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Measuring Technical and Scale Efficiency of Banks in India Using DEA

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Abstract: *This study uses CRR model and BCC model to estimate the technical and scale efficiency of commercial banks in India during the periods 2006-2010. The results indicate that deregulation of banking sector has led to an increase in the efficiency of commercial banks in India. This increase in efficiency of banks in India is not only because of increase in pure technical efficiency but also due to increase in its scale efficiency. The results show large spread of technical efficiency between companies during the period. The estimated results also shows that performance of private sector banks has been better than public sector banks during the period and source of inefficiency is mainly due to its scale rather than pure technical inefficiency.*
Keywords: *DEA; Efficiency; DMU; CCR model; BCC model*

I. Introduction

A sound and strong banking system contributes in an extensive way to economic growth in any country. Thus, study of banking efficiency is important for policy makers, industry leaders and many others who rely on banking sector. Several studies have been carried out in the area of measuring efficiency of firms, companies, banks and other decision making units. Studies in the past used conventional ratios such as return on assets to evaluate efficiency. Most of these studies which look at the efficiency concentrate on cost, profit income or revenue efficiencies. Later research in the area used various measures of performance which include financial index (Wu et. al 2006), a non parametric approach- Data Envelopment Approach (DEA) (Wu, 2005), parametric approach and Stochastic Production Approach (SPA) (Radam et. al 2008). DEA is frequently used to measure relative efficiency of decision making units. DEA is defined by Charnes et al (1978) as a mathematical programming model applied to observations data that provide a new way of obtaining empirical estimate of relations such as the production functions or efficient production possibility surface which are considered to be the corner stone of modern economics. It is a non-parametric multiple input output efficiency technique that measures the relative efficiency of decision making units.

The CRS assumption in CCR model limits its application to efficiency studies. It is appropriate only when all the firms are operating at optimal scale. However, in a market driven economy where competition, price differences and constraints with resources are present, all firms may not be operating at optimal scale. Hence, Banker, Charnes and Cooper (1984) came out with a DEA model for firms operating under variable returns to scale (VRS) popularly known as BCC model. In the CCR model, the technical efficiency calculated is composed of both pure technical efficiency and scale efficiency. The BCC model decomposes the technical efficiency obtained from CCR model into components of pure technical efficiency and scale efficiency by relaxing the CRS assumption in the model. The BCC model can be applied to multiple inputs and multiple output situations also. The objective of this paper is to estimate the relative efficiency of major Indian commercial banks over the years 2006-2010. The data on various inputs and outputs has been taken from RBI website, www.rbi.org.in. This study uses CRR model and BCC model to estimate technical and scale efficiency of commercial banks in india.

II. Literature Review

In India , several studies have been carried out on Efficiency Analysis using DEA approach. Noulas and Ketkar (1996) measured the efficiency of public sector banks of India by using the Data Envelopment Analysis. The study considered 18 public sector banks and the necessary information for analysis have been collected from the RBI publications for the year 1993. The study identified that pure technical efficiency was 1.5 percent and scale inefficiency was 2.25 percent and none of the banks were operating under decreasing returns to scale.

Bhattacharya et al (1997) used DEA to measure the productive efficiency of Indian commercial banks in the late 80s to early 90s and studied the impact of policy on liberalizing measures taken in 1980s on the performance of various categories of banks. They found that Indian Public banks were the best performing banks as the banking sector was overwhelmingly dominated by Indian public sector banks while the new private sector banks were yet to emerge fully in the Indian banking scenario. Sathye (2001) studied the relative efficiency of Indian banks in late 1990s and compared the efficiency of Indian banks with that of banks of other countries. He found that public sector banks have a higher mean efficiency score as compared to the private sector banks in India, but found mixed results when comparing public banks and foreign commercial banks in India. He also found that most banks on efficient frontier are foreign owned. Rammohan and Ray (2004) compared the revenue maximizing efficiency of public, private and foreign banks in India using physical quantities of inputs and outputs in 1990s with deposits and operating costs as input and loans, investment and other income as outputs. They found that public sector banks were significantly better than private banks on revenue maximization efficiency, but between public and private sector banks the difference in efficiency was not significant. Sanjeev (2006) studied efficiency of private, public and foreign banks operating in India during the period 1997-2001 using DEA. He also studied if any relationship can be established between the efficiency and non-performing assets of the bank. He found that there is an increase in efficiency in post reform period and that non-performing assets and efficiency are negatively related.

