Efficiency Analysis by using Data Envelop Analysis Model: Evidence from Indian Banks

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***Abstract* - The structure of Indian banking has substantially changed over the past decades, partially as a result of adoption of new technologies and process of reforms and accompanying deregulation has embodied an incentive for bank management to focus on improving efficiency, especially given the more competitive banking environment. This study aims to examine the efficiency of Indian commercial banks during 2000 – 2010 by utilizing Data Envelopment Analysis (DEA). Based on the sample of 8 commercial banks, our findings reveal that the mean of cost (economic) efficiency, technical efficiency, and allocative efficiency are 0.991, 0.995, and 0.991 in VRS model and 0.936. 0.969, and 0.958 in CRR model, respectively using DEA approach. Inputs and outputs of this study were analyzed based on intermediation approach. In addition, the results suggest that Bank of India and ICICI bank are more efficient as compare to other banks in India and result confirmed that selected Public Sector Banks are more efficient than Private sectors during the study period in India.**

Keyword: Data envelop analysis, economic efficiency, allocative and technical efficiency, Indian banks.

1. Introduction

Investigating the efficiency of the financial system and in particular banks has gained a lot of popularity in recent times for several reasons. First, the efficiency of banks is directly linked to the productivity of the economy. Banking system assets constitute a substantial proportion of total output (Bauer Paul et al, 1992). Banks provide liquidity, payments and safekeeping for depositors` and channel these funds into investment and working capital requirements. In addition, banks are supposed to play a special role in funding small businesses that often have very limited access to other sources of external finance. Banks also play a major role in ensuring a smoothly functioning payment system, which allows financial and real resources to flow freely to their highest-returns uses. A basic benefit of enhanced efficiency is a reduction in spreads between lending and deposit rates. This is likely to stimulate both greater loan demands for industrial investment (and thus contribute to higher economic growth) and greater mobilization of savings through the banking system. Banks in most developing countries operate with relatively wide spreads. Although government policies and regulations are considered major causes of such wide spreads, studies on banking efficiency has pointed at operating inefficiencies as one other possible source that needs to be investigated. Wide spreads affect intermediation and distort prices thus impairing the role of the financial system in contributing to rapid economic growth (Ikhide. S, 2000).

Indian financial services industry is dominated by the banking sector and the banking structure in India is broadly classified into public sector banks, private sector banks and foreign banks. The public sector banks continue to dominate the banking industry, in terms of lending and borrowing, and it has widely spread out branches which help greatly in pooling up of resources as well as in revenue generation for credit creation.

The Indian financial sector reform of 1991 has greatly changed the face of Indian Banking system. In addition to the nationalized banks, several private Banks were newly founded or created by previously extant financial institutions. India has also seen the entry of over two dozen foreign banks since the beginning of financial reforms. In the face of increased competition, the banks have to operate more efficiently in order to sustain and perform better. In the context of increased competition and the importance of banks in financial markets, it becomes very much essential to evaluate whether these banks operate efficiently. Primarily, there are two chief reasons to measure the efficiency of banking institutions. Firstly, this assists to identify the most efficient banks and benchmarks the relative efficiency of individual banks against the most efficient banks. Secondly, it helps to evaluate the

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impact of various policy measures on the performance of banks.

The objective of this paper is to estimate technical and total economic efficiency of commercial banks in India for the period 2000-2010. The paper is structured as follows: the first section will discuss review of literature in banking followed by methodology, data and specification of bank inputs and outputs. Empirical findings are discussed in the next section followed by the conclusion.

2. Literature review

During the late 1980s and particularly in the 1990s, the DEA method has been used extensively to evaluate banking institutions. Sathye (2003) used DEA to study the relative efficiency of Indian banks in the late 1990's with that of banks operating in other countries. He found that the 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 sector banks and foreign commercial banks in India. Kumbhakar and Sarkar (2004) estimated the cost efficiency of public and private sector banks in India by using the stochastic cost frontier model with specification of translog cost function. The study used data of 50 banks for the analysis and necessary information have been collected from the various issues of the annual reports published by the Indian Banks' Association for the period 1986-2000. The empirical results revealed that deregulation not only increased the cost inefficiency but also affected the rate of fall in inefficiency of banks. During this period private banks were more efficient than the public sector banks according to study.

