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Efficiency of Commercial Banks in India: A DEA Approach

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ABSTRACT

The purpose of this paper is to study the efficiency of commercial banks operating in India. Data Envelopment Analysis (DEA) technique has been applied to a sample of 57 banks. Data had been gleaned from the annual reports of banks on input variables namely Capital, Total assets, Advances, Number of employees and Cost to income ratio and the output variables namely Return on assets, Interest spread, Non-interest income, Deposits to advances ratio and percentage decrease in non-performing assets. The study covers a period of four years from 2009-2010 and 2012-2013. Results indicated an overall level of inefficiency in commercial banks at 47%. This implies that the commercial banks have the scope of producing 1.88 times as much output from the same inputs. The overall Capital utilisation needs to be increased and the number of employees and Advances should be reduced. Further, the study suggests that very large size and very small size banks are more efficient compared with medium size banks. In India, foreign banks are the most efficient while private Banks operate at a higher level of efficiency compared with public banks. The study may help bank managements and banking regulators in addressing issues relating to efficiency of commercial banks and identifying the causes of inefficiency in the banks. However, since the study is covers only Indian commercial banks from2009-10 and from 2012-13, the results and findings cannot be generalised to beyond this group of banks or to a different study period.

Keywords: Commercial banks, data envelopment analysis, efficiency

INTRODUCTION

Economic liberalisation in India has resulted in the Banking sector to undergo enormous changes. Until 1991 public sector banks have been the major players in banking sector but liberalisation catalysed the

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growth of private banks and eased the entry of foreign banks. Currently, there are four major categories of banks, namely public sector banks, private sector banks, foreign banks and regional rural banks. The Public sector banks (PSBs) are bigger with a major share in the banking business and where a majority stake (more than 50%) is held by the government. However, the PBSs are facing tough competition from private and foreign banks which are growing rapidly. The overall exponential growth in the banking sector has resulted in a highly competitive environment in the banking industry. The banks are required to perform better than their competitors for survival and growth. It has become important to re-evaluate how efficient the banks are from time to time. The banks are cognisant of their efficiency level vis a vis their peers and strive to improve it by reducing inputs and increasing outputs. A comparative analysis of bank efficiency provides useful feedback for investors, customers, and policymakers.

According to Rickets and Stover (1978), a firm's performance has traditionally been analysed through ratio analysis. Various financial ratios have been calculated to measure performance and hence, efficiency of a firm. However; it has been observed that analysis of a bank's financial data differs significantly from other companies due to differences in structure and operating systems. The ratios such as ROA, ROE, Net profit margin, Debt-Equity ratio among others are valuable and suitable measures of performance for other business organisations. For banks, some of these ratios may give different meanings and therefore, deserve different interpretations. For example, a high debt-equity ratio in a business organisation indicates an undesirable high financial leverage. For the banks, a high financial leverage is a norm since deposits are the bank's main liabilities while equity forms only a small portion of the bank's liabilities and capital. Thus, different parameters and techniques are needed in place of financial ratios analysis in order to measure bank efficiency.

LITERATURE REVIEW

A literature review on the subject reveals that substantial research efforts have been devoted in assessing a bank's performance. Many studies however, used financial ratios, which were fairly similar, although with different analytical techniques.

Liliana (2001) argues indicators of banking problems, which are appropriate for industrialised countries, do not work in emerging markets, because of severe deficiencies in the accounting and regulatory framework and lack of liquid markets for bank liabilities and assets. She emphasised he traditional CAMEL system of bank rating works where the quality of data and the supervisory framework are effective. Liliana conducted an empirical study on three Latin American countries and three East Asian countries. On the basis of the findings, she suggested an alternate set of indicators of bank strength: Implicit interest rate paid on deposits, spread between lending and deposit rates, rate of loan growth and growth of inter bank debt. Joshi and Joshi (2002) in their article on SWOT analysis of Balance sheets believe it is of paramount importance for bankers to look critically at the various tools for analysing the balance sheets and

use them as audits of their management capabilities. The authorities assessing bank performance are accustomed to using CAMEL (Capital adequacy, Asset quality, Management, Earnings and Liquidity) rating ratios to assess performance on the basis of capital adequacy and asset liability management. These progress cards related to good management highlight strengths and weaknesses, and point to the tasks ahead. Raghunathan and others (2003) have found that performance management in many banks has been largely synonymous with measuring financial performance vis-à-vis the CRAMEL framework or its variants. However, they state that these financial measures are primarily lag indicators, a post mortem view of the business, rather than lead indicators that assess the banks' ability to create value in the future. They affirmed this by saying that emergence of business segments such as retail assets, fee-based services, and delivery channels have required the banks to manage traditional consumer goods businesses with a focus on active 'customer acquisition' and 'customer retention' rather than passive 'service'. There is an increasing need for banks to focus on methods to increase income, improve quality of service and reduce cost of operations. These strategies require measurement in a manner that extends beyond CRAMEL and stand-alone non-financial measures. Berger et., al. (1997) in their study on Problem Loans and Cost Efficiency in Commercial Banks found problem loans precede reductions in measured cost efficiency; cost efficiency precedes reductions in problem loans and that reductions in capital at thinly capitalised banks precede increases in problem loans. Hence, cost efficiency may be an important indicator of future problem loans and problem banks.

