unable to maintain their growth on yearly basis. Such fluctuations are not unusual in DEA studies, since the DEA method is much sensitive to year-to-year changes in inputs and outputs. The case of Electric industry is peculiar in the sense that utilities has fixed levels of capital and often fairly fixed levels of labour endowment in the short run, but a fluctuating demand for their output (sales, number of consumers and network length etc.) over time. If the utility is showing recession, electricity sales may fall but inputs will not change very much, leading to fall in levels of efficiency and productivity. Alternatively, if the industry has under-utilised capacity and sales boom, then productivity levels will also rise significantly.

Fig.4 presents the TFP results of the four best performing SEBs, and indicates that productivity growth for all four SEBs is relatively similar from 1997-98 to 1998-99. From

[11] The Indian government unravels and declares policy objectives and plans for attainment of targets encompassing the entire economy once every five years. Currently the Tenth Five Year Plan is underway.

1998-99 to 1999-2000 except Himachal Pradesh[12] other three SEBs have substantially improve their performance. Drastic improvements for Himachal Pradesh and Rajasthan occurred in 2000-01 to 2001-02 with productivity growth jumping from 1.9 to 1.99 and 1.03 to 1.73 respectively.

For West Bengal year 1999-2000 was most fruitful as this state significantly raises their rate of productivity in this year as TFP jumps from 1.18 to 1.52. Unfortunately SEBs is not able to sustain their growth. Fig.5 presents TFP index for the Four less performing SEBs. Tripura negative growth from 1997-98 to 1998-99 having less than one M-index and this index has even reduced next year. Year 1999-2000 is important for the state as it has shown M-index more than one (1.56) next year is still positive growth that is followed by a negative growth in year 2001-02. Nagaland results are truly fluctuating showing progress from 1997-98 to 1998-99 and then downward trend in 1999-2000 to 2000-01 and then almost similar performance in followed year.

The conclusion from the above performance analysis is that although SEBs have improved their performances, but they have largely not been able to sustain the improvement.

6.4.3. Performance Analysis of SEBs

Individual efficiency score of the SEBs is evaluated using DEA, Constant return to scale (CRS), results for 1996-97 and 2001-02 are shown in the Table 2. It is evident from Table 2 that Indian Electric utilities display significant variations in efficiency levels. The total efficiency had a mean score of 71% in the year 1996-97 which reduce to 68% for the year 2001-02. These results are very important which shows that although SEBs has improved their productivity index but their average performance has reduced. For the year 2001-02 majority of utilities (14 out of 26), lie below the average value of 68%. Three utilities

[12] Himachal Pradesh is a small state, but is unique in certain aspects. It was the first hill state in the country to achieve 100% electrification of all census villages in the year 1988, and has also achieved unique distinction of 100% metering, billing and collection. The state ranks amongst the least charging tariffs in the country, and has the highest household coverage ratio of about 98%. The state has vast potential for hydro generation (20386.07 MW) out of which 6045.07 MW is harnessed so far. It is therefore also known as a “Hydro Power State”.

turned out to be the best practices, and all three best utilities are designated State Electricity Departments. Two of them, Sikkim and Nagaland, belong to the North-Eastern India (regarded as relatively underdeveloped region) and the third utility of Pondicherry belongs to the Southern region and it is a union territory of India. The remaining 23 utilities exhibited varying degrees of inefficiencies.

To explore the scale effects, the BCC formulation that assumes a variable Returns to Scale by taking into consideration the sizes of utilities was employed. This formulation ensures that similar sized utilities are benchmarked and compared with each other. Scale efficiency are then calculated and shown in the Table 2. It is observed that all the utilities, with the exception of the best practices and the Mizorm, exhibited decreasing returns to scale (Table 2) indicating that further expansion of services may not be productive and average productivity can be increased with smaller scale size. . This outcome supports the unbundling policy of the GoI, as envisaged in the Electricity Act 2003[13]. Some of the States like Andhra Pradesh, Delhi, Haryana, Rajasthan, Karnataka, Uttar Pradesh and Madhya Pradesh have already embarked the path of unbundling activities, while others must follow suit to take advantage of returns to scale.