Rammohan and Ray (2004) compared the revenue maximizing efficiency of banks in India in 1990's. Deposits and operating costs were taken as inputs while loans, investments and other income were taken as outputs. Their research found that public sector banks were significantly better than private sector banks on revenue maximization efficiency. However it was found that the difference in efficiency between public sector banks and foreign banks was not significant.

Das et al, (2004) examined the efficiency of Indian banks by using DEA model. Four input measures: deposits and other borrowings, number of employees, fixed assets and equity, and three output measures: investments, performing loan assets and other non-interest fee based incomes were used in the analysis. He found that Indian banks did not exhibit much of a difference in terms of input or output oriented technical and cost efficiency. However, in terms of revenue and profit efficiencies prominent differences were seen. He also found that size of the bank, ownership of the bank, and listing on the stock exchange had a positive impact on the average profit and revenue efficiency scores.

Soori et al, (2005) analyzed efficiency of Iranian banking system and the main Purpose of the study was to investigate the comparative efficiency of commercial banks in Iran using stochastic frontier function as a parametric and data envelopment analysis as a non-parametric approaches. The data used cover the period 1996-2004. The findings of this paper show that there is a significant difference between non–parametric and parametric methods in measuring the efficiency in the commercial banks of Iran. Debasish (2006) also attempted to measure the relative performance of Indian banks, using the output-oriented CRR DEA model. The analysis used nine variables and seven output variables in order to examine the relative efficiency of commercial banks over the period 1997 – 2004.

Mostafa, M. (2007) investigated the efficiency of top 85 Arab banks using DEA and Neural networks for the year 2005. He found that, eight banks as per the CCR Score and four banks as per BCC Score were positioned on the efficient frontier. He suggested that future studies should test the existence of positive rank-order correlations between efficiency scores obtained from DEA analysis and traditional efficiency measures such as financial ratios. His results further demonstrate that, Al-Rajhi Bank and National Commercial Bank were placed among the top ten Arab banks with a relative ranking of eight and ten respectively.

Moh'd Al-Jarrah (2007) is used data Envelopment Analysis (DEA) approach to investigate cost efficiency levels of banks operating in Jordan, Egypt, Saudi Arabia and Bahrain over 1992-2000. The estimated cost efficiency is further decomposed into technical and allocative efficiency at both variable and constant return to scale. Later on, the technical efficiency is further decomposed into pure technical and scale efficiency. Cost efficiency scores ranged from 50 to 70% with some variations in scores depending on bank's size and its geographical locations. The results suggested that the same level of output could be produced with approximately 50-

70% of their current inputs if banks under study were operating on the most efficient frontier.

Chansarn (2008) conduct a study aimed to examine the relative efficiency of Thai commercial banks during 2003 – 2006 by utilizing Data Envelopment Analysis (DEA). Based on the sample of 13 commercial banks, findings revealed that the efficiency of Thai commercial banks via operation approach is very high and stable while the efficiency via intermediation approach is moderately high and somewhat volatile. In term of size, large, medium and small banks, in average, were efficient via operation approach with the average efficiencies of 100%. However, small banks were the most efficient banks via intermediation approach

AlKhathlan and Abdul Malik (2008) used basic DEA models i.e. CCR and BCR to evaluate the relative efficiency of Saudi Banks using annual data from 2003 through 2008. The results showed that, on a relative scale, Saudi banks were efficient in the management of their financial resources. In addition, the results would provide crucial information about Saudi banks' financial conditions and management performance for the benefit of bank regulators, managers and bank stock investors.

Kumar and Gulati (2008) conducted a study aimed to measure the extent of technical, pure technical, and scale efficiencies in 27 public sector banks (PSBs) operating in India in the year 2004/05. The empirical findings of study revealed that PSBs (Public sector banks) operate at 88.5 percent level of overall technical efficiency i.e., inputs could be reduced by 11.5 percent without sacrificing output if all banks were efficient as 7 benchmark banks identified by DEA. Further, the contribution of scale inefficiency in overall technical inefficiency has been observed to be smaller than what been observed due to managerial inefficiency (i.e., pure technical inefficiency). The findings pertaining to returns-to-scale in Indian public sector banking industry highlight that the predominant form of scale inefficiency is decreasing returns-to-scale. The results of logistic regression analysis also provide that the exposure of the banks to off-balance sheet activities (i.e., non-traditional activities) has a strong and positive impact on the overall technical efficiency of banks in India.