Sensharma and Ghosh (2004) found that ownership structure, proportion of investment in government securities, proportion of lending to priority sector, CRAR, and NPAs have a significant impact on the net interest margin of a commercial bank, which is considered to be an indicator of bank performance and efficiency. Saumitra and Shanmugam (2005) studied the performance of banks after the banking sector reforms. In their analysis, they looked at Return on asset, operating profit ratio, net interest margin, operating cost ratio and staff expenditure ratio as performance indicators. The results of analysis showed that foreign banks were superior in terms of performance on return on assets, operating profit ratio and net interest margin. The performance of PSBs has also improved. The operating profit ratio and net interest margin fell in the case of private sector banks; however, they have managed to maintain their status by reduction in operating expenditures particularly those related to staff. Chipalkatti and Rishi (2005) critically analysed post reform performance of Indian banks by examining quantitative data on bank profitability and risk. They considered the following parameters: Profitability- spread, return on equity, return on assets, total assets-to-total shareholder equity ratio, capital adequacy ratio; Credit risk- Gross

NPA to total assets, gross NPA to total advances, net NPA to total assets ratio, net NPA to total advances ratio, allowances as a percentage of total assets, total allowances to gross NPA ratio; Interest Rate Risk-asset liability mismatch; net worth-to-total assets, net NPAs/total assets, cushion/ total assets.

Thus, Return on assets (ROA) was the most common ratio used to measure bank performance by many researchers such as Wu, Chen and Shiu, (2007), Sharma and Mani, (2012). A high ROA ratio indicated a well- capitalised bank and that the bank operated with a low cost-to-income ratio (Kosmidou, 2008). Size was also used and had a positive and statistically significant impact on a bank's performance. Cost efficiency to some researchers was highly important and was inversely related to problem loans in the bank. It was found that cost efficiency would fall with the increase in impaired loans since the latter (impaired loans) were costly to recover as well as to write them off as bad loans (Berger & Young, 1997). In India, the Priority sector advances significantly contributed to problem loans and thus, had an impact on the banks' profitability. A study on the banking sector's performance in India from 1980 to 2005 measured its performance on the basis of ROA, nonperforming assets, spread and non-interest income (Verma & Verma, 2002). It was discovered that spread, which is the difference between interest rate earned and interest rate paid, was a significant factor that has affected banks' profitability. A study on banks' performance employed two types of parameters: the operational parameter which included total income, interest earned, interest spread, net profit as percentage of interest spread, interest income as percentage of working funds, non-interest income as percentage of working funds, non-performing assets as percentage of net advances, capital adequacy ratio; the Productivity parameter on the other hand is represented by the profit per employee, ROA and business per employee (Ramasastri & Samuel, 2006). Arora and Verma, (2007) found that a reduction in operating expenses from rationalisation of employee costs was another parameter that could have significant impact on a bank's profitability.

Based on literature review, the author selected the following variables for the study: Capital, Number of employees, Advances, Total assets, Cost-to-income ratio, Spread, Non-interest income, Return on assets, Deposits-to-advances ratio and Non-performing assets.

In search of a suitable analytical technique, it is observed that many researchers have found that the Data Envelopment Analysis (DEA) is an appropriate technique for evaluating a bank's efficiency (Dell'Atti, *et al.*, 2015; Balfour *et al.,* 2015). Kumar and Verma (2002-03) used the DEA for measurement of technical efficiency of public sector banks. In the calculation of efficiency measures, physical capital, labour, loanable funds as inputs and spread and non-interest income as output were used. Grigorian *et al*. (2002) estimated indicators of commercial bank efficiency by applying the DEA to 515 banks in 16 transition economies. Using the Tobit analysis, they found that foreign ownership

with controlling power and enterprise restructuring enhances a commercial bank's efficiency while the effects of prudential tightening on a bank efficiency vary across banks based on different measures adopted. They established a strong relationship between profitability and lending behaviour of banks. Excessive risk taking in lending would point to the possibility that banks are trading off greater short term accounting profits at the expense of long term gains. Spread, non-interest income, physical capital, labour and loanable funds have been used as input and output variables in the DEA technique. Soteriou and Zenios (1999) claimed that based on the DEA technique, a bank's efficiency could be studied by examining its operations, quality and profitability.

OBJECTIVE OF THE STUDY

The study, based on literature review, adopts the main parameters to measure the performance of a bank: Capital, Number of employees, Advances, Total assets, Cost-to-income ratio, Spread, Non-interest income, Return on assets, Deposits-to-advances ratio and Non-performing assets. The objective of this study is to measure and compare the performance of banks operating in India by calculating their scores and categorising them into: relatively best-performing banks and relatively worst-performing banks. The study will also attempt to suggest the peer group of the efficient and inefficient banks and the changes in inputs and outputs needed to turn the inefficient banks into efficient banks.

RESEARCH METHODOLOGY

DEA Technique

The DEA technique has been successfully used to assess the relative efficiency of banking institutions. It is a linear programming method that measures the efficiency of multiple decision-making units (DMUs) when the measurement involves multiple inputs and outputs. The DEA further compares individual observation with the others for calculating a discrete piece-wise linear frontier. The DMUs that lie on the linear frontier are the most efficient units, each having an efficiency score of one. An inefficient DMU is inefficient because either it uses too much input and/ or it does not produce enough output.

