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Measuring Technical Efficiency of Indian Banking Sector in Post Subprime Crises Scenario: A Non Parametric Frontier Based Approach

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Abstract

This study gives a comparative analysis of the technical efficiency of top Indian banks during 2007-2011. This period is characterized by far reaching experience of sub-prime crisis (2008-2009) and its impact on Indian banking sector. Efficiency assessment of Indian banking sector has become highly imperative now a days because of intense competition, changing reforms, and instability in banking environment. This study uses Data Envelopment Analysis (DEA), a non parametric linear programming based technique, for evaluating the relative efficiency of top public, private and foreign banks in India. The present paper, based on empirical analysis, shows that the levels of input and output variables in efficiency measurement have changed significantly during this period and banks have improved their relative efficiency score over the period of time. Results support the fact that after sub-prime crisis, Advances (A) and Investments (I) are getting importance as output variables, while Operating Costs (OC), Fixed Assets (FA) and Capital (C) are considered as important input variables. This study also recommends that Data Envelopment Analysis (DEA) could be a suitable tool for measuring relative efficiency score of Indian banking sector.

Key words: *Technical Efficiency, Sub Prime Crisis Period, Non Parametric Approach, Data Envelopment Analysis.*

1. Introduction

Performance of any financial institution can be judged through its *efficiency*. But *efficiency* itself is a technical term, which can be further simplified as the ratio of output and input of the firm. In a broad context, management of a firm is always concerned about the proper utilization of inputs to get the desired combination of outputs, through the right channel of operations (Saha and Ravisankar, 2000). Motivation behind the study can be explained through various factors: now days' banks are operating in very competitive environment and the chances of bankruptcies are very high due to high uncertainty in their business environment. In this uncertain setting, it is important to determine and evaluate the *technical efficiency* of these banks. In the financial Institutions environment, technical efficiency depicts the degree of utilization of different resources: human, physical and financial resources and evaluation of these resources will be very important during any disturbance in the setting (Saha and Ravisankar, 2000). During recent sub- prime crisis, Indian banking system could not remain disconnected with these changes.

This study analyses the relative efficiency of the Indian banking sector during recent financial crisis (2008-2009) using Data Envelopment Analysis (DEA). The duration of this study has been taken as 2007 to 2011, to capture the efficiency variables in the pre crises environment (2007-08), subprime crises (2008-09) and post subprime crises (2009-11). This study also finds whether top banks (on the basis of sales and profit) of India have improved their efficiency in this period or not?

2. Literature Review

Studies have reported that banks having high operating efficiency, ensures future sustainability and the less technically efficient banks have high chance of failure (Berger and Humphrey, 1992a; Wheelock and Wilson, 1995). Sometimes efficiency scores also predict the impact of market and regulatory framework on the banking system of the country. In this way it can provide a mechanism to the regulators to avoid the systematic failures (Lacasta, 1988). Although research on efficiencies is not a new phenomenon, still there is lacuna exist in terms of measuring efficiencies for

financial and non financial firms (Leibenstein, 1966). *But prior to existing research gap of the current topic, it will be imperative to have a look on the growth and development of efficiency measures over the period of time.*

Growth and development of efficiency measures can be easily under stable through advancement of its different forms; scale efficiency, scope efficiency and technical efficiency. While discussing the development in terms of *scale efficiency*, Berger's (1993) work can be considered as a base for this domain. Before Berger (1993), researchers suggested some models for small and large banks (Bauer, Berger and Humphrey, 1993; Berger and Humphrey, 1992a, 1997; Ferrier and Lovell, 1990; Hunter andTimme, 1986, 1991; Hunter, Timme and Yang, 1990; Noulas, Ray and Miller, 1990). But they were not being able to incorporate the technology of small and large banks in a common model or some factors, which were related with bank size, might be excluded from that model. At the same time for *scope efficiency*, it should be cleared that previous literature work of scope efficiency is more problematic than scale efficiency. There were very less financial firms' data available for the estimation of *scope efficiency* and if some data were available, those were not efficient frontier data set. As scope efficiency could be defined with only frontier data set, it was difficult to get the clear picture about this efficiency (Berger and Humphrey, 1991; Mester, 1993). However this study does not cover these two efficiencies because of the type of context[1], limitation of dataset and modelling used in this paper. This study centres on the estimation of technical efficiency of Indian Banks.

In the literature, there are two different approaches available to measure bank performance. The first one leads to the estimation of profit and cost X-efficiency frontiers through parametric and nonparametric methods, such as Data Envelopment Analysis (DEA) or Stochastic Frontier Analysis (SFA) (Berger and Humphrey, 1997; Bonin, Hasan and Wachtel, 2005). Researchers used these methods as per requirement of the study and availability of dataset. It has been found that foreign-owned banks are the most efficient than state-owned banks(Bonin, et al., 2005; Patti and Hardy, 2005). Similarly, Frontier Analysis (SFA) has been applied for different objectives (Berger, Hasan and Zhou, 2009; Fu and Heffernan, 2007).

