# Technical Efficiency Measurement of Indian Banking companies: An Investigation Using DEA and Super Efficiency Model

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***Abstract*—This paper investigates the efficiency of Indian banks enlisted in Bombay Stock Exchange. We applied Data Envelopment Analysis (DEA), to estimate the efficiency of the Indian banks using publicly available financial data of various different parameters related to the financial health of Indian banks. The efficiency of each company in comparison with other companies of the banking sector is estimated. We applied super efficiency model to measure the most efficient bank over a certain time horizon among all the banks. Bank efficiency scores derived using the DEA contributes significant information towards identifying the scope for improvement.**

***Index Terms*—bank efficiency, data envelopment analysis, Constant Return to Scale (CRS), Variable Return to Scale (VRS), super efficiency model.**

## I. Introduction

Banks are the principal source of financial intermediation. It plays a key role in a country's economic development and growth. In addition to their large financial significance, the prevalence of a very competitive market structure necessitates the importance of evaluating the banks' performance to find scope for improvement. Another very important use of such analysis is to evaluate the effectiveness of fund allocation and rearranging business in comparison with the leaders in the business. It is very challenging to select a suitable methodology. Historically, the banks have been trying to improve on their efficiency, but absence of suitable measure of efficiency worked as constraints. It should highlight the extent of inefficiency with considerations of internal and external environmental impacts and provide management the tool to monitor efficiency in comparative terms.

The events of the worldwide financial meltdown in 2008–2009 have resulted stringent efficiency measurement requirements. Moreover, operational issues and policies are scrutinized more stringently in an attempt to prevent another series of problems.

Despite the importance of the Indian banking sector to the domestic, regional, and international economies, there are only a few microeconomic studies performed in this area of research. This study thus attempts to fill a demanding gap by providing the most recent evidence on the performance of the Indian banking sector. Unlike the previous studies on banks' efficiency, the present study attempts to examine the efficiency of the Indian banking sector by using the Data Envelopment Analysis (DEA), [1] first proposed by Charnes *et al*. (1985). We believe that it is more appropriate to investigate the efficiency of the Indian banking sector by using the DEA method [2] because the method provides a greater degree of freedom to the sample (Reisman, 2003) and the greater degree of freedom could provide better explanatory power. The present study contributes to the existing literature in at least two important ways. First, Constant Return to Scale (CRS) and Variable Return to Scale (VRS) models look into the scale efficiency and technical efficiency of BSE enlisted Banks. Second, the study attempt to examine the Super Efficiency among Indian banks with regard to the Indian banking sector.

## II. Literature Review

Before the introduction of DEA, various approaches for measurement of efficiency were typically limited to the methods like ratio analysis. Prevalence of unlimited number of ratios some time made this confusing and contradictory. The limitations of ratio analysis have led to the development of more advance efficiency measurement tools. In the past three decades, five popular frontier efficiency approaches have been used in bank efficiency measurements; three of them are Parametric Econometric Approaches: Stochastic Frontier Approach (SFA), Thick Frontier Approach (TFA), and Distribution Free Approach (DFA). The other two are nonparametric linear programming approaches: Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH). These approaches primarily differ in the assumptions imposed on the specifications of the efficient frontier, the existence of random error, and the distribution of the inefficiencies and random error [3] (Bauer 1990; Berger and Humphrey 1997). Econometric analyses require a prior specification of the form of the production function and typically include two error components: an error term that captures inefficiency and a random error. While

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mathematical, nonparametric methods require few assumptions when specifying the best-practice frontier, they generally do not account for random errors. [4] Some researchers (such as Ferrier and Lovell 1990; [5] Resti 1997; [6] Bauer et al. 1998 [7] Weill 2004) have comparatively studied the consistency and robustness of the estimations generated by the various frontier techniques.