Himachal Pradesh SEB has shown DEA efficient for the year 1997 but performed badly in compare to other SEBs in 2002, with a score of 55%. The main reason evident is scale inefficiency and thus state need to decrease its scale of operation, thus restructuring which adopted by the state (HP State Electricity Regulatory Commission, 2005) is the move in the right direction.

Thus it is clear from the analysis that although SEBs have done productivity growth from 1996-97 to 2001-02 but there is a need for induction of efficiency in the power supply services in India. What becomes obvious from the above analysis is the fact that there is a distinct possibility of making significant savings through efficiency improvements. The

[13] Unfortunately the Electricity Act 2003 is on a hold following the change of government in the elections held in 2004 and no time frame has been specified for implementing the provisions of the Act. It is a reflection on what the political wrangling can do to the major policies in the developing countries.

resultant reduced costs may yield enough savings and finances to expand and improve services.

Concluding Remarks

This study attempted to carry out an in-depth performance analysis of the government owned and operated State Electricity Boards, the main electric power utilities, in India. A non-parametric approach to frontier analysis was adopted and efficiency scores for the different SEBs were determined using DEA. Malmquist productivity index was employed to analyse the productivity changes over the periods from 1996-97 to 2001-02. Total factor productivity was decomposed into the effects of technical change and pure efficiency change. It is clear from the analysis that SEBs have attained productivity progress from 1996-97 to 2001-02 mainly due to investments in the electricity sector. The technical progress also occurred, but was rather subdued mainly due to the organization structures and lack of competition in the sector. The SEBs have reported productivity growths, but have been unable to sustain their growth and this need urgent attention of the policy-makers. Individually, their operations are relatively inefficient and there is a lot of scope for efficiency improvement. These efficiency and productivity assessments can result in a potentially useful exercise: one that is likely to reap significant returns, and it does definitely constitute a step that echoes a point raised by Smith and Mayston (1987) who remind us that “the resources released by any improvement in technical efficiency can then be diverted to satisfy other objectives of the Government.”

Acknowledgements

The author is grateful to the Commonwealth Association (UK) for providing financial assistance for doing this research at Centre for Energy Petroleum Mineral Law and Policy (CEPMLP), University of Dundee. The author is also grateful to IIT-Delhi and to MANIT, Bhopal, India for providing support.

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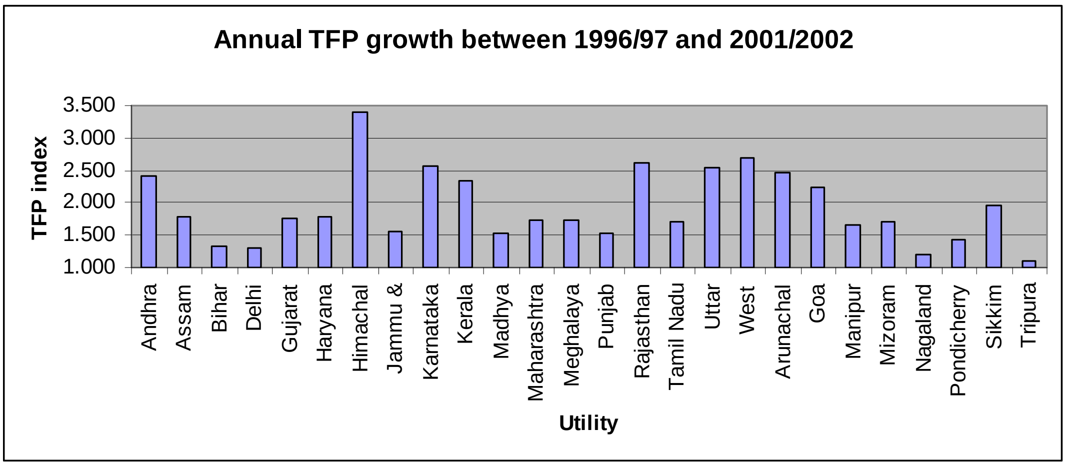