Each of these approaches is mutually different in terms of their assumptions and their way to calculate the pattern of the banking efficiency**.** Ferrier and Lovell (1990), has explained about the econometric frontier approach (EFA) approach that the error term of this approach follow a symmetric normal distribution and inefficiency follow an asymmetric half-normal distribution. They also stated that these two factors are orthogonal to the cost function (Bauer, et al., 1993; Timme and Yang, 1991). Similarly Berger and Humphrey (1991) explained the assumptions of the thick frontier approach (TFA) approach. They stated the random error in terms of deviations from predicted cost for a specific size of bank (Berger, 1993). In the same line of explanation, Berger (1993) has posited that DFA is free from the instability of efficiency differences and he assumes that these are stable over period of time (Berger, 1995). He also stated that in DFA approach, random errors average out over time (Bauer, et al., 1993; Berger and Humphrey, 1992b). At the end, Rangan, et al. (1988), has mentioned about DEA that, in this approach there is no random fluctuation. Hence, all the deviation from the efficient frontier represent the inefficiency (Aly, Grabowski, Pasurka and Rangan, 1990; Elyasiani and Mehdian, 1990).

Berger (1993) stated in his study that there in no simple rule through which we can describe the nature of banking data. Exact problem is starts, when one want to arrive at a common conclusion by using these methods, but it is hard to get same results by these models. Many researchers had applied different techniques: econometric frontier approach (EFA), thick frontier approach (TFA), distribution-free approach (DFA) & data envelopment analysis (DEA) for evaluating above argument (Ferrier and Lovell, 1990). But they find that the average inefficiencies as a percentage of the cost were different for different techniques. It was also found that the rank calculation for the individual bank was not similar for different techniques.

The second wing of the literature considers profitability aspects of banking sector, usually measured by ROA, ROE, Net Interest Margin (NIM) and Economic Value added (EVA). Some researchers have evaluated the performance of European banks through ROE and concluded that, there was a relatively weak relationship between size and profitability (Goddard, Molyneux and Wilson, 2004).

In this study Data Envelopment Analysis (DEA) has been used for measuring the technical efficiency. Rationales behind the choosing DEA approach between DEA and stochastic frontier approach is controversial (Olesen and

[1] In this context, constant return of scale has been assumed for efficiency estimation. Hence, there is no scale economies exist. On the other hand, study of scale economy can be considered to the future study of the current study.

Petersen, 1996). The strength of the stochastic approach is that it permits hypothesis testing, while major drawback of this econometric approach is the requirement of the assumptions of functional form for the proper dissemination of technical inefficiency term and frontier technology. On the other hand, DEA is a non parametric test and there is no need of these assumptions. It also permits multiple outputs and inputs. Here, basic requirement of this study is to incorporate multiple outputs and inputs, for the study of Indian banking sector's efficiency.

There are some studies available in which, DEA method have been used for efficiency measurements in developed country (Aly, et al., 1990; Miller and Noulas, 1996; Rangan, Grabowski, Aly and Pasurka, 1988). On the other side, application of this approach is modest in developing country (Gilbert and Wilson, 1998; Leightner and Lovell, 1998). There is another line of researcher, who compared the performance of Indian banking sector to the other country (Bhattacharyya, Lovell and Sahay, 1997; Chatterjee, 1997; Saha and Ravisankar, 2000). Some of the imperative studies of this method have been given chronologically in table 1. Crucial worth of this table can be judged through a snapshot of the application and development in this methodology.

Most of reforms in India have been started since 1992, which have changed the picture of Indian Banking System. Since DEA analysis was initially developed in late seventies (Charnes, Cooper and Rhodes, 1978) in USA, the earliest application of this approach for banking industry was done by (Sherman and Gold, 1985). In India the earliest application of DEA approach was done by Luther Committee (1977) for banking performance evaluation. They examined the performance of nationalized banks for a period of 1969-1975. Some of the researchers have analysed various matters regarding the banking performance in India (Rangarajan and Mampilly, 1972; Thyagarajan, 1975). But in all studies, it can be found that no one have analysed the efficiency of banks' after financial reforms in India. Recent financial crisis influenced the financial firms across the globe. Unfortunately efficiencies of Indian Banking System have not kept disconnected with theses changes.

Enough studies have been found, which have used DEA for the performance evaluation of Indian banking sector (Bhattacharyya, et al., 1997; Chatterjee, 1997; Kumar, 2008; Saha and Ravisankar, 2000). *All of these studies have some limitations: limited data set, different context, having only one type of banks (Bhattacharyya, et al., 1997; Bodla & Bajaj, 2010; Saha & Ravisankar, 2000; Sanjeev, 2006) focused only upon getting relative efficiency scores and not about the realization of significant input and output variables, not focused on evaluating the impact of this recent financial crisis on the banking performance etc.* At present time private and foreign banks are growing very fast and giving tough competition to the public sector banks in India. Hence, there is a need to have a comparative study of these institutions during sub-prime crisis period. *In the above review, we have seen some studies in Indian context, but most of them have done their study to see the effect of liberalization and financial reform (Bhattacharyya, et al., 1997; Das, Nag and Ray, 2005; Saha and Ravisankar, 2000). Since, sub-prime crisis is a recent phenomenon, and no study has been quoted to see* the *effect on Indian banking efficiency during this period, this paper is analysing the same in the sub prime crisis period. Also this study is exploring different variables, which had influenced banking efficiency during this period*

4. Methodology

4.1. Data Envelopment Analysis (DEA)

Data Envelopment Analysis had been developed by Charnes, Cooper and Rhodes in 1978. They had built this model (CCR Model) over the seminal work of (Farrell, 1957), in which they applied linear programming to estimate an empirical production frontier. *First time in banking industry, DEA concept was by Sherman and Gold (1985) for assessing the efficiency of bank branches*. Later this concept has been proved as an efficient tool for measuring the relative efficiency in banking sector.

