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A DEA Approach to Measure the Performance of Indian Software Companies: An Empirical Study

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Abstract

This empirical study deals with measurement and comparison of the performance of Indian Software Companies using Data Envelopment Analysis (DEA) methodology. The inputs and outputs of the software companies were identified and using DEA, the performance (efficiency) scores for each company were arrived at. The results were used to segregate the efficient companies and the inefficient companies. Further analysis was done to suggest measures to be taken by the inefficient companies to become efficient. These measures are in terms of reallocating their resources to make them more efficient. The efficiency scores of the companies are also compared to their total revenue earnings.

It has been observed that the top Indian Software Companies in terms of their total revenue earnings are not necessarily the most efficient companies as identified by DEA methodology.

Keywords: Data Envelopment Analysis (DEA), efficiency, performance evaluation, software.

Introduction

In the past the performance of the Indian software companies has been analyzed primarily in terms of their total revenue earnings as well as other accounting and financial ratios such as Return On Capital Employed (ROCE), Return On Assets (ROA), Return On Investment (ROI) or similar ratios. These methods have their own inherent limitations as it fails to capture the true performance of the companies (firms) when multiple inputs are converted to multiple outputs. The performance of a particular company (firm) may be considerably good in terms of its total revenue earnings even when some of its other input and output parameters are not showing good figures. In such a scenario the company (firm) may be apparently making profits and earning impressive revenues in the short run while there is a possibility that the company (firm) is actually making losses in the long run. This may be due to sub-optimal use of the resources. In such a case it is necessary for the management to identify possible areas where inputs could be optimally utilized.

Literature Review

Earlier several studies have used financial statements for assessing the performance of the company using DEA methodology. Some of them are Abriksten and Forsund (1990) **[1]**, Sickles and Streitwieser (1992) **[7]**, Banker and Johnston (1993) **[2]**, Forsund (1993) **[6]**. Thore, Kozmetsky and Philips (1994) **[11]** used financial data to estimate the evolution of productive efficiency in the U.S. computer industry.

Other studies are by Thanassoulis, Boussofiane and Dyson (1996).**[8]** Thompson, Dharmapala, Rothenberg and Thrall (1994, 1996) **[9], [10]** employed single industry group as a tool for analysis of financial statements using DEA methodology.

Worthington (1998) **[12]** used financial statements data for measuring the performance of some Australian Gold Production and Exploration companies. A sample of thirty listed Australian gold producers was used to compare the financial

performance measures using DEA methodology. The results indicated that DEA methodology provides better efficiency rankings compared to simple ratios.

Dataquest magazine comes up with rankings of software companies based on Return On Capital Employed (ROCE) in its annual online publication DataQuest Top 20 in its website www.dqindia.com (31st July, 2004). This study is an attempt to apply Data Envelopment Analysis approach for measuring the performance of the Indian software companies.

Objective

The study was conducted with the objective of measuring and comparing the relative performance of the selected Indian software companies in relation to each other using DEA approach over five year period (2000-2004).

In this study performance is measured in terms of conversion of inputs (resources) to outputs. A company is said to be efficient if it is able to maintain a certain level of output at minimum costs over time. The objective is to optimize the use of resources in the operations of the less efficient companies so that necessary management interventions can be made for increased operating efficiency and thereby improved performance.

The Methodology:

The study has been carried out in two stages. The first stage consists of the selection of the inputs and output variables for measuring the performance of the selected software companies. The data for the selected input and output variables were compiled for five years (2000-2004).

The second stage involves determining the efficiency score for each of the selected software companies using DEA.

The Model

When multiple inputs and multiple outputs are considered for a particular firm, then as per the DEA model efficiency is defined as

Efficiency = (weighted sum of outputs) / (weighted sum of inputs)

Here, the underlying assumption is that weights associated with a particular input and output have already been predetermined as deemed appropriate for that particular firm in its operating environment.

Data Envelopment Analysis (DEA) is a non-parametric approach for determining the performance of a set of peer entities where multiple units are converted to multiple outputs.**[3]** It uses linear programming technique to determine the efficiency frontier. The points, which lie on the frontier comprises the efficient companies and the inefficient companies lie below the frontier.

