

Efficiency Analysis of Indian Commercial Banks: A DEA Approach

Jyoti Singh*, A. K. Vashisht**, Meena Sharma***

Abstract

The banking industry is a vital part of the economy and is continually facing intense competition with changing bank reforms. An efficient and stable banking industry is today's demand and essential for productivity of the economy. This paper examines the efficiency of 46 Indian private and public sector banks from 2010 to 2014 using non-parametric DEA methodology. The study reveals that private banks are relatively more efficient than public banks and form a major part of the efficient frontier. The study also reveals that managerial inefficiency is the main cause for overall technical inefficiency of private banks than scale inefficiency. On the other hand, public banks have suffered more from scale inefficiency for some years than managerial inefficiency. Moreover, on an average, the difference between efficiency scores of private and public banks is found to be statistically insignificant except scale efficiency, significant for three years continuously i.e. 2010, 2011 and 2012.

Keyword: Indian Banks, Data Envelopment Analysis, Efficiency

significance lately. Moreover, the main cause of continued interest in this area is the dynamic banking business environment throughout the world (Galagedera, 2004). There is a continuous change in regulation, technology and competition in the global financial service sector. Adoption of financial deregulation policies lead to the competitiveness in the banking industry, and India is no exception.

Being a part of developing and emerging country, Indian banks are becoming more competitive. Rising cost-income ratios and declining profitability are the signs of increased competitive pressure on Indian banks (Dash and Charles, 2009). More efficient the banks are, more will be the productivity of the economy. It is, therefore, crucial to benchmark the performance, efficiency and stability of the Indian banks.

Efficiency is primarily an engineering concept used to evaluate the performance and utilization of resources of any institution. It is basically measured as the value of one output for a given amount of input. In other words, efficiency relates to complete utilization of available inputs to attain an optimum mix of outputs. In literature, to evaluate the performance of banks, various efficiency measures have been proposed, like scope efficiency, scale efficiency, allocative efficiency, technical efficiency and many more. Earlier, the investors, regulators, manager and analysts in the banking sector were usually dependent on accounting measures to evaluate the bank efficiency. These financial ratios assist in evaluation of bank performance. The main idea behind using ratios as an instrument for performance valuation is to permit comparison between banks of similar size with some benchmark while controlling sector specific traits.

1. Introduction

A strong and well flourishing economy is a desire of every country. Efficiency and soundness of the financial sector are one of the foremost areas of macro economy. Banks are bloodline flowing through every vital part of the financial sector. A stable, efficient and properly performing banking industry is directly linked to the growth of the economy. Hence, looking into the bank efficiency has made a lot of

* Senior Research Scholar (SRF), University Business School, Panjab University, Chandigarh, India. Email: jyotijsj88@gmail.com

** Professor, University Business School, Panjab University, Chandigarh, India. Email: akvashisht@pu.ac.in

*** Professor, University Business School, Panjab University, Chandigarh, India. Email: sharma94mk@rediffmail.com

Besides, these accounting ratios are easy to understand and use. The accounting ratios widely used as a proxy for efficiency in banks are cost to income ratio, profit/loss per employee, return on asset, business per branch, return on equity etc. (Halkos, 2004). However, to measure bank performance, the use of these accounting-based financial ratios have been criticized. The reasons are that ratios do not signify economic value-maximizing behaviour (Kohers *et al.*, 2000), and input price and the output mix concept is not considered (Berger and Humphrey, 1992).

Berger and Humphrey (1997) concluded that in terms of measuring performance, efficient frontier approaches seem to be superior to traditional financial ratios. The frontier efficiency approach is based on the thought that some banks will not be as productive and successful as others in fulfilling their goals. Hence, this technique shows the performance or efficiency of each bank relative to the efficient or best frontier comprising of dominant banks in the banking industry. Various models are used in frontier technique for deriving a reference set from sample of banks and then showing the relative position of other banks. The econometric or mathematical programming techniques are usually used to estimate an efficient frontier. The frontier efficiency technique holds back the conventional ratio analysis in the sense that they are more certain and substantive measures for bank evaluation. As a result of these kinds of attributes connected with frontier method, the traditional percentage evaluation has turned out-of-date. Generally, two approaches are used to determine the efficiency frontier namely parametric and non-parametric approaches.