Initially this concept was used in USA for the measurement of banking industry by a group of researcher (Aly, et al., 1990; Elyasiani and Mehdian, 1990; Ferrier and Lovell, 1990; Grabowski, Rangan and Rezvanian, 1994; Rangan, et al., 1988; Yue, 1992). After this, a group of researcher had applied this concept for the banking efficiency measurement outside the USA. Berg et al. (1991; 1993) applied this approach for the efficiency measurement of Norwegian banks and the Nordic countries. (Fukuyama, 1993; 1995) had applied this DEA concept to measure the efficiency of Japanese commercial banks. In the same way (Resti, 1997)and Favero and Papi (1995) applied this for Italian banking industry. (Chen and Yeh, 1998) used the DEA approach for Taiwanese banking sector for measuring the relative operating efficiency of the publicly operated banks. DEA is a non parametric model, which computes the efficiency of a decision

making units (DMU), by involving multiple inputs and outputs. We consider each bank as a DMU for the efficiency calculation. In this analysis, we run the solver one time for each bank, and save the output result (Relative efficiency score) for the same DMU. This technique identifies the most efficient banks in a sample and provides a relative efficiency score for all others. In this approach, most efficient banks will have an efficiency score of one, while the others will have score between zero and one. It should be clear that DEA does not give a measure of optimal efficiency, but it gives a relative efficiency score for all the DMUs, so that one can differentiate the lest and highly efficient DMU of the sample.

For the formulation part of this method (DEA), previous research works of different scholars (Berg, Førsund, Hjalmarsson and Suominen, 1993; Saha and Ravisankar, 2000; Sanjeev, 2006) have been referred. Most of them have used CCR (Charnes, Cooper & Rhodes) model for their analysis. In this study, same CCR model has been used for evaluating the relative efficiency for Indian banking sector during sub-prime crisis. For the formulation part, let we assume a sample of p banks and each bank is having m inputs and n outputs. If $X_{ik,}$ and $Y_{jk,}$, represent the i_{th} input and j_{th} output of k_{th} bank, where $i= 1,2,3....m,$ and $j=1,2,3....n,$ and $k=1,2,3...p.$ In this case, the relative efficiency of the K_{th} bank can be defined as:

$$Ek = \frac{\sum_{j=1}^{n} Vjk * Yjk}{\sum_{i=1}^{m} Uik * Xik} \tag{1}$$

Where, V_{jk} is the weight assigned for j_{th} output and U_{ik} is the weight assigned for i_{th} input of the K_{th} bank and

$$\sum_{j=1}^{n} Vjk = \sum_{i=1}^{m} Uik \qquad \text{For all k} \tag{2}$$

From the equation (1), it is clear that, the efficiency of each DMU depends on the values of these weights. In DEA, we will try to select a combination of weights, which maximizes the efficiency score of that bank under the condition that efficiency ratio and weights should not exceed one. Basically the original formulation of DEA approach would not be a linear programming problem (linear fractional programming problem), rather we have to transform them into a set of linear problems. The above DEA model (equation 1) will be formulized for each bank and we will get a set of result by solving the model for each bank. In this study, 15 banks *(k=1, 2, 3, 4, 5....15)* have been taken for the analysis. So for all theses banks, the above model (equation1) can be transformed into an equivalent linear programming problem as:

$$\text{Maximize Ek}= \sum_{j=1}^{n} Vjk * Yjk \tag{3}$$

Subject to the conditions:

$$\sum_{i=1}^{m} Uik * Xik = 1$$

$$\sum_{j=1}^{n} Vjk * Yjk - \sum_{i=1}^{m} Uik * Xik \le 0$$

$$Uik \ge 0, \qquad \text{i=1,2,3,....,m,}$$

$$Vjk \ge 0, \qquad \text{J=1,2,3,....,n,}$$

$$\sum_{i=1}^{m} Uik = \sum_{j=1}^{n} Vjk$$

In the above DEA model, selection of the Input and output variables are very important [Brown and Gardner (1995), Resti Andrea, (1997)]. So, in the next part, criteria for input and output selection vane been discussed.