Many models of DEA have evolved over the period. The most basic one is Charnes, Cooper & Rhoades' input-oriented constant returns to scale (CRS) model. However, the CRS model is limited in that it is only reliable when all DMUs are operating at an optimal scale. To address this limitation, Banker, Charnes and Cooper (1984) proposed a variable returns to scale (VRS) model. The VRS model is able to calculate the technical efficiencies of the selected parameters without being affected by the efficiencies of other parameters (such as size and scale). There are two ways to improve the performance of inefficient DMUs. One is to reduce its input so it can reach the efficient frontier, and the other is to increase its output to reach the efficient frontier. As a result, DEA models will have two orientations: input-oriented and output-oriented. Input-oriented models are used to

test if a DMU under evaluation can reduce its inputs while keeping the outputs at their current levels. Output-oriented models are used to test if a DMU under evaluation can increase its outputs while keeping the inputs at their current levels. The DEA technique is popular in measuring performance efficiency, as its input-oriented feature is able to accurately calculate the amount by which inputs should be relatively reduced to achieve efficiency by keeping the outputs fixed.

The input-oriented variable return to scale DEA model is chosen for this study, since it is also capable of taking into account the correct convexity of DMUs when ratio variables are used (Emrouznejad & Amin, 2009). To calculate the overall efficiency of the banks, this study chooses input and output variables that serve to measure production efficiency, intermediation efficiency and profitability of the banks.

The following DEA model is an input-oriented model (Banker *et al*., 1984)

$$w^* = \min w$$

subject to

$$\sum_{j=1}^{n} \lambda_j \, x_{ij} \leq w x_{io} \qquad i = 1,2, \ldots \ldots, m;$$

$$\sum_{j=1}^{n} \lambda_j \, y_{rj} \leq w y_{ro} \qquad r = 1,2, \ldots \ldots, s;$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \qquad j = 1,2, \ldots \ldots, n$$

where x_{io} and y_{ro} are the ith input and rth output for DMU_o respectively. If w* = 1, then the current input levels cannot be reduced (proportionally), indicating that DMUo is on the frontier. Otherwise, if w* < 1, then DMU_o is dominated by the frontier. w* represents the (input-oriented) efficiency score of DMU_o . The efficiency scores range between 0 and 1. By using the linear frontier as bench-mark, the DEA provides a performance measurement score for each DMU relative to other DMUs (Kumar & Verma, 2003). If a DMU is efficient, its outputs will be best produced using all of its own inputs. On the other hand, if DMU is inefficient, its outputs will be best produced by a mixture of other DMUs using a fraction of all its inputs. The optimal value of w is

$$w * = Max\left[\left(\sum_{t=1}^{q} \mu_{tm} \; c_{tk}\right) / \left(\sum_{t=1}^{q} \lambda_{tm} \; a_{tk}\right)\right] \qquad [1]$$

λ_{tm}, μ_{tm} are the weightings which it should use for its inputs and outputs in order to maximise its ratio of weighted outputs to inputs. Where, a_{ij} is the amount of input i used by DMUj for i = 1, … , p and c_{tj} is the amount of output t produced by DMUj for t = 1, … , q. (Gautam, A. & Williams, H. P., 2002). Calculation of w for inefficient banks brings forth the formation of their respective reference-set banks. The reference-set allows a bank to determine based on its own efficiency number, the amount of inputs it needs to change in order to raise its efficiency level to that of the bank in its reference- set.

Sampling

In India, the banking sector is divided into four major categories namely Public Sector banks (PSBs), Private Sector banks, Foreign Banks and Regional Rural banks. This study is focused on PSBs, private sector banks and foreign banks operating in India from 2009-2010 and 2012- 2013. The Regional Rural banks are excluded from the study since their scope of work and size of operations are not comparable to those of other banks. There were 26 PSBs, 20 Private Sector banks and 41 foreign banks operating in India in March 2013. Out of the total 87 banks, 57 banks were examined in this study. It included all 26 Public Sector banks, all 20 Private Sector banks and 11 Foreign banks (shown in Table 5). The other 30 foreign banks were excluded because their complete dataset for the study period was not available. Banks omitted from the study include those which started operations after 2009-2010 and a few older ones that ceased to operate or merged with some other banks before 2012-2013.

Data Collection

This study uses accounting data of individual bank from the data sets obtained from the annual publications of Reserve Bank of India from 2009-2010 and from 2012-2013.

Data was collected based on 10 variables gleaned from literature review. The input variables are Capital, Labour, Loans, Size and Cost to Income ratio where Capital indicates total capital of bank, Labour means the number of employees in the bank, Loans indicate total advances and the Size is measured by total assets of the bank. The output variables are Spread, Non-interest income, Return on Assets, Deposits to advances ratio and percentage of decrease in non-performing assets. The Spread is the difference between interests earned and interest expended and Non interest income indicates fee based income. Details related to variables are given in Table I.

