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Benchmarking the Efficiency of Philippines Electric Cooperatives Using Stochastic Frontier Analysis and Data Envelopment Analysis

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Benchmarking the Efficiency of Philippines Electric Cooperatives Using Stochastic Frontier Analysis and Data Envelopment Analysis

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Abstract

This paper attempts to determine alternative methods of benchmarking the efficiency of electric companies to aid the regulator in crafting policies in enticing them to pursue more efficient production. This paper utilizes the data of electric cooperatives (ECs) in the Philippines, the one in charge of missionary electrification yet the smallest and most heavily indebted part of distribution sector. Using a panel composed of 119 cooperatives from 1990 to 2002, a cost function is estimated for the ECs. This estimation was used to identify appropriate cost variables that will determine the frontier. It was found out that the main cost drivers (as represented by total operating and maintenance costs) are total sales, prices of labor and capital, distribution network, transmission capacity, actual billed customers, service area, demand structure, and system losses. Based on this specification, efficiency frontiers are computed using Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). The efficiency of each cooperative was then ranked and compared for consistency checks. The SFA reports that on the average, ECs are 34 percent away from the cost frontier while that of DEA estimates 42 percent. The panel data also allowed for DEA to calculate Total Factor Productivity changes based on the Malmquist index. On the average, TFP increased by 1.7 percent from 1990 to 2002.

The rankings and productivity values will prove to be useful for the energy regulator in determining efficiency targets. The fact that DEA and SFA are based on theoretically determined cost function will lead to results that are more representative of the ECs actual performance, rather than basing them on single ratios, which, when considered alongside other ratios will lead to results that are rather misleading.

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1. Introduction

In this paper, the cost function for a panel of 119 Philippine electric distribution cooperatives is estimated as a basis for efficiency benchmarking. Even with deregulation, electricity distribution utilities will still have a monopoly franchise to deliver electricity within their service territories so that rate regulation by the regulatory commission is still deemed necessary. If regulation is not undertaken, it is possible that distribution utilities could raise the rates above what they would be in a competitive market. Similar to regulation of generation sub-sector, this raises the problem of determining proper rates for the delivery of electricity at the local level. Prices should be high enough to guarantee the viability of regulated firms; at the same time, prices should not be set too high to cause welfare losses. Because of asymmetric information, the regulator does not know the firm's true costs. High costs may be due to the firm's particular production situation or just because of its inefficiency.

To facilitate comparison, benchmarking can help to address information asymmetry. In essence, benchmarking is a system in which the ratios of a firm's inputs to outputs, the production costs or the quality are compared to external references. By comparing the costs of similar companies the regulator can establish a set of "yardsticks" of performance from which he could infer any one firm's attainable cost efficiency level. With this, the dependence of the price that any company received on its own cost level would be broken. Therefore, benchmarking analysis can be used to set the informational basis for more effective regulation, as it reduces informational asymmetries between firms and regulators regarding costs. Benchmarking exercises also make it possible to identify the scope for further efficiency improvements of each cooperative and to measure comparative improvement in their performance over time.

A traditional performance measurement system, however, provides a very unbalanced picture of performance that can lead firm managers and regulators to miss important opportunities for improvement. The most common method of comparison or performance evaluation is ratio analysis that involves selecting two significant figures, expressing their relationship as a proportion or fraction. The most common types in the analysis of distributional firms are return to investment, number of employees per customer, load factor, system loss, and others. These measures are often inadequate due to the existence of multiple inputs and outputs related to different resources, activities and environmental factors. Finding the appropriate measurement of relative efficiency through the use of multiple inputs and outputs has then become a key issue in benchmarking studies.

The purpose of this essay is to make a contribution to the method of assessing the efficiency of electric cooperatives in the Philippines. In the next five years, the ECs through the guidance of NEA, need to pursue far reaching improvements in their performance. The EPIRA (Section 60) and its Implementing Rules and Regulations (Rule 31) states that the outstanding obligations of the ECs shall be assumed by PSALM in accordance with the rehabilitation program approved by the President of the Philippines. Executive Order 119 outlines the restructuring program for cooperatives outlining the Performance Improvement Program (PIP) and the Rehabilitation and Efficiency Plan (REP) for cooperatives. The present study makes an important contribution in that it is the first study to consider multi-output distance functions in assessing the efficiency of rural electric cooperatives. From the researcher's knowledge, it is also the first to apply two different methods of benchmarking efficiency to one data set and to estimate productivity gains of each cooperatives from 1990 to 2002.

The study also hopes to contribute on the debate regarding the move from rate-of-return regulation to incentive regulation on pricing of the distribution network in the future. Yardstick regulation is suggested as the method to regulate prices for the distribution network. By emphasizing the incorporation of service area characteristics to correct the yardsticks for influences due to the heterogeneity of output, the study hopes to start a process of determining the feasibility of moving from ROR to alternative forms of regulation.

2. Methodology

To be able to fully assess the efficiency of electric cooperatives, this study will cover a number of approaches that is currently used by regulators around the world. Both econometric and non-parametric estimates will be assessed. Specifically, an econometric model, SFA and a non-parametric DEA (one with variable returns to scale and another with constant returns to scale) will be estimated. Finally, since a panel data from 1990 to 2002 is available, Malmquist DEA is also utilized to estimate the productivity of each electric cooperative throughout these years.

2.1 Model Specification

An efficiency measure is defined as the distance of the observed practice to the efficient frontier. Since the efficiency frontier is not known, this has to be estimated. There are various ways of estimating the frontier. The main difficulty, however, is that different sometimes lead to different estimates of the frontier. By estimating efficiency using both DEA and SFA, this essay will present the efficiency estimates obtained from the two methods and how the results complement each other. This section then outlines the steps undertaken to be able to come up with a model that will lead to consistent efficiency estimates.

The first step was the assumption of relationship to be estimated: (i) a cost function or (ii) a production function. After considering the studies in the past and the data obtained and after analyzing the inherent qualities of the electricity industry, it was decided that the cost function is the better specification. Since the cooperatives are under obligation to provide the electricity at the specified tariffs, they must be able to meet the demand for their service without having able to choose the level of electricity that they will distribute. Given the exogeneity of the output levels, the ECs maximize profit simply by minimizing the cost of delivering a certain level of electricity. With this argument, a cost function specification is deemed to be the more appropriate one.