4.2. Input & Output Variables

Secondary dataset (capitaline dataset) has been used for this study. In this study 15 top banks'[2] (5 public, 5 private, and 5 foreign banks as illustrated in *Appendix- Table-2*) data has been taken for the period 2007-2011. The most crucial part of this approach is the selection part of the input and output variables. These variables are highly contextual, and it depends on how banking sector is considered in terms of business environment: whether institutions are doing their business in unstable/stable country environment, types of services, or mode of service providers (Provider of money/user of money). There are two approaches of inputs/outputs selection, available in the existing literature: *production approach* and *Intermediation approach* (Sanjeev, 2006). Ferrier and Lovell (1990) followed *production approach*, where they considered banks to be producing deposits and loans as output by using capital and labour as input variables (Fried, Knox, Lovell and Eeckaut, 1993).While, second approach is *Intermediation approach.* Some previous works (Bhattacharyya, et al., 1997; Isik and Hassan, 2002; Luo, 2003) have been reviewed and their inputs and outputs variables are tabulated in *Table 3.* Most of the studies have been taken from Indian context and followed same approach. (Mester, 1997) used intermediate approach in his study where, he mentioned that deposits are regarded as being converted into loans. Basically, in this approach, banks are considered as an intermediary between supplier and user of funds.

Elyasiani and Mehdian (1990) explained that, this approach also covers interest expenses, which accounts a major part of the banks' cost (Berger and Humphrey, 1991). On the basis of previous review work, various outputs and inputs have been selected for this study. For input variables: Capital (C), Fixed Assets (FA), Interest Expenses (IE), Total Borrowing (TB), Total deposits (TD), Total Liabilities (TL), Operating Cost (OC), and for the output variable: Advances (A), Investments (I), Net Profit (NP), Total Revenue (TR) have been considered.

5. Result Analysis

MS-Excel Solver has been used to run the Data envelopment Analysis (DEA) model. Since 15 banks have been taken for this study, 15 linear programming problems (LPPs) will be formed for one years' analysis[3]. LPPs have been solved in MS-EXCEL 2007 for each year and results are summarized and discussed in following sections. Each time, model is run for one bank, keeping others constant. Similar run has been done for the rest of the banks for the year under consideration. In this way data set of a particular year has been generated. Same analysis has been done for rest of the years.

Results have been summarized in table 2(a) - 4(b). In the first part of tables, percentage of inputs and outputs weights are given, which have been calculated by efficiency optimization of individual banks. The relative efficiency score of banks (for five years) have been given in the second part of these tables. Table 2 (a) reports the DEA result on optimal weight scores of each bank for 2007. Result shows that *Interest Expenses is least significant among input variables followed by Fixed Asset and Capital. Among input variables, we can state that all banks have given very high importance to the Operating Cost*. It means that operating cost is most important input vector of these banks for their efficiency measurement in 2007. *On the output variable side, Net Profit (NP) was the most significant output variable for these banks during 2007. Also Advances (A) can be considered as a least significant output variable for this year, followed by Investment (I) and Total Revenue (TR).*

Apart from this, Total Revenue (TR) is the least significant output variable for public sector banks. It is also interesting to note that, Punjab National Bank (PNB), and Bank of Baroda (BOB) are having only one important output variable during this year. PNB has considered Net Profit (NP), and BOB has taken Advances as a major output variable for their efficiency calculation. While on input side, BOB has taken Total Borrowing (TB) as major input in 2007. In Table 2 (b), results show that the maximum efficiency score for SBI is 1. Result of others banks instantiate that, despite of having biasness towards maximizing the SBI efficiency, other banks had also performed very well (having score 1) with same weighting pattern and except IndusInd Bank (IB), all bank have achieved relative score 1 (Table 2b).

[2] Top banks have been selected on the basis of sales/ profit figure.

[3] Since data set has been collected over a period of 5 years (2007-2011); hence 75 linear programming problems will be formed and solved for the analysis.

This can be explained on the basis of some negative weights allotment to some variables for achieving relative score 1. But in this study, we have a constraint that we are not assigning negative weights to any variables (all weights ≥ 0). Each row represents the relative efficiency score of that *specific bank* and other banks, while optimizing the efficiency of the *same bank*. Looking into the relative efficiency score table 2 (b), we find that IB has got very low relative score compared to PNB. This can be explained on the output variables' weight of these two banks. Here, we found that IB has considered Total Revenue (TR) and PNB have taken Net Profit (NP) as a major output variable for their efficiency calculations. When PNB has taken TR as a major output for its efficiency measurement, IB has allotted minimum weights to TR for its efficiency Calculation.

While moving to 2008 [Table 3 (a)] data set, same preference of output variable for PNB & BOB have been found, as in 2007. Again PNB has chosen Net Profit and BOB has chosen Advances for their efficiency measurement. The trend of output selection for these banks is same as in last year. Going further, we find a change in the preferences of output variable. In this year Total Revenue (TR) is the most significant output variable followed by Net Profit & Advances (A), while Investment (I) is least important variables in this year.

On the other side, trend of input variables is different from last year. Capital (C) is the least significant input for this year, followed by Fixed Assets and Interest Expenses. However, we have noticed the similar trend for Operating Costs (OC) in this year. While analysing Table 3 (b), similar trend in relative efficiency score has been found. Same pattern has been calculated in IB and PNB for this year and that can be explained in similar way as in 2007. However in this year, less variation in the relative efficiency score can be observed. Except one case (PNB *vs* IB) no score is less than .35; it shows that majority of banks follow same type of methodology for their efficiency calculation.