DEA was initially developed by Charnes, Cooper and Rhodes (1978) (CCR model) to evaluate the relative efficiency of public sector not-for-profit organizations assuming

constant return to scale. The efficiency score of the companies lie between 0 and 1. The companies having an efficiency score of 1 are the relatively efficient companies.. The other companies having efficiency score less than 1 are relatively inefficient. One point to be noted here is that the term 'relatively efficient' means that the companies are efficient in relation to other companies in the sample. The CCR model allows the respective companies to adjust its own weights accordingly so that it becomes relatively efficient. So, the efficiency score is the ratio of the weighted set of inputs to the weighted set of outputs.

The CCR Model **[3]** is illustrated below:
Let there be n number of companies to be evaluated. Each company consumes P different inputs to produce Q different outputs. More precisely, company j consumes x_{pj} of p^{th} input and produces y_{pj} of the q^{th} output. (where j = 1,2,3, …n). We further assume that $x_{p\,j} >= 0$ and $y_{q\,j} >= 0$.

The model is as follows:
CCR Model in Fractional Form

$$\text{Max } E_B = \left(\sum_{q=1}^{Q} u_{qB}. y_{qB} \Big/ \sum_{p=1}^{P} v_{pB}. x_{pB} \right)$$

Subject to

$$\left(\sum_{q=1}^{Q} u_{qB}. y_{qj} \Big/ \sum_{p=1}^{P} v_{pB}. x_{pj} \right) \leq 1$$

(for j = 1,2,3…..n)

$$u_{qB} \geq 0,\ v_{pB} \geq 0,\ \varepsilon \geq 0$$

where
E_B = efficiency of the a particular company (say B)
y_{qB} = amount of qth output produced by the company B
x_{pB} = amount of pth input consumed by the company B
y_{qj} = amount of qth output produced by jth company
x_{pj} = amount of pth input consumed by the jth company
u_{qB} = weight assigned to the qth output of the company B
v_{pB} = weight assigned to the pth input of base company B
ε = a sufficiently small positive number

The above fractional form can be converted to the following equivalent linear programming form

$$\text{Max } E_B = \left(\sum_{q=1}^{Q} u_{qB}. y_{qB} \right)$$

Subject to

$$\sum_{p=1}^{P} v_{pB}. x_{pB} = 1$$

$$\sum_{q=1}^{Q} u_{qB}. y_{qj} - \sum_{p=1}^{P} v_{pB}. x_{pB} \leq 0 \quad \text{for } (j = 1,2,3,\ldots..n)$$

$$u_{qB},\ v_{qB} \geq \varepsilon \geq 0$$

We are interested in the relative efficiency of the company B with respect to all the other firms in the sample. Relative efficiency means we are comparing the ratio of the weighted outputs (virtual output) to the weighted inputs (virtual input) relative to the company B. The objective is to maximize E_B (ratio of the virtual output to virtual input) by comparing the inputs and outputs of all the other companies such that none of

them have efficiency greater than 1. It is noted that the unknown weights u_{qB} and v_{qB} are obtained through optimization.

Sample Selection:

The paper is based on a study of 48 Indian software companies. The companies were so chosen so that they were profitable throughout 2000-2004. The data for the years 2000-04 have been compiled from the Prowess database provided by CMIE (Center for Monitoring Indian Economy)

Identification of Input-Output Variables:

In software industry the most significant input parameter is salaries and wages as it constitutes bulk of the total expenses. Added to that the administrative costs also plays an important role in measuring productive efficiency. Cost of production indicates the cost incurred by the company throughout the Software Development Cycle (SDLC) right from Requirement Analysis to the Implementation phase. Gross Fixed Asset primarily represents the machinery involved in the production which in the software industry mainly comprises of desktop terminals, servers, networking equipments, VSAT terminals (if any) etc. It also includes the expenses in infrastructure development such as land, building related costs. Sales is one of the most important factors for a successful software company. Apart from determining the strength of the company it also signifies it ability to sign on large and long-term contracts providing stability to its operations. Other output variables chosen for the study are Profit After Tax (PAT) and Total Income.