Fig 1. Annual TFP growth between 1996-97 and 2001-2002

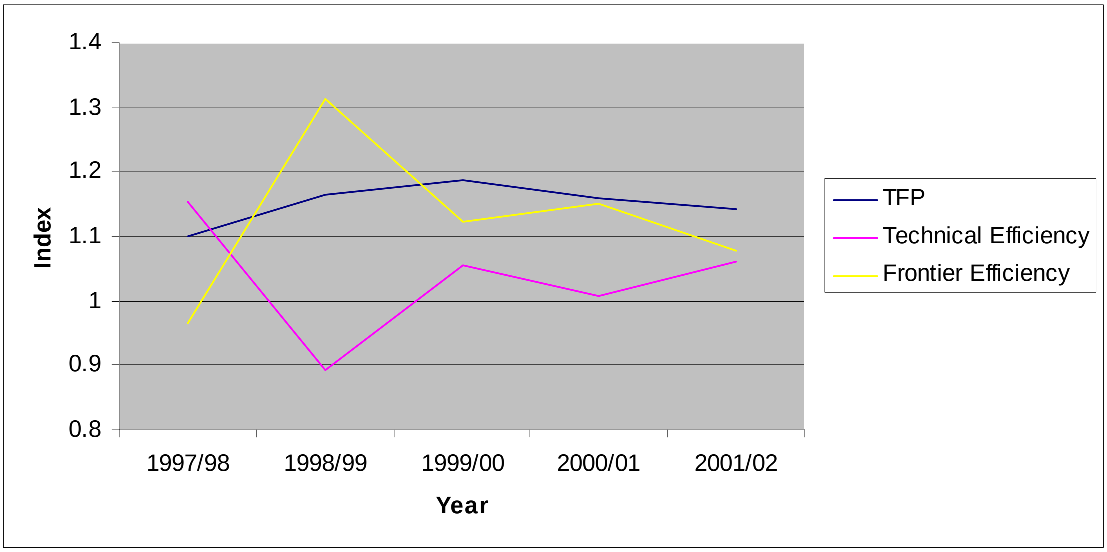

Fig. 2. Accumulative indices of efficiency change, technical change and total factor productivity change for the Indian electric utilities