Another issue to be decided on is what cost to focus on. Since the ERC as well as regulators around the world evaluate the performance of regulated firms using operating costs, NEA's non-power cost was chosen. Non-power cost is essentially total operating and maintenance expenditure defined as the sum of distribution, consumer accounts, administrative and general expenses.

Having specified the function to be estimated, the input and output variables that should be included in the analysis has to be specified. The cost drivers chosen are based on the definition that the costs of operating a distribution system are the costs of building and maintaining the system of service lines, mains and transformers, and of measuring and billing electricity. The variables that were utilized to come up with an appropriate cost function for Philippine ECs are drawn from the comprehensive list of cost factors enumerated by Burns and Weyman-Jones (1996), such as:

a. the total number of customers served;
b. the type of consumer;
c. the dispersion of the consumers;
d. the size of the distribution area;
e. the total kWh sold;
f. maximum demand on the system;
g. system loss;
h. the length of distribution line; and
i. the transformer capacity.

When the appropriate cost function is found, it is then used for estimating efficiency rankings for SFA.

The next challenge is identifying the inputs and outputs for DEA. Since prices for labor and capital inputs are available, both allocative efficiency and technical efficiency are estimated. To make it comparable with SFA results however, the restrictive specification of cost-DEA was relaxed and the variables used for input and output are made similar to those used in SFA. The core output variable is specified to be total electricity delivered measured by total sales in KWh. The core input variable is identified to be total operating and maintenance expenditures, transformer capacity and length of distribution line, all of which are widely accepted in literature as a required input variables. However, as pointed out by Kumbhakar and Hjalmarsson (1998), length of distribution lines, which measures the amount of capital in the form of network, has to be treated with caution because it can be misleading since it can reflect geographical dispersion of consumers rather than differences in productive efficiency. Therefore, in previous studies of relative efficiency differences, network capital was treated either as an output or as input but only after controlling for geographical dispersion. In this essay, the second position is adopted and geographical dispersion is accounted for by including environmental variables. Exogenous variables specific to each cooperative are captured by including the abovementioned environmental variables. Service area and number of actual billed customers are exogenous operating characteristic of each cooperative's environment, both of which encapsulate consumer density which accounts for geographical dispersion. The idea is that customer density should capture the effect of demographic features, in the sense that higher values of this variable can be expected to enable a firm to deliver more output per unit of input. For similar reasons, measurement of the effect of delivering energy at different voltages required by different customers is also needed, and therefore the proportion of total energy delivered that is distributed to residential customers is included as an additional operating characteristic (Estache, Rossi and Ruzzier, 2002). Finally, system loss and maximum demand on the system as measured by peak load are included as environmental input variables to account for technological differences among cooperatives in delivering electricity.

Following the discussion above and the availability of data, the initial model for the DEA and SFA, as determined by the cost function, will be:

Table 1 Variables in the Initial Model

Output	Inputs	Environmental Variables
1. Total Sales	1. Total Operating and Maintenance Expenditure	1. Service Area (output)
	2. Distribution Network	2. Actual Billed Customers (output)
	3. Transformer Capacity	3. Demand Structure (output)
		4. System Loss (input)
		5. Maximum Demand (input)

The final model is obtained after testing the statistical significance of the environmental variables. The idea is that a frontier model has two parts: the “core” of the model and the environmental variables (Rossi and Ruzzier, 2000). In a cost function approach the theoretically determined core is formed by the input and output variables, whereas the set of environmental variables include those factors that might influence the ECs’ performance which cannot be directly controlled by them. The initial specification for the core of the model is subject to theoretical considerations. Environmental variables, on the other hand, are not theoretically determined and will only be included in the final model if they are statistically significant and economically sound.

When the appropriate variables are determined for DEA, the data will then be utilized to derive Malmquist Index to measure total factor productivity changes among ECs from 1990 to 2002.

2.2 Data

Given the above model specification, the data utilized for this paper are as follows:

1. ***Total Sales***—in kWh, calculated as total sales minus sales to other electric companies;
2. ***Maximum Demand***—as represented by peak load, in kW;
3. ***Total Operating and Maintenance Expenditures***—in pesos, calculated as the sum of distribution, consumer accounts and administrative and general expenses;
4. ***Transformer Capacity***—in kVA, measured by transformer capacity rating for each cooperative;
5. ***Distribution Network***—measured as total circuit km lines;
6. ***Service Area***—in sq. km., as the total land area of each cooperatives' mandated franchise area;
7. ***Actual Billed Customers***—total number of customers connected to each cooperative, measured as the sum of different types of customers disaggregated as residential, commercial, industrial, public building, street lights, large road, irrigation, BAPA, water system, wholesale to sister cooperative, and others;
8. ***Demand Structure***—in KWh, measured as residential sales' share of the total sales;
9. ***System Loss***—in percent, as calculated by NEA; and
10. ***Peak Load***—in KW.

The data for all 119 cooperatives from 1990 to 2002 are obtained from the NEA database. Since service area is measured by NEA as number of municipalities and *barangays* energized, total service area that is measured in land area is derived by identifying the land area covered of each cooperatives' franchise based on the Rural Electrification Chronicle (1999) published by NEA. Land area of each municipality is then obtained from the total land area assessment by the Land Economics and Statistics Section of the Department of Environment and Natural Resources for each municipality. The total operating and maintenance expenditure is expressed in real values

(1994=100) using the CPI index for Fuel, Light and Water as published by the National Statistical Coordination Board.

2.3 Methodological Issues

Based on the literature reviewed, it is evident that benchmarking studies of distribution utilities have adopted different methods and a wide range of input and output variables. This creates a problem since there is no defined consensus as to how the basic functions of the utilities should be modeled, despite the fact that the technologies and characteristics of the distribution utilities are relatively similar. As in the case of distribution lines, in some studies it was used as an input while others used it as an output variable. Nevertheless, the inputs and outputs used in previous studies can give an indication of which of variables are more widely chosen. A review of the frequency with which different input and output variables are used was conducted by Jamasb and Pollitt (2001). They found that the most frequently used inputs are operating costs, number of employees, transformer capacity, and network length while the most widely used outputs are units of energy delivered, number of customers, and the size of service area. Given this finding, the specification in this essay conforms to the norm undertaken in other benchmarking studies.

3. Efficiency Analysis Using DEA and SFA

This section will outline the process used to estimate the cost function which was then used in the specification for SFA. Using the same set of variables, DEA was run to test comparability of results. Finally the Malmquist index was calculated to measure the productivity changes among cooperatives from 1990 to 2002.