The input and outputs that have been considered for this study are as follows:
Table - 1

Inputs	Outputs
X1 = Salaries and Wages	Y1 = Net Sales
X2 = Cost of Production	Y2 = Total Income
X3 = Administrative Expenses	Y3 = Profit After Tax (PAT)
X4 = Total Costs	
X5 = Gross Fixed Assets	

With the above set of inputs and outputs for efficiency measurement, it is clear that the ratio appearing in the objective functions of DEA model is the ratio of weighted sum of revenues to the weighted sum of expenses, hence an index of profitability.

The data for the sample companies were analyzed using DEAExcelSolver software developed by Joe Zhu.

Empirical Results

The following table gives the average efficiency of the 48 software companies for each of the years in the period 2000-04. (Complete efficiency scores for 48 companies for each of the years in the period 2000-04 is given in appendix -1)

Table 2 (Efficiency Table)

Year	2000	2001	2002	2003	2004	Avg
Avg	78.247%	86.635%	84.74%	80.961%	80.177%	82.152%
Std.Dev	0.15735%	0.11904%	0.13829%	0.14903%	0.13676%	0.14009%
Max	100%	100%	100%	100%	100%	100%
Min	47.674%	56.186%	42.532%	54.96%	59.551%	52.18%
No. of Companies having 100% efficiency	10	11	12	11	10	

The average efficiency of the selected software companies has increased by 2.46% from 2000 to 2004. The average efficiency increased by 10.71% from year 2000 to year 2001. It then declined by 2.18% from year 2001 to year 2002. It then further declined in 2003 by 4.45%. From 2003 to 2004 it marginally declined by 0.9%

64.5% of the selected companies were found to have their efficiency scores in the range 70% and 90%

The following four companies were found to be consistently efficient having 100% efficiency during these five years namely

- B S E L Infrastructure Realty Ltd.
- Cranes Software International Ltd.
- Helios and Matheson Information Technology Ltd.
- Hinduja TMT Ltd.

The following six companies were found to have efficiency (E) less than 70%. These companies are:

Lanco Global Systems Ltd. (E=60%)
VJIL Consulting Ltd. (E=63%)
California Software Co. Ltd. (E=64%)
Integrated Hitech Ltd (E=66%)
Softpro Systems Ltd. (E=67%)
Infotech Enterprises Ltd. (E=69%)

General Findings

The study shows that contrary to popular belief the top profitable companies in terms of their total revenue earnings are not necessarily the most efficient ones using DEA methodology. Top software companies such as Infosys, Satyam and Wipro having revenues of Rs. 4776 crores, Rs. 2542 crores and Rs. 5136 crores in the year 2004 (Source: Dataquest July 31st, 2004) are not the most efficient ones. On the other hand the smaller software companies were found to be consistently efficient over these five years.

So, it can be concluded that top profitable companies are not necessarily the most efficient ones. Added to that size is not an important determinant for measuring efficiency.

Six companies were found to have less than 70% efficiency.

Suggestions for Improvements

The study suggests some output targets based on the data for the year 2004 for the above mentioned software companies in terms of their chosen input and output variables, so that they become efficient by reallocating their resources.
The following table gives the output targets for efficiency.

Table 3
Output Targets for Efficiency (All figures are in crores of Rs.)

Company Name	Total income	PAT	Net Sales
Lanco Global Systems Ltd	2.98147	1.31991	2.86000
VJIL Consulting Ltd.	16.37000	5.86974	15.09794
California Software Ltd.	18.90382	17.76246	17.87000
Integrated Hitech Ltd.	0.76000	0.28038	0.72737
Softpro Systems Ltd.	6.17000	2.21712	5.69013
Infotech Enterprises Ltd.	129.13922	52.80460	124.36000

The above table implies that given its present input level of resource utilization for the year 2004, the companies need to produce the target value of the output parameters in order to remain efficient.

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