[8] Sherman and Gold (1985) started the first significant DEA bank analysis paper and it was the beginning of a long list of DEA applications to banking from several different angles. [6], [9] The studies on bank efficiency are fast growing, but the vast majority of studies cover the U.S. and other developed countries (Berger *et al.* 1993; Berger and Humphrey, 1997). A Number of studies have been carried on the efficiency of the Chinese banking industry. Among them are studies by Chen et al. (2005), Fu and Heffernan (2007), Ariff and Can (2007) and Yao *et al* (2007). Chen et al (2005) examined the cost, technical and allocation efficiency of 43 Chinese banks over the period 1993 to 2000. The results show that the large state-owned banks and smaller banks are more efficient than the medium sized Chinese banks. In addition, technical efficiency consistently dominates the allocation efficiency of Chinese banks. The financial deregulation of 1995 was found to improve cost efficiency levels, including both technical and allocative efficiency. Fu and Heffernan (2007) employed the Stochastic Frontier Approach (SFA) to investigate Chinas banking sector‘s cost efficiency over the period 1985 to 2002. A considerable number of papers have been published on the banking industry (both banks as entities and branches) using DEA since the technology was introduced. [9] Berger and Humphrey (1997) summarized these works and listed 41 DEA studies in a number of countries; US banking research predominated with 23 papers. Fethi and Pasiouras (2010) review the 196 studies that employ operational research and artificial intelligence techniques in the assessment of bank performance; among them there are 151 studies using DEA-like techniques to estimate various measures of bank efficiency and productivity. From 1997 to 2010, the survey identified 225 DEA applications in the banking industry, 162 at the institution level and 63 at the branch level. These applications cover 43 countries/regions; among them there are 28 studies with international scope. Clearly, the work keeps going on and will likely continue in the foreseeable future, especially the aftermath of the 2008–2009 financial meltdowns.

## III. Research Methodology

In this paper, we investigated the Efficiency and the Super Efficiency of Indian Banking Companies. Publicly available financial data of various parameters related to the financial health of these companies are collected. The Constant Return to Scale (CRS) and Variable Return to Scale (VRS) models of DEA were employed to estimate the technical efficiency and scale efficiency of BSE enlisted Banks (for which data was available for the period under consideration). Then Super Efficiency Model was applied to find the most efficient bank. This gives us a clear idea regarding performance of different banks over the stipulated time horizon.

## IV. Data Envelopment Analysis (DEA)

DEA is a ‘data-oriented’ approach for evaluating the performance of a set of peer entities called Decision-Making Units (DMUs). These DMUs convert multiple inputs into multiple outputs. The phrase DMUs can also include nonmarket agencies like schools, hospitals, and courts, as well as market agencies. The efficiency of a DMU can be rated as 1 on the basis of available evidence if the comparative performance of that DMU with other DMUs does not show that some of its inputs can be reduced further without reducing some of its inputs. When a DMU under evaluation is not included in the reference set of the envelopment models, the resulting DEA model is called Super-Efficiency DEA model. [10] Charnes, Haag, Jaska and Semple (1992) used a Super Efficiency model to study the sensitivity of the efficiency classifications. [11] Zhu (1996), Seiford and Zhu (1998) developed a number of new Super Efficiency models to determine the efficiency stability regions. Also, the Super-Efficiency DEA Models can be used in detecting influential observations (Wilson, 1995) and in identifying the extreme efficient DMUs (Thrall, 1996). Seiford and Zhu (1999) studied the infeasibility of various super-efficiency models developed from the envelopment models.

The input-oriented measure of technical efficiency of any firm under VRS requires the solution of the following LP problem due to Banker, Charnes, Cooper, 1978:

Min θ

Subject to

$$\sum_{j=1}^{n} w_j x_i^j \leq \theta x_i^t; i = 1,2,3 \ldots m$$

$$\sum_{j=1}^{n} w_j y_r^j \geq y_r^t; r = 1,2,3 \ldots s$$

$$\sum_{j=1}^{n} w_j = 1;$$

$$w_j \geq 0 (j = 1,2,3, \ldots, n);$$

where $w_j$ is the weight of the jth DMU, $x_i^j$ is value of the $i^{th}$ input variables for $j^{th}$ DMU, $y_r^j$ is value of the $r^{th}$ output variables for $j^{th}$ DMU and $x_i^t$ is the value of $i^{th}$ input variable for $t^{th}$ DMU. Number of inputs is m, number of outputs is s and number of DMU is n. Here value of θ signifies the efficiency of $t^{th}$ DMU.