Avkiran used DEA model, taking interest expense and non-interest expense as input variable and interest income and non-interest income as output variables to examine the efficiency of Australian trading banks for the period 1986 to 1995 and found that their efficiency rose in the post regulation period and acquiring banks were more efficient than target banks. Chen and Yeh (1998) calculated the operating efficiencies of 34 commercial banks of Taiwan's banks using the DEA model where in input variables included staff employed, interest expense and output variables include loans investment and interest revenue, non-interest revenue and bank assets. The author concluded that a bank with better efficiency does not always mean that it has better effectiveness. In the case of Turkish Banks, (Mehmet Hasan Eken Suleyman Kale, A J B M vol. 5(3) PP 889-901, 4 Feb, 2011), it is apparent that branch size and scale efficiency are related to each other. As branch size increases scale efficiency increases too and after the most productive scale size, however, as the size increases efficiency decreases.

Al-Shammari and Salimi (1998) have examined the comparative operating efficiency of Jordanian commercial banks from 1991-1994 using a modified version of DEA and found that the majority banks were fairly inefficient over the period 1991-1994. Noulas (2001) employed both DEA model and the traditional approach to study the effect of banking deregulation on private and public owned banks. The interest expense and non-interest expense were the input variable and interest revenue and non-interest revenue were the output variables. The result reveals that the state banks were less efficient than the private banks and the gap widened during the study period. Shanmugam and Das (2004) studied banking efficiency using a Stochastic Frontier Production function model during the reform model period 1992-99. The study considers the input variables (viz deposits, borrowings, labour and fixed assets) and four output variables (viz net interest income, non-interest income, credits and investments). They found that deposits are dominant in producing all outputs and technical efficiency of raising interest margin is varied across the banks. In particular they found that reform measures introduced since 1992 have not helped the banks in raising their interest margin. Also, in general, they found that private foreign banks performed better than public banks.

III. Research Methodology

The present study considers ten commercial banks as decision making units. Out of these, five are public sector banks and other five are private sector banks. Selecting various inputs and outputs is a challenging task in the model because they can be misleading in nature. The three inputs considered in the study are deposits, number of employees, operating expenses and the three outputs are investments, other income and advances. In this study the data related to various input and outputs over the period 2006 - 2010 have been taken from RBI website (www.rbi.org.in). The ten decision making units (banks) considered in the present study are as follows:

Public Sector Banks	**Private Sector Banks**
State Bank of India(A)	HDFC Bank(F)
Punjab National Bank(B)	Axis Bank(G)
Canara Bank(C)	ICICI Bank(H)
Vijaya Bank(D)	Yes Bank(I)
Allahabad Bank(E)	Kotak Mahindra Bank(J)

CCR Model

CCR-Model was introduced by Charnes, Cooper and Rhodes (1978). This model measures the efficiency of each DMU which is obtained as a maximum of the ratio of total sum of weighted outputs to total sum of weighted inputs. Consequently, the efficiency can be defined as follow.

$$\text{Efficiency} = \frac{\text{Weighted sum of outputs}}{\text{Weighted sum of inputs}}$$

The weights for the ratio are determined by the restriction that the similar ratios for every DMU have to be less than or equal to unity, thus reducing multiple inputs and outputs to a single "virtual" input and single "virtual" output without requiring pre-assigned weights. Therefore, the efficiency score is a function of the weights or the "virtual" input-output combination. Suppose that there are n DMUs, each with n inputs and s outputs, relative efficiency score of a given DMU_0 is obtained by solving the following linear programming model.

$$\max\ \left(\theta = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{r=1}^{m} v_i x_{i0}}\right)$$

subject to

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{r=1}^{m} v_i x_{ij}} \leq 1\ ;\ j = 1,2,\ldots,n$$

where

$$v_i \geq 0; i = 1,2,\ldots,m$$
$$u_i \geq 0; r = 1,2,\ldots,s$$

and

x_{ij} = the amount of input i utilized by the jth DMU

y_{rj} = the amount of output r produced by the jth DMU

v_i = weight given to input i

u_r = weight given to output r

Following the Charnes – Cooper transformation (1962), one can select a representative solution (v,u) for which

$$\sum_{r=1}^{m} v_i x_{i0} = 1$$

Hence, the denominator in the efficiency score θ shown above is set equal to one, the transformed linear programming model for DMU_0can be written as follow.