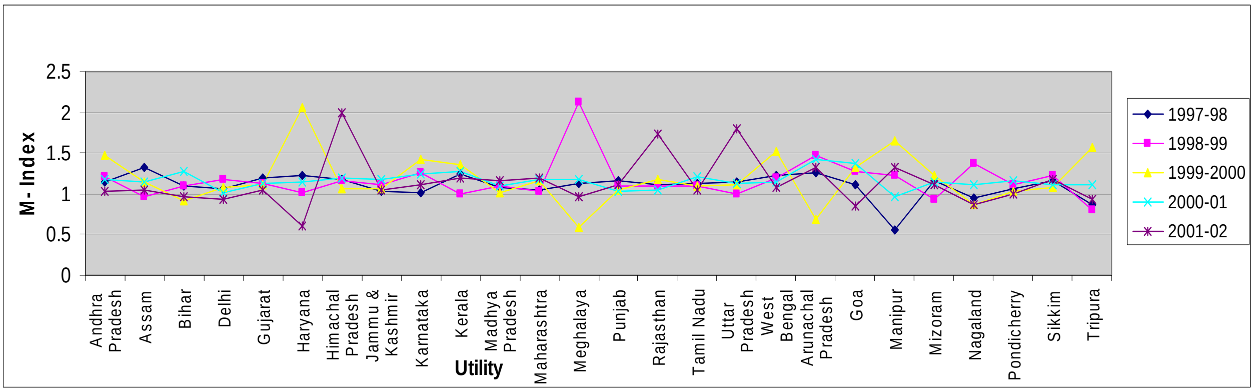

Fig 3. Yearly TFP growth from 1997-2002

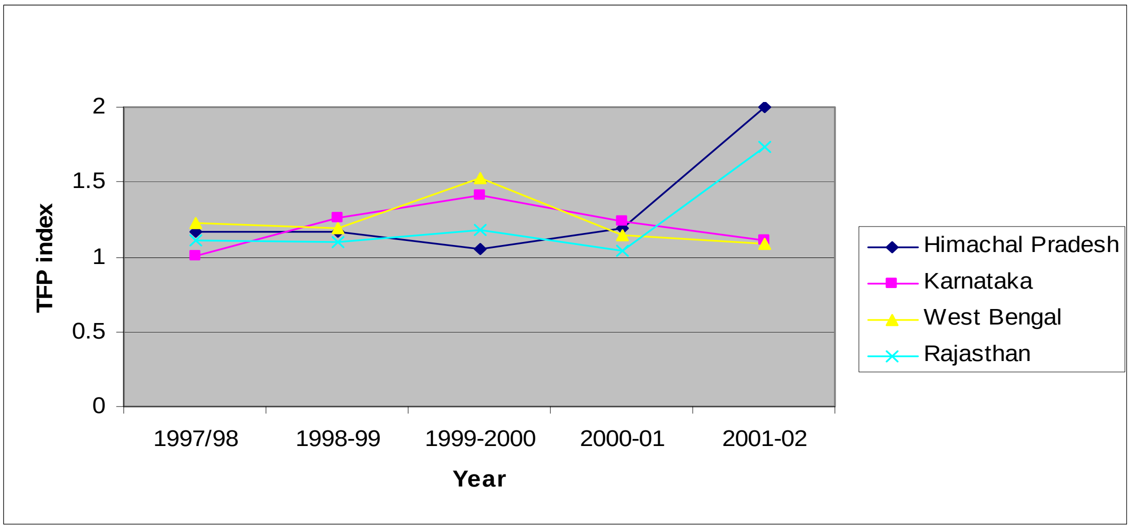

Fig 4. TFP index for the Four leading performing SEBs

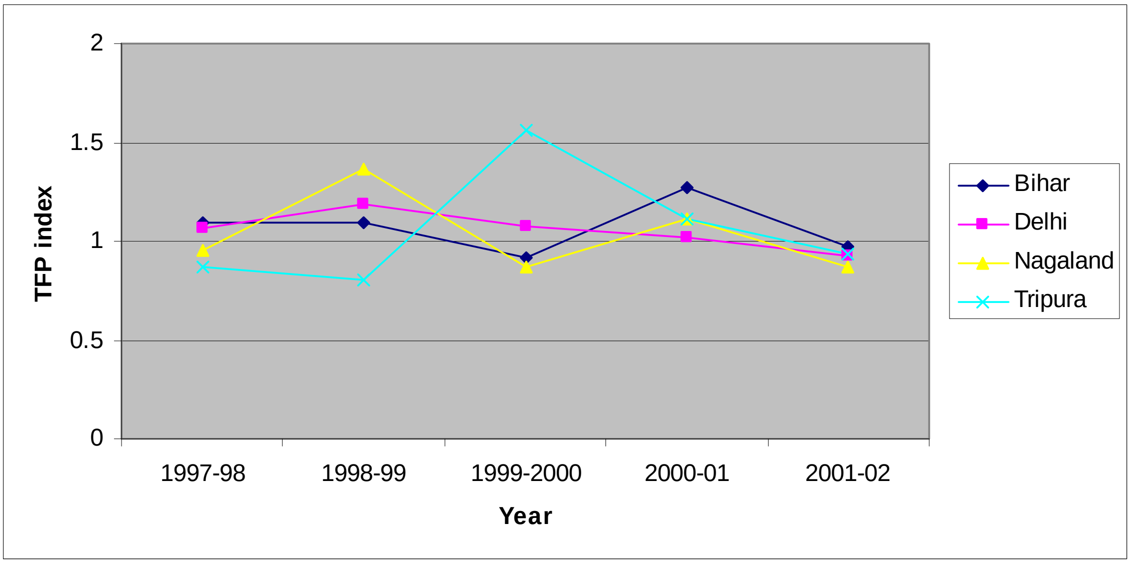

Fig 5. TFP index for the Four less performing SEBs

Table1 Average output and input values for 1996-97and 2001-02

	Year 1996	Year 2002	Change
Outputs			
Number of Customers (Million)	3.37	4.33	28.62%
Distribution line length (circuit Kms)	192710.04	234895.23	21.89%
Energy sold (Mkwh)	10121.15	12640.81	24.89%
Input			
Total Cost (Rs, Million)	21622.37	52642.47	143.46%

Table 2 Main results for productivity development from 1997-2002

DMUs	Malmquist Index	Efficiency Change	Frontier Shift	Technical Efficiency score 1996	Technical Efficiency score 2002	Scale efficiency 1997	Scale efficiency 2002	Return to Scale (2002)
Andhra Pradesh	2.407	1.321	1.822	0.679	0.514	68%	51%	Decreasing
Assam	1.792	0.971	1.845	0.449	0.462	63%	54%	Decreasing
Bihar	1.334	0.795	1.679	0.495	0.623	87%	81%	Decreasing
Delhi	1.298	0.775	1.674	0.396	0.511	89%	82%	Decreasing
Gujarat	1.763	1.144	1.541	0.689	0.603	76%	72%	Decreasing
Haryana	1.773	1.034	1.715	0.594	0.575	85%	80%	Decreasing
Himachal Pradesh	3.389	1.847	1.835	1.000	0.542	100%	82%	Decreasing