3.1 Cost Function Estimation

The total operating and maintenance cost (*TOM*) is a function of output (*S*), input factor prices (P_i), distribution length (*DL*), transformer capacity (*TC*), and exogenous variables (Z_i),

$$TOM= f(S, P_i, DL, TC, Z_i). \qquad (1)$$

In this essay, the most general functional form for electricity distribution in the Philippines is a Cobb-Douglas cost function:[2]

$$\ln TOM = \beta_0 + \beta_1 \ln S + \beta_2 \ln P_L + \beta_3 \ln P_K + \beta_4 \ln DL + \beta_5 \ln TC + u_i \qquad (2)$$

where P_L and P_K are the prices of labor and capital, respectively.[3]

The cost function specified above does not include environmental variables. There are two approaches in their inclusion: (1) including them directly into the cost function as regressors, assuming that they influence the shape of the technology, and (2) accounting for their effect after the cost function estimation, assuming that they directly influence the degree of technical efficiency (Coelli, Perelman, and Romano, 1999). Following Estache, Rossi and Ruzzier (2002), the first approach was taken in this study in order to get efficiency measures that are net of environmental influences. Coelli, Perelman and Romano (1999) emphasized that the measurement of net efficiency is useful as it allows one to predict how companies would be ranked if they were able to operate in equivalent environments.

Adding the environmental variables, the function is specified as follows:

$$\begin{aligned} \ln TOM = {} & \beta_0 + \beta_1 \ln S + \beta_2 \ln P_L + \beta_3 \ln P_K + \beta_4 \ln DL + \beta_5 \ln TC \\ & + \beta_6 \ln SA + \beta_7 \ln CUST + \beta_8 \ln DS + \beta_9 \ln SL + \beta_{10} \ln PL + u_i \end{aligned} \qquad (3)$$

where *SA* is service area, *CUST* is the number of actual billed customers, *DS* is the demand structure, *SL* is the system loss and *PL* is the peak load.

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[2] A translog production function with the form

$$\begin{aligned} \ln TOM = {} & \beta_0 + \beta_1 \ln S + \beta_2 \ln P_L + \beta_3 \ln P_K + \beta_4 \ln DL + \beta_5 \ln TC \\ & + \beta_6 \ln^2 S + \beta_7 \ln^2 P_L + \beta_8 \ln^2 P_K + \beta_9 \ln^2 DL + \beta_{10} \ln^2 TC \\ & + \beta_{11} \ln S \ln P_L + \beta_{12} \ln S \ln P_K + \beta_{13} \ln S \ln DL + \beta_{14} \ln S \ln TC \\ & + \beta_{14} \ln P_L \ln P_K + \beta_{15} \ln P_L \ln DL + \beta_{16} \ln P_L TC + \beta_{17} \ln P_K \ln DL \\ & + \beta_{18} \ln P_K \ln TC + \beta_{19} \ln DL \ln TC + \beta_{20} \ln SA + \beta_{21} \ln CUST \\ & + \beta_{22} \ln DS + \beta_{23} \ln SL + \beta_{24} \ln PL + u_i \end{aligned}$$

is estimated however, most of the coefficients turned out to be statistically insignificant.

[3] P_L is obtained by dividing the actual administrative expenses over the number of employees while P_K is obtained by dividing distribution expenses over transformer capacity (Hattori, 2002).

The descriptive statistics of each variable are presented in Table 2.

Table 2 Descriptive Statistics

VARIABLE	Obs	Dimension	Mean	Std. Dev.	Minimum	Maximum
TOM	1533	100,000 pesos	269.69	206.01	4.76	1413.04
S	1533	in KWh	42931.04	50467.38	92.00	369215.00
PL	1532	100,000 pesos per employee	0.65	0.25	0.10	1.67
PK	1356	100,000 pesos per KVA	0.03	0.005	0.01	0.06
DL	1528	km.	1460.50	991.66	11.00	6424.00
TC	1357	KVA	27290.63	63153.36	750.00	1016800.00
SA	1529	sq. km.	3006.95	7125.32	104.46	76422.38
CUST	1533	customer unit	32191.78	23147.18	268.00	122088.00
DS	1533	%	0.56	0.16	0.06	3.55
SL	1532	%	0.17	0.07	-0.10	0.43
PL	1396	KW	12570.43	12463.52	82.00	90902.00

Following the methodology of Estache, Rossi, and Ruzzier (2002), the core cost function was estimated and the environmental variables were added into the model depending on their statistical significance. Peak load is dropped from the model due to an insignificant coefficient. Additional test the significance for the environmental variables is conducted using the log likelihood ratio test with the null hypothesis that $\beta_6 = \beta_7 = \beta_8 = \beta_9 = 0$. The null is strongly rejected by the data, suggesting that environmental variables cannot be omitted in the estimation of cost function in this sector.[4]

After correcting for heteroscedasticity, the following is the cost function estimated for an unbalanced panel of 119 firms using data from 1990 to 2002:

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[4] The χ^2 value obtained is 325.53, the test statistic of which indicates that it exceeds the 99th percentile for the corresponding χ^2 distribution.

Table 3 Results of Panel Regression Using Total Cost

	Coefficient	Std. Err.	z-value
S	0.1646*	0.0087	18.9750
P_L	0.2087*	0.0071	29.2300
P_K	0.4429*	0.0082	53.8310
DL	0.4428*	0.0090	49.1170
TC	0.0718*	0.0081	8.9090
SA	0.0274*	0.0036	7.5810
CUST	0.2025*	0.0120	16.8320
DS	0.0321*	0.0084	3.8310
SL	0.0814*	0.0070	11.5520
Constant	-0.6412*	0.0662	-9.6810

NOTE: * significant at 0.01 level of significance.

To be able to check the consistency of these results, an average cost function is also estimated. The results of the regression estimates are as follows:[5]

Table 4 Results of Panel Regression Using Average Cost

	Coefficient	Std. Err.	z-value
S	-0.9877*	0.0099	-99.516
P_L	0.3803*	0.0066	57.851
DL	0.6169*	0.0082	75.502
TC	0.0512*	0.0083	6.148
SA	0.0135*	0.0040	3.369
CUST	0.2182*	0.0152	14.385
DS	-0.0344*	0.0145	-2.365
SL	0.1433*	0.0084	17.096
Constant	0.4496*	0.0696	6.46

NOTE: * significant at 0.01 level of significance.