## V. Technical and Scale Efficiencies

Given the fact that firms are assigned different efficiencies in case of CRS and VRS assumptions, we can distinguish two different kinds of efficiencies namely Technical and Scale Efficiencies.

The CRS model estimates the gross efficiency of a DMU. This efficiency comprises technical efficiency and scale efficiency. Technical efficiency describes the efficiency in converting inputs to outputs, while scale efficiency recognizes that economy of scale cannot be attained at all scales of production, and that there is one most productive scale size, where the scale efficiency is maximum at 100 per cent.

The VRS model takes into account the variation of efficiency with respect to the scale of operation, and hence measures pure Technical Efficiency. In other words, scale efficiency of a DMU can be computed as the ratio of its CRS efficiency to its VRS efficiency. Hence Scale Efficiency can measure whether a DMU operates in the most productive scale size.

Productivity and technical efficiency are two closely related but different measures of performance of a firm. They are equivalent only when the technology exhibits constant returns to scale (CRS). The basic DEA model formulated by CCR for measurement of technical efficiency of individual firms under CRS using observed input–output quantity data. A simple transformation of the variables reduces the CCR ratio model involving a linear fractional functional programming into an equivalent Liner Programming problem. The CRS assumption is relaxed when the VRS model applicable to technologies with variable returns to scale. The maximum average productivity attained at the most productive scale size (MPSS) is compared to the average productivity at the actual scale of production to measure scale efficiency.

## VI. DATA

Selection of inputs and outputs and number of DMUs is one of the core difficulties in developing a model and in preparation of the data. In this brief review, we will focus on the managerial reasoning for selection of input and output factors. To avoid imbalance in data one of the best ways is to have them at the same or similar magnitude. A way of making sure the data is of the same or similar magnitude across and within data sets is to mean normalize the data.

While inputs and outputs are easily identified in most businesses, that is hardly the case in banking. Even today, there is no unanimous agreement on the identification and determination of bank's inputs and outputs. In the banking theory, literature, there are two main competing approaches with respect to the measurement of inputs and outputs of a bank, namely the production and intermediation approaches (Sealey and Lindley, 1977).

Under the production approach pioneered by Benston (1965), a financial institution is defined as a producer of services for account holders, that is, they perform transactions on deposit accounts and process documents such as loans. Hence, both loans and deposits are treated as outputs. The intermediation approach, on the other hand, assumes that financial firms act as an intermediary between savers and borrowers and conceives total loans and securities as outputs, whereas deposits along with labour and physical capital are defined as inputs. Although the intermediation approach is widely used in different empirical studies, neither approach is completely satisfactory due to the controversy over treatment of deposits as input or output. According to Berger and Humphrey (1997), the production approach might be more suitable for branch efficiency studies, whereas the intermediation approach is best suited for measuring bank efficiency. This is because at most time's bank branches process customer documents and bank funding, while investment decisions are not under the control of branches. The target group of this research is not the separate branches, but the performance of the whole bank, which (Freixas and Rochet (1997)) confirms the use of intermediation approach. For the purpose of this study, a variation of the intermediation approach or asset approach originally developed by Sealey and Lindley (1977) is adopted in the definition of inputs and outputs used.

The choice of inputs and outputs is guided by choices made in previous studies as well as the availability of data. In the current study, three inputs and two outputs have been used. The input vectors are ($x_1$) Total Deposits, ($x_2$) Fixed Assets and Operating Expenses($x_3$) while ($y_1$) Total Loans, which includes loans to customers and other banks and ($y_2$) Investments are the output vectors. In this approach, deposits are not covered as an independent output; instead they are treated only as a conduit to generating loans. Higher deposits would indicate that banks are not pushing loans adequately. In most banking systems, bank investments (in addition to loans) are also considered as a legitimate output. The interest expenses are not included as an input because there is bound to be collinearity between the deposits and interest expenses. Moreover, the interest rates are not independently decided by the banks, but are regulated by the Reserve Bank of India. Since, banks are not typical manufacturing units; the investment in fixed assets should be reduced to the necessary minimal. In India, the investment by banks is no longer restricted to Government securities only. A bank can make equity investments in subsidiaries and other entities that are engaged in financial services together with equity investments in entities engaged in non-financial services, activities, though it should not exceed 20 percent of the bank's paid-up share capital and reserves. Hence, it is a significant output of the banking sector.