Jammu & Kashmir	1.547	0.930	1.663	0.509	0.547	86%	84%	Decreasing
Karnataka	2.562	1.367	1.875	0.784	0.574	78%	62%	Decreasing
Kerala	2.333	1.210	1.927	1.000	0.826	100%	83%	Decreasing
Madhya Pradesh	1.524	0.901	1.691	0.664	0.737	69%	73%	Decreasing
Maharashtra	1.722	1.075	1.601	0.691	0.643	69%	64%	Decreasing
Meghalaya	1.721	1.011	1.702	0.909	0.899	100%	90%	Decreasing
Punjab	1.542	0.983	1.569	0.763	0.777	79%	78%	Decreasing
Rajasthan	2.616	1.533	1.706	0.614	0.401	79%	71%	Decreasing
Tamil Nadu	1.697	0.943	1.800	0.773	0.820	77%	82%	Decreasing
Uttar Pradesh	2.540	1.542	1.648	0.643	0.417	76%	78%	Decreasing
West Bengal	2.692	1.634	1.647	0.696	0.426	84%	81%	Decreasing
Arunachal Pradesh	2.462	1.177	2.092	0.961	0.817	96%	84%	Decreasing
Goa	2.226	1.302	1.710	0.960	0.737	99%	93%	Decreasing
Manipur	1.657	0.915	1.810	0.620	0.677	89%	85%	Decreasing
Mizoram	1.701	0.879	1.935	0.521	0.593	87%	100%	Increasing
Nagaland	1.193	0.650	1.834	0.650	1.000	85%	100%	Constant
Pondicherry	1.441	0.982	1.468	0.982	1.000	99%	100%	Constant
Sikkim	1.972	1.000	1.972	1.000	1.000	100%	100%	Constant
Tripura	1.089	0.582	1.873	0.510	0.876	87%	94%	Decreasing
Average	**192%**	**110%**	**176%**	**71%**	**68%**	**85%**	**81%**	