Max $\theta = \sum_{r=1}^{s} u_r y_{r0}$

Subject to

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{r=1}^{m} v_i x_{ij} \leq 0\ ;\ j = 1,2,\ldots,n$$
$$\sum_{r=1}^{m} v_i x_{i0} = 1$$
$$v_i \geq 0; i = 1,2,\ldots,m$$
$$u_i \geq 0; r = 1,2,\ldots,s$$

BCC Model

Max output (y)

Subject to: output constraint

$$\sum_{n=1}^{N} y_n \lambda_n - \theta y_i \geq 0$$

input constraint

$$\sum_{n=1}^{N} z_n \lambda_n - \theta z_i \geq 0$$

for$\lambda_n > 0,\ n = 1,2,\ldots,N$

$\boldsymbol{\lambda}$ represents the Lagrange multiplier and in the solution it indicates the efficient peer DMUs. **Θ** represents the factor by which the current levels of input constraints are solved for overall TE $(\mathrm{CSR_{TE}}) = \frac{1}{\Theta}$ under CRS assumption.

Pure TE$(\mathrm{VRS_{TE}})$ of DMU can be arrived at by relaxing CRS assumption and new Θ value (Θ^*) is computed by imposing assitional constraints i.e.

$$\sum_{n=1}^{N} \lambda_n = 1$$

Scale efficiency is given by $\mathrm{SE} = \frac{\mathrm{CRS_{TE}}}{\mathrm{VRS_{TE}}} = \frac{\Theta}{\Theta^*}$

Whether the DMUs are operating under DRS, IRS or CRS all previously mentioned constraints are solved for$\Theta^{**}$with additional constraints$\sum_{n=1}^{N} \lambda_n \leq 1$ at $\mathrm{NIRS_{TE}} = \frac{1}{\Theta^{**}}$

$$\text{if } NIRS_{TE} \text{ and } VIRS_{TE} \neq 0 \Rightarrow \text{IRS and}$$
$$\text{if } NIRS_{TE} \text{ and } VIRS_{TE} = 0 \Rightarrow \text{DRS}$$

IV. Results and conclusion

The Data considering the various inputs and outputs is written in the form of linear programming equations. Then, the equations are solved using DEA technique. Analysis is presented in a descriptive statistical format using the graphs and tables. The linear programming model shown above will be run n times in identifying the relative efficiency score of all the DMUs. Each DMU selects input and output weights that maximize its efficiency score. Generally, a DMU is considered to be efficient if it obtains a score of 1.00, implying 100% efficiency; whereas a score of less than 1.00 implies that it is relatively inefficient.

Table 1: Technical and Scale Efficiency Scores,2006-2010

	2006			2007			2008			2009			2010		
DMU	PTE	SE	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE	TE
A	1	0.896	0.896	1	0.939	0.939	1	0.98	0.98	1	0.897	0.897	1	0.901	0.901
B	0.902	0.921	0.832	0.892	0.995	0.888	0.956	0.986	0.943	1	1	1	0.976	0.921	0.9
C	0.834	0.998	0.833	1	1	1	1	1	1	1	0.995	0.995	1	1	1
D	1	1	1	1	1	1	1	0.966	0.966	1	1	1	1	1	1
E	0.992	0.953	0.946	0.993	0.981	0.975	1	1	1	0.972	0.939	0.914	0.901	0.992	0.894
F	1	1	1	1	0.893	0.893	1	1	1	0.789	0.99	0.782	0.838	0.999	0.837
G	0.624	0.991	0.619	1	1	1	1	1	1	0.942	0.996	0.939	0.915	0.956	0.875
H	1	0.994	0.994	1	1	1	1	1	1	1	1	1	1	0.969	0.969
I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
J	1	1	1	1	1	1	1	1	1	1	0.961	0.961	1	1	1
Average	0.9352	0.9753	0.912	0.9885	0.9808	0.9695	0.9956	0.9932	0.9889	0.9703	0.9778	0.9488	0.963	0.9738	0.9376
Max	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Min	0.624	0.896	0.619	0.892	0.893	0.888	0.956	0.966	0.943	0.789	0.897	0.782	0.838	0.901	0.837

Table 2 Average Efficiency scores,2006-2010

	2006	2007	2008	2009	2010
PTE	0.9352	0.9885	0.9956	0.9703	0.963
SE	0.9753	0.9808	0.9932	0.9778	0.9738
TE	0.912	0.9695	0.9889	0.9488	0.9376

