# DATA ENVELOPMENT ANALYSIS AS A METHOD TO MEASURE EFFICIENCY OF PERFORMANCE IN CO-OPERATIVES

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## *ABSTRACT*

*This article basically discusses an introduction to the Data Envelopment Analysis (DEA) method, the work of Farrell (1957) which is extended by Charnes, Cooper and Rhodes (1978) and Banker, Charnes and Cooper (1984). Researchers in operational research and economic have worked actively with DEA in measuring performance of profit and non-profit organisation such as health care, agricultural production, banking and many other applications. However this method is rare in application of co-operative research. As this method has its special characteristics that outperformed many other methods in performance analysis, thus this article is focused on the usefulness of the method that is worth to be considered. Perhaps this method will solve some issues in treating the multiple inputs and outputs variables in cooperative performance analysis*

# INTRODUCTION

DEA (Data Envelopment Analysis) is a novel approach to measure relative efficiency where there are multiple inputs and outputs. If a suitable set of measurement can be defined, DEA provides an efficiency measurement not relying on the application of a common weighting of the input and outputs. Additionally the method identifies peer units and targets for inefficient units.

Basically DEA is a linear programming-based technique developed to evaluate the relative efficiency of non-profit and public sector decision–making units that uses multiple inputs to produce multiple outputs. It is the optimisation method of mathematical programming to generalise the Farrell (1957) single-input / single-output technical efficiency measure to the multiple inputs /multiple outputs case by constructing a relative efficiency score as the ratio of a single virtual output to a single virtual input. Thus DEA has become a new tool in operational research for measuring technical efficiency.

Originally, DEA was developed by Charnes, Cooper, Rhodes (1978) with constant return to scale (CRS) and was extended by Banker, Charnes, Cooper (1984) to include variable return to scale (VRS). So the basic DEA models are known as CCR and BCC. As a new method of measuring the efficiency of decision-making units (DMUs), there are over 400 articles that have used variations of DEA in analysing performance and most of them can be downloaded from the internet. Up to now, the DEA measurement has been used to evaluate and compare educational departments (school, college and university), health care (hospital and clinics), prison, agricultural production, banking, index number, construction and many other applications.

## Why DEA Method is Applicable to Co-operatives?

The following are some important findings from studies carried out by distinguished researchers in the area of productivity that gives DEA special characteristics in evaluating an organizational efficiency. Bowlin et al. (1985) developed a hypothetical dataset for hospital units with known efficiencies and inefficiencies. They used this dataset to test DEA against ration and regression analyses. They found that DEA outperformed both ratio analysis and least squares regression in identifying sources and amount of inefficiencies.

In another study, Banker et al. (1986), compared efficiency characterisation obtained from DEA and econometric models using empirical data from a sample of North Carolina hospital. His study concluded that the DEA model was able to identify inefficiencies and uncover return to scale possibilities in individual hospital that were not evident in the translog model. In addition Banker et al. (1986) report that DEA's efficiency estimates appear to be more closely related to the degree of capacity utilisation that the translog estimates.

In the past, regression approaches have been commonly used for measuring efficiency. Unlike these traditional approaches, DEA does not require explicit specification of the functional forms relating inputs to outputs. More than one function (e.g. more than one production function) is admitted and the DEA solution can be interpreted as providing a local approximation to whatever function is applicable in the neighborhood of the coordinate values formed from the outputs and inputs of the DMUs (decision making units) being evaluated. Thus DEA is more flexible in recognising differences in production functions between DMUs.

DEA is oriented towards DMU and determines the efficiency level of each. It provides the sources of input and output and amount of inefficiencies besides the method provides an empirical evaluation of a DMU's ability to convert its current inputs into output without explicitly specifying the input-output relationship. In other words the DEA model provides information about the extent to which an input should be decreased or an output augmented by an inefficient organisation in order for it to become efficient. The result will point out less efficient institution and areas where efficiency could be improved. The coefficient or weight developed via DEA is unique to individual organisation under evaluation.

DEA allows for the inclusion of multiple input and output variables that are calculated simultaneously. DEA does not require an assumption of a functional form relating inputs to outputs. DEA are directly compared against a peer or combination of peers.

## Restriction of DEA

When DEA method is employed in a study, one has to analyse with caution as DEA also has its limitation. Firstly, the method does not provide a model for predicting the performance of an organisation for years. Those are not included in the evaluation as it might be possible with regression. DEA cannot be used as regression to prepare a model to be extended outside the database used to develop the model. Therefore DEA cannot be used to estimate or predict future performance for a class of entities instead of an individual entity. Or if the result of the analysis is to be used to predict performance outside the relevant range of data, DEA may tend to confuse random fluctuation with inefficiencies represented in the data. As a solution to this limitation, regression and DEA may be used in combination.

Secondly, DEA results are sample-specific. Since DEA is an extreme point technique, measurement error can cause significant problems. DEA is good at estimating 'relative' efficiency of DMU but it converges very slowly to 'absolute' efficiency. Thus, it can tell us how well you are doing compared to your peers but not to a "theoretical maximum".