San O et al, (2011) in their study utilizes non parametric Data Envelopment Analysis (DEA) to analyze and compare the efficiency of foreign and domestic banks in Malaysia. The analysis was based on a panel data set of 9 domestic banks and 12 foreign banks in Malaysia over the period of 2002-2009. Intermediation approach is used to define the inputs and outputs in computerizing the efficiency scores. Surprisingly, the findings are inconsistent with most of the findings of previous studies where the foreign banks were outperforming their domestic peers in term of efficiency. Conversely, the finding of this study shows that domestic banks have a higher efficiency level than foreign banks, this imply that domestic banks are relatively more managerially efficient in controlling their costs. The second stage of the empirical results was based on the Tobit model, which suggests that the pure technical efficiency (PTE) of banks in Malaysia is mainly affected by capital strength, loan quality, expenses and asset size.

3. Methodology

The literature distinguishes two main approaches in measuring banking efficiency; a parametric and a non-parametric approach in which the specification of a production cost function is required in both approaches.

The parametric approach engages in the specification and econometric estimation of a statistical or parametric function, while the non-parametric method offers a linear boundary by enveloping the experimental data points, known as "Data Envelopment Analysis" (DEA). This study uses non-parametric approach-Data Envelopment Analysis (DEA) to estimate technical and economic efficiency of Indian commercial banks. The main objective of DEA is to determine which firms are operating on their efficient frontier and which firms are not. If the firm's input-output combination lies on the DEA frontier, the firm is considered efficient; and the firm is considered inefficient if the firm's input-output combination lies inside the frontier. The present study uses the latest available published data for the year 2000 compiled by 2010.

3.1 Data envelop analysis

Data Envelopment Analysis (DEA) developed by Charnes et al. (1978) is a linear programming based technique. DEA occasionally called frontier analysis is a performance measurement technique which can be used for analyzing the relative efficiency of productive units, having the same multiple inputs and multiple outputs. It is a non-parametric analytic technique which allows us to compare the relative efficiency of units as benchmark and by measuring the inefficiencies in input combinations in other units relative to the benchmark. One of the earliest studies on DEA is the study of Farrell (1957) who attempted to measure the technical efficiency of production in single input and single output case. DEA was originally developed by Charnes, Cooper and Rhodes (1978) with the assumption of constant return to scale (CRS) in attempt to propose a model that generalizes the single-input, single output measure of a DMU to a multiple inputs, multiple outputs setting. Thus DMU is an entity that uses input to produce output. DEA was extended by Banker, Charnes and Cooper (1984) to include variable return to scale (VRS). Up to now the DEA measure has been used to evaluate and compare educational departments, health care, agricultural production, banking, armed forces, sports, market research, transportation and many other applications.

DEA is a deterministic methodology for examining the relative efficiency, based on the data of selected inputs and outputs of a number of entities called decision–making units (DMUs). From the set of available data, DEA identifies relative efficient DMUs (which are used as reference points) which define the efficiency frontier and evaluate the inefficient of other DMUs which lie below that frontier.

DEA is an alternative analytic technique to regression analysis. Regression analysis approach is characterized as a central tendency approach and it evaluates DMUs relative to an average. In contrast, DEA is an extreme point method and compares each DMU with the only best DMU. The main advantage of DEA is that, unlike regression analysis, it does not require an assumption of a functional form relating inputs to outputs. Instead, it constructs the best production function solely on the basis of observed data; hence statistical tests for significance of the parameters are not necessary (Chansarn, 2008).

Return to scale

Return to scale refers to increasing or decreasing efficiency based on size. For example, a manufacturer can achieve certain economies of scale by producing thousand Integrated Circuits at a time rather than one at a time. It might be only 100 times as hard as producing one at a time. This is an example of increasing returns to scale (IRS). On the other hand, the manufacturer might find it more than trillion times difficult to produce a trillion Integrated Circuits at a time because of storage problems and limitations on the worldwide Silicon supply. This range of production illustrates Decreasing Returns to Scale (DRS). Combining the extreme two ranges would necessitate Variable Returns to Scale (VRS). Constant Return 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. But, CRS efficiency scores will never be higher than that of VRS efficiency scores. In a CRS model, the input-oriented efficiency score is exactly equal to the inverse of the output-oriented efficiency score. This is not necessarily true for inefficient DMUs in the case of other return to scale assumptions. The CRS version is more restrictive than the VRS and yields usually a fewer number of efficient units and also lower efficient score among all DMUs. In DEA literature the CRS model is typically referred to as the CCR model after the originators of the seminal publication, by Charnes, Cooper and Rhodes (1978).

