ORIGINAL RESEARCH PAPER

Management

PERFORMANCE OF INDUSTRIES IN SOUTHERN STATES OF INDIA DURING 2013-14: A DEA APPROACH

KEY WORDS: Data Envelopment Analysis, Decision Making Unit, Returns to Scale, Linear Programming.

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ABSTRACT

The present paper gives an idea that which of the States in Southern India performs efficiently by considering two inputs Fixed Capital and Total Persons engaged to get one output Net Value Added. The technic of Data Envelopment Analysis is applied to decide the states' performance and how to make inefficient to efficient by adjusting the inputs to get output.

1. DATA ENVELOPMENT ANALYSIS (DEA)

DEA is a popular management tool. This technic was launched by Charns, Cooper and Rhodes (1978) and improved by Banker, Charns and Cooper (1984). DEA is commonly used to evaluate the efficiency of a number of producers. Generally, in Statistics Central tendency approach is used to evaluate producers relative to an average producer. In contrast, DEA compares each producer with only the 'best' producers. In DEA literature each producer is usually called as decision making unit or DMU. The production process for each producer is to take a set of inputs and produce a set of outputs. For instance, among a set of farmers, each farmer has a different inputs like the cultivation methods, fertilizers applied etc which results different yields taken as outputs. DEA helps to determine which of the farmer is most efficient and also specifies the inefficiencies of the other farmers.

Let us assume a producer, A, is capable of producing Y(A) units of outputs with X(A) inputs, then other producers should also be able to produce same outputs if they were efficient. Similarly, if producer B is capable of producing Y(B) outputs with X(B) inputs, then other producers should also be capable of same production schedule. The producers A, B and others can then be combined to form a composite producer with composite inputs and composite outputs. This composite producer does not necessarily exist, and is called a virtual producer. The main aim of the analysis is to find 'best' virtual producer for each real producer. If the virtual producer is better than the original producer by either making more output with the same input or making same output with less input, then the original producer is inefficient. The subtleties of DEA are introduced in the various ways that producers A and B can be scaled up or down and combined.

2. GRAPHICAL METHOD FOR DEA

The single input-two output or two input-one output problems are easy to analyse graphically.

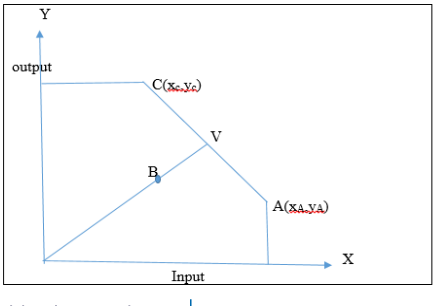

Figure 1

Input is taken along horizontal axis; output is taken along vertical axis. The line AC is a production possibility set, A and C are efficient DMUs. It is also called efficiency frontier line. Clearly B is an inefficient DMU. B can be made efficient by projecting OB to V, the vertical point, which is the convex combination of A and C. The efficiency of B is calculated by finding the fraction of inputs that V would to produce as many outputs as B. Graphic method is useful in single, two dimensional example, but gets much harder in higher dimensions. The normal method of evaluating the efficiency of B is by using a linear programming formulation of DEA.

3. SCALE EFFICIENCY

Returns to scale refers to increasing or decreasing efficiency based on size. Suppose a manufacturer achieves more outputs than the required for the given inputs is an increasing returns to scale (IRS). On the other hand, if a manufacturer achieves less outputs than the required for the given inputs, it is decreasing returns to scale (DRS). Combining the two extreme ranges would necessitate variable returns to scale (VRS). Constant returns to scale (CRS) means that the producers are able to linearly scale the inputs and outputs without increasing or decreasing efficiency. This is a significant assumption. The assumption of CRS may be valid over limited ranges but its use must be justified. As an aside, CRS tends to lower the efficiency scores while VRS tends to raise efficiency scores.

2. USING LINEAR PROGRAMMING

DEA is a LPP for a frontier analysis of inputs and outputs. DEA assigns '1' to a DMU which is efficient in the use of inputs and outputs. DEA assigns an efficiency score less than '1' to inefficient DMUs. If a DMU scores less than '1', it means it requires linear combination of other units that could produce same vector of outputs using a smaller vector of inputs. The score reflects the radial distance from the estimated production frontier to the DMU under consideration.

There are number of equivalent formulations for DEA. The mostly used formulation is as follows.

Let Xi be the vector of inputs into DMU i. Let Yi be the corresponding vector of output s. Let X0, Y0 be the inputs and outputs for the DMU which we want to determine its efficiency. The measure of efficiency for DMU0 is given by the following linear program.

$$\text{Min } \theta$$

$$\text{Such that } \sum \lambda_i X_i \leq \theta X_0 \quad \text{.............}(1)$$

$$\sum \lambda_i Y_i \geq Y_o$$

$$\lambda \geq 0$$

where λi is the weight given to DMU 'i' in its efforts to dominate DMU '0' and θ is the efficiency of DMU '0'. So 's and are variables. The optimal θ can't possibly be more than 1. In solving the LPP, we get the number of things.