## Questions that DEA Can Help to Answer

DEA may help to identify possible benchmarks towards which performance can be targeted. The weighted combination of peer and the peer themselves may provide benchmarks for relatively less efficient organisations. It can also be promulgated for the information of managers of organisations aiming to improve performance. The ability of DEA to identify possible peer or role model as well as simple efficiency scores gives it an edge over other measures.

Fried et al. (1993) listed the following as questions that DEA can help to answer for managers like i) how do we select appropriate role models to serve as possible benchmarks for a program of performance improvement? ii) Which facilities are the most efficient? iii) If all my operations were to perform according to the best practice, how many more service outputs could we produce and how much could my resource inputs be reduced, and in what areas? iv) What are the characteristics of efficiency operating facilities and how can they guide us in choosing locations for expansion? v) What is the optimum scale for my operations and how much could we save if all our facilities were at the optimum size? vi) How do we account for differences in external circumstances in evaluating the performance of individual operating facilities?

The simple DEA model will answer the first four questions. For the last two questions an extension model is required i.e. scale efficiency and input and output orientation.

## Application of DEA in Evaluating Efficiency of an Organisation

The quest for greater efficiency is never ending as managers are always been put under pressure to improve the performance of their organisations. In the public sector, governments are constantly seeking better value for tax payers' money, while the emergence of more global economy has intensified competitive pressure on commercial companies. The onus is therefore on managers to achieve better results from the resources available to them. The use of a powerful technique called Data Envelopment Analysis (DEA) therefore will be of great assistance.

The analysis begin by comparing the relative efficiency of organisational 'units' such as bank branches, hospitals, vehicles, shops and other instances where units perform similar tasks. These units utilise similar resources, referred to as inputs, to generate similar outputs. For example, a shop has inputs of staff and floor space, and has outputs of sales volume and revenue. However, there can be considerable differences in the way in which individual unit combines inputs to produce outputs. In addition there may also be differences in potential among units caused by the available technology, their geographical location or catchments population.

DEA allows us to take account of all the important factors that affect a unit performance to provide a complete and comprehensive assessment of efficiency. DEA does this by converting the multiple inputs and outputs into a single measure of productive efficiency. By doing so it identifies those units, which are operating efficiently and those, which are not. The efficient units, those making the best use of resources, are rated as being 100% efficient whilst the inefficient ones obtain lower scores. DEA generates efficiency scores for all units being analysed. It shows how much inefficient units need to reduce their inputs or increase their outputs in order to become efficient.

DEA uses two approaches in determining efficient frontier i.e. either an input orientation (technical efficiency is measured as a proportion reduction in inputs) or an output orientation (technical efficiency is measured as a proportion reduction in output). Basically there are two basic types of frontiers (envelopment surfaces), which can be estimated; constant return to scale (CRS) and variable returns to scale (VCR).

For CRS, those two orientations give the same efficiency ranking but under the VRS, both approaches may give different efficiency ranking. As Coelli (1996) states, 'one should selectan orientation according to which quantities (input or outputs) the managers have most control over'.

The output orientation is commonly used in measuring non-profit organisation efficiency like co-operatives. The rationale of using this as discussed by Smith, Cargill and Meyer (1981) is, non-profit organisations are likely to focus on the benefits of its members.

DEA developed simple linear programming techniques to calculate efficiency. Estimation of the non-parametric deterministic frontier and the disposability of output and input are expressed in term of minimising input requirements. To calculate the efficiency, DEA provides the general model as the following:

$$MaxE_o = \frac{\sum_{r=1}^{s} U_r Y_{ro}}{\sum V_i X_{io}}$$

$$s.t. \frac{\sum_{r=1}^{s} U_r Y_{rj}}{\sum_{i=1}^{m} V_i X_{ij}} \leq 1$$

$$U_r > 0$$

$$V_i > 0$$

Where, $Y_{rj}$, denotes the quantity of r $^{th}$ output of the j $^{th}$

DMU, $X_{ij}$ is the vector of quantity inputs employed by $FA_{rj}$,

o is DMU under evaluation in set j= 1.....n DMU,

s is the number of output produced by DMU,

m is the number of input used by DMU.

$U_r$, denotes the weight given to r $^{th}$ outputs and

$V_r$ is the weight given to j$^{th}$ input. The weights may be either fixed in advance or derived from the data. The former is sometimes referred as a prior determination.

When the coefficient takes this structure, the value taken by E always lies between zero and one. When coefficient or index is 1.0, it denotes complete efficiency. The efficiency figure can also be represented as a percentage or a decimal point value, but however it is expressed; it signifies a degree of efficiency. Efficiency here denotes an input / output relationship and is thus a measure of productivity.

## CONCLUSION

DEA a non-parametric method, a fractional programming model that can include multiple output and input without recourse to a prior weight (as in index number approaches) and without requiring explicit specification of functional relation between inputs and outputs (as in regression approaches). DEA computes a scalar measurement of efficiency and determines efficient levels of inputs and outputs for organisation under evaluation. It concentrates on revealing best-practice frontier rather than on central tendency properties of frontiers as the focus is on individual observation, rather than population averages. For each production unit, DEA produces a single aggregate measure of the utilisation of input factors to produce desired outputs. This non-parametric Data Envelopment Analysis has focused on the development of multiple-input and multiple output models.

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