EMPIRICAL RESULTS

Results of the input-oriented VRS model are provided in Table 2 which presents the efficiency scores obtained from the DEA model for individual banks and their respective reference-set banks. The results indicate presence of a marked deviation of the efficiency scores from the best-practice frontier.

The third column in Table 2 indicates the efficiency score of sample banks relative to their peers. From the table, it can be observed that out of 57 banks, 30 were found to be relatively efficient (score equal to one), while 27 are relatively inefficient (scored less than one). The lowest efficiency score is 64.61% for Bank of Maharashtra. The 30 efficient banks are Pareto-Koopmans efficient i.e. having the efficiency scores of one and the slacks of zero. These are the banks that operate at high levels of efficiency. The average efficiency score of all the sample banks is 92.75% which implies that except for a few banks, the majority of the sample banks are operating at high levels of efficiency during the study

An in-depth analysis of the relatively inefficient banks reveals the development

and content of their respective reference-set banks (Calculated according to eq. 1). As reflected in column 4 to column 17, a bank defined as inefficient carries its own efficiency-weight relative to the other banks in its reference-set. The reference-set allows a bank to determine based on its own efficiency-weight the amount of inputs it needs to change in order to raise its efficiency level to that of the banks in its reference-set. For example, given that bank B1 (Allahabad Bank) is 82.22% as efficient as its reference set (banks B17, B24, B26, B38, B40 and B47), bank B1 can become equally efficient as its reference-set banks by simply reducing its inputs by 17.78% (i.e., 100-82.22 = 17.78%). Against the individual bank in its reference-set, the efficiency objective of bank B1 is to raise its efficiency level by 57.85% of B17, 4.13% of B24, 9.23% of B26, 8.85% of B38, 18.57% of B40 and 1.37% of B47. Since the efficiency-weight of B17 (City Union Bank) is highest, it is suggested that Allahabad Bank should emulate the management style and practice of City Union Bank in order to become more efficient.

This study further analyses the value of slacks to find out the reasons that account for inefficiency of the 27 banks in the sample. Each of the banks can achieve overall efficiency by adjusting their inputs to the suggested levels of inputs. The efficiency scores and the optimal slack values as given in Table 3 provide the target points on the efficient frontier that the inefficient banks can reach by adjusting its input and output levels. The slack values can be subtracted from or added to the value of inputs or the outputs in order to put the inefficient banks

TABLE 1
Variables description

Variables	Description
Input variables	
CAPITAL	This is the total capital of the bank. It shows the amount of equity to absorb any shocks that the bank may experience.
LABOR	Indicates the total number of employees in the bank.
LOANS	This is the total amount of advances extended by the bank
SIZE	The accounting value of the bank's total assets
COST	This is the cost-to-income ratio. It provides information regarding the operating expenses relative to the revenues generated by the bank.
Output variables	
SPREAD	This is the difference between the amount of interest earned and the interest expended by the bank in that year. A high amount indicates high profitability.
NII	It is the Non interest income earned by the bank from fee-based activities.
ROA	The return on assets of the bank
DEPADV	This is Deposits to Advances ratio. It is a measure of liquidity. Higher figure indicates high liquidity
NPA	This is the percentage decrease in Non-performing assets of the bank

TABLE 2
Efficiency Scores, efficient peers and weights

Bank	Name of Bank	Scores	Bank	Weight	Bank	Weight	Bank	Weight	Bank	Weight	Bank	Weight	Bank	Weight	Bank	Weight
B1	Allahabad Bank	0.8722	B17	0.5785	*B24*	0.0413	*B26*	0.0923	*B38*	0.0885	*B40*	0.1857	*B47*	0.0137		
B2	Andhra Bank	0.8711	B10	0.1558	*B17*	0.3824	*B24*	0.0508	*B38*	0.2096	*B40*	0.1221	*B44*	0.0793		
B3	Antwerp Diamond Bank	1.0000	B3	1.0000												
B4	Axis Bank	1.0000	B4	1.0000												
B5	Bank of Bahrain & Kuwait	0.7096	B7	0.9825	*B17*	0.0080	*B20*	0.0013	*B42*	0.0062	*B44*	0.0020				
B6	Bank of Baroda	1.0000	B6	1.0000												
B7	Bank of Ceylon	1.0000	B7	1.0000												
B8	Bank of India	0.8990	B4	0.0024	*B24*	0.0046	*B26*	0.2301	*B38*	0.2205	*B40*	0.4861	*B44*	0.0562		
B9	Bank of Maharashtra	0.6461	B17	0.8067	*B24*	0.0473	*B31*	0.0240	*B38*	0.0340	*B40*	0.0880				
B10	Bank of Nova Scotia	1.0000	B10	1.0000												
B11	Bank of Tokyo-Mitsubishi UFJ	0.9428	B7	0.3867	*B10*	0.4939	*B20*	0.0616	*B36*	0.0175	*B37*	0.0403				
B12	BNP Paribas	1.0000	B12	1.0000												
B13	Canara Bank	0.9635	B17	0.1644	*B26*	0.1190	*B38*	0.4304	*B40*	0.1932	*B47*	0.0929				
B14	Catholic Syrian Bank	0.7890	B7	0.4541	*B42*	0.1071	*B52*	0.4388								
B15	Central Bank of India	0.7481	B17	0.3642	*B31*	0.0241	*B38*	0.4500	*B40*	0.1362	*B47*	0.0255				
B16	Citibank	1.0000	B16	1.0000												
B17	City Union Bank	1.0000	B17	1.0000												
B18	Corporation Bank	0.9584	B4	0.0733	*B10*	0.0027	*B17*	0.8179	*B25*	0.0319	*B26*	0.0232	*B46*	0.0221	*B47*	0.0289
B19	Dena Bank	0.7657	B17	0.7530	*B31*	0.0382	*B38*	0.1898	*B40*	0.0139	*B47*	0.0052				
B20	Deutsche Bank	1.0000	B20	1.0000												
B21	Development Credit Bank	0.6988	B7	0.5384	*B20*	0.0203	*B37*	0.3539	*B42*	0.0563	*B44*	0.0310				
B22	Federal Bank	0.8781	B10	0.0818	*B17*	0.7100	*B23*	0.0088	*B40*	0.0695	*B44*	0.0784	*B52*	0.0516		
B23	HDFC Bank	1.0000	B23	1.0000												