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[5] The average cost function estimated takes the form:

$$\ln\frac{AC}{P_K} = \beta_0 + \beta_1 \ln S + \beta_2 \ln\frac{P_L}{P_K} + \beta_3 \ln DL + \beta_4 \ln TC$$
$$+ \beta_5 \ln SA + \beta_6 \ln CUST + \beta_7 \ln DS + \beta_8 \ln SL + \beta_9 \ln PL + u_i$$

where AC is TOM divided by S. Since linear homogeneity in factor prices is imposed, the price of capital is specified to be the numeraire.

The estimated functions are both well behaved**.** All parameter estimates are statistically significant with the expected signs. Since the total and average costs as well as the dependent variables are in natural logarithms and have been normalized, the first order coefficients are interpretable as cost elasticities evaluated at the sample median. The total operating and maintenance cost is expected to increase given an increase in all its cost drivers. The average cost model gave negative output elasticity which implies that an increase in the production of output will decrease average cost. This confirms the presence of economies of scale, as what is expected from natural monopolies. An increase in service area and number of customers will positively affect average cost, however, an increase in the percentage of residential customers will decrease average cost. A possible explanation is that as more residential customers become connected to the network, all others held constant, there is a higher customer utilization of the network thereby bringing down cost.

Based on the cost function estimations, the functional form that SFA will assume is determined. The validity of the variables that will be used for SFA and DEA are also verified.

3.2 Stochastic Frontier Analysis Efficiency Estimates

Following the cost function estimation, the general functional form for the stochastic frontier among rural electric cooperatives in the Philippines is:

$$\begin{aligned} \ln TOM = \beta_0 + \beta_1 \ln S + \beta_2 \ln P_L + \beta_3 \ln P_K + \beta_4 \ln DL + \beta_5 \ln TC \\ + \beta_6 \ln SA + \beta_7 \ln CUST + \beta_8 \ln DS + \beta_9 \ln SL + v_{it} + u_{it} \end{aligned} \tag{4}$$

where v_{it} are independent and identically distributed random variables and u_{it} are non-negative random variables representing inefficiency. Table 5 shows the results of the econometric estimation.

Table 5 Estimated Variable Parameters and Statistics for SFA

	Coefficient	Std. Err.	t-value
S	-0.9032	0.1286	-7.0246
P_L	0.3207	0.0200	16.0701
P_K	0.2212	0.0107	20.7546
TC	0.3701	0.0104	35.6650
DN	0.3716	0.0124	29.8974
SA	-0.0005	0.0123	-0.0421
CUST	0.0855	0.0080	10.6989
DS	0.0695	0.0225	3.0854
SL	0.1539	0.0227	6.7846
Constant	-0.0024	0.0100	-0.2376
σ^2	0.0219	0.0029	7.6253
γ	0.7375	0.0203	36.2640

NOTE: * significant at 0.01 level of significance.

All the variables are statistically significant except for service area. The table includes statistics on the statistical noise in the estimation of the stochastic frontier. The sigma square σ^2 is the sum of variances of statistical noise σ_v^2 and inefficiency σ_u^2. Gamma $\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2}$ measure the significance of undertaking stochastic frontier estimation. If the null hypothesis, that γ equals zero, is accepted, this would indicate that σ_u^2 is zero and hence that the u_{it} term should be removed from the model. The parameters can then be consistently estimated using ordinary least squares. In the case of Philippine cooperatives, the null hypothesis is rejected and thus, undertaking SFA for efficiency benchmarking is appropriate for the sector.

The yearly efficiency estimates based on these parameters is reported in Table 6.

Table 6 SFA Cost Efficiency (Annual Means)

YEAR	**SFA Efficiency**
1990	1.4624
1991	1.4504
1992	1.4389
1993	1.4276
1994	1.4167
1995	1.4062
1996	1.3959
1997	1.3859
1998	1.3762
1999	1.3668
2000	1.3577
2001	1.3488
2002	1.3402
Mean	**1.3980**

SFA efficiency scores measure the distance an electric cooperative is operating away from its cost frontier. On the average, the 105 electric cooperatives are operating about 39.8 percent higher than the cost efficient frontier.

3.3 Data Envelopment Analysis Efficiency Estimates

DEA, an alternative benchmarking methodology is estimated not only to have a basis of comparison for the SFA rankings but also due to the wealth of information that can be obtained from the model. DEA can readily provide a range of efficiency scores that disaggregates different sources of efficiency including: (1) *allocative efficiency* which measures the efficiency of the usage of least cost input mix, (2) *technical efficiency* which measures the efficiency of obtaining maximum output given a set of inputs, and (3) *scale efficiency* which measures the efficiency of operating at the optimum size given the output level produced.

DEA results provide values for input reduction (in the case of input-oriented DEA) or output enhancement (in the case of output-oriented DEA) that can serve as guide to regulators in setting efficiency targets. DEA also identifies relevant peers for each cooperative that can serve as performance models as well as the economies of scale of each EC. This information will be useful for the regulator as it can open avenues for implementing yardstick regulation in the sector.

Since the data is a pooled cross section and time series, several possibilities arise within the computation of efficiency using DEA. According to Estache, Rossi, and Ruzzier (2002), three alternative approaches are possible. The first alternative would be to compute a frontier for each thirteen periods and to compare each of these cross-section results. This way, a frontier is constructed in each year and the efficiency of each firm is calculated relative to the frontier in each period. The second possibility is to treat the panel as a single cross-section (each firm in each period being considered as an independent observation), pooling all the 1365 observations together. With this approach, a single frontier is computed, and the relative efficiency of each firm in each period is calculated in reference to this single frontier. The last approach would be the window analysis approach proposed by Charnes et al. (1985). The problem with this approach, however, is that the choice of width for the windows poses an additional complication given that it is entirely ad hoc, and "currently determined by trial and error" (Charnes et al., 1994). In this essay, the first and second alternatives are undertaken. The first approach is used for the estimation of a Cost-DEA while the second approach is used to compare the efficiency ranking results with that of SFA.

The data obtained allows for the estimation of both Cost-DEA and Technical Efficiency DEA (TE-DEA). The estimation of Cost-DEA, however, does not allow for the inclusion of environmental input variables in the specification, making the results not comparable with SFA. Given this constraint, TE-DEA is then estimated to facilitate comparison between the two approaches. The estimates of Cost-DEA, however, are still presented since it allows for the disaggregation of technical, allocative and cost efficiencies.