1. The efficiency of DMU 0 (θ), with =1, meaning that the unit is efficient.

2. The units' "comparables". (those DMU with non-zero)

3. The 'goal' inputs. (the difference between X0 and $\sum \lambda_i X_i$)

4.Alternatively, we can keep inputs fixed and get 'goal' outputs $(\frac{1}{\theta} \sum Y_i)$

DEA assumes that the inputs and outputs have been correctly identified. Usually, as the number of inputs and outputs increase, more DMUs tend to get an efficiency rating of 1 as they become too specialized to be evaluated with respect to other units. On the other hand, if there are too few inputs and outputs, more DMUs tend to be comparable. In any study, it is important to focus on correctly specifying inputs and outputs.

5. EMPERICAL ANALYSIS

To assess the efficiency of different DMUs, the data is collected from the Annual Survey of Industries 2013-14 regarding seven southern states of India whereas Fixed Capital and Total Persons Engaged are taken as two inputs and Net Value Added as single output. The data obtained as follows.

Table: 1

S.No	STATE	INPUT I	INPUT II	OUTPUT I
		Fixed Capital (Rs Lakhs)	Total Persons Engaged (No)	Net Value Added (Rs Lakhs)
1	Andhra Pradesh	852	41	146
2	Karnataka	1686	96	555
3	Kerala	390	60	219
4	Odisha	7688	109	905
5	Puduchery	643	73	589
6	Tamil Nadu	936	74	308
7	Telangana	450	63	254

To decide efficient DMUs and the efficiencies of other DMUs we try to solve the optimization problem of LPP model given in (1) with the help of DEA Solver in Excel work sheet. We get Efficiency Rating (θ) and Efficiency Reference Set (λ's). The best practice units are relatively efficient and are identified by an efficiency rating of θ = 1. If θ < 1, that indicates inefficiency. Efficiency rating is generally denominated between zero and 1, equally referred as an efficiency percentage between zero and 100%. The upper limit is set as 1 or 100% to reflect the view that a limit can't be more than 100% efficient. If efficiency rating is less than 100%, it indicates, that percentage of inputs are enough to get the given output. So the inefficient DMU is running with excess of inputs. How much inputs have to be reduced with the comparison of efficient DMUs, is given in the Efficiency Reference Set (ERS)? These are 's, coefficients of inputs and outputs of efficient DMUs.

Table 2: DEA results for Seven Southern States

S.No.	State	Efficiency Rating θ	Efficiency Reference Set (ERS)
1	Andhra Pradesh	0.43887	0.03202 (Odi) 0.19868 (Pud)
2	Karnataka	0.71358	0.08914 (Odi) 0.80532 (Pud)
3	Kerala	0.61302	0.37182 (Pud)
4	Odisha	1	
5	Puduchery	1	
6	Tamil Nadu	0.51492	0.02175 (Odi) 0.48950
7	Telangana	0.61619	0.43124 (Pud)

6. CONCLUSSIONS

DEA results indicates that the States Odisha and Puduchery are efficient DMUs with Efficiency Rating = 1 or 100%. Andhra Pradesh is inefficient DMU and its efficiency is 43.9%. That means 43.9% reduction of inputs make it efficient as compared to Odisha and Puduchery. By ERS, the targets calculated for Andhra Pradesh are

$$0.03202 \begin{bmatrix} 7688 \\ 109 \\ 905 \end{bmatrix} + 0.19868 \begin{bmatrix} 643 \\ 73 \\ 589 \end{bmatrix} = \begin{bmatrix} 374 \\ 18 \\ 146 \end{bmatrix}$$

i.e Andhra Pradesh is running with excess of inputs by Rs. 374 lakhs 'Fixed Capital' and 18 'Persons engaged' to get the output 'Net Value Added' Rs. 146 lakhs. Similarly, for other States also.

Table 3: Percentage of Reduction in inputs and Excess of inputs for inefficient DMUs

S.No.	State	Percentage of Reduction in inputs	Excess of inputs		Output
			Fixed Capital (in lakhs)	Total Persons Engaged (No.)	Net Value Added (in lakhs)
1	Andhra Pradesh	43.9%	478	23	146
2	Karnataka	71.3%	483	27	555
3	Kerala	61.3%	151	33	219
4	Tamil Nadu	51.5%	454	36	308
5	Telangana	61.6%	173	31	254

There are some points to be kept in mind. Here two states are selected as efficient DMUs by DEA analysis. Two states are taken for benchmark from the available states. This may or may not be same continue as a benchmark if the number of states are increased. This is only introductory paper for DEA analysis. There are several technics developed to discuss like Distance Functions, Directional Distance Functions, Free Disposable Hull etc.

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