TABLE 2 (*continue*)

Bank	Name of Bank	Scores	Bank	Weight	Bank	Weight	Bank	Weight	Bank	Weight	Bank	Weight	Bank	Weight	Bank	Weight
B24	HSBC Bank	1.0000	B24	1.0000												
B25	ICICI Bank	1.0000	B25	1.0000												
B26	IDBI Bank Ltd.	1.0000	B26	1.0000												
B27	Indian Bank	0.9394	B10	0.1200	*B17*	0.3681	*B24*	0.1271	*B38*	0.0236	*B40*	0.2493	*B44*	0.0580	*B57*	0.0538
B28	Indian Overseas Bank	0.7588	B10	0.1450	*B17*	0.3288	*B24*	0.0196	*B38*	0.2104	*B40*	0.2581	*B57*	0.0381		
B29	IndusInd Bank	0.7292	B10	0.0823	*B17*	0.5195	*B23*	0.0098	*B44*	0.1586	*B52*	0.1915	*B57*	0.0384		
B30	ING Vysya Bank	0.8206	B4	0.0592	*B17*	0.4929	*B42*	0.1317	*B44*	0.0739	*B52*	0.2423				
B31	Jammu & Kashmir Bank	1.0000	B31	1.0000												
B32	Karnataka Bank	0.9193	B17	0.2831	*B25*	0.0114	*B31*	0.2529	*B37*	0.3368	*B57*	0.1158				
B33	Karur Vysya Bank	0.8854	B17	0.5396	*B37*	0.0390	*B46*	0.0480	*B52*	0.2212	*B57*	0.1521				
B34	Kotak Mahindra Bank	1.0000	B34	1.0000												
B35	Lakshmi Vilas Bank	0.8877	B10	0.1453	*B17*	0.1684	*B37*	0.3404	*B52*	0.3250	*B57*	0.0208				
B36	Mizuho Corporate Bank	1.0000	B36	1.0000												
B37	Nainital Bank	1.0000	B37	1.0000												
B38	Oriental Bank of Commerce	1.0000	B38	1.0000												
B39	Punjab and Sind Bank	0.7653	B10	0.2885	*B38*	0.2034	*B46*	0.0350	*B52*	0.0380	*B57*	0.4350				
B40	Punjab National Bank	1.0000	B40	1.0000												
B41	Ratnakar Bank	1.0000	B41	1.0000												
B42	Sonali Bank	1.0000	B42	1.0000												
B43	South Indian Bank	0.9707	B17	0.1857	*B37*	0.2148	*B46*	0.0943	*B52*	0.2475	*B57*	0.2576				
B44	Standard Chartered Bank	1.0000	B44	1.0000												
B45	State Bank of Bikaner & Jaipur	0.8211	B17	0.1717	*B40*	0.0806	*B46*	0.0079	*B47*	0.0080	*B52*	0.7190	*B57*	0.0127		

TABLE 2 (*continue*)

Bank	Name of Bank	Scores	Bank	Weight	Bank	Weight	Bank	Weight	Bank	Weight	Bank	Weight	Bank	Weight	Bank	Weight
B46	State Bank of Hyderabad	1.0000	B46	1.0000												
B47	State Bank of India	1.0000	B47	1.0000												
B48	State Bank of Mysore	0.9254	B10	0.0251	*B17*	0.0425	*B40*	0.0816	*B46*	0.0798	*B52*	0.7710				
B49	State Bank of Patiala	0.9539	B17	0.1024	*B31*	0.0049	*B38*	0.1065	*B40*	0.0599	*B46*	0.0669	*B57*	0.6595		
B50	State Bank of Travancore	0.9059	B40	0.0110	*B46*	0.3774	*B47*	0.0066	*B52*	0.5191	*B57*	0.0859				
B51	Syndicate Bank	0.8401	B10	0.0380	*B40*	0.2396	*B47*	0.0139	*B57*	0.7084						
B52	Tamilnad Mercantile Bank	1.0000	B52	1.0000												
B53	UCO Bank	1.0000	B53	1.0000												
B54	Union Bank of India	1.0000	B54	1.0000												
B55	United Bank of India	1.0000	B55	1.0000												
B56	Vijaya Bank	1.0000	B56	1.0000												
B57	Yes Bank	1.0000	B57	1.0000												