CCR’s model: The model has developed the Farrell’s efficiency measurement concept from several inputs and one output to several inputs and several outputs. In this model (Charnes et al (1978)) using a linear combination, different inputs and outputs are changed into one virtual input and output which the ratio of these virtual combinations of outputs to inputs will be the estimation of efficiency boundary for the measurement of relative efficiency given that the yield is constant.

BCC’s model: In contrast to constant yield in the above mentioned model, the BCC’s model (Banker et al (1984)) assumes a variable output with respect to the scale. In the model, the technical efficiency is decomposed to pure technical efficiency and scaled efficiency in order to measure the output to scale as well as efficiency itself.

Mathematically, relative efficiency of a DMU is defined as the ratio of weighted sum of outputs to weighted sum of inputs. This can be written as:

$$\boldsymbol{ho} = \frac{\int_{r=1}^{s} Ur\, Yro}{\int_{i=1}^{m} Vi\, Xio} \quad (1)$$

Where:
S= number of outputs:
Ur= weight of output r:
Yro= amount of r produced by the DMU:
M=number of inputs:

Vi= weight of input I :and,
Xio= amount of input I used by the DMU:

Equation 1 assumes CRS and controllable inputs. While outputs and inputs can be measured and entered in this equation without standardization, determining a common set of weights can be difficult (Avkiran, 1999). DMUs might assess their outputs and inputs in a different way. This issue is answered in the Charnes, Cooper and Rhodes (known as CCR) model. Charnes et al. (1978) developed the CCR model that had an input orientation and assumed

CRS. The result of CCR model indicates a score for overall technical efficiency (OTE) of each DMU. In other words, this model calculates the technical efficiency and scale efficiency combined for each DMU. The CCR model addressed the above problem by allowing a DMU to take up a set of weights that maximize its relative efficiency ratio without the same ratio for other DMUs exceeding one. Thus equation 1 is rewritten in the form of a fractional programming problem:

$$\max ho = \frac{\int_{r=1}^{s} Ur\ Yro}{\int_{i=1}^{m} Vi\ Xio} \quad (2)$$

Subject to:

$$\frac{\int_{r=1}^{s} \boldsymbol{Ur\ Yro}}{\int_{i=1}^{m} \boldsymbol{Vi\ Xio}} \leq \text{For each DMU in the sample}$$

Where j=1,……, n (number of DMUs)

To measure efficiency, equation 2 is converted into a linear programming problem. In equation 3, the denominator is a set of constant and the numerator is maximized:

$$\max ho = \int_{r=1}^{s} Ur\ Yro \quad (3)$$

$$\int_{i=1}^{m} Vi\ Xio = 1$$

$$\int_{r=1}^{s} Ur\ Yrj - \int_{i=1}^{m} Vi\ Xij \leq 0,$$

$$Ur, Vi \geq \in,$$

Therefore, in order to avoid the exclusion of an output or an input in the calculation of efficiency, weights *u* and *v* are not permitted to fall below non-Archimedean small positive numbers ($\in$). Equation 3 utilizes controllable inputs and CRS. It is a linear programming problem that models input minimization.

Then, Banker et al. (1984) introduced the usage of VRS that splits OTE into two components, namely pure technical efficiency (PTE) and scale efficiency (SE). This is popularly referred as Banker, Charnes and Cooper (known as BCC) model. The BCC linear programming problem that calculates pure technical efficiency is depicted in equation 4:

$$\max ho = \int_{r=1}^{s} Ur\ Yro + Co \quad (4)$$

$$\int_{i=1}^{m} Vi\ Xio = 1$$

$$\int_{r=1}^{s} Ur\ Yrj - \int_{i=1}^{m} Vi\ Xrj - Co < 0,$$

$$Ur, Vi \geq \in,$$

On the whole, the former concerns about the capability of managers to use the firms' given resources, while the latter refers to utilizing scale economies by working at a point where the production frontier shows CRS.