## VII. OUTPUT TABLES

TABLE I. EFFICIENCY TABLE

| YEAR | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|
| Allahabad Bank | 0.866598 | 0.851896 | 0.859291 | 0.841419 | 0.805343 | 0.634506 | 0.62043 | 0.857073 | 0.855983 | 0.759377 |
| Andhra Bank | 1 | 0.958088 | 0.955018 | 1 | 1 | 0.999629 | 0.889624 | 0.939671 | 0.950961 | 0.946607 |
| Axis Bank Ltd. | 0.872311 | 0.91944 | 0.964745 | 0.951952 | 1 | 1 | 0.721379 | 0.680921 | 0.878741 | 1 |
| BOB | 1 | 0.981808 | 0.931376 | 0.789791 | 0.889715 | 0.792712 | 0.748161 | 0.899833 | 0.919354 | 0.86566 |
| India | 0.993957 | 0.913939 | 0.929575 | 0.851379 | 0.897675 | 0.849391 | 0.926819 | 1 | 1 | 1 |

 

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Bank Of Maharashtra | 0.812226 | 0.819853 | 0.838713 | 0.890725 | 0.907669 | 1 | 0.997027 | 1 | 1 | 0.975042 |
| Canara Bank | 1 | 0.889263 | 0.868081 | 0.786867 | 0.975674 | 1 | 1 | 1 | 1 | 0.852902 |
| Central Bank Of India | 0.833949 | 0.797458 | 0.7782 | 0.716977 | 0.856646 | 0.874341 | 0.781828 | 0.924669 | 0.847348 | 0.752976 |
| City Union Bank Ltd. | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Corporation Bank | 1 | 1 | 1 | 0.936874 | 0.954842 | 0.911884 | 0.815496 | 0.963078 | 0.962617 | 0.856925 |
| Dena Bank | 0.879644 | 0.89031 | 0.815087 | 0.785236 | 0.736458 | 0.532813 | 0.712685 | 0.893587 | 0.9127 | 0.774068 |
| Development Credit Bank Ltd. | 1 | 1 | 1 | 0.903802 | 1 | 0.988933 | 0.750867 | 0.869573 | 0.651731 | 0.505862 |
| Dhanlaxmi Bank Ltd. | 0.933758 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0.947222 |
| Federal Bank Ltd. | 0.884637 | 0.940577 | 0.908937 | 1 | 0.906444 | 0.780781 | 0.634206 | 0.882085 | 0.809321 | 0.784041 |
| H D F C Bank Ltd. | 0.879234 | 0.87154 | 0.939625 | 1 | 0.993521 | 0.823426 | 0.665697 | 1 | 1 | 1 |
| I C I C I Bank | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| I D B I Bank | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| I N G Vysya Bank Ltd. | 0.843709 | 0.884788 | 0.885328 | 0.810698 | 0.802321 | 0.522862 | 0.479427 | 0.878938 | 0.691638 | 0.581813 |