Source: Author's calculations

TABLE 3
Input / Output Slacks

Bank	Name of Bank	CAPITAL	LABOR	LOANS	SIZE	COST	SPREAD	NII	ROA	DEPADV	Dec in NPA
B1	Allahabad Bank	1,169	0	0	55,188	0	0	0	0	0	24
B2	Andhra Bank	0	0	2,62,183	0	0	0	10,438	0	0	24
B3	Antwerp Diamond Bank	0	0	0	0	0	0	0	0	0	0
B4	Axis Bank	0	0	0	0	0	0	0	0	0	0
B5	Bank of Bahrain & Kuwait	0	0	3,133	0	0	0	219	0	0	2
B6	Bank of Baroda	0	0	0	0	0	0	0	0	0	0
B7	Bank of Ceylon	0	0	0	0	0	0	0	0	0	0
B8	Bank of India	0	0	12,52,132	21,94,222	0	0	0	0	0	28
B9	Bank of Maharashtra	12,543	0	1,607	0	0	0	5,822	0	0	11
B10	Bank of Nova Scotia	0	0	0	0	0	0	0	0	0	0
B11	Bank of Tokyo-Mitsubishi UFJ	87,678	0	22,362	0	0	0	2,554	0	1	0
B12	BNP Paribas	0	0	0	0	0	0	0	0	0	0
B13	Canara Bank	3,335	0	12,93,377	16,89,737	0	0	6,837	0	0	21
B14	Catholic Syrian Bank	0	962	0	16,807	0	1,078	490	0	0	16
B15	Central Bank of India	1,07,272	3,707	0	1,57,609	0	0	0	0	0	16
B16	Citibank	0	0	0	0	0	0	0	0	0	0
B17	City Union Bank	0	0	0	0	0	0	0	0	0	0
B18	Corporation Bank	0	0	14,47,396	24,70,425	0	0	0	0	0	0
B19	Dena Bank	8,153	50	39,416	0	0	0	0	0	0	3
B20	Deutsche Bank	0	0	0	0	0	0	0	0	0	0
B21	Development Credit Bank	0	844	29,083	0	0	1,244	0	0	0	0
B22	Federal Bank	278	0	48,629	0	0	0	10,526	0	0	0
B23	HDFC Bank	0	0	0	0	0	0	0	0	0	0
B24	HSBC Bank	0	0	0	0	0	0	0	0	0	0
B25	ICICI Bank	0	0	0	0	0	0	0	0	0	0
B26	IDBI Bank Ltd.	0	0	0	0	0	0	0	0	0	0
B27	Indian Bank	0	0	2,01,496	0	0	0	13,734	0	0	0
B28	Indian Overseas Bank	8,447	0	0	7,986	0	0	6,269	0	0	0

TABLE 3 (*continue*)

Bank	Name of Bank	CAPITAL	LABOR	LOANS	SIZE	COST	SPREAD	NII	ROA	DEPADV	Dec in NPA
B29	IndusInd Bank	7,291	1,898	70,718	0	0	0	0	0	0	0
B30	ING Vysya Bank	0	2,054	13,878	0	0	6,415	0	0	0	0
B31	Jammu & Kashmir Bank	0	0	0	0	0	0	0	0	0	0
B32	Karnataka Bank	2,996	896	0	8,284	0	17,547	0	0	0	0
B33	Karur Vysya Bank	0	925	22,537	0	0	1,676	3,541	0	0	0
B34	Kotak Mahindra Bank	0	0	0	0	0	0	0	0	0	0
B35	Lakshmi Vilas Bank	0	745	0	9,424	0	2,346	1,225	0	0	0
B36	Mizuho Corporate Bank	0	0	0	0	0	0	0	0	0	0
B37	Nainital Bank	0	0	0	0	0	0	0	0	0	0
B38	Oriental Bank of Commerce	0	0	0	0	0	0	0	0	0	0
B39	Punjab and Sind Bank	0	0	6,19,791	8,85,576	0	0	9,058	0	0	0
B40	Punjab National Bank	0	0	0	0	0	0	0	0	0	0
B41	Ratnakar Bank	0	0	0	0	0	0	0	0	0	0
B42	Sonali Bank	0	0	0	0	0	0	0	0	0	0
B43	South Indian Bank	0	1,296	47,041	0	0	2,854	7,821	0	0	0
B44	Standard Chartered Bank	0	0	0	0	0	0	0	0	0	0
B45	State Bank of Bikaner & Jaipur	0	782	61,815	0	0	0	0	0	0	0
B46	State Bank of Hyderabad	0	0	0	0	0	0	0	0	0	0
B47	State Bank of India	0	0	0	0	0	0	0	0	0	0
B48	State Bank of Mysore	0	1,250	51,551	0	0	0	4,431	0	0	0
B49	State Bank of Patiala	0	2,668	1,07,417	0	0	0	7,379	0	0	0
B50	State Bank of Travancore	0	1,870	1,18,277	0	0	0	4,430	0	0	0
B51	Syndicate Bank	6,654	1,303	3,69,795	0	0	0	27,697	0	0	0
B52	Tamilnad Mercantile Bank	0	0	0	0	0	0	0	0	0	0
B53	UCO Bank	0	0	0	0	0	0	0	0	0	0
B54	Union Bank of India	0	0	0	0	0	0	0	0	0	0
B55	United Bank of India	0	0	0	0	0	0	0	0	0	0
B56	Vijaya Bank	0	0	0	0	0	0	0	0	0	0
B57	Yes Bank	0	0	0	0	0	0	0	0	0	0

