Productivity Analysis Of Indian Power Distribution Utilities

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***Abstract*—The main aim of the electricity sector reform in India is to introduce competition into electricity generation and supply, and to improve the efficiency of the natural monopoly activities of distribution and transmission through structural and regulatory reforms. To incorporate the various sources of productivity changes, TFP (Total Factor Productivity) analysis has used to measure the total effect for the multiple outputs and inputs used in the production. In this paper, DEA Malmquist approach has applied to estimate the TFP of a set of 56 Indian distribution utilities. This methodology requires only the physical data quantities of input employed and output produced for the estimation of technical and scale efficiency. For this reason, we use this methodology to decompose the productivity evolution of the distribution firms in terms of technical efficiency and technical progress.**

Keywords: Electric Power utility, India, Malmquist, Efficiency, TFP

I. INTRODUCTION

Structural and regulatory reforms in electricity industry normally expects to increase investments; increase number of customer connected, reduces losses and cut number of employees in the utilities to strengthen the performance of the individual utility. The regulator is also interested in knowing the rate of efficiency gains of the utilities. The target of the regulatory reforms is to provide the utilities with incentives to improve their investments and operating efficiency and to ensure that consumers' benefit from the efficiency gains. With time series data, it is possible to determine the Malmquist Productivity Index, which is a combination of the technical efficiency change and frontier shift or the technological change [1]. This exercise provides valuable information on the rate at which the efficiency frontier has moved over recent years after implementing the reforms process in India. This information can be useful in establishing the appropriate X-factor based regulation schemes for providing incentives to utilities as already in practice in UK, Norway, Netherlands and Australia [2]. Jamasb and Pollitt point out the importance of efficiency and productivity studies to illustrate the performance of electricity industry before and after regulatory reforms in different countries [3]. It is applied to check the results of the reform process in the distribution segment in many developed and developing countries [4, 5].

II. OBJECTIVE

Total Factor Productivity (TFP) has applied in the literature to various industries to find the following:

- The trend of growth of TFP in the group of companies in operation.
- The contributions of technical change and efficiency change in the productivity development separately.
- Improvement in productivity of an individual company over the years.
- Most efficient company in operation.
- Number of inefficient utilities and the extent of their inefficiency.

This paper examines the relative performances of Indian power supply utilities between 2005-06 and 2007-08, applying the Total Factor Productivity based on the individual data using the Malmquist index. Total factor productivity growth has been further examined by decomposing it into efficiency change and technical change [6].

III. METHODOLOGY

In economics, productivity is defined as the ratio of what is produced to what is required to produce. The earliest approach to productivity measurement was based on a single or a partial factor productivity measurement. Although easy to calculate, this index is too simple in practice but provides a misleading picture of performance when there is more than one output or input. Electricity distribution firms usually use multiple inputs to get multiple outputs, so this feature is to be considered while measuring the productivity.TFP is a generalization of the single-factor productivity measures. TFP growth refers to the change in productivity over time. There are several approaches available in literature to find the productivity measurement. In order to take into account the contribution of efficiency change to productivity change, we are going to use a frontier approach. In the frontier approach a best practice frontier, has estimated. It can be found using non-parametric or parametric techniques but, in both cases, some assumptions about technology are to be considered. Both approaches have their merits and drawbacks. The two most often methods used in literature are Data Envelopment Analysis (DEA) in the non-parametric group and Stochastic Frontier Analysis (SFA) in the parametric one. We have used non- parametric, DEA technique for TFP analysis of the present data of Indian utilities.

A. *Measurement of Productivity*

The Malmquist TFP index has been applied to analyze the productivity change and its decomposition using DEA. Malmquist productivity indexes were introduced in detail by [7]. They named these indexes after Malmquist, who proposed to construct input quantity index as a ratio of distance functions. Distance functions describe a multi-input, multi-output production technology without making behavioral assumption (such as cost minimization or profit maximization) which is especially suitably in regulated industries. In this paper, we follow an input oriented approach. The input oriented measure answers the question "By how much can input quantities be proportionately reduced without changing the output quantities produced?" [8].

B. *Malmquist index through DEA technique*

After a detailed literature survey, it finds that the majority of the empirical studies that measure the Malmquist productivity index have used DEA. In DEA, estimation of the Malmquist productivity index as well as its sources of growth are obtained by computing appropriate ratios of distance function values corresponding to the constant returns to scale (CRS) and the variable returns to scale (VRS). It utilizes a piecewise linear programming to calculate the efficient technologies. The input-oriented Malmquist compares the input requirements xt for producing output level y_t in period t, with the input that would have been required if the production technology was the same as that in a later period, s. [9].

The Malmquist total factor productivity 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 Malmquist input oriented TFP change index between period s and period t is

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

An equivalent way of writing this index is:

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

Here, the first ratio on the right hand side measured change in efficiency between period's s and t. The remaining part of the index in the equation measures technical change, so that

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

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

Thus tfpch = effch x techch 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 signifies the geometric mean of the shift in technology between the two periods, evaluated at xt and at xs [10]. The value of the index greater than one signifies increase in productivity and vice- versa.