The parametric approach requires a priori in specific production function form like Cobb-Douglas or cost function together with constant parameters. In parametric approach, efficiency scores depend upon the relationship between input and output or chosen functional form. Contrarily, non-parametric approach does not require a pre-specified functional form. In fact, it is a mathematical linear programming technique to obtain efficiency scores for banks individually. Under, parametric and non-parametric techniques, the Stochastic Frontier Approach and Data Envelopment Analysis (DEA) are widely used, respectively. The present study uses the DEA methodology to measure the efficiency of public and private sector banks.

2. Literature Review and Hypothesis Formulation

Lately, there has been a growth in the studies on efficiency analysis of financial institutions especially banks. Most of the DEA efficiency studies of banks concentrate on developed countries (Das, 2010). In developing countries like India, studies have been focused on measuring and analysing the effect of banking reforms and financial liberalization on bank's efficiency. The following studies have been reviewed to understand the relationship between efficiency and ownership.

In 1997, Bhattacharya *et al.*, studied the impact of liberalization on the efficiency of Indian banks by means of DEA technique and SFA regression model. A sample of the study was of 70 Indian banks from 1986 to 1991. The input-output configuration was based on the intermediation approach to calculate technical efficiency scores. The input variables were operating expenses and interest expenses, and output variables were advances, investments and deposits. The results showed that public banks were relatively efficient than foreign and private banks. Saha and Ravisankar (2000) concluded that DEA was a suitable approach to measure the performance of the bank. Data on twenty five public banks was collected for four years. Using intermediation approach, the input variables taken were branch, staff, establishment and non-establishment expenditure. The output variables were advances, investments, deposits, spread, working funds, and interest and non-interest income. The study showed that efficiency of public banks had increased from the year 1992. Similar results were given by Mukherjee *et al.*, (2002) who explored technical efficiency and benchmark of the performance for 68 commercial banks using the DEA technique from the period 1996 to 1999. The intermediation approach was adopted. The input variables were net worth, borrowings, operating expenses which related to non interest related expenses such as rent, taxes, electricity, etc., no. of employees and no. of bank branches whereas output variables were deposits, net profits, advances, non-interest income such as commission, sale of investments, dividends, and interest spread. They found that both private and foreign banks were relatively less efficient than public banks.

Sathye (2003) also showed that public banks were relatively efficient than private and foreign banks. The study was focused on the productive efficiency of 94 Indian commercial banks from the period 1997 to 1998 using DEA technique under intermediation approach. On the other hand, Ataullah *et al.*, (2004) showed a comparative study of technical efficiency between commercial banks in India and Pakistan for the period 1988 to 1998. It was revealed that Indian public banks were more efficient. In 2006, Das and Ghosh, analysed the relationship between efficiency and set of variables, i.e., ownership, bank size, capital adequacy ratio, management quality and non-performing loans from 1992 to 2002. DEA technique and Tobit regression were used and results showed that public banks were more efficient and bank size had a positive relation with the efficiency. The results were again confirmed by Jagwani (2012) who concluded that ownership had an impact on banks, and public banks had a relatively higher efficiency than foreign and private banks. Ray and Das (2010) estimated cost and profit efficiency of all major Indian banks. The study covered 7 years, starting with financial year 1996-97. It showed that profit efficiency was different among ownership categories.