| Indian Overseas Bank | 0.907773 | 0.839496 | 0.836555 | 0.983773 | 0.960167 | 0.825211 | 0.736135 | 0.868821 | 0.929446 | 0.887333 |
| Indusind Bank Ltd. | 0.843464 | 0.92722 | 0.811922 | 0.79032 | 0.787426 | 0.798034 | 0.576417 | 0.982262 | 0.857337 | 1 |
| Jammu & Kashmir Bank Ltd. | 1 | 0.93869 | 0.967102 | 0.950085 | 0.928132 | 1 | 0.923581 | 1 | 1 | 0.886337 |
| Karnataka Bank Ltd. | 1 | 1 | 1 | 1 | 1 | 1 | 0.810611 | 0.958877 | 1 | 0.976613 |
| Karur Vysya Bank Ltd. | 0.983056 | 0.984813 | 0.991294 | 0.999717 | 0.947801 | 0.789342 | 0.622291 | 1 | 0.881872 | 0.684743 |
| Kotak M Bank Ltd. | 1 | 1 | 1 | 1 | 1 | 0.847806 | 0.76539 | 1 | 1 | 1 |
| Lakshmi Vilas Bank Ltd. | 0.955206 | 1 | 1 | 1 | 1 | 1 | 0.79725 | 1 | 1 | 0.970818 |
| OBC | 0.842941 | 0.86568 | 0.862578 | 1 | 1 | 1 | 0.920933 | 1 | 1 | 1 |
| PNB | 0.926742 | 0.933284 | 0.904779 | 0.849056 | 0.907254 | 0.818508 | 0.848661 | 0.936172 | 0.899159 | 0.863457 |
| South Indian Bank Ltd. | 0.992094 | 0.9959 | 0.926503 | 0.949981 | 0.847746 | 0.794929 | 0.758816 | 0.905774 | 1 | 0.934033 |
| State Bank Of Bikaner & Jaipur | 0.965824 | 1 | 0.979056 | 0.959823 | 0.974884 | 0.938309 | 0.915995 | 0.9748 | 1 | 1 |
| State Bank Of India | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| State Bank Of Mysore | 0.871158 | 0.92833 | 0.858097 | 1 | 0.93272 | 0.800039 | 0.903904 | 0.975175 | 1 | 1 |
| State Bank Of Travancore | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Syndicate Bank | 0.990775 | 1 | 0.990216 | 0.866706 | 0.88095 | 0.870036 | 0.820718 | 0.832907 | 0.883028 | 0.777377 |
| Uco Bank | 0.873678 | 1 | 0.966002 | 0.869293 | 0.893074 | 0.773325 | 0.781805 | 0.879523 | 0.853135 | 0.779791 |
| Union Bank Of India | 0.881812 | 0.860282 | 0.802245 | 0.789065 | 0.951333 | 0.87917 | 0.732705 | 0.888374 | 0.999825 | 0.659575 |
| Vijaya Bank | 0.827474 | 0.861606 | 0.849523 | 0.976652 | 0.998543 | 0.934375 | 0.860069 | 0.916217 | 0.883695 | 0.878936 |