In 2009[4], Capital (C) has received better score compared to the previous years (2007-2008). It means that during this period majority of banks had accepted capital as a better input variable than Fixed Assets (FA), Total Borrowing (TB), Total Deposits (TD) & Total Liability (TL). It is also interesting to note that none of the banks have 1 weight score. It indicates that all variables are important for the banks and these variables have been contributing in efficiency measurements. Again, Operating Cost is the most significant input variable for all the banks during this period. Looking into the output, we find that Net Profit (NP) is the most significant output variable for this year, which has been changed compared to last year (TR). In 2009, we also find that relative efficiency scores have been improved compared to previous year. While analysing the score after crisis period, we notice that Fixed Assets is getting importance and Interest Expense is the least significant input variable. However, Operating Cost is again a major input variable for the efficiency analysis. On the output side, it can be observed that Total Revenue (TR) is the highest significant output variable for this year. It is also interesting to note that, Advances and Investments are getting importance this year.

Most of the banks have improved their efficiency (As we are getting more 1 score) after crisis period (2010[5]). Results also show that most of the banks have secured more than .5 relative score, which was not present in starting year 2007. It means that banks are following same methodology for their efficiency calculation and proving more synchronous behaviour compared to the starting year 2007. In 2011 [Table 4 (a)], it can be observed that Fixed Assets are getting importance as input vector, while it was not significant in crisis period. Total Deposits and Total Liabilities are the least important input vectors this year. Results show that Operating Cost (OC) is still a major input variable for banks, but significance level is decreased compared to last years. Similar trend has been found in output variable case. Advances and Investments are getting importance this year, which was not present in 2007. If we look at the relative score Table 4 (b), it can be observed that, banks have improved their scores after crisis period. None of the banks have relative scores less than .5. It confirms higher synchronization in their efficiency measurements compared to previous years.

6. Discussion

The results of this study depict that, Indian banks are giving higher preference to the capital over the years. This observation is also in line of Basel Accords[6]. According to the Basel Reports, capital requirement for safe operation of banking sector is increased over the period of time. In Basel I, Capital requirement is 8% of the risk weighted Assets; while in Basel II & Basel III, it has been increased to 9% and 10.5- 13.5 % of the risk weighted assets respectively.

[4] Results are not disclosed here, due to constraint in page limits. It can be reproduced as per demand of the readers
[5] Results are not disclosed here, due to constraint in page limits. It can be reproduced as per demand of the readers
[6] Data source is BIS (Bank for International Settlement) document

Thus, in synchronization with Basel Accords, this study reveals the fact that CAR ratio became important for the efficient operation of Indian Banking Sector over the years.

While analysing the result, we found that Fixed Assets are also securing higher preferences after the crisis period. This is because Indian Banks are expanding their Retail Offices, ATMs, Core Banking for tapping larger population of India, especially after the crisis period. And apart from these expansions, banks are also adopting higher automation for their effective operations and efficiency. These facts might justify the trend of Fixed Assets in the result part.

Although this growth has been reported after the liberalization, relatively higher growth in the above segments has been more noticeable after crisis period. These discussions are also supported by the facts that over the period of time, there is an increasing utilization of net block, computers and other necessary equipments associated with the automation of Indian banking Industry. If we look at the increasing significance of the advances and Investments, it can be observed that there are increasing preferences for these variables after crisis period. It has been reported that banks are investing comparatively higher amount in government securities, debentures & bonds after recession to be on safer side[7]. As far as Advances are concerned the term loan advancement, loaning, and bill purchasing have also been increased after recession.

7. Conclusions

This study provides a comparative analysis of technical efficiency of Indian banking sector during the period 2007-2011. The results also show the pattern of changes in the significance level of input and output vectors, used in the calculation of banking efficiency. Using non parametric DEA approach, we find that top banks of India have improved their relative efficiency score during this period. The results suggest that after sub prime crisis, banking sector started giving higher preferences to Advances (A), and Investment (I) as compared to before crisis. However, Net Profit (NP) and Total Revenue (TR) are consistently most significant output variables throughout the study period. Some little changes in input side are also observed: Capital and Fixed Assets are getting more importance, while Total Deposits (TD) and Total Liabilities (TL) are getting down in preference list. Hence this study observes variation in the preferences of input and output vectors. For the relative efficiency score, the results show that there is still a room for the improvement for those banks, which have not achieved the efficient frontier. This gap can be filled by adding some new variables or omitting some older ones from the input-output variable preferences of aforementioned banks.

The study also has certain limitations regarding the data set, and variables selection. The sample considered here comprises of only 15 banks and this number can be extended in future work. Limited variables selection has been done on the basis of literature, which can also be extended further by adding and deleting some variables in the exiting list. One of the major implications of this study is to get the relative efficiency score and weights of other banks by optimizing the most regulated and well performing bank. In this way we can find the means of improvement for other banks. In future the impact of this study can be increased by creating an ideal bank through simulation and getting relative score for rest of the banks. In that case we will have a chance to bring all the major banks of India on efficient frontier and maximize their outputs and efficiency. Apart from this, study can also be performed by segmenting the banks into their major operational activities and factoring the variables into different components through Principle Component Analysis.

