Performance Management and Measurement with Data Envelopment Analysis

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Evaluation of electricity distribution sector in Iran using parametric and non-parametric methods

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ABSTRACT

This paper conducts a comparative technical efficiency analysis of 36 Electricity Distribution firms using data of 2007-2008 and two Methods: Deterministic Frontier Production Function (DFPF) and Data Envelopment Analysis (DEA). The results of DEA and DFPF Analysis are compared with correlation method.This comparison indicates a relatively good correlation.
Keywords: *Electricity Distribution Sector, Parametric Method, DEA*

INTRODUCTION

This study applies two techniques of efficiency measurement in a sample of electricity distribution firms in Iran.

The aim of this paper is to compare the relative efficiency of 36 firms working in the Electricity Distribution Sector in Iran. For this purpose DEA and DFPF models are applied to evaluate the efficiencies of the firms.

Detailed statistics from Iranian Electricity consumption for the years 2007-2008 was. Used as the source of information for the variable of models.

PREVIOUS STUDIES

Cullman et al. (2008) tested the hypothesis that the economic transition toward a market economy increases the efficiency of firms. They studied 32 polish electricity distribution companies between 1997 and 2002, by applying common benchmarking methods to the panel, the nonparametric data envelopment analysis (DEA), the free disposal hull (F.D.H), and, as a parametric approach, the stochastic frontier analysis (S.F.A). They found that the technical efficiency of the companies has indeed increased during the transition, while allocate efficiency has deteriorated.

Hattori (2001) conducted U.S-Japan comparison of performance of electric utilities during 1982 through 1997, but it focuses on electricity distribution and used stochastic Frontier Analysis to estimate technical efficiency of the utilities.

Jamasb and Pollitt (2001) reported an efficiency of 63 European electricity distribution utilities to assess the potential of and issues involved in the use of cross-country analysis as input incentive regulation process.

The sample includes utilities from the UK, Norway, Netherlands, Portugal, Italy and Spain. They used the authors used DEA, SFA and COLS method with Different models specification to a set of data from 1997-8.

Murillo-Zamorano L.R. et al. (2001) reported that parametric frontier models and non-parametric methods have monopolized the recent literature on productive efficiency measurement.

Park Soo-UK and J.B. Lesourd (2000) conducted The efficiency of conventional fuel power plants in south Korea by comparison of parametric and non-parametric approaches.

DATA

Using data are three imputes and one output for 36 firms in Electricity distribution sector in Iran. In the models inputs and output are as follows:

X_1 = number of professional employees

X_2 = low voltage line (km)

X_3 = capacity of transformers (MVA)

Y = Total Electricity sales (MWh)

MODELS

The Parametric and Non-Parametric methods have been applied to measure efficiency in electricity distribution sector by researchers.

In this study, the CCR input oriented model is used to measure relative technical efficiency with constant return to scale (CRS).

In modeling deterministic frontier production function (DFPF) for electricity distribution sector, it was assumed that total Electricity sales (y) is produced by three inputs: X_1, X_2, X_3

A Cobb-Douglas functional form was first applied as follows:

$$y^* = A_0(X_1^{a_1})(X_2^{a_2})(X_3^{a_3})$$

The deterministic frontier production that has not a random error function is estimated by using the Linear Programming Model as follows (Aigner et al., 1977):

$$Min\ Z = a_0 + a_1\overline{X}_1 + a_2\overline{X}_2 + a_3\overline{X}_3$$

$$S.to:$$

$$a_0 + a_1(\ln X_{j1}) + a_2(\ln X_{j2}) + a_3\ln(X_{j3}) \geq \ln(y_j) \quad j = 1 \ldots 36$$

$$a_0, a_1, a_2, a_3 \geq 0$$

Where, $\overline{X}_1 = \sum_{j=1}^{36} \ln X_{j1} \Big/ 36$

$$\overline{X}_2 = \sum_{j=1}^{36} \ln X_{j2} \Big/ 36$$

$$\overline{X}_3 = \sum_{j=1}^{36} \ln X_{j3} \Big/ 36$$

$a_0 = \ln A_0$

The estimated model is as follows:

$$y^* = A_0(X_1^{a_1})(X_2^{a_2})(X_3^{a_3})$$

Where, $A_0 = e^{a_0} = 8645.5$

$a_1 = 0.0$

$a_2 = 0.0$

$a_3 = 0.8397$

The coefficient of professional employees and low voltage line are zero, therefore in the final model, only capacity of transformers included.

In parametric model, the efficiencies are computed as follows:

Efficiency of j firm = y_j / y_j^*

Where:

y_j = the actual output of j firm

y_j^* = the function output of j firm

j = 1, 2... 36

RESULTS

Results in terms of both Non-parametric (CCR) and parametric (deterministic frontier production function) efficiencies are given in Table (1).

The comparison of correlation coefficient (r = 0.824) indicates a good correlation between two approaches. In this case a null hypothesis (no difference in efficiencies average as evidenced by two approaches) can not be rejected at the significant level of 0.05.

The efficiency measures generated by the different approaches have similar means.

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Table (1): Efficiency results

#	EFF1	EFF2	#	EFF1	EFF2
1	0.867	0.860	19	0.647	0.420
2	0.678	0.670	20	0.896	0.850
3	0.687	0.720	21	1.0	1
4	0.630	0.570	22	0.813	0.770
5	0.830	0.870	23	0.560	0.570
6	0.722	0.840	24	0.563	0.530
7	0.604	0.550	25	0.491	0.430
8	0.815	0.750	26	0.599	0.610
9	0.609	0.630	27	0.708	0.720
10	0.568	0.570	28	0.814	0.710
11	0.781	1.0	29	0.750	0.770
12	0.679	0.630	30	0.603	0.570
13	0.872	0.950	31	0.580	0.620
14	0.904	0.990	32	0.525	0.580
15	0.884	0.750	33	0.520	0.490
16	0.624	0.540	34	0.519	0.520
17	1.0	0.740	35	1.0	0.760
18	0.797	0.760	36	0.905	0.900
#: Number of firm					
EFF1: CCR efficiency (with constant returns to scale)					
EFF2: Parametric efficiency (deterministic frontier production function)					

Comparison: T-test results, paired samples statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair	EFF1	0.7234	36	0.15117	0.02520
	EFF2	0.6997	36	0.15947	0.02658

Paired Samples Correlations

	N	Correlation	Sig.
Pair EFF1 & EFF2	36	0.824	0.000

Paired Samples Test

	Paired Differences					t	df	Sig.(2-tailed)
	Mean	Std. Deviation	St. Error Mean	95% confidence Interval of the Difference				
				Lower	Upper			
Pair EFF1-EFF2	0.02372	0.09241	0.1540	-0.00754	0.05499	1.154	35	0.132

EFF1: CCR efficiency
EFF2: Parametric efficiency