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Efficiency Measurement on Banking Sector in Bangladesh

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Abstract

Nowadays banking sector in Bangladesh plays a considerable role in the economic development and business improvement, in this aspect ranking of banks is vital. In this study, an attempt has been made to rank some of the Bangladeshi Banks. Also, the most efficient bank is identified here. Data Envelopment Analysis is used for this purpose. The data from the annual reports of different banks are used in this study for the purpose of efficiency checking. In Data Envelopment Analysis two types measurement techniques are used – constant returns to scale and variable returns to scale. Since this study attempts to maximize output, that is, the operating profit, so the output oriented Data Envelopment Analysis is used here. The most efficient bank is identified here by the highest efficiency score obtained by that specific bank.

Keywords: Efficiency Measurement, Ranking, Data Envelopment Analysis, Constant Returns to Scale, Variable Returns to Scale.

I. Introduction

Financial institutions around the world experienced substantial changes in the last few years. Technological progress, reduced information costs, competition among both bank and non-bank financial intermediaries and ongoing deregulation all led to substantial changes in numerous financial systems. Bank efficiency has been an important issue in transition. There are two broad types of methods for arriving at measures of comparative efficiency: parametric and non-parametric methods. Thus efficiency frontier is typically constructed according to parametric or non-parametric methods. The non-parametric approaches use mathematical programming techniques, and the widely used non-parametric method is Data Envelopment Analysis (DEA). The primary focus of DEA is modeling the production or performance function of DMUs (Decision Making Unit).

DEA evaluates the inputs consumed and outputs produced by DMUs and identify those units that comprise an efficient frontier and those that lie below the frontier. The standard DEA models have an input and output orientation. An input orientation identifies the efficient consumption of resources while holding outputs constant. An output orientation identifies the efficient level of output production given existing resource consumption. In addition, DEA models can be either constant or variable returns to scale [Banker et. al.[1](1984)]. We can run a DEA model with very little data precisely because it is a non-parametric approach.

Jackson and Fethi[2] (2000) study on Turkish banks found that the profitable banks are more likely to operate at higher levels of technical efficiency. In this study, the DEA approach has been used. This approach has been used since "recent research has suggested that the kind of mathematical programming procedure used by DEA for efficient frontier estimation is comparatively robust" [Seiford and Thrall[3] (1990)]. In 1957 M. J. Farrell[4] published a paper entitled "The Measurement of Productive Efficiency" which proved to be seminal. Farrell[4] stimulated interest in the area of production frontier estimation and led to the development of several techniques for the measurement of technical and economic efficiencies. DEA is a linear programming model introduced by Charnes et. al.[5] (1978) to measure efficiency under the assumption of constant returns to scale and extended by Banker et. al.[1](1984) to allow variable returns to scale. A 'large number of papers have extended and applied the DEA methodology'[Coelli[6] (1996)].

Bhattacharyya et al.[7] (1997) examined the productive efficiency of 70 Indian commercial banks during early stages (1986-1991) prior to liberalization. They used Data Envelopment Analysis to calculate radial technical efficiency scores. Sathye[8] (2003) measured the productive efficiency of banks in India. It was done using Data Envelopment Analysis. The study shows that the mean efficiency score of Indian banks compares well with the world mean efficiency score and the efficiency of private sector commercial banks. DEA has become increasingly popular in measuring efficiency in different national banking institutes.

II. Data and Methodology

The sample data for conducting this study are collected from 21 banks. These data are collected from the annual reports of these respective banks. Some of the annual reports are obtained from respective bank's websites and some others are collected from the respective bank's headquarters. The data collected from the 21 banks are of year 2009. That is, the type of the data is cross sectional and only the data of year 2009 are considered. For conducting this study we mainly emphasis on five variables. These are - operation

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profit, operation income, operation cost, total assets and deposits. For our purpose of efficiency analysis operation profit is considered as output variable which we want to maximize and the other four, operation income, operation cost, total assets and deposits are considered as input variables.

Data Envelopment Analysis (DEA) is a nonparametric method in operations research and economics for the estimation of production frontiers. DEA is a mathematical programming approach which is used to construct a frontier or production possibilities curve for a set of decision making units (DMUs). A linear program is applied to create a virtually efficient DMU that sits on the efficiency frontier, in which each DMU has a hundred (100) percent efficiency relative to every other DMU. The linear program does this by using two constraints. The first constraint forces the virtual DMU to produce at least as many outputs as the studied DMU. The second constraint finds out how much less input the virtual DMU would need.