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Table 2 (a). Weight Score Summary - 2007

2007	C	FA	IE	TB	TD	TL	OC	A	I	NP	TR
SBI	0.0590	0.0000	0.0841	0.0115	0.0245	0.0000	**0.8209**	0.0446	0.1521	**0.6910**	0.1123
PNB	**0.6115**	0.0000	0.0000	0.0000	0.0021	0.0000	0.3864	0.0000	0.0000	**1.0000**	0.0000
CB	0.0000	0.0000	0.0000	0.3535	0.2508	0.0327	**0.3630**	0.3833	0.1509	0.4658	0.0000
BOB	0.0000	0.1332	0.0000	**0.7187**	0.0000	0.1481	0.0000	1.0000	0.0000	0.0000	0.0000
BOI	0.0000	0.4401	0.0000	0.0000	0.0000	0.0414	**0.5185**	**0.7245**	0.2755	0.0000	0.0000
ICICI	0.0048	0.0000	0.0000	0.0098	0.0185	0.0143	**0.9526**	0.0212	0.1065	**0.6650**	0.2073
HDFC	0.0048	0.0000	0.0000	0.0098	0.0185	0.0143	**0.9526**	0.0212	0.1065	**0.6650**	0.2073
AXIS	0.0048	0.0000	0.0000	0.0098	0.0185	0.0143	**0.9526**	0.0212	0.1065	**0.6651**	0.2073
KM	0.0144	0.0000	0.0264	0.0162	0.0407	0.0000	**0.9023**	0.0396	0.1649	**0.7257**	0.0699
YB	0.0048	0.0000	0.0000	0.0098	0.0185	0.0143	**0.9526**	0.0212	0.1065	**0.6651**	0.2073
SC	0.0048	0.0000	0.0000	0.0098	0.0185	0.0143	**0.9526**	0.0212	0.1065	**0.6651**	0.2073
HSBC	0.0048	0.0000	0.0000	0.0098	0.0185	0.0143	**0.9526**	0.0212	0.1065	**0.6651**	0.2073
DB	0.0125	0.0540	0.0000	0.0157	0.0358	0.0000	**0.8820**	0.0259	0.1469	**0.7153**	0.1120
IB	0.0000	0.0000	0.0000	0.0877	0.0000	0.0588	**0.8536**	0.0000	0.0000	0.0000	**1.0000**
RBS	0.0048	0.0000	0.0000	0.0098	0.0185	0.0143	**0.9526**	0.0212	0.1065	**0.6651**	0.2073

Where, C=Capital, FA= Fixed Assets, IE=Interest Expenses, TB=Total Borrowing, TD=Total deposits, TL=Total Liabilities, OC= Operating Cost and for the output variable: A= Advances, I=Investments, NP=Net Profit, TR= Total Revenue.

Table 2 (b) Relative Efficiency Score - 2007

2007	SBI	PNB	CB	BOB	BOI	ICICI	HDFC	AXIS	KM	YB	SC	HSBC	DB	IB	RBS
SBI	**1.00**	1.00	0.95	0.89	0.92	1.00	1.00	1.00	0.93	1.00	1.00	0.96	0.83	0.76	1.00
PNB	1.00	**1.00**	0.83	0.68	0.69	0.74	0.75	0.60	0.19	0.21	1.00	0.23	0.21	0.10	0.74
CB	1.00	1.00	**1.00**	0.96	0.96	0.95	1.00	0.89	0.92	0.99	1.00	0.85	0.56	0.89	1.00
BOB	0.79	1.00	1.00	**1.00**	0.87	0.59	0.79	0.67	0.44	0.73	0.60	0.52	0.17	0.82	0.52
BOI	1.00	1.00	0.90	0.95	**1.00**	0.90	0.82	0.86	0.86	0.96	0.73	0.67	0.51	0.78	1.00
ICICI	0.98	1.00	0.97	0.88	0.92	**1.00**	1.00	1.00	0.90	1.00	1.00	1.00	0.90	0.83	1.00
HDFC	0.98	1.00	0.97	0.88	0.92	1.00	**1.00**	1.00	0.90	1.00	1.00	1.00	0.90	0.83	1.00
AXIS	0.98	1.00	0.97	0.88	0.92	1.00	1.00	**1.00**	0.90	1.00	1.00	1.00	0.90	0.83	1.00
KM	0.95	0.93	0.91	0.83	0.87	1.00	1.00	1.00	**1.00**	1.00	1.00	0.99	1.00	0.78	1.00
YB	0.98	1.00	0.97	0.88	0.92	1.00	1.00	1.00	0.90	**1.00**	1.00	1.00	0.90	0.83	1.00
SC	0.98	1.00	0.97	0.88	0.92	1.00	1.00	1.00	0.90	1.00	**1.00**	1.00	0.90	0.83	1.00
HSBC	0.98	1.00	0.97	0.88	0.92	1.00	1.00	1.00	0.90	1.00	1.00	**1.00**	0.90	0.83	1.00
DB	0.95	0.94	0.90	0.82	0.87	1.00	1.00	1.00	0.97	1.00	1.00	1.00	**1.00**	0.77	1.00
IB	0.89	1.00	0.96	0.90	0.87	0.85	1.00	0.81	0.70	0.80	1.00	0.97	0.67	***0.98***	0.95
RBS	0.98	1.00	0.97	0.88	0.92	1.00	1.00	1.00	0.90	1.00	1.00	1.00	0.90	0.83	**1.00**