To discuss DEA in more detail it is necessary to look at the different concepts of efficiency. The most common efficiency concept is technical efficiency: the conversion of physical inputs (such as the services of employees and machines) into outputs relative to best practice. In other words, given current technology, there is no wastage of inputs whatsoever in producing the given quantity of output. An organization operating at best practice is said to be 100% technically efficient. If operating below best practice levels, then the organization's technical efficiency is expressed as a percentage of best practice. Managerial practices and the scale or size of operations affect tech Allocative efficiency refers to whether inputs, for a given level of output and set of input prices, are chosen to minimize the cost of production, assuming that the organization being examined is already fully technically efficient. Allocative efficiency is also expressed as a percentage score, with a score of 100% indicating that the organization is using its inputs in the proportions that would minimize costs. An organization that is operating at best practice in engineering terms could still be allocatively inefficient because it is not using inputs in the proportions which minimize its costs, given relative input prices. Finally, cost efficiency *(*total economic efficiency) refers to the combination of technical and allocative efficiency. An organization will only be cost efficient if it is both technically and allocatively efficient. Cost efficiency is calculated as the product of the technical and allocative efficiency scores (expressed as a percentage), so an organization can only achieve a 100% score in cost efficiency if it has achieved 100% in both technical and allocative efficiency.

3.2 The Data and model specification

This study includes 8 major commercial banks of India, State Bank of India (SBI), Bank of India (BOI), and Central Bank of India (CBI), Panjab National Bank (PNB), and Union Bank of India (UBI) as public bank and, ICICI Bank, HDFC Bank, and Axis Bank as private bank. The annual balance sheet and income statement used were taken from different reports of Reserve Bank of India.

In the literature in the field, there is no consensus regarding the inputs and outputs that have to be used in the analysis of the efficiency of the activity of commercial banks (Berger and Humphrey, 1997). In the studies in the field, five approaches for defining inputs and outputs in the analysis of the efficiency of a bank were developed, namely: the intermediation approach; the production approach; the asset approach; the user cost; the value added approach. The first three approaches are developed according to the functions banks fulfill (Favero and Papi, 1995). The production and the intermediation approaches are the best known ones and the most used in the quantification of bank efficiency (Sealy and Lindley, 1997).

In the production-type approach, banks are considered as deposit and loan producers and it is assumed that banks use inputs such as capital and labor to produce a number of deposits and loans. According to the intermediation approach, banks are considered the intermediaries that transfer the financial resources from surplus agents to the fund deficit ones. In this approach it is considered that the bank uses as inputs: deposits, other funds, equity and work, which they transform into outputs such as: loans and financial investments. The opportunity for using each method varies depending on circumstances (Tortosa- Ausina, 2002). The intermediation approach is considered relevant for the banking sector, where the largest share of activity consists of transforming the attracted funds into loans or financial investments (Andrie and Cocris, 2010).

In the analysis we will use the following set of inputs and outputs to quantify the efficiency of banks in India:

- Outputs: loans and investments
- Inputs: fixed assets, deposits, and number of employees.

Before explaining the empirical DEA models for estimating cost and profit efficiency, we discuss the data and selection of inputs and outputs in the subsequent section.

This study uses the intermediation approach to define bank inputs and outputs. Under the intermediation approach, banks are treated as financial intermediaries that combine deposits, labour and capital to produce loans and investments. The values of loans and investments are treated as output measures; labour, deposits and number of employees is inputs. Price information is necessary for analyzing cost efficiency therefore in this section we will explain prices of inputs and calculation of them:

For the price of employees we used Employee expense per capita (P1) which means employees expense divided by number of employees. For the price of deposits we used Average of interest paid by the banks (P2) that could be calculated as an interest expense over total value of deposits and for price of fixed assets (P3) we used depreciation costs on fixed assets.