For the present work, we used time series data for a set of 56 distribution companies for the relevant input and output parameters. The summary result of the technical efficiency change also called the catching up effect, (E) and technological change (T) is present in Table 1.0 and Figure1.0

C. *Data and Variables*

The data used in this work consists of a balanced panel of 56 Indian electricity distributions over a period from 2005 to 2008. The data set is prepared based on reports of Power Finance Corporation of India and Central Electricity Authority of India, published from time to time. The final basic model for the distance function includes two output parameters, energy delivered and number of customers, and three input parameters namely, total expenditure, Aggregate technical and commercial losses and network line length.

IV. OBSERVATIONS

In this section, the result of the Malmquist Index has given with a focus on the analysis of the TFP evolution. With this information, here, we have answered the question," To what degree the reforms have improved the productivity and efficiency of the industry?", that is, the main target of this study.

TABLE 1. MALMQUIST INDEX OF FIRMS

Utility No.	Utility (State)	MPI	(E)	(T)
1	BSEB (Bihar)	1.15	1.21	0.96
2	JSEB (Jharkhand)	1.27	1.35	0.94
3	CESCO (Orrisa)	0.90	0.83	1.10
4	NESCO (Orrisa)	0.90	0.79	1.14
5	SESCO (Orrisa)	1.04	1.04	1.00
6	WESCO (Orrisa)	0.97	0.87	1.11
7	SIKKIM PD	0.93	0.79	1.18
8	WBSEDCL(WB)	1.30	1.23	1.06
9	Arunachal PD	1.20	1.11	1.09
10	CAEDCL (Assam)	0.70	0.77	0.91
11	LAEDCL (Assam)	0.57	0.59	0.97
12	UAEDCL (Assam)	0.71	0.74	0.96
13	Manipur PD	2.12	2.10	1.01
14	MeSEB	1.11	0.91	1.21
15	Mizoram PD	0.96	0.95	1.01
16	Nagaland PD	0.95	1.09	0.87
17	Tripura PD	0.97	0.92	1.05
18	BSES Rajdhani (Delhi)	1.00	0.85	1.18
19	BSES Yamuna (Delhi)	1.27	1.18	1.08
20	NDPL (Delhi)	1.16	1.00	1.16
21	DHBVNL (Haryana)	0.92	0.88	1.05
22	UHBVNL (Haryana)	0.93	0.77	1.22
23	HPSEB (HP)	0.87	0.69	1.25
24	J&K PDD (J&K)	0.99	1.00	0.98
25	PSEB (Punjab)	1.01	0.77	1.32
26	AVVNL (Rajasthan)	0.87	0.75	1.15
27	JDVVNL (Rajasthan)	1.05	0.77	1.36
28	JVVNL (Rajasthan)	0.90	0.71	1.27
29	DVVN (UP)	0.90	0.92	0.98
30	MVVN (UP)	0.88	0.95	0.93
31	Pash VVN (UP)	1.02	1.06	0.97
32	Poorv VVN (UP)	1.17	1.32	0.88
33	KESCO (UP)	0.96	1.00	0.96
34	UtPCL (Uttarakhand)	0.98	0.81	1.21
35	APCPDCL (AP)	0.97	0.72	1.35
36	APEPDCL (AP)	1.36	1.00	1.36
37	APNPDCL (AP)	0.87	0.81	1.07
38	APSPDCL (AP)	0.96	0.89	1.07
39	BESCOM (Karnataka)	0.94	0.89	1.06
40	GESCOM (Karnataka)	0.89	0.94	0.94
41	HESCOM (Karnataka)	0.98	1.07	0.92
42	MESCOM (Karnataka)	0.91	1.00	0.91
43	CHESCOM (Karnataka)	0.97	1.11	0.88
44	KSEB (Kerala)	0.93	1.00	0.93
45	Pondicherry PD	1.00	1.00	1.00
46	TNEB (TN)	1.04	1.00	1.04
47	CSEB (Chattisgarh)	1.00	0.74	1.35
48	Goa PD (Goa)	0.97	1.00	0.97
49	DGVIJ (Gujarat)	1.02	0.90	1.14
50	MGVIJ (Gujarat)	0.97	0.96	1.01
51	PGVIJ (Gujarat)	0.76	0.60	1.27
52	UGVIJ (Gujarat)	0.96	0.66	1.44
53	MP Madhya Kshetra VVCL (MP)	0.87	0.75	1.16
54	MP Paschim Kshetra VVCL (MP)	0.78	0.66	1.18
55	MP Purv Kshetra VVCL (MP)	0.92	0.91	1.01
56	MSEDCL (Maharashtra)	1.33	1.13	1.18
	MEAN	1.01	0.94	1.09