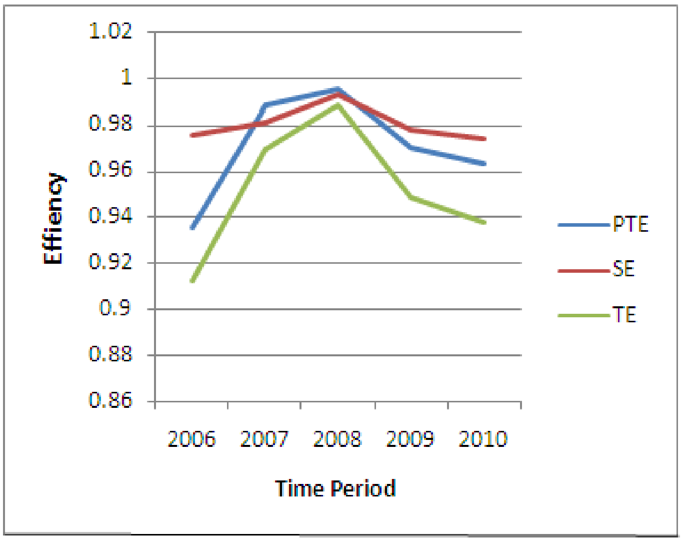

Figure 1: Efficiency trend Graph 2006 - 2010

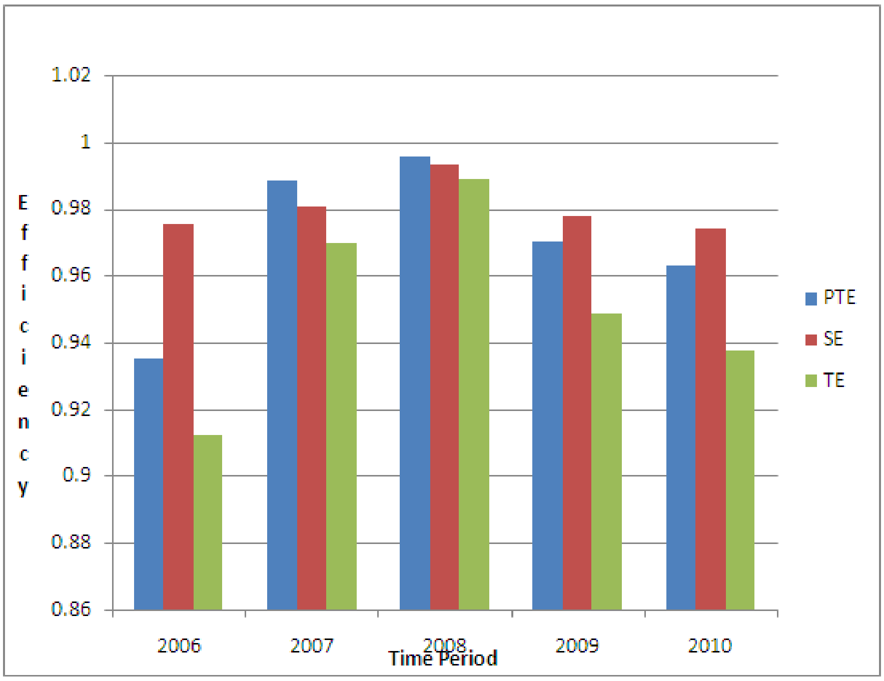

Figure 2: Efficiency scores 2006 - 2010

V. Conclusion

- This paper attempts to investigate the technical as well as Scale efficiency of Indian commercial banks over the period 2006-2010. The BCC and CCR models have been used to obtain the various efficiency scores for ten Indian commercial banks (DMUs).
- The efficiency trend graph in fig.1 shows that the mean technical and Scale efficiency improved from 2006 to 2008 and then declined during the period 2008 to 2010. The result also shows that the banks like SBI,PNB and ICICI have higher pure technical efficiency as compared to their scale efficiency where as banks like Allahabad bank, HDFC and AXIS banks have higher Scale efficiency.
- The low efficiency scores obtained in the study by the DMUs like SBI, PNB and HDFC during the reference period is due to their huge amounts of deposits and operating expenses.
- The fact that the performance of private sector banks is better than public sector banks during the period of investigation, 2006-2010,(Nand kumar and Archana Singh,2014) is vindicated in terms of Scale efficiency as well.

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