Table 1. Total economic efficiency (CRS model)

Bank	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**Average**
SBI	0.819	0.882	0.980	1	0.999	0.896	0.851	0.933	0.968	1	1	0.938
BOI	0.853	0.933	0.972	1	0.973	0.952	0.872	0.955	0.989	0.989	1	0.953
CBI	0.815	0.896	0.919	1	0.947	0.910	0.834	0.915	0.920	0.924	1	0.916
UBI	0.822	0.851	0.952	1	0.936	0.956	0.957	0.969	0.954	1	1	0.945
PNB	0.793	0.819	0.885	0.928	1	0.817	0.851	0.996	0.918	0.965	1	0.906
ICICI	0.875	0.927	1	0.993	0.979	0.947	0.945	1	0.984	0.966	1	0.965
HDFC	0.935	1	0.920	1	1	0.920	0.921	0.865	0.890	0.947	1	0.945
Axis	0.883	0.981	0.858	0.730	0.899	1	0.990	0.983	1	0.895	0.937	0.923
Average	0.849	0.911	0.935	0.956	0.966	0.924	0.902	0.952	0.952	0.960	0.992	0.936

4. Empirical result

The summary result for the analysis via intermediation approach is presented in Tables

Table 2. Total Economic Efficiency (VRS Model)

Bank	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Average
SBI	1	0.982	1	1	1	1	1	1	0.970	1	1	0.995
BOI	1	1	1	1	1	1	0.995	1	1	1	1	0.999
CBI	1	0.978	1	1	0.999	1	0.972	0.949	0.935	0.940	1	0.979
UBI	1	0.990	1	1	0.981	1	1	0.987	0.968	1	1	0.993
PNB	1	0.986	1	0.990	1	0.953	1	0.996	1	0.990	1	0.992
ICICI	1	1	1	1	1	1	0.902	1	1	0.988	1	0.998
HDFC	1	1	0.953	1	1	0.989	0.945	1	0.997	0.950	1	0.985
AXIS	1	1	0.897	0.796	0.921	1	0.992	0.994	1	0.929	1	0.957
Average	1	0.992	0.985	0.993	0.987	0.995	0.989	0.995	0.988	0.982	1	0.991

Table 3. Technical Efficiency (CRSS)

Bank	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	average
SBI	0.897	0.921	1	1	1	0.987	0.976	0.982	1	1	1	0.978
BOI	0.934	0.974	1	1	1	1	1	1	1	1	1	0.992
CBI	0.921	0.900	0.974	1	1	1	1	0.877	0.925	0.953	1	0.959
UBI	0.883	0.896	0.977	1	0.964	1	1	0.993	0.971	1	1	0.971
PNB	0.912	0.906	0.983	0.976	1	0.920	1	0.967	0.965	0.984	1	0.965
ICICI	0.932	0.957	1	1	1	1	1	1	1	0.983	1	0.988
HDFC	0.953	1	0.937	1	1	0.979	0.980	1	0.980	0.986	1	0.942
AXIS	0.908	1	0.887	0.750	1	1	0.995	0.999	1	0.963	1	0.955
Average	0.918	0.944	0.969	0.965	0.995	0.986	0.994	0.977	0.980	0.983	1	0.969

Table 4. Technical efficiency (VRS model)

Bank	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Average
SBI	1	1	1	1	1	1	1	1	1	1	1	1
BOI	1	1	1	1	1	1	1	1	1	1	1	1
CBI	1	1	1	1	1	1	1	0.962	0.989	0.985	1	0.994
UBI	1	0.998	1	1	0.999	1	1	1	0.972	1	1	0.997
PNB	1	1	1	0.994	1	0.978	1	1	1	0.993	1	0.997
ICICI	1	1	1	1	1	1	1	1	1	1	1	1
HDFC	1	1	0.965	1	1	1	0.981	1	1	0.989	1	0.994
AXIS	1	1	1	0.839	1	1	1	1	1	0.963	1	0.982
Average	1	0.999	0.979	0.979	0.999	0.997	0.997	0.995	0.995	0.991	1	0.995

All computation was performed using DEA Frontier program. The efficiency of commercial banks in Indian was first examined by applying the DEA approach for each year by using a common frontier. We then examine the analysis by examining the efficiency of private banks only, public banks only and a pooled common frontier for all banks for all years.

Tables 1 and 2, give results of efficiency scores estimated according to the DEA method respectively under the assumption of CRS and VRS. Scores efficiency is obtained by calculating the average score for each bank. The average efficiency score over all the period is 0.936 with CRS and 0.985 with VRS.

Average total economic efficiency that shows ability of firm in efficient allocation of inputs according to their prices is equal to 0.991. According to tables efficiency trend is increasing as it decreased from 2000 but again increased to efficient level in 2011. Among the banks during this period Bank of India (BOI) and ICICI Bank respectively with 0.999 and 0.998 had the highest average efficiency and Axis bank had the lowest average efficiency (0.957).