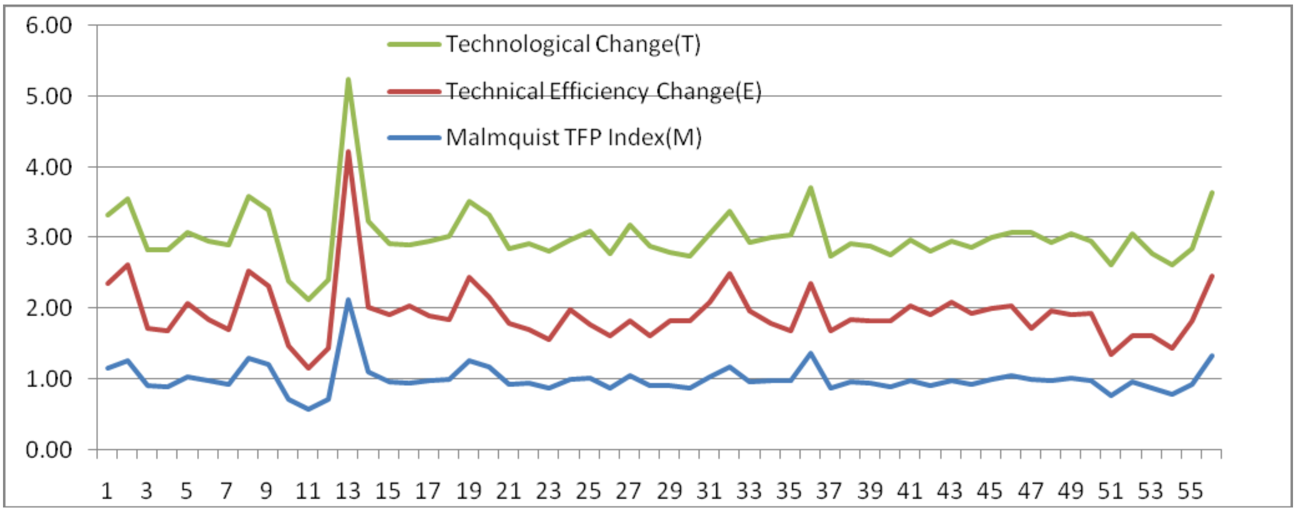

Figure 1. TFP growth between 2005 - 2008

V. RESULT AND DISCUSSION

The table above reveals the overall productivity trend during the period considered. The average contribution from all utilities technical efficiency change is -6% and from frontier shift is +9%, this shows that the contribution from technical efficiency change is less on the TFP growth of utilities in India. It is evident from Figure 1.0, that the shape of TFP index curve is driven positive by technological change but is dragged down by retarding technical efficiency trend.

In the present sample, the large maximal growth of Manipur is striking, indicating improvement of 112% in total productivity, with catching up improvement of 110% and frontier change of 101%. It is followed by APEPDCL in Andhra Pradesh with a productivity change of 36% per annum and technological change of 36%. Among the poor performers, LAEDCL, CAEDCL, UAEDCL, all operating in Assam state has the maximum decline of more than 30% in the productivity levels. MP Purv Kshetra VVCL, MP Madhya Kshetra VVCL, and MP Paschim Kshetra VVCL of Madhya Pradesh has also shown significant decline of approximately 25% respectively.

An uneven trend has observed with some big utilities like, BSEB, JSEB, SESCO, WBSEDCL, BSES Yamuna, NDPL Delhi, MSEDCL and APEPDCL etc., demonstrating improvement in productivity while other indicates decline. The result indicates that technological advancements such as High Voltage Distribution Systems, Automatic Meter Reading and Geographic Information System technologies that are common in the developed countries are yet to be adopted by the Indian companies. Few distribution companies are in the process of conducting pilot tests with some advanced technological options, whereas the broader attention seems to be focus on extracting efficiency gains from the assets available. While this strategy appears to be a logical path, looking to the current socio-political constraints of the country, we recommend a more rapid absorption of advanced technologies based on cost-benefit analysis.

While the analysis above has based on data for a limited number of years, it does reveal an important underlying trend that the distribution companies have not adequately focused on improving the production technology. We believe that it is important that they start paying attention to technological leap in order to achieve long-term reduction in cost and improvements in quality along with the focus on extracting immediate efficiency gains. When more accurate and long time series data will be available, further research in this area shall be useful in highlighting the policy options and priorities for management action.

VI. CONCLUSION

The average result of the study shows that the productivity evolution of the sample companies in the whole period depend much more on the frontier shift (i.e., technical change) mainly, due to technological innovations. The pure technical efficiency (the catching up effect) shows that the firms have not improved their behavior, which allows us to reach to the conclusion that the incentives derived from the reforms in the regulation do not seem to have produced the expected results. However, there are large variations within the utilities.

The results indicate a mixed trend in TFP productivity for all the utilities; however, the growth is not persistent at the same rate to the all the state owned or public sector owned distribution companies. Since most of the states, which have unbundled their distribution sector, are not mature enough, it will be too early to conclude that the effect of reform is not reflecting in the performance of the utilities as expected. The state power departments, which are bundled, are adopting the new technologies and working efficiently as compared to some of the unbundled states. For decision makers it has now become important to know the units that decline the frontier and their relative weights to make the sector sustainable. While a few distribution companies are adopting advanced technological options, their main attention for present seems to be focus on extracting efficiency gains from the current assets

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