Most of the studies revealed that public banks were more efficient, while some studies showed the opposite results. In 2009, D. Delis *et al.*, examined cost and profit stochastic frontiers of 28 Greek commercial banks from 1993 to 2005. The DEA and SFA techniques were used. The results showed that public and foreign banks were less efficient than private banks whereas SFA technique showed that state owned banks were dominant and efficient than private banks. Similarly, Gupta *et al.*, (2008) study revealed that private banks had a higher efficiency than nationalized banks. They measured efficiency of Indian banks using DEA approach and determinants were determined through TOBIT model. Data for 57 banks (public, private and foreign) was compiled from the year 1999 to 2003. The output and input variables selected were fee based income, interest income, investment, and interest expenses, operating expenses, respectively. The study discovered that SBI and its group were more efficient, followed by private banks and then nationalized banks. Chakrabarti and Chawla (2008) also showed that private banks were highly efficient.

However, Kyj and Isik (2008) and Zhao *et al.*, (2010) showed an insignificant relationship between ownership and bank efficiency. Kyj and Isik (2008) explored the correlation of x-efficiency in Ukraine with a number of

independent factors, specifically bank size, ownership and service location by taking a sample of 150 banks from the period 1998 to 2003. The results showed an insignificant relationship between the ownership of banks and efficiency using the Generalized Least Square method. Zhao *et al.*, (2010) examined impacts of financial sector reforms on ownership-cost efficiency relationship in Indian banking from the period 1992 to 2004 for 65 banks by using intermediation approach and SFA technique. The study showed that there was an insignificant relationship between ownership and efficiency of banks.

The studies showed that there are mixed results showing the difference in efficiency scores across ownership. Mukherjee *et al.*, (2002), Kyj and Isik (2008), Kumar and Gulati (2010) and Zhao *et al.*, (2010) showed an insignificant relationship, whereas D. Delis (2009) and Chatterjee and Sinha (2006) showed that private banks were more efficient. While the other studies showed that public banks were more efficient. Based on the review of these studies, following alternative hypothesis is formulated and tested in this study.

H₁ -Efficiency difference between public and private banks is significant.

3. Objectives of the Study

- a. To measure the efficiency of Indian banks by using the DEA model.
- b. To further explore the reasons of inefficiency, whether it is pure technical or scale inefficiency.
- c. To find out whether the difference between efficiency scores of private and public banks is statistically significant or not.

4. Research Methodology

4.1 Sample and Period

Public (26) and private (20) sector banks are taken for the present study from the financial year 2009-10 to 2013-2014. These banks are selected on the basis of their presence in all 5 years of study, others are excluded.

4.2 Data Sources

The data is collected from various sources like CMIE prowess database, financial journals, annual reports of banks and statistical tables relating to banks in India from the RBI website.

4.3 Variables

Mainly three approaches are used for calculating efficiency, namely intermediation, value added and production

approach. Under intermediation approach, financial institutions are seen as intermediators of funds between investors and savers. The intermediation approach is used in this study, with input and output variables used are the same as used by most of the researches in earlier studies.

Table 1. Specification of Variables

<i>S.No.</i>	<i>Variables</i>	<i>Connotation</i>	<i>Measurement</i>
A.	INPUT VARIABLES		
A1	Physical capital	x_1	Fixed assets
A2	Loanable funds	x_2	Deposits and borrowings
A3	Labour	x_3	Number of employees
B.	OUTPUT VARIABLES		
B1	Advances	y_1	Total advances in India and Outside India
B2	Investments	y_2	Total investments in India and Outside India
B3	Non-interest income	y_3	Other income (Commission, exchange, brokerage, etc., Net profit(loss) on sale of investments, Net profit(loss) on revaluation of investments, Net profit(loss) on exchange transactions, Net profit(loss) on sale of land and other assets Miscellaneous receipts

4.4 Tools

4.4.1 Data Envelopment Analysis

Under 1st stage of analysis, efficiency scores have been estimated using the DEA technique for each bank. DEA technique was originally propounded by Charnes, Cooper, and Rhodes in 1978 to measure the efficiency of non-profit public organizations. The DEA technique comprises the employment of linear programming technique to create a piecewise frontier over the actual and chosen input and output data of entities. The entities, referred here are Decision Making Units (DMUs). The piecewise linear combination obtained by connecting a set of best practice entities from sample works as a convex production frontier for other entities in the sample in order to compute and compare efficiencies relative to this surface. It does not need explicit arrangement of practical relations between multiple outputs and multiple inputs (as in regression approaches). The initial model was given by Farrell (1957) which considers single input and output only of an organization. Virtually, these sort of circumstances are infeasible because of the presence of multiple inputs and outputs in relation to unique resources, environmental factors and activities.