The input oriented **constant returns to scale** (CRS) model considers there are data on K inputs and M outputs on each of N DMU's. For the i-th DMU these are represented by the vectors x_i and y_i, respectively. The $K \times N$ input matrix, X, and the $M \times N$ output matrix, Y, represent the data of all DMU's. For each DMU we would like to obtain a measure of the ratio of all outputs over all inputs such as $u'y_i/v'x_i$ as efficiency score, where u is an M×1 vector of output weights and v is a K×1 vector of input weights.

Now for selecting optimal weights we write the mathematical programming problem as follows:

$$
\begin{aligned}
& max_{u,v}\,(u'y_i/v'x_i),\\
& such\ that\ u'y_j/v'x_j \le 1,\ j = 1,2,\dots,N,\\
& \quad u,v \ge 0. \qquad (1)
\end{aligned}
$$

This involves finding values for u and v such that the efficiency measure of the i-th DMU is maximized, subject to the constraint that all efficiency measures must be less than or equal to one. A great problem with this particular ratio formulation is that it has an infinite number of solutions. To avoid this we can impose the restriction $v'x_i = 1$, which gives:

$$
\begin{aligned}
& max_{\mu,v}\,(\mu' y_i),\\
& such\ that\ v'x_i = 1,\\
& \mu' y_j - v' x_j \le 0,\ j = 1,2,\dots,N,\\
& \quad \mu, v \ge 0, \qquad (2)
\end{aligned}
$$

where, the notation change from v to μ and v is reflecting the transformation. This form is called the **multiplier** form of the linear programming problem. Using the duality in linear programming; one can derive an equivalent **envelopment** form of this problem:

$$
\begin{aligned}
& min_{\theta,\lambda}\,\theta,\\
& such\ that\ -y_i + Y\lambda \ge 0,\\
& \quad \theta x_i - X\lambda \ge 0,\\
& \quad \lambda \ge 0, \qquad (3)
\end{aligned}
$$

where, θ is a scalar and λ is a N× 1 vector of constants. This envelopment form involves fewer constraints than the multiplier form (K+M < N+1), and hence is generally the preferred form to solve. The value of θ obtained will be the efficiency score for the i-th DMU. The value of θ obtained will be the efficiency score for the i-th DMU. It will satisfy $\theta \le 1$, with a value of 1 indicating a point on the frontier and thus a technically efficient DMU is obtained according to the Farrell (1957) definition.

The CRS linear programming problem can be easily modified to account for variable returns to scale (VRS) by adding the convexity constraint: $N1'\lambda = 1$ to (3) to provide:

$$
\begin{aligned}
& min_{\theta,\lambda}\,\theta,\\
& such\ that\ -y_i + Y\lambda \ge 0,\\
& \quad \theta x_i - X\lambda \ge 0,\\
& \quad N1'\lambda = 1\\
& \quad \lambda \ge 0, \qquad (4)
\end{aligned}
$$

where, N1 is an $N \times 1$ vector of ones. This procedure provides TE (technical efficiency) scores which are greater than or equal to those obtained using the CRS model.

Scale efficiency is calculated as follows:

$$Scale\ Efficiency = TE\ obtained\ from\ CRS / TE\ obtained\ from\ VRS$$

One limitation of this measure of scale efficiency is that the value does not indicate whether the DMU is operating in the area of increasing or the decreasing returns to scale. This may be determined by running an addition DEA problem with non- increasing returns to scale (NIRS) imposed. This can be done by altering the DEA model in equation 4 by substituting the $N1'\lambda = 1$ restriction with $N1'\lambda \le 1$, to provide:

$$
\begin{aligned}
& min_{\theta,\lambda}\,\theta,\\
& such\ that\ -y_i + Y\lambda \ge 0,\\
& \quad \theta x_i - X\lambda \ge 0,\\
& \quad N1'\lambda \le 1\\
& \quad \lambda \ge 0, \qquad (5)
\end{aligned}
$$