The outputs specified in the computation of Cost-DEA are total electricity delivered, number of customers billed, service area covered and demand structure. Transformer capacity and number of employees are identified as input variables, while P_K and P_L account for their prices, respectively.

Cost-DEA is estimated by pooling all the observations for each firm in 13 years into one single cross-section. This way, the results estimated will be robust. On the average, the electric cooperatives in the Philippines has a technical efficiency of 0.606, implying that the cooperatives could have delivered the same output using only 60.6 percent of its inputs. In terms of cost efficiency, had the cooperatives could have realigned their input mix, they could have been using only 57.7 percent of their costs.

The annual means of Cost-DEA is presented in Table 7.

Table 7 DEA Efficiency Estimates (Annual Means)

YEAR	Technical Efficiency	Allocative Efficiency	Cost Efficiency
1990	0.536562	0.94839	0.511048
1991	0.564038	0.948971	0.536571
1992	0.549962	0.947343	0.521229
1993	0.561952	0.944781	0.529638
1994	0.560448	0.946952	0.529657
1995	0.592733	0.958105	0.566743
1996	0.60439	0.957124	0.577295
1997	0.612524	0.957429	0.584914
1998	0.632819	0.955924	0.603352
1999	0.639857	0.953429	0.608581
2000	0.657076	0.952048	0.624638
2001	0.663781	0.956819	0.634467
2002	0.70379	0.958029	0.67381
Mean	**0.606149**	**0.952719**	**0.577073**

3.4 Consistency of Results

To be able to facilitate comparison among the ranking of two benchmarking methods, the variables used have to be identical. Based on the original estimated cost function, variables were chosen to run TE-DEA and SFA. To make the frontier identical, cross-section DEA and SFA were run for years 2001. The results for year 2001 are presented in Table 8.

Columns 3 to 6 show DEA technical efficiency scores. Increased efficiency is associated with using fewer inputs for a given level of output. The DEA technical efficiency measures provided in this study reflect the degree to which quantities of inputs are higher than are necessary to provide current quantities of outputs.

Column 3 shows the overall technical efficiency score which demonstrates the existence of inefficiency and the extent of that inefficiency. The interpretation is the same as outlined in Cost-DEA. However, from a manager's or regulator's perspective, the existence of inefficiency is of limited use in itself. Information is needed on the sources of that inefficiency, and the extent of inefficiency that is attributable to management. Columns 4 and 5 show the decomposition of overall technical efficiency score decomposed into two elements: (1) pure technical efficiency (column 4) relates to efficiency due to the operating environment and, in part, to controllable management and work practices; and (2) scale efficiency (column 5) indicates whether or not the distributors are operating at an optimum size. Whether the distributor is operating in a region of increasing or decreasing returns to scale is shown in Column 6.

For 2001, the pure technical efficiency score is on the average 86 percent. This score suggests that the cooperatives could probably reduce their inputs by around 14% and still be able to produce same level of output if they were to operate at a level commensurate with the best practice of other similar distributors in the sample.

It can be noted that the rankings of DEA and SFA are similar when comparison with outlier cooperatives are disregarded. Since one of the drawbacks of DEA is giving an efficient score of 1 to a firm who has no peer among the cohort, by using DEA and SFA simultaneously, the outlier firms can easily be identified. From the table above, cooperatives BENECO, OMECO, CENECO and FICELCO can immediately identified as an outlier firm just by comparing the rankings of DEA and SFA. True enough, the DEA results indicate that these five firms have no peer among the sample and are thus merely outliers, not frontier cooperatives.

The National Electrification Administration also does its own cooperative classification and categorization. Cooperatives are classified based on their respective sizes as measured by circuit km of lines, total sales and residential connections. Based on these indicators, cooperatives are classified as extra large (EL), large (L), medium (M) and small (S). Categorization, on the other hand, deals with the compliance efficiency targets of NEA for the cooperatives. Cooperatives are categorized as A+, A, B, C, D, E, depending on the points they garner regarding the following indicators: amortization payment, system loss, collection efficiency, payments of purchased power, and non power cost. Since categorization of cooperatives cover slightly different parameters from the one covered by DEA and SFA, this essay will instead utilize NEA's classification of cooperatives. By disaggregating the efficiency estimates according to NEA's classification, problems such as outlier firms described above might be minimized. This will also aid NEA in specifying appropriate efficiency targets for cooperatives operating on a particular classification.

Table 8 DEA and SFA Ranking for Year 2001

COOPERATIVES	OBS NO.	CRS-DEA	VRS-DEA	SE	RTS	SFA	SFA-RANK
PELCO1	26	1	1	1	-	1.00459	1
PELCO3	27	1	1	1	-	1.00464	2
BOHECO2	64	1	1	1	-	1.00470	3
MOPRECO	7	1	1	1	-	1.00480	6
CENPELCO	9	1	1	1	-	1.00480	8
MORESCO2	86	1	1	1	-	1.00481	10
PRESCO	28	1	1	1	-	1.00482	12
DASURECO	100	1	1	1	-	1.00485	14
MAGELCO	103	1	1	1	-	1.00485	15
SOCO2	97	1	1	1	-	1.00486	18
MARELCO	35	1	1	1	-	1.00490	26
PELCO2	20	1	1	1	-	1.00491	29
ISECO	8	1	1	1	-	1.00491	30
SIARELCO	85	1	1	1	-	1.00492	34
QUEZELC2	39	1	1	1	-	1.00493	35

Table 8 DEA and SFA Ranking for Year 2001 (Cont.)

BILECO	76	1	1	1	-	1.00494	41
CAGELCO1	14	1	1	1	-	1.00494	44
BATALEC2	33	1	1	1	-	1.00498	61
PENELCO	21	1	1	1	-	1.00499	64
GUIMELCO	54	1	1	1	-	1.00500	70
KAELCO	12	1	1	1	-	1.00501	71
INEC	4	1	1	1	-	1.00501	72
TAWELCO	81	1	1	1	-	1.00502	75
LEYTE4	71	1	1	1	-	1.00503	78
ZAMCELCO	79	1	1	1	-	1.00506	84
FICELCO	42	1	1	1	-	1.00511	96
CENECO	55	1	1	1	-	1.00512	97
OMECO	36	1	1	1	-	1.00514	100
BENECO	5	1	1	1	-	1.00515	101
SOLECO	66	0.993	1	0.993	drs	1.00480	7
ALECO	48	0.993	1	0.993	drs	1.00493	36
TARELCO2	23	0.99	1	0.99	irs	1.00485	16
IFELCO	15	0.983	1	0.983	irs	1.00492	32
DANECO	101	0.934	1	0.934	drs	1.00496	53
LUELCO	3	0.924	1	0.924	drs	1.00499	67
SAMAR1	68	0.88	1	0.88	irs	1.00494	45
CEBECO3	61	0.912	0.993	0.919	irs	1.00492	33
ANTECO	57	0.805	0.988	0.814	drs	1.00509	91
TARELCO1	29	0.957	0.974	0.982	drs	1.00490	28
LEYTE1	74	0.844	0.972	0.868	irs	1.00503	80