Table 3 (a) Weight Score Summary - 2008

2008	C	FA	IE	TB	TD	TL	OC	A	I	NP	TR
SBI	0.0000	0.0947	0.2037	0.0658	0.0518	0.0105	**0.5735**	0.1459	0.0792	0.3303	**0.4447**
PNB	0.1042	0.1573	0.0000	0.0000	0.0057	0.0000	**0.7328**	0.0000	0.0000	**1.0000**	0.0000
CB	0.1087	0.0000	0.2177	0.0455	0.0238	0.0287	**0.5755**	0.0936	0.0230	0.0000	**0.8834**
BOB	0.2017	0.0000	0.1936	**0.4830**	0.1217	0.0000	0.0000	**1.0000**	0.0000	0.0000	0.0000
BOI	0.0000	0.0000	0.1263	0.0341	0.0420	0.0209	**0.7767**	0.0618	0.0652	0.8550	0.0180
ICICI	0.0000	0.0000	0.2269	0.0640	0.0486	0.0183	**0.6422**	0.1412	0.0791	0.2139	**0.5657**
HDFC	0.0000	0.0000	0.2269	0.0640	0.0486	0.0183	**0.6422**	0.1413	0.0791	0.2138	**0.5658**
AXIS	0.0293	0.3655	**0.5806**	0.0090	0.0000	0.0156	0.0000	0.1267	0.0378	0.8355	0.0000
KM	0.0169	0.0000	0.2296	0.0617	0.0439	0.0165	**0.6313**	0.1514	0.0727	0.0000	**0.7759**
YB	0.0000	0.0000	0.2269	0.0640	0.0486	0.0183	**0.6422**	0.1413	0.0791	0.2138	**0.5658**
SC	0.1039	0.0000	0.1746	0.0295	0.0156	0.0092	**0.6672**	0.0444	0.0000	0.0000	**0.9556**
HSBC	0.1039	0.0000	0.1746	0.0295	0.0156	0.0092	**0.6672**	0.0444	0.0000	0.0000	**0.9556**
DB	0.0000	**0.4258**	0.0502	0.0624	0.0640	0.0000	0.3975	0.0700	0.0646	**0.8655**	0.0000
IB	0.0000	0.0000	0.0000	0.4462	0.0000	**0.5538**	0.0000	0.0557	0.0000	0.0000	**0.9443**
RBS	0.0000	0.0000	0.2269	0.0640	0.0486	0.0183	**0.6422**	0.1413	0.0791	0.2138	**0.5658**

Table 3 (b) Relative Efficiency Score - 2008

2008	SBI	PNB	CB	BOB	BOI	ICICI	HDFC	AXIS	KM	YB	SC	HSBC	DB	IB	RBS
SBI	**1.00**	1.00	0.96	0.95	0.99	1.00	1.00	0.95	1.00	1.00	1.00	1.00	0.92	0.86	1.00
PNB	1.00	**0.94**	0.68	0.69	1.00	0.93	0.78	0.70	0.48	1.00	1.00	0.95	0.42	0.16	0.70
CB	0.97	1.00	**1.00**	0.96	1.00	1.00	1.00	0.93	1.00	1.00	1.00	0.95	0.75	0.90	1.00
BOB	0.89	1.00	1.00	**1.00**	1.00	0.70	0.84	0.86	0.67	0.83	0.82	0.61	0.38	0.82	0.52
BOI	0.99	1.00	0.94	0.93	**1.00**	1.00	1.00	0.95	0.94	1.00	1.00	1.00	0.97	0.79	1.00
ICICI	0.99	1.00	0.98	0.96	1.00	**1.00**	1.00	0.94	1.00	1.00	1.00	1.00	0.92	0.88	1.00
HDFC	0.99	1.00	0.98	0.96	1.00	1.00	**1.00**	0.94	1.00	1.00	1.00	1.00	0.92	0.88	1.00
AXIS	1.00	1.00	0.80	0.95	1.00	0.79	1.00	**1.00**	0.92	0.84	0.95	0.93	1.00	0.61	1.00
KM	0.99	1.00	0.98	0.96	0.99	1.00	1.00	0.94	**1.00**	1.00	1.00	1.00	0.88	0.89	1.00
YB	0.99	1.00	0.98	0.96	1.00	1.00	1.00	0.94	1.00	**1.00**	1.00	1.00	0.92	0.88	1.00
SC	0.98	1.00	0.99	0.95	0.99	1.00	1.00	0.90	0.94	1.00	**1.00**	1.00	0.67	0.85	1.00
HSBC	0.98	1.00	0.99	0.95	0.99	1.00	1.00	0.90	0.94	1.00	1.00	**1.00**	0.67	0.85	1.00
DB	1.00	0.95	0.88	0.88	0.94	1.00	1.00	0.93	1.00	1.00	1.00	0.99	**1.00**	0.72	1.00
IB	0.87	0.92	1.00	0.88	0.92	0.94	0.94	0.86	1.00	1.00	0.94	0.86	0.84	**0.97**	0.87
RBS	0.99	1.00	0.98	0.96	1.00	1.00	1.00	0.94	1.00	1.00	1.00	1.00	0.92	0.88	**1.00**