Caused by these restrictions, Charnes et al., (1978) proposed a model by reformulating the single input and

output concept to multiple inputs and outputs. The new model had an input orientation and presumed constant returns to scale (CRS). The CRS assumption is only suitable when all DMUs are functioning at an optimal scale. Practically, all DMUs are not able to operate at optimal scale caused by some variables like constraints on financing along with imperfect competition. Subsequently, the usage of the CRS specification delivers only measures of technical efficiency and assumes no relationship between efficiency and scales of operation. This technical efficiency would show whether a bank can produce given amount of outputs through a proportional reduction in the amount of inputs (Isik, 2003). As a result, the VRS specification, introduced by Banker et al., in 1984, has been the generally used specification (D. Delis, 2009). This specification allows the overall technical efficiency (OTE) to get split into two components, namely pure technical efficiency (PTE) along with scale efficiency (SE). PTE is the term for managers' capacity to employ firms' given assets and SE refers to proportional reduction to achieve optimum scale of size. Methodologically, DEA technique converts I inputs of N units into J outputs. Charnes et al., put forward the use of optimization to ease this transforming process. The efficiency is calculated through the ratio of weighted outputs to weighted inputs of that DMU, subject to the condition that efficiency value all other DMUs would be less than or equal to one. That is (Sathye, 2003)-

Subject to

$$\frac{\sum_{j=1}^J u_j^0 y_j^n}{\sum_{i=1}^I v_i^0 x_i^n} \leq 1; \quad n=1, \dots, N,$$

$$v_i^0, u_j^0 \geq 0; \quad i=1, \dots, I; \quad j=1, \dots, J.$$

$$\max e^0 = \frac{\sum_{j=1}^J u_j^0 y_j^0}{\sum_{i=1}^I v_i^0 x_i^0}$$

Where $y_j^n; x_i^n$ are positive well-known outputs in addition to the inputs of the n th DMU and $v_i^0; u_j^0$ are the variable weights to be determined by solving above problem. DEA efficiency scores given to DMU⁰ is the maximum of the objective function e^0 in the above situation. If efficiency

Subject to

$$\sum_{i=1}^I v_i^0 x_i^0 = 1, \quad \sum_{j=1}^J u_j^0 y_j^n - \sum_{i=1}^I v_i^0 x_i^n \leq 0;$$

$$n = 1, \dots, N, \quad v_i^0 \geq \varepsilon, \quad u_j^0 \geq \varepsilon, \quad i = 1, \dots, I,$$

$$\max h^0 = \sum_{j=1}^J u_j^0 y_j^0$$

Where $h^0 = 1$ ensures that DMU⁰ is efficient, otherwise DMU is inefficient (Sathye, 2003). In this paper, both VRS and CRS specifications with input oriented model are used. The DEAP software has been used for measuring efficiency scores.

To investigate the significant difference between public and private banks' efficiency, Mann-Whitney U test is applied. This non-parametric test is used as the normality assumption of population is not satisfied.

5. Findings and Analysis

In this section, empirical findings have been discussed. DEA input oriented analysis is carried out to find the relative efficiency of private and public sector banks. Using the CRS model, overall technical efficiency (OTE) is measured, and pure technical efficiency (PTE) and scale efficiency (SE) is calculated using VRS specification. In addition, Mann-Whitney U test is applied to find the

difference in efficiency scores among private and public banks. Tables 2 and 3 show results related to the objective one and two of the present study respectively, while Table 4 shows empirical findings of the third objective.

5.1 Findings and Analysis Related to Measuring Efficiency and Efficient Frontier

The relative efficiency scores i.e OTE, SE and PTE, for each bank operating from financial year 2009-10 to 2013-14 are shown in Table 2 with the mean, minimum and maximum efficiency scores. In 2010, it was observed that 18 banks (8 public and 10 private banks) were relatively efficient and 28 banks were technically inefficient, with OTE score equal to 1 and less than 1, respectively. The efficient frontier made by banks reduced to 17 in 2011. Public banks were found to be less efficient than they were in 2010 and found no change in private banks. Not only the numbers had been changed, but the configuration of efficient and inefficient public banks also altered yearly. Earlier in 2010, Andhra bank and Vijay bank were not efficient, but in 2011 they were. Similarly State bank of Bikaner & Jaipur, State bank of Patiala and United bank of India were excluded from the list of inefficient banks. In case of private banks, City Union bank and Federal bank were found to be technically inefficient in 2011. For other years, it was found that the efficient frontier of banks had been increased to 25 from 18. Table 3 shows the list. In 2012, the relatively efficient banks included 6 public & 12 private banks. It can be observed that private banks have improved more than public banks. Similarly, in 2013, 10 public and 11 private banks formed the reference set for inefficient banks. However, in 2014, the efficiency of both private and public sector banks improved and formed efficient frontier of 12 private and 13 public banks.

Some private and public banks showed a regular behaviour while others revealed mix behaviour. Following public and private banks continue to be the part of efficient frontier and are forming the reference set for five years, namely (public) Corporation Bank, IDBI Bank, Oriental Bank, (private) Axis Bank, ICICI Bank, ING Vysya Bank, Karnataka Bank, Kotak Mahindra Bank, Nainital Bank, Tamilnad Bank, Ratnakar Bank and Yes Bank. On the other hand, some banks are permanent part of inefficient frontier namely Allahabad Bank, Bank of Maharashtra, Canara Bank, Central Bank of India, Dena Bank, Indian Overseas Bank, Punjab National Bank, UCO Bank,

Union Bank, Catholic Syrian Bank, Development Credit Bank, Dhanlaxmi Bank, Karur Vysya Bank, Lakshmi Vilas Bank.

The efficient banks show that their production process is functioning well without any waste of inputs. It can be noticed that on an average, private banks are relatively efficient than public banks.

5.2 Findings and Analysis Related to Source of Inefficiency

This section deals with analysis related to source of inefficiency. Table 3 reveals the discrimination of banks into efficient and inefficient banks with the possible reasons of their deviations from OTE score. The results show that on the basis of OTE score, the efficient public banks decreased from the year 2010 to 2012 and afterwards they started increasing. Out of 26 public banks, 13 were found to be more efficient in 2014 as compared to 8 in 2010 with mean OTE scores increasing from .970 to .985. The possible reason of increase in efficient banks is the improved scale efficiency of banks. The mean SE score was observed to be .980 in 2009-10. It indicates that the extent of Scale Inefficiency (SIE) in public sector banks has been observed to be nearly 2%. It explains further that 3% of Overall Technical Inefficiency (OTIE) was derived from SIE than Pure Technical Inefficiency (PTIE) i.e. 1%. Similar results were displayed for the year 2010-11 and 2011-12. Afterwards, for the year 2012-13 and 2013-14, SIE contributed 1.1% and .8% out of 2.2% and 1.5% OTIE respectively, another was backed by PTIE. It implies that public sector banks start to operate at optimal scale. While the PTE score revealed that nearly 42% of the banks cut out of the list of efficient banks because of underutilization of inputs in the year 2014 from 2010. In order to achieve economies of scale, public banks need to give more emphasis on technological development, introducing innovative and sophisticated services on par with private banks. It will help banks in reducing their inputs, namely labour, physical capital and loanable funds while producing the same level of outputs. Public banks are attempting to follow the path of comprehensive automation while providing improved service quality, but there is a great path ahead. Moreover, the growing problem of non-performing assets needs to be tackled. However, management of public banks is starting to improve with the introduction of managerial autonomy package by the Government of India on February 22, 2005.

On the other hand, private sector banks' OTIE was mainly obtained due to PTIE. In 2009-10, the average level of PTIE was 1.6% out of 2.33% OTIE. Similar results showed in other years. For the year 2011-12 and 2013-14, only .5% and .6% of OTIE was backed by SIE, the rest 1.67% and .83% were given by PTIE respectively. It shows that efficiency of private sector banks mainly suffered because of inappropriate management practices and less by operating at sub optimal scale size. No doubt, it is observed that PTIE marginally starts reducing. In 2010, the mean of PTE score was .984 which was enhanced to .992 in 2014. Removal of various regulations empowered private banks to attain a high level of capacity utilization. However, results also showed that there is a lack of proper management practices and managers are not paying attention to select appropriate input combinations. Overall, private banks have an edge over public banks in terms of innovation in technology through introducing communication networking system and management information system.

5.3 Findings and Analysis Related to Efficiency Score Differences between Private and Public Banks

This section indicates the empirical result of non-parametric test to find out whether the efficiency difference between private and public banks is statistically significant or not. The results of Mann Whitney U test are shown in Table 4. The null hypothesis will be rejected when the p - value is less than .05, which leads to the acceptance of alternative hypothesis. The difference in the SE scores was found to be significant for the year 2010, 2011 and 2012. It shows that there was difference in efficiency of public and private banks in these years due to scale inefficiency. As regards, OTE and PTE scores, the difference was found to be insignificant. The results of hypothesis testing relating to the year 2011-12, OTE and SE scores were found to be significant whereas PTE showed insignificant results. However, the years 2012-13 and 2013-14, the null hypothesis was rejected for all the efficiency scores and difference was found to be insignificant. The results revealed that on an average, there is an insignificant relationship between ownership and efficiency.

6. Conclusion

This paper empirically estimates the efficiency scores of Indian private and public banks. In five years, on an

average it is found that private sector banks relatively formed the efficient frontier or best practice. Out of 20 private banks, 11 to 12 private banks are continuing to be the part of the efficient frontier. However, the configuration of these efficient banks may vary with the time. Some of private banks outstandingly performed for these 5 years, namely Axis Bank, ICICI Bank, Karnataka Bank, Kotak Mahindra Bank, Nainital Bank, Tamilnad Bank, Ratnakar Bank and Yes Bank. For the second objective, it is concluded that inefficiency on the part of management has been the main cause of overall technical

inefficiency for private banks whereas scale inefficiency was less governing. In public sector banks it is observed that till 2011–12, scale inefficiency was the main reason for OTIE. Afterwards, PTIE took the lead from being a major part for OTIE. The results clearly indicate that our Indian banking industry is mainly suffering because of unsuitable managerial practices rather than operating at a sub - optimal level. The empirical results for the third objective show that difference in OTE scores is insignificant except for the year 2011–12. Similarly, difference in SE scores was found to be significant except for the years 2012–13 and 2013–14. On the other hand,

the PTE score difference between public and private banks is insignificant for all five years. It concludes that ownership has an impact on Indian banks in relation to scale efficiency.

Table 2. Efficiency Scores (OTE, PTE and SE) of Public and Private Banks from the Years 2009-10 to 2013-2014

DMU no.	Name of the bank	2014			2013			2012			2011			2010		
		OTE	PTE	SE	OTE	PTE	SE	OTE	PTE	SE	OTE	PTE	SE	OTE	PTE	SE
	Public sector banks															
1	State Bank of Bikaner & Jaipur	1	1	1	1	1	1	1	1	1	0.973	1	0.973	1	1	1
2	State Bank of Hyderabad	1	1	1	1	1	1	0.978	1	0.978	0.946	1	0.946	0.982	1	0.982
3	State Bank of India	1	1	1	1	1	1	0.99	1	0.99	1	1	1	1	1	1
4	State Bank of Mysore	0.978	0.979	0.999	0.957	0.97	0.987	0.948	0.967	0.981	0.93	0.99	0.939	0.998	1	0.998
5	State Bank of Patiala	0.983	0.983	1	1	1	1	0.971	0.972	0.999	0.97	0.993	0.977	1	1	1
6	State Bank of Travancore	0.994	0.995	0.999	0.991	0.991	1	0.972	0.972	1	1	1	1	1	1	1
7	Allahabad Bank	0.974	0.991	0.983	0.962	0.966	0.996	0.952	0.997	0.955	0.939	0.985	0.953	0.963	1	0.963
8	Andhra Bank	0.986	0.994	0.992	1	1	1	1	1	1	1	1	1	0.947	0.992	0.955
9	Bank of Baroda	1	1	1	1	1	1	1	1	1	0.999	1	0.999	0.985	1	0.985
10	Bank of India	1	1	1	0.972	1	0.972	0.961	0.99	0.97	0.939	1	0.939	0.94	0.982	0.958
11	Bank of Maharashtra	0.985	0.988	0.996	0.955	0.962	0.992	0.928	0.94	0.987	0.902	0.963	0.936	0.891	0.911	0.978

DMU no.	Name of the bank	2014			2013			2012			2011			2010		
		OPE	PTE	SE	OPE	PTE	SE	OPE	PTE	SE	OPE	PTE	SE	OPE	PTE	SE
12	Canara Bank	0.941	1	0.941	0.944	1	0.944	0.949	1	0.949	0.948	1	0.948	0.983	1	0.983
13	Central Bank of India	0.959	1	0.959	0.947	0.965	0.981	0.928	0.976	0.951	0.892	0.957	0.933	0.869	0.944	0.92
14	Corporation Bank	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	Dena Bank	0.979	0.98	0.999	0.924	0.925	0.999	0.974	1	0.974	0.936	1	0.936	0.941	1	0.941
16	IDBI Bank Ltd.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	Indian Bank	1	1	1	1	1	1	0.976	1	0.976	0.976	1	0.976	0.999	1	0.999
18	Indian Overseas Bank	0.95	0.955	0.996	0.951	0.966	0.985	0.939	0.96	0.978	0.918	0.971	0.946	0.923	0.955	0.967
19	Oriental Bank of Commerce	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	Punjab and Sind Bank	1	1	1	0.985	0.985	0.999	0.968	0.972	0.996	0.976	0.982	0.994	0.955	0.958	0.997
21	Punjab National Bank	0.957	1	0.957	0.97	1	0.97	0.945	0.996	0.949	0.938	1	0.938	0.971	1	0.971
22	Syndicate Bank	1	1	1	0.972	1	0.972	0.953	1	0.953	0.974	1	0.974	0.981	1	0.981
23	UCO Bank	0.967	0.972	0.995	0.948	0.99	0.958	0.93	0.961	0.968	0.91	1	0.91	0.966	1	0.966
24	Union Bank of India	0.979	0.99	0.989	0.988	1	0.988	0.988	1	0.988	0.984	1	0.984	0.953	0.985	0.967
25	United Bank of India	1	1	1	0.937	0.942	0.994	0.933	0.937	0.995	0.889	0.942	0.943	1	1	1
26	Vijaya bank	1	1	1	0.946	0.948	0.998	0.953	0.965	0.987	1	1	1	0.98	1	0.98
	Mean	0.985	0.9933	0.992	0.975	0.985	0.989	0.966	0.984	0.981	0.959	0.991	0.967	0.970	0.990	0.980
	Minimum	0.941	0.955	0.941	0.924	0.925	0.944	0.928	0.937	0.949	0.889	0.942	0.91	0.869	0.911	0.92
	Maximum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Private sector banks															
27	Axis Bank	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	Catholic Syrian Bank Ltd	0.968	1	0.968	0.926	0.951	0.974	0.903	0.924	0.977	0.874	0.892	0.98	0.921	0.939	0.981
29	City Union Bank Ltd	1	1	1	0.997	1	0.997	1	1	1	0.92	0.926	0.994	1	1	1
30	Development Credit Bank Ltd	0.994	1	0.994	0.938	1	0.938	0.965	1	0.965	0.947	1	0.947	0.977	1	0.997
31	Dhanlaxmi Bank	0.885	0.931	0.951	0.906	0.917	0.988	0.894	0.896	0.997	0.848	0.894	0.948	0.928	0.936	0.992
32	Federal Bank	0.999	1	0.999	0.982	0.992	0.99	0.979	0.989	0.99	0.964	1	0.964	1	1	1

DMU no.	Name of the bank	2014			2013			2012			2011			2010		
		OTE	PTE	SE	OTE	PTE	SE	OTE	PTE	SE	OTE	PTE	SE	OTE	PTE	SE
33	HDFC Bank	1	1	1	1	1	1	1	1	1	1	1	1	0.977	1	0.977
34	ICICI Bank	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
35	Indusind Bank	1	1	1	1	1	1	0.988	1	0.988	0.934	0.954	0.979	0.926	0.926	1
36	ING Vysya Bank	0.97	0.972	0.997	0.981	0.986	0.995	0.95	0.951	0.999	0.974	0.976	0.998	0.939	0.941	0.997
37	Jammu Kashmir Bank Ltd	1	1	1	1	1	1	1	1	1	1	1	1	0.969	1	0.969
38	Karnataka Bank Ltd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
39	KarurVysya Bank	0.964	0.965	1	0.956	0.963	0.993	0.957	0.958	0.999	0.956	0.976	0.979	0.985	0.985	1
40	Kotak Mahindra Bank Ltd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
41	Lakshmi Vilas Bank	0.966	0.991	0.976	0.944	0.958	0.986	0.938	0.949	0.988	0.871	0.895	0.973	0.936	0.947	0.988
42	Nainital Bank	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
43	South Indian Bank	0.974	0.975	0.999	0.936	0.939	0.997	1	1	1	0.936	1	0.936	0.964	1	0.964
44	Tamilnad Mercantile Bank Ltd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
45	The Ratnakar Bank Ltd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
46	Yes Bank Ltd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.986	0.991	0.994	0.978	0.985	0.992	0.978	0.983	0.995	0.961	0.975	0.984	0.976	0.984	0.993
	Minimum	0.885	0.931	0.951	0.906	0.917	0.938	0.894	0.896	0.965	0.848	0.892	0.936	0.921	0.926	0.964
	Maximum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 3. Discrimination and Sources of OTIE

DMUs Efficient (2014)	DMUs Inefficient	Reason(s) for inefficiency	DMUs Efficient (2013)	DMUs Inefficient	Reason(s) for inefficiency	DMUs Efficient (2012)	DMUs Inefficient	Reason(s) for inefficiency	DMUs Efficient (2011)	DMUs Inefficient	Reason(s) for inefficiency	DMUs Efficient (2010)	DMUs Inefficient	Reason(s) for inefficiency
Public banks	Public banks		Public banks	Public banks		Public banks	Public banks		Public banks	Public banks		Public banks	Public banks	
1	4	MI & SI	1	4	MI & SI	1	2	SI	3	1	SI	1	2	SI
2	5	M	2	6	MI	8	3	SI	6	2	SI	3	4	SI
3	6	MI & SI	3	7	MI & SI	9	4	MI & SI	8	4	MI & SI	5	7	SI
9	7	MI & SI	5	10	SE	14	5	MI & SI	11	5	MI & SI	6	8	MI & SI
10	8	MI & SI	8	11	MI & SI	16	6	MI	14	7	MI & SI	14	9	SI
14	11	MI & SI	9	12	SI	19	7	MI & SI	16	9	SI	16