The evolution of technical efficiency scores by banks (VRS assumptions) over the considered period reveals that Bank of India (BOI), State bank of India (SBI), and ICICI bank have an stable tendency, while Central bank of India (CBI) and Axis bank have unstable ones. The special case of CBI, decreasing tendency from 2006 to 2009 and increasing after is due to the raise of the investment and loans at the end of the period, while the inputs levels remained steady. Therefore, CBI banks were more efficient in producing that specific asset with almost the same level of inputs than the other years.

A more detailed analysis, of efficiency degrees per banks groups (state owned and private) shows that on average public banks are more efficient ones except ICICI bank which is pioneer private bank in the case of technology adoption in India.

For each year in the testing period, there are more technically efficient Indian banks than allocative and cost efficient banks (see tables). The mean technical efficiency score peaked at 1 in the years 2000. It then decreased slowly for the rest of the examining period till 2011. This could be partially explained by the inability of most Indian banks to capture the full benefits of upgrading their equipment and systems, particularly in respect to staffing level and branch locations.

Among the public banks, Bank of India (BOI) and State Bank of India (SBI) show better performance and are the most efficient banks and Central bank of India (CBI) has the lowest efficiency as compare to other public banks and among private banks ICICI bank is the most efficient bank and Axis bank has the lowest rank.

The results show a fluctuating trend in efficiency scores of banking sector operating in India. As per CCR models, banks' efficiency increased from 2000-01 to 2004-05 then from 2005-06 trend faced a slight decline to 2007-08 and after that increased slightly to efficient level as the score is 1 which means 100% efficiency in 2010-11. According to BCC models, bank's efficiency decreased from 2000-01 to 2002-03. In the next year it starts to increase to 2005-06 and from 2006-07 to 2009-10 trends was unstable till to 2010-11 it increased up to efficient level 1.

The efficiency scores from the analysis clearly indicate from the selected Banks, Public banks more efficient with the highest efficient level as close to 1 in all the years by both the models. It is clearly shown that Indian financial market is still dominated by public banks.

5. Conclusion

Using non-parametric approach Data Envelopment Analysis (DEA) methodology enables us to estimate economic, technical, and allocative efficiency. We have run tests for each year, Public banks, private banks, and for all banks for all years.

The results suggest that the mean overall or economic efficiency was 100 percent in 2000, decreasing to 98 percent in 2002, and remained unstable from 2003 to 2009 with fluctuating in percentage till 2010-11 which reached to 100 percent again.

The cost efficiency estimated for the banks under study averaged 93% when the estimates are derived under constant return to scale while the estimates averaged around 99% under variable return to scale over 2000-2010. The efficiency scores vary across banks based on their relative size and across their geographical locations. Based on the size, the largest banks are found to be relatively the most cost efficient. These cost estimates suggest that the same level of output could be produced with approximately 93- 99% of their current inputs if banks under study were operating on the most efficient frontier.

When we decomposed the cost efficiency into technical and allocative efficiency, the allocative efficiency scores in particular, vary considerably based on bank's size and bank's geographical location. The technical efficiency averaged around 99% for the banks under study with insignificant differences among the banks under study. This suggests that the banks under study might increase one or more of their current outputs by around 1% without reduction in their other outputs or without a need for more inputs. Bank of India averaged the highest technical efficiency in both model while the Central bank of India along with Axis bank averaged the least under both constant and variable returns to scale.

The allocative efficiency scores averaged around 0.991 for the banks under study and the bank of India, ICICI bank, and State bank of India are found to be the most allocative efficient and realized an efficient score the highest while the Axis banks are found to be the least.

Finally, while the India have implemented many economic and financial reforms over the last decades or so, these do appear to have positive impact on the efficiency of the respective banking systems under study and it shows an increasing trend in performance of Indian banks caused by IT innovation, competition, better supervision, and enlarged investment in new information technology during the recent time period (2000-01 to 2010-11). The banks were left with no option but to improve their functional attitude, strategies and policies. In this paper, while the author proposes ways to achieve compromise solutions, recommend further research in the area to incorporate the dynamic nature of such decisions.

In comparison with international standards, Indian banks would need to improve their technological orientation, to continue their efforts to reduce the percentage of non-performing assets and expand the possibilities for augmenting their financial activities in order to improve their profit efficiency in the near future.

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