TABLE II. SUPER-EFFICIENCY TABLE

| YEAR | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|
| Allahabad Bank | | | | | | | | | | |
| Andhra Bank | 1.017048 | | | 1.118809 | 1.186821 | | | | | |
| Axis Bank Ltd. | | | | | 1.245937 | 1.080851 | | | | 1.079114 |
| BOB | 1.148877 | | | | | | | | | |
| India | | | | | | | | 1.112154 | 1.085436 | 1.134645 |
| Bank Of Maharashtra | | | | | | 1.001862 | | 1.033987 | 1.03136 | |
| Canara Bank | 1.073918 | | | | | 1.154335 | 1.077179 | 1.038072 | 1.066717 | |
| Central Bank Of India | | | | | | | | | | |
| City Union Bank Ltd. | 1.829114 | 1.114838 | 1.37948 | 1.046671 | 1.214774 | 1.096883 | 2.321429 | 1.300799 | 1.781189 | 1.713673 |
| Corporation Bank | 1.869923 | 1.647248 | 1.256037 | | | | | | | |
| Dena Bank | | | | | | | | | | |
| Development Credit Bank Ltd. | 2 | 1.5 | 1.082965 | | 1.024679 | | | | | |
| Dhanlaxmi Bank Ltd. | | 1.273588 | 1.424946 | 1.531915 | 1.469649 | 1.370487 | 1.333333 | 1.333333 | 1.033123 | |
| Federal Bank Ltd. | | | | 1.004668 | | | | | | |
| H D F C Bank Ltd. | | | | 1.165251 | | | | 1.099139 | 1.088804 | 1.159297 |
| I C I C I Bank | 1.763908 | 1.535374 | 1.269258 | 1.212507 | 1.091654 | 1.116807 | 1.184117 | 1.581872 | 1.646403 | 2.792446 |
| I D B I Bank | 1.178865 | 2.261874 | 1.860959 | 1.772231 | 1.909908 | 2.273164 | 3.680504 | 2.795657 | 7.01186 | 10.81948 |
| I N G Vysya Bank Ltd. | | | | | | | | | | |
| Indian Overseas Bank | | | | | | | | | | |
| Indusind Bank Ltd. | | | | | | | | | | 1.391295 |
| Jammu & Kashmir Bank Ltd. | 1.155553 | | | | | 1.029243 | | 1.073838 | 1.278625 | |
| Karnataka Bank Ltd. | 1.116893 | 1.126857 | 1.246836 | 1.011654 | 1.047127 | 1.158304 | | | 1.030291 | |
| Karur Vysya Bank Ltd. | | | | | | | | 1.027434 | | |
| Kotak M Bank Ltd. | 1.184663 | 1.005153 | 1.314727 | 1.272257 | 1.465843 | | | 1.180512 | 7.684167 | 10.02092 |
| Lakshmi Vilas Bank Ltd. | | 1.02929 | 1.02882 | 1.117854 | 1.142699 | 1.196743 | | 1.135405 | 1.032647 | |
| OBC | | | | 1.54162 | 1.449519 | 1.012236 | | 1.50671 | 1.306032 | 1.408575 |
| PNB | | | | | | | | | | |
| South Indian Bank Ltd. | | | | | | | | | 1.070774 | |
| State Bank Of Bikaner & Jaipur | | 1.008346 | | | | | | | 1.024946 | 1.030208 |
| State Bank Of India | NFS | NFS | NFS | NFS | NFS | NFS | NFS | NFS | NFS | NFS |
| State Bank Of Mysore | | | | 1.045823 | | | | | 1.209275 | 1.357677 |
| State Bank Of Travancore | 1.024719 | 1.070467 | 1.068738 | 1.058499 | 1.149733 | 1.11576 | 1.50115 | 1.112542 | 1.162744 | 1.021656 |
| Syndicate Bank | | 1.026477 | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Uco Bank | | 1.030379 | | | | | | | | |
| Union Bank Of India | | | | | | | | | | |
| Vijaya Bank | | | | | | | | | | |

## VIII. Result & Discussion

Selection of inputs and outputs and number of DMUs is one of the core difficulties in developing a model and in preparation of the data. In this brief review, we will focus on the managerial reasoning for selection of input and output factors. To avoid imbalance in data one of the best ways is to have them at the same or similar magnitude. A way of making sure the data is of the same or similar magnitude across and within data sets is to mean normalize the data.

The efficiency score of a DMU states the efficiency of the DMU in utilizing the inputs to generate the outputs in comparison with other DMUs. Since we are using an input oriented model, the major aim is to decrease inputs as much as possible, keeping the output either constant or increasing it, if possible. The banks with an efficiency score of 1 indicate that the inputs cannot be further decreased in their case and if it is decreased, it will always have a negative impact on the output. The banks with an efficiency score of less than 1 indicate that there is still scope for improvement and keeping the output constant the inputs can be further reduced thus the efficiency of the firm can be increased.

The input oriented technical efficiency of the different banks is depicted in Table I. Sample output from Lingo software for first DMU (Allahabad Bank) for year 2011 is shown in Appendix A. Each efficiency score indicates the factor by which the inputs can be reduced, i.e., the present input variables have to be multiplied by the VRS efficiency factor to get the optimal input when the bank operates at its peak technical efficiency. The analysis of a 10 year time-horizon we considered, shows that City Union Bank Ltd., I C I C I Bank Ltd., I D B I Bank Ltd., State Bank of India and State Bank Of Travancore have proved to be efficient over all the years as compared to the other banks included in the study. They have been able to make the optimal utilization of the input consistently throughout the period. They have set examples for others to replicate. They have been able to convert most of their deposits into loans and investment and have been successful in minimizing their operating cost and investment in fixed assets. Development Credit Bank Ltd., Dhanlaxmi Bank Ltd., Karnataka Bank Ltd., Kotak Mahindra Bank Ltd., Lakshmi Vilas Bank Ltd. and Oriental Bank of Commerce have also fared well over the decade included in the study.