The nature or characteristics of the scale inefficiencies (i.e. due to increasing or decreasing returns to scale) for a particular DMU can be determined by seeing whether the NIRS TE score is equal to the VRS TE score The output-oriented models are very similar to their input-oriented counterparts. Let us assume the example of the following output-oriented VRS model:

$$\begin{aligned} & max_{\emptyset\lambda}\ \phi, \\ st\quad & -\phi y_i + Y\lambda \geq 0, \\ & x_i - Y\lambda \geq 0, \\ & N1'\lambda = 1 \\ & \lambda \geq 0 \end{aligned} \qquad (6)$$

where, $1 \leq \emptyset < \infty$, and $\emptyset - 1$ is the proportional increase in outputs that could be achieved by the i-th DMU, with input quantities held constant. Note that $1/\emptyset$ defines a TE score which ranges between zero and one. One point that should be noted is that the output- and input- oriented models will estimate the same frontier and therefore, identify the same set of DMU's as being efficient.

III. Results and Interpretations

The following table shows the descriptive statistics of the sample n=21 banks.

Table. 1. Descriptive Statistics of the Banks

Variables	Mean	Median	Minimum	Maximum	Standard deviation
Operation profit	313.60	251.84	65.33	857.81	198.4311
Operation income	561.8	423.5	171.8	1370.2	359.3789
Operation cost	248.20	176.48	61.07	908.78	195.1144
Assets	9306	7195	3998	29689	6448.278
Deposits	7758	5939	3111	24618	5904.188

The above table is figured in units of crore taka.

Under the constant returns to scale (CRS) assumption both the output and input oriented technical efficiency scores are same. Here, all the efficiency scores of DEA are obtained using the DEAP- xp1 software developed by Tim Coelli[6] (1996). All the CRS (output), VRS (output) and scale efficiency scores of the banks along with the peers are given in the following table 2.

Table. 2. Efficiency Scores obtained using DEA

DMUs	CRS TE	CRS Peers	VRS TE	VRS Peers	SCALE TE	
1	0.846	3	0.923	20,3,16	0.916	DRS
2	0.561	3	0.629	6,20,3	0.892	DRS
3	1.000	3	1.000	3	1.000	-
4	0.808	3	0.879	20,3,6	0.919	DRS
5	0.701	3,10	0.850	10,6,3	0.826	DRS
6	0.822	3	1.000	6	0.822	DRS
7	0.904	3	0.953	16,3	0.949	DRS
8	0.695	3	0.775	20,3,6	0.897	DRS
9	0.815	3	0.896	3,17	0.909	IRS
10	1.000	10	1.000	10	1.000	-
11	0.701	3	0.795	3,17	0.882	IRS
12	0.595	10,3	0.917	10,6	0.649	DRS
13	0.698	3	0.733	16,3	0.952	DRS
14	0.833	3	0.840	16,3	0.992	DRS
15	0.670	3	0.714	20,3,16	0.939	DRS
16	0.804	3	1.000	16	0.804	DRS
17	0.485	3	1.000	17	0.485	IRS
18	0.840	10,3	0.961	6,10,3	0.874	DRS
19	0.624	10,3	0.741	10,6,3	0.842	DRS
20	0.798	3	1.000	20	0.798	DRS
21	0.668	3	0.721	3,16	0.926	DRS
MEAN	0.756		0.873		0.870	

(Each bank is a DMU)

This table shows the technical efficiency scores for all the DMUs. Here we see that under only two banks- CITI BANK (DMU 3) and ONE BANK LIMITED (DMU 10) are technically efficient because they have the technical efficiency scores equal to one. We note that the technical efficiency (TE) of DMU 1 is 0.846. That is DMU 1 should be able to increase the operating profit by 13.4% without increasing inputs. Similar interpretation holds for the other DMUs. A remarkable thing is that DMU 3 is recognized as most efficient bank because the linear combination of DMU 3 is more used than DMU 10 as peer. So, using CRS output oriented multi stage DEA, the DMU 3 is most efficient though both of DMU 3 and 10 have technical efficiency score equal to one.

Under the VRS output results the banks- CITI BANK (DMU 3), PRIME BANK LMITED (DMU 6), ONE BANK LIMITED (DMU 10), ISLAMI BANK LIMITED (DMU 16), SOCIAL ISLAMI BANK LIMITED (DMU 17) and JANATA BANK LIMITED (DMU 20) are technical efficient. Other 15 banks are technically inefficient as their efficiency scores are less than one. Technical efficient DMUs are peer of themselves only. We know that only the efficient DMUs form the linear combinations for the inefficient DMUs for efficiency perspective. For example, DMU 15 is a linear combination of the DMUs 20, 3 and 6. That is, this linear combination of 20, 3 and 6 determines the efficient output of DMU 15. The peer counts for DMU 3 is 14 whereas for DMU 6 it is 7 and for the other efficient DMUs 10, 16, 17 and 20 the peer counts are 4, 6, 2 and 5 are respectively. Since DMU 3 is most used, so the most efficient bank is DMU 3.