Source: Author's calculations

on the efficient frontier. It can be observed that all efficient banks show zero slack for all the input and output variables. Zero slacks in some banks suggest that no change is required in the inputs and output variables of such banks as the banks are already on the efficient frontier. For this reason, the inefficient banks would show slack values in some variables.

Adjusting the input and the output variables against their respective slack values will yield the values of Virtual Inputs and Virtual outputs for all the sampled banks. These virtual values tell how much changes in the input variables are needed in order to achieve a higher level of efficiency. For instance, from Table 3, the virtual value of CAPITAL for bank B1 is 24,404 (Current value of Capital of 25,573 – Capital slack value of 1,169) while its value of virtual SIZE is 7,737,721 (7,792,909 – 55,188). These two values imply that, at current levels of outputs, bank B1 is not utilising its capital and labour efficiently. Hence, the virtual values suggest that bank B1 needs to reduce its capital by 24,404 Rupees and its size by 7,737,721 in order to improve its efficiency. In fact, this suggestion confirms earlier findings that smaller capitals are attributes of efficient banks in Europe (Dell'Atti *et al.*, 2015) and that capital is inversely related to efficiency in Bangladesh banks (Miah & Sharmeen, 2015).

On the output side, similar adjustment shows that the virtual value of NPA for bank B1 is 10 - 24 or 13, which indicates that bank B1 may move to the efficient frontier by reducing its non-performing assets by 13%. The other output variables for bank B1 namely SPREAD, NII, ROA and DEPADV, have zero slack values, which mean these output variables can no longer be increased by mere reduction in input variables. A similar interpretation can be made for other inefficient banks.

An overall analysis of input and output variables in Table 4 shows the required reduction in the input variables and increases in the output variables in order to achieve maximum efficiency for all the inefficient banks. Thus, efficiency is maximised by reducing the overall capital by 11%, number of employees by 2% and advances by 3% and by increasing the overall non-interest income by 3%, return on assets by 41%, deposits-to-advances ratio by 3% and decreasing the NPAs by 9%. From this overall analysis, it can be said that two major variables must be addressed in order to maximise efficiency. First, the banks should utilise their capital fully and efficiently in order to generate a higher ROA. Second,

TABLE 4
Changes required in Input and Output Variables as per DEA

	Input variables					Output Variables				
Variable	CAPITAL	EMPLOYEES	LOANS	SIZE	COST	SPREAD	NII	ROA	DEPADV	NPA
Change required	11%	2%	3%	2%	0%	0%	3%	41%	3%	9%

the banks should focus on quality loans in order to reduce non-performing assets and improve profitability.

Comparative Analysis

A comparative efficiency analysis of the public sector, private sector and foreign banks in Table 5 reveals that foreign banks, with 9 out of 11 or 75% of them lying on the efficient frontier, are the most efficient banks, followed by private sector banks (55% on efficient frontier), and public sector banks (38% on efficient frontier). This finding is consistent with results of a study that private banks have taken over from public banks as drivers of efficiency in the Indian banking system (Nguyen & Nghiem (2015).

Table 5 also shows that among the public sector banks, Bank of Maharashtra, Central Bank of India, Indian Overseas Bank and Dena Bank are the most inefficient banks. Among the ~~In~~ private sector banks, the Development Credit Bank, IndusInd Bank, Punjab and Sind Bank and Catholic Syrian Bank are the most inefficient banks. In the Foreign banks category, Bank of Bahrain & Kuwait remains the most inefficient bank among the foreign banks.

Table 6 categorises bank efficiency by size in accordance with their respective sectors. The inefficient banks, having an efficiency score of less than 1.0, is written in bold letters. It can be observed that, with 87% of them sitting on the efficient frontier, Very Small banks are the most efficient banks, followed by Very Large banks (with 73% sitting on efficient frontier). The large-, the medium- and the small-sized banks are mostly inefficient. This finding is generally in agreement with another finding that large banks that are able to capitalise on economies of scale are more efficient than the smaller banks. (Dell'Atti *et al.*, 2015; Miah & Sharmeen, 2015).

CONCLUSION

The study provides empirical evidence on the efficiency of 57 commercial banks operating in India between 2009 and 2010 and between 2012 and 2013. The overall level of inefficiency in the commercial banks has been found to be 47%. This implies that the commercial banks have the scope of producing 1.88 times as much output from the same inputs. It has been noted that Non-performing assets, underutilisation of capital, underutilisation of employees are the major causes of inefficiency in commercial banks. Further, the study suggests that very large-size and very small-size banks are more efficient compared with medium- and small-size banks. Foreign banks are the most efficient while Private Banks are operating at higher level of efficiency compared with PSBs in India.