Eight banks, namely Allahabad Bank, Central Bank Of India, Dena Bank, I N G Vysya Bank Ltd., Punjab National Bank, Union Bank of India., Vijaya Bank and Indian Overseas Bank has not been able to match their competitors in any of the 10 years included in the study. They have not been able to utilize the inputs to their fullest. Detailed analysis of the efficiency scores along with their corresponding weights reflects the specific benchmark efficient banks in each of the inefficient banks in each year. These banks need to replicate the strategies adopted by the other efficient banks so as to convert deposits into loans and investments. The detailed analysis shows the optimal value as well as slackness in respect of input utilisation (refer Appendix A).

The year 2005 seemed to be the worst of the lot wherein only two banks other than the initially mentioned five efficient banks would make optimal utilization of the inputs as compared to the other players in the banking sector. The year 2003 proved to be the best year out of the 10 years included in the study wherein a total of 18 banks out of the 36 banks attend an efficiency score of 1.

The trend shows that the number of banks attaining an efficiency score of 1 decreased over time. This is attributable to the fact that there has been an increase in the number of banks and the other avenues that have emerged who are providing easy loans to the borrowers like the gold loans, the private finance companies and the micro finance companies. The tedious legal formalities that the borrowers have to go through in applying and getting a bank loan sanctioned is also acting as a deterrent.

Out of the multiple banks, which have been proved to be efficient each year, we had tried to identify the most efficient one by the super-efficiency analysis. These super efficiency sores among all efficient banks has been represented in Table II. The analysis highlights IDBI bank to be the most efficient for 9 out of the 10 years included in the study. Only in 2011, Development Credit Bank Ltd. has emerged as the super-efficient bank. IDBI Bank Ltd. is a Universal Bank with its operations driven by a cutting edge core Banking IT platform. The Bank offers personalized banking and financial solutions to its clients through its large network of branches, ATMs spread across the length and breadth of India. Though it is a public bank, it has kept pace with the private sector banks in modernization and technology. Being a government owned bank, it has the confidence of the population. It has transparent procedure which leads to more people approaching them for deposits and loan. Being a universal bank, it also engages in developmental activities to provide finance at concessional rates to the priority sectors like SME finance and agricultural finance as well. It has adopted appropriate strategies to mitigate the entire range of risks, effectively cope with the challenges and capitalize on the emerging opportunities by participating effectively in the country’s growth process. It is also in the process of setting up overseas branches and representative offices for exploiting emerging global opportunities.

## IX. Limitations

In our research paper, we have applied DEA to Indian banks considering banking sector homogeneous, though ownership wise they are heterogeneous in nature. Keeping in mind the constraints of DEA choice of input and output variables is very crucial as correlated variables restrict choice of variables. Thus, further research and analysis have to be carried out to assess the impact of variables on efficiency. Year wise comparative analysis of each company considering each year as a separate DMU can be carried out in future. Window analysis can also be carried out in future. Identification of outlier performance and exclusion of that bank can impact the efficiency of each bank, in future this can also be attempted.

## APPENDIX A

Sample DEA output (VRS) for Allahabad Bank for the year 2011

| | |
|---|---|
| Objective value: | 0.8665976 |
| Variable | Value |
| THETA | 0.8665976 |
| W10 (Corporation Bank) | 0.2816085 |
| W16 (ICICI Bank) | 0.5869119E-01 |
| W17 (IDBI Bank) | 0.1551272 |
| W30 (State Bank of India) | 0.1243655E-01 |
| W32 (State Bank of Travancore) | 0.4921366 |

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