Table 4 (a) Weight Score Summary - 2011

2011	C	FA	IE	TB	TD	TL	OC	A	I	NP	TR
SBI	0.0579	0.2827	0.2824	0.0003	0.0114	0.0000	**0.3654**	0.1099	0.0987	**0.7913**	0.0000
PNB	0.0579	0.2827	0.2824	0.0003	0.0114	0.0000	**0.3654**	0.1099	0.0987	**0.7914**	0.0000
CB	0.0000	0.3080	0.1366	0.0549	0.0226	0.0000	**0.4780**	0.2331	0.1753	**0.5915**	0.0000
BOB	0.0563	0.2896	0.2678	0.0000	0.0122	0.0000	**0.3741**	0.1068	0.0829	**0.8102**	0.0000
BOI	0.1060	0.2020	0.2584	0.0041	0.0000	0.0000	**0.4295**	0.2482	**0.7518**	0.0000	0.0000
ICICI	0.0579	0.2827	0.2824	0.0003	0.0114	0.0000	**0.3654**	0.1099	0.0987	**0.7914**	0.0000
HDFC	0.0445	0.1696	0.1518	0.0222	0.0277	0.0000	**0.5842**	0.1062	0.0817	**0.4942**	0.3178
AXIS	0.0590	0.2724	0.2953	0.0000	0.0115	0.0000	**0.3618**	0.1184	0.1022	**0.7793**	0.0000
KM	0.0579	0.2827	0.2824	0.0003	0.0114	0.0000	**0.3654**	0.1099	0.0987	**0.7915**	0.0000
YB	0.0579	0.2827	0.2824	0.0003	0.0114	0.0000	**0.3654**	0.1099	0.0987	**0.7915**	0.0000
SC	0.0674	0.0712	**0.4388**	0.0074	0.0208	0.0000	0.3944	**0.4929**	0.3299	0.0000	0.1772
HSBC	0.0771	0.2346	0.2670	0.0110	0.0180	0.0000	**0.3923**	0.1464	0.1513	**0.7023**	0.0000
DB	0.0445	0.1696	0.1518	0.0222	0.0277	0.0000	**0.5843**	0.1062	0.0817	**0.4942**	0.3179
IB	0.0000	0.0000	0.0000	0.1207	0.0290	0.2957	**0.5547**	0.0839	0.0000	**0.4101**	0.5060
RBS	0.0579	0.2827	0.2824	0.0003	0.0114	0.0000	**0.3654**	0.1099	0.0987	**0.7915**	0.0000

Table 4 (b) Relative Efficiency Score - 2011

2011	SBI	PNB	CB	BOB	BOI	ICICI	HDFC	AXIS	KM	YB	SC	HSBC	DB	IB	RBS
SBI	**1.00**	1.00	0.91	1.00	0.93	1.00	0.99	1.00	1.00	1.00	0.85	1.00	1.00	0.80	1.00
PNB	1.00	**1.00**	0.91	1.00	0.93	1.00	0.99	1.00	1.00	1.00	0.85	1.00	1.00	0.80	1.00
CB	1.00	1.00	**1.00**	1.00	0.98	0.79	1.00	0.92	0.83	1.00	0.76	1.00	0.98	0.82	0.83
BOB	1.00	1.00	0.91	**1.00**	0.93	1.00	0.99	0.99	1.00	1.00	0.85	0.97	1.00	0.80	0.98
BOI	1.00	1.00	0.90	0.98	**1.00**	0.90	0.94	0.98	0.81	1.00	0.66	1.00	0.56	0.71	1.00
ICICI	1.00	1.00	0.91	1.00	0.93	**1.00**	0.99	1.00	1.00	1.00	0.85	1.00	1.00	0.80	1.00
HDFC	1.00	1.00	0.94	0.95	0.92	1.00	**1.00**	0.96	1.00	1.00	0.92	1.00	1.00	0.90	1.00
AXIS	1.00	1.00	0.91	1.00	0.94	1.00	0.99	**1.00**	1.00	0.99	0.86	0.99	1.00	0.80	1.00
KM	1.00	1.00	0.91	1.00	0.93	1.00	0.99	1.00	**1.00**	1.00	0.85	1.00	1.00	0.80	1.00
YB	1.00	1.00	0.91	1.00	0.93	1.00	0.99	1.00	1.00	**1.00**	0.85	1.00	1.00	0.80	1.00
SC	1.00	1.00	0.91	0.98	0.95	1.00	1.00	1.00	1.00	0.92	**1.00**	0.96	1.00	0.84	1.00
HSBC	1.00	1.00	0.93	0.98	0.94	1.00	1.00	1.00	1.00	1.00	0.88	**1.00**	0.91	0.84	1.00
DB	1.00	1.00	0.94	0.95	0.92	1.00	1.00	0.96	1.00	1.00	0.92	1.00	**1.00**	0.90	1.00
IB	0.95	1.00	0.98	0.94	0.90	0.87	1.00	0.96	1.00	0.94	0.89	0.73	1.00	**1.00**	1.00
RBS	1.00	1.00	0.91	1.00	0.93	1.00	0.99	1.00	1.00	1.00	0.85	1.00	1.00	0.80	**1.00**