With the use of DEA technique, this study provides a deeper understanding on the major determinants of bank efficiency, which would not be possible when using the conventional ratio analysis. Nevertheless, with a limited number of banks included in this study over a broken, four-year period, the findings should not be generalised to beyond this group of banks or to a different study period. Further research involving

TABLE 5
Category-wise Efficiency Scores

S.No.	Public Sector Banks	Score	S.No.	Private Sector Banks	Score	S.No.	Foreign Banks	Score
1	Bank of Maharashtra	0.6461	1	Development Credit Bank	0.6988	1	Bank of Bahrain & Kuwait	0.7096
2	Central Bank of India	0.7481	2	IndusInd Bank	0.7292	2	Bank of Tokyo-Mitsubishi UFJ	0.9428
3	Indian Overseas Bank	0.7588	3	Punjab and Sind Bank	0.7653	3	Antwerp Diamond Bank	1.0000
4	Dena Bank	0.7657	4	Catholic Syrian Bank	0.7890	4	Bank of Ceylon	1.0000
5	State Bank of Bikaner & Jaipur	0.8211	5	ING Vysya Bank	0.8206	5	Bank of Nova Scotia	1.0000
6	Syndicate Bank	0.8401	6	Karur Vysya Bank	0.8854	6	BNP Paribas	1.0000
7	Andhra Bank	0.8711	7	Lakshmi Vilas Bank	0.8877	7	Citibank	1.0000
8	Allahabad Bank	0.8722	8	Karnataka Bank	0.9193	8	Deutsche Bank	1.0000
9	Federal Bank	0.8781	9	South Indian Bank	0.9707	9	Hongkong & Shanghai Banking Corporation	1.0000
10	Bank of India	0.8990	10	Axis Bank	1.0000	10	Mizuho Corporate Bank	1.0000
11	State Bank of Travancore	0.9059	11	City Union Bank	1.0000	11	Standard Chartered Bank	1.0000
12	State Bank of Mysore	0.9254	12	HDFC Bank	1.0000			
13	Indian Bank	0.9394	13	ICICI Bank	1.0000			
14	State Bank of Patiala	0.9539	14	Jammu & Kashmir Bank	1.0000			
15	Corporation Bank	0.9584	15	Kotak Mahindra Bank	1.0000			
16	Canara Bank	0.9635	16	Nainital Bank	1.0000			
17	Bank of Baroda	1.0000	17	Ratnakar Bank	1.0000			
18	IDBI Bank Ltd.	1.0000	18	Sonali Bank	1.0000			
19	Oriental Bank of Commerce	1.0000	19	Tamilnad Mercantile Bank	1.0000			
20	Punjab National Bank	1.0000	20	Yes Bank	1.0000			
21	State Bank of Hyderabad	1.0000						
22	State Bank of India	1.0000						
23	UCO Bank	1.0000						
24	Union Bank of India	1.0000						
25	United Bank of India	1.0000						
26	Vijaya Bank	1.0000						

TABLE 6
Category-wise list of Banks with Efficiency Indicator*

(Amounts in millions INR)

Size	Foreign Banks	Private Banks	Public Sector Banks
Very Large (Above 100,00,000)		Axis Bank	Central Bank of India
		HDFC Bank	Bank of India
		ICICI Bank	Canara Bank
			Bank of Baroda
			IDBI Bank Ltd.
			Punjab National Bank
			State Bank of India
			Union Bank of India
Large (50,00,000 to 100,00,000)	Citibank	Punjab and Sind Bank	Indian Overseas Bank
	HSBC Bank		Syndicate Bank
	Standard Chartered Bank		Andhra Bank
			Allahabad Bank
			Indian Bank
			Corporation Bank
			Oriental Bank of Commerce
			State Bank of Hyderabad
			UCO Bank
Medium (10,00,000 to 50,00,000)	Deutsche Bank	IndusInd Bank	Bank of Maharashtra
		ING Vysya Bank	Dena Bank
		Karur Vysya Bank	State Bank of Bikaner & Jaipur
		Karnataka Bank	Federal Bank
		South Indian Bank	State Bank of Travancore
		Jammu & Kashmir Bank	State Bank of Mysore
		Kotak Mahindra Bank	State Bank of Patiala
		Yes Bank	United Bank of India
			Vijaya Bank

TABLE 6 (*continue*)

Size	Foreign Banks	Private Banks	Public Sector Banks
Small (2,00,000 to 10,00,000)	Bank of Tokyo-Mitsubishi UFJ	Development Credit Bank	
	Bank of Nova Scotia	Catholic Syrian Bank	
	BNP Paribas	Lakshmi Vilas Bank	
		City Union Bank	
		Tamilnad Mercantile Bank	
Very Small (below 2,00,000)	Bank of Bahrain & Kuwait	Sonali Bank	
	Antwerp Diamond Bank	Nainital Bank	
	Bank of Ceylon	Ratnakar Bank	
	Mizuho Corporate Bank		

* The banks highlighted in bold are the inefficient banks (with efficiency score less than one).

a larger sample and over a longer period should shed more light on the efficiency attributes of Indian banking industry.

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