Table 8 DEA and SFA Ranking for Year 2001 (Cont)

COOPERATIVES	OBS NO.	CRS-DEA	VRS-DEA	SE	RTS	SFA	SFA-RANK
PANELCO3	6	0.962	0.965	0.997	irs	1.00494	43
ORMECO	37	0.915	0.959	0.954	drs	1.00490	27
FIBECO	90	0.922	0.927	0.994	irs	1.00484	13
ZAMECO1	30	0.885	0.922	0.96	irs	1.00493	39
ANECO	94	0.918	0.92	0.997	irs	1.00501	73
LEYTE3	72	0.899	0.919	0.978	irs	1.00495	46
LEYTE2	73	0.899	0.919	0.978	irs	1.00495	47
SURNECO	84	0.902	0.909	0.992	irs	1.00478	5
AURELCO	31	0.882	0.901	0.978	drs	1.00509	92
ISELCO3	16	0.9	0.9	1	-	1.00495	48
CEBECO1	63	0.887	0.887	0.999	irs	1.00487	21
NEECO1	18	0.882	0.887	0.994	drs	1.00496	50
CEBECO2	62	0.876	0.886	0.988	drs	1.00493	38
ZAMSUR2	78	0.86	0.886	0.971	irs	1.00487	22
SORECO1	41	0.875	0.884	0.99	drs	1.00493	40
ISELCO2	11	0.862	0.883	0.976	drs	1.00496	51
BATALEC1	32	0.835	0.881	0.948	drs	1.00510	95
QUIRELCO	13	0.858	0.874	0.981	irs	1.00507	86
PANELCO 1	2	0.826	0.861	0.96	drs	1.00481	11
NEECO3	19	0.845	0.856	0.987	irs	1.00510	94
BOHECO1	65	0.809	0.856	0.945	drs	1.00515	102
CAMELCO	91	0.73	0.856	0.853	irs	1.00505	81
CAGELCO2	10	0.779	0.852	0.914	drs	1.00500	69
QUEZELC1	38	0.786	0.849	0.926	drs	1.00499	65
ILECO1	53	0.839	0.846	0.992	drs	1.00510	93
MOELCI1	89	0.81	0.843	0.961	irs	1.00496	54
NORECO1	60	0.791	0.841	0.941	irs	1.00477	4

Table 8 DEA and SFA Ranking for Year 2001 (Cont.)

CASUREC3	44	0.828	0.835	0.991	drs	1.00514	99
CASUREC2	45	0.783	0.812	0.964	irs	1.00509	90
ZANECO	77	0.802	0.809	0.991	drs	1.00488	24
SURSEC1	96	0.784	0.809	0.969	irs	1.00481	9
NORECO2	59	0.799	0.808	0.989	irs	1.00496	55
SOCO1	98	0.794	0.808	0.983	irs	1.00494	42
MOELCI2	88	0.788	0.804	0.98	irs	1.00486	19
CAPELCO	56	0.79	0.799	0.989	irs	1.00502	77
SURSECO2	95	0.782	0.799	0.979	irs	1.00493	37
NOCECO	50	0.755	0.797	0.947	drs	1.00498	60
AKELCO	58	0.796	0.796	1	-	1.00497	58
LANECO	104	0.788	0.791	0.997	drs	1.00488	25
ESAMELCO	75	0.787	0.787	0.999	drs	1.00496	52
ASELCO	93	0.785	0.787	0.997	irs	1.00486	20
ZAMECO2	24	0.776	0.787	0.985	irs	1.00516	103
ABRECO	1	0.785	0.786	0.998	drs	1.00506	85
DORECO	99	0.746	0.781	0.954	irs	1.00487	23
BUSECO	92	0.762	0.777	0.981	irs	1.00485	17
FLECO	34	0.772	0.773	0.998	irs	1.00495	49
SAJELCO	22	0.71	0.771	0.921	irs	1.00497	57
ZAMSUR1	80	0.754	0.754	1	-	1.00512	98
COTELCO	105	0.736	0.743	0.99	irs	1.00499	68
SAMELCO2	67	0.714	0.736	0.97	irs	1.00491	31
SUKELCO	102	0.721	0.73	0.987	irs	1.00496	56
BASELCO	83	0.704	0.717	0.983	irs	1.00499	62
NUVELCO	17	0.703	0.716	0.982	drs	1.00499	63
LEYTE5	70	0.706	0.71	0.993	irs	1.00497	59

Table 8 DEA and SFA Ranking for Year 2001 (Cont.)

NORSAMAR	69	0.691	0.708	0.977	irs	1.00508	89
MORESCO1	87	0.663	0.701	0.947	irs	1.00506	83
CASUREC4	43	0.641	0.693	0.925	irs	1.00508	88
NEECO2	25	0.661	0.688	0.961	irs	1.00501	74
CASUREC1	46	0.674	0.687	0.982	irs	1.00507	87
VRESCO	49	0.683	0.686	0.995	drs	1.00499	66
ILECO2	52	0.67	0.672	0.997	drs	1.00502	76
ILECO3	51	0.623	0.645	0.966	irs	1.00506	82
SULECO	82	0.589	0.642	0.917	irs	1.00503	79
SORECO2	40	0.585	0.591	0.989	irs	1.00528	105
CANORECO	47	0.561	0.562	0.999	-	1.00519	104
	Mean	**0.858**	**0.878**	**0.977**		**1.00496**	

3.5 Malmquist DEA

Equally important to the regulator is information about the rate at which efficiency gains are be made. Accordingly, this paper examines historic rates of productivity change within the ECs. Total factor productivity changes are calculated for the period 1990 to 2002 using the Malmquist DEA.

The Malmquist TFP calculations are based upon DEA-like linear programs.[6] The input and output variables used in these calculations are the same as those used in the DEA technical efficiency calculations. The Malmquist TFP results for the Philippine rural electric cooperatives are presented in Table 9 while annual TFP changes are presented in Table 10.