The VRS efficiency results also give output scale efficiency scores with VRS efficiency scores. A DMU is considered as scale efficient if its output scale efficiency score is equal to one.

Table. 3. Descriptive Statistics of TE Scores for n=21 Banks

Methods	Mean	Median	Maximum	Minimum	Standard Deviation
CRS DEA	0.7536	0.7980	1.0000	0.4850	0.1341
VRS DEA	0.8727	0.8960	1.0000	0.6290	0.1179
SCALE	0.8702	0.8970	1.0000	0.4850	0.1201

Only two banks- CITI BANK (DMU 3) and ONE BANK LIMITED (DMU 10) are scale efficient as their output scale efficiency scores are equal to one. So, in common we get two banks DMU 3 and DMU 10 which are efficient under both CRS and VRS assumption and they are scale efficient too. Whether the DMU is operating in an area of increasing or decreasing returns to scale can be checked by running an additional DEA problem with non-increasing returns to scale (NIRS) imposed. If the NIRS TE score and VRS TE score are unequal for a DMU, then increasing returns to scale (IRS) exist for that DMU. For our given data, IRS exists for DMU 9, 11 and 17. DRS exist for the remaining 16 DMUs other than 3, 9, 10, 11 and 17. In such cases VRS TE scores and NIRS TE scores are the same (e.g. for the DMU 1, 2, 7 etc).

The descriptive statistics of the technical efficiency scores obtained from these methods are given below:

The mean and median of TE scores of CRS DEA is smaller than other two methods. Maximum TE score is one for all methods but minimum score is not same for all the three methods. The range (maximum-minimum) is biggest for CRS DEA and smallest for VRS DEA. Standard deviation of TE scores also reflects this. A graphical comparison of CRS TE scores and VRS TE scores is shown here:

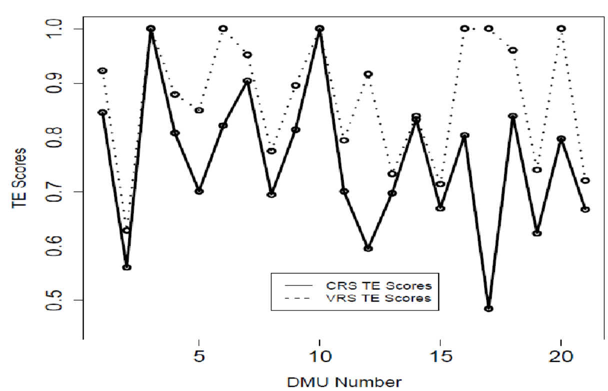

Fig. 1. Comparison Graph of CRS DEA and VRS DEA TE Scores

IV. Conclusion

Here CRS DEA gives two efficient banks (DMUs 3 and 10), VRS DEA gives six efficient banks (DMUs 3, 6, 10, 16, 17 and 20). Now we can rank the banks according to their efficiency scores. The banks with higher technical efficiency posses top ranks. Here few banks have efficiency scores equal to one and their ranking can be determined by considering peer counts. However, the most efficient bank is CITI Bank (DMU 3) which is valid for both methods applied. This is because in CRS DEA efficient DMU 3 has 20 peer counts while other efficient DMU 10 has only 5. DMU 3 possesses rank 1 and DMU 10 has rank 2. Other rankings are done according to the decreasing value of the TE scores. Similar ranking can be provided in VRS DEA case. Here efficient DMUs 3, 6, 10, 16, 17 and 20 posses ranking 1, 2, 5, 3, 6 and 4 respectively.

We find that CRS-DEA consists of 2 efficient banks and the range of the efficiency scores is too large whereas VRS-DEA consists of 6 efficient banks and the range of efficiency scores is smaller than CRS-DEA. So, it may be inappropriate to use CRS-DEA instead of VRS-DEA in this case. Again, VRS assumption overcome the shortcoming of CRS assumption and seems to be more appropriate.

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