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[6] For further reading, refer to Coelli (1996).

Table 9 Malmquist Index Summary of Firm Means 1991-2002

COOPERATIVE	OBS NO.	TE _	TECH _	PURE TE _	SCALE EFF _	TFP _
ABRECO	1	1.017	0.987	1.006	1.011	1.004
PANELCO 1	2	1.016	0.997	1.009	1.007	1.013
LUELCO	3	1.014	1.018	1.014	1	1.032
INEC	4	1	1.006	1	1	1.006
BENECO	5	1.016	1.061	1.013	1.003	1.079
PANELCO3	6	0.991	1.019	0.991	0.999	1.01
MOPRECO	7	1	0.954	1	1	0.954
ISECO	8	1	1.022	1	1	1.022
CENPELCO	9	1	0.978	1	1	0.978
CAGELCO2	10	1.037	0.992	1.024	1.013	1.029
ISELCO2	11	1.026	1.03	1.028	0.997	1.056
KAELCO	12	1.013	0.998	1.01	1.003	1.011
QUIRELCO	13	1.005	1.014	1.008	0.997	1.018
CAGELCO1	14	1.045	1.025	1.044	1.001	1.07
IFELCO	15	1.024	0.98	1.02	1.004	1.004
ISELCO3	16	1.03	0.998	1.031	1	1.028
NUVELCO	17	1.026	1	1.026	1.001	1.026
NEECO1	18	0.99	1.008	0.99	1	0.998
NEECO3	19	0.997	0.989	0.997	1	0.986
PELCO2	20	1.007	1.015	1	1.007	1.022
PENELCO	21	1	1.029	1	1	1.029
SAJELCO	22	1	1	1	1	1
TARELCO2	23	1.001	1.009	1	1.001	1.01
ZAMECO2	24	0.987	0.999	0.987	1	0.986
NEECO2	25	0.989	1.007	0.989	1	0.996
PELCO1	26	1.014	1.012	1.014	1	1.026
PELCO3	27	1	1.013	1	1	1.013
PRESCO	28	1	0.977	1	1	0.977
TARELCO1	29	1.02	1.005	1.02	1.001	1.025
ZAMECO1	30	0.989	1.013	0.987	1.002	1.002
AURELCO	31	0.997	1.025	0.992	1.005	1.021
BATALEC1	32	0.989	1.016	0.989	1	1.004

Table 9 Malmquist Index Summary of Firm Means 1991-2002 (Cont)

COOPERATIVE	OBS NO.	TE _	TECH _	PURE TE _	SCALE EFF _	TFP _
BATALEC2	33	1.034	1.025	1.031	1.003	1.06
FLECO	34	0.982	1.011	0.982	1	0.993
MARELCO	35	1.019	1.017	1.018	1.001	1.037
OMECO	36	1.039	1.017	1.034	1.005	1.057
ORMECO	37	1.046	1.001	1.045	1.001	1.048
QUEZELC1	38	1	1.023	1	1	1.023
QUEZELC2	39	1.026	1.016	1.021	1.004	1.042
SORECO2	40	0.987	1.019	0.987	1	1.006
SORECO1	41	1.023	0.988	1.023	1	1.011
FICELCO	42	1.021	1.043	1.016	1.005	1.065
CASUREC4	43	1.044	0.978	1.017	1.026	1.021
CASUREC3	44	1.009	1.023	1.006	1.003	1.032
CASUREC2	45	1.028	1.008	1.028	1	1.036
CASUREC1	46	1.008	1.008	0.998	1.01	1.016
CANORECO	47	0.98	1.02	0.975	1.005	0.999
ALECO	48	1	1.022	1	1	1.022
VRESCO	49	1.057	1.022	1.054	1.003	1.081
NOCECO	50	1.007	1.017	1.003	1.004	1.024
ILECO3	51	1	1.021	1.003	0.997	1.022
ILECO2	52	1.035	1.005	1.03	1.004	1.039
ILECO1	53	1.039	1.042	1.038	1.001	1.082
GUIMELCO	54	0.994	1.01	1	0.994	1.004
CENECO	55	1	1.021	1	1	1.021
CAPELCO	56	0.994	1.028	0.996	0.998	1.022
ANTECO	57	1.025	0.999	1.015	1.01	1.023
AKELCO	58	0.97	0.971	0.971	0.999	0.943
NORECO2	59	1.018	1.023	1.015	1.003	1.042
NORECO1	60	1.031	1.01	1.011	1.019	1.041
CEBECO3	61	1	1.019	1	1	1.019
CEBECO2	62	1.015	1.007	1.008	1.007	1.022
CEBECO1	63	1.017	1.013	1.01	1.006	1.029
BOHECO2	64	1.031	1	1.029	1.001	1.031

Table 9 Malmquist Index Summary of Firm Means 1991-2002 (Cont)

COOPERATIVE	OBS NO.	TE _	TECH _	PURE TE _	SCALE EFF _	TFP _
BOHECO1	65	0.999	0.988	0.999	1	0.987
SOLECO	66	1.041	0.988	1	1.041	1.029
SAMELCO2	67	1.023	1.005	1.02	1.003	1.028
SAMAR1	68	0.998	1.018	0.99	1.007	1.015
NORSAMAR	69	1.002	1.003	1.002	1	1.005
LEYTE5	70	1.016	1.005	1.013	1.003	1.022
LEYTE4	71	1.039	1	1.011	1.028	1.04
LEYTE3	72	1.006	1.001	1.01	0.996	1.007
LEYTE2	73	1.006	1.001	1.01	0.996	1.007
LEYTE1	74	1.009	1.029	1.021	0.989	1.039
ESAMELCO	75	1.003	1.001	1.003	1	1.003
BILECO	76	1.004	1.002	1	1.004	1.006
ZANECO	77	1.009	1.015	1.01	0.999	1.024
ZAMSUR2	78	1.003	1.02	0.998	1.005	1.023
ZAMCELCO	79	1	1.044	1	1	1.044
ZAMSUR1	80	1.012	1.028	1.01	1.002	1.04
TAWELCO	81	1	0.999	1	1	0.999
SULECO	82	0.952	1.006	0.957	0.995	0.957
BASELCO	83	0.98	1.023	0.98	1	1.003
SURNECO	84	0.995	1.012	0.993	1.003	1.008
SIARELCO	85	1	0.978	1	1	0.978
MORESCO2	86	1.042	1.012	1.03	1.012	1.055
MORESCO1	87	0.988	0.96	1	0.988	0.948
MOELCI2	88	1.009	1.024	1.002	1.006	1.032
MOELCI1	89	1.008	1.003	1.012	0.996	1.011
FIBECO	90	1.012	1.013	1.007	1.005	1.025
CAMELCO	91	0.983	0.98	0.999	0.983	0.963
BUSECO	92	1.001	1.004	0.995	1.006	1.005
ASELCO	93	1.017	1.01	1.016	1.001	1.027
ANECO	94	1.003	1.019	1.003	1	1.022
SURSECO2	95	0.997	1.006	0.999	0.998	1.003
SURSEC1	96	0.991	1.019	0.994	0.997	1.011

Table 9 Malmquist Index Summary of Firm Means 1991-2002 (Cont)

COOPERATIVE	**OBS NO.**	**TE _**	**TECH _**	**PURE TE _**	**SCALE EFF _**	**TFP _**
SOCO2	97	1.011	1.039	1	1.011	1.051
SOCO1	98	0.985	1.024	0.986	0.999	1.009
DORECO	99	1.016	1.003	1.003	1.014	1.019
DASURECO	100	1.01	1.021	1.006	1.004	1.031
DANECO	101	1	1.054	1	1	1.054
SUKELCO	102	1.008	1.012	1.012	0.997	1.02
MAGELCO	103	1	0.958	1	1	0.958
LANECO	104	1.037	0.987	1.032	1.005	1.023
COTELCO	105	0.981	1	0.982	0.999	0.981
	Mean	**1.009**	**1.009**	**1.006**	**1.002**	**1.017**

Table 10 Malmquist Annual TFP Index

YEAR	**TE _**	**TECH _**	**PURE TE _**	**SCALE EFF _**	**TFP _**
1991	1.047	0.991	1.029	1.017	1.038
1992	0.97	1.03	0.966	1.004	1
1993	1.073	0.933	1.074	0.999	1.001
1994	1.002	1.034	0.996	1.005	1.035
1995	1.019	0.999	1.016	1.003	1.018
1996	1.009	0.978	1.009	1.001	0.987
1997	0.999	1.03	0.995	1.005	1.029
1998	0.996	0.998	0.997	0.998	0.994
1999	0.982	1.018	0.99	0.992	1
2000	1.003	1.029	1.003	1	1.032
2001	0.981	1.082	0.976	1.005	1.061
2002	1.025	0.991	1.026	0.999	1.016
Mean	**1.009**	**1.009**	**1.006**	**1.002**	**1.017**

The overall technical efficiency change (shown in column 2) represents changes in technical efficiency (position relative to the frontier), and this is made up of pure technical efficiency change (column 4) and scale efficiency change (column 5). The technical change index number (column 3) indicates how far the frontier against which technical efficiency is assessed has moved (frontier shift). Overall TFP growth (column 6) is a combination of technical efficiency change (column 2) and frontier shift or technical change (column 3).

The interpretation of the Malmquist index numbers presented in the tables above is explained using ABRECO as an example. ABRECO had a TFP growth of 0.4 percent from 1991 to 2002 (represented by the index number in column 6 of Table 9 of 1.004). This is made up of an overall technical efficiency change of 1.7 percent, and technical change of -1.3 percent. The combined TFP change is therefore 0.4 percent (1.7 x 0.987). The overall technical efficiency change can be further decomposed into a pure technical efficiency change of 0.6 percent and a scale efficiency change of 1.1 percent.

On the average, TFP increased by 1.7 percent from 1991 to 2002. Changes due to movements in the efficient frontier and technical efficiency improvement are equal. This indicates that the ECs at the frontier are driving efficiency improvements at the same rate that less efficient cooperatives are improving.

On a yearly basis, 2001 posted the highest TFP improvement among all the years surveyed. TFP increased by 6.1 percent in 2001 primarily due to a frontier shift of 8.2 percent. This implies that ECs on the frontier were driving efficiency rate improvements. Conversely, TFP decreased by 1.3 percent in 1996.

Performance varied widely among Philippine ECs. Some cooperatives achieve a TFP increase of as high as 70 to 80 percent while some decreased their productivity growth by 50 to 60 percent.

4. Concluding Remarks

This essay attempted to accomplish two main tasks: first, investigation of the characteristics of the ECs’ cost function, and second, calculation of efficiency and productivity scores for each firm.

The empirical findings based on a panel data of 119 ECs from 1990 to 2002 are:

1. The parameter estimates of both the total and average cost functions have the expected signs and are statistically significant (at 0.01 level of significance). After conducting log-likelihood tests, the appropriate cost function is found to be a Cobb Douglas rather than a translog function.

2. The SFA estimates show that on the average, ECs are 34 percent way from the cost frontier. Had the ECs been operating on the efficient frontier, the cooperatives could have saved thirty four percent, on the average, of their total non-power cost.

3. The Cost-DEA estimates based on a single frontier of all the years covered show that ECs should have saved 42 percent of their costs. Although very similar to the SFA results, these are not directly comparable due to differences in variables used and the presence of time effects in SFA.

4. When DEA and SFA were ran using the same set of variables on a same time frame, the rankings are consistent, although not perfectly identical. When outlier DEA ECs are taken out of the ranking, the results prove to be very similar.

5. The Malmquist Productivity Index shows that from 1991 to 2003, the change in total factor productivity has, on the average, been 1.7 percent. The increase in TFP came both from frontier shifts and per firm technical efficiency improvements.

The rankings and productivity values will prove to be useful in the recent Performance Enhancement Program of NEA for the condonation of EC debts. When used alongside the current NEA classification and categorization method of the agency, the efficiency targets will result to a more holistic and appropriate efficiency rankings and estimates. The fact that DEA and SFA are based on theoretically determined cost function will lead to results that are more representative of the ECs actual performance, rather than basing them on single ratios, which, when considered alongside other ratios will lead to results that are rather misleading.

The DEA provides a wealth of information that can guide the ECs and NEA in pursuing their efficiency enhancement program. The CRS-DEA and VRS-DEA include in their output a firm by firm estimate of input targets. For the current NEA methodology of cooperative categorization, DEA can help calculate targets for total distribution and operating expenditure (non-power cost in NEA records) and system losses which are based on the performance of technology comparable ECs. This can then aid NEA in evaluating efficiency targets submitted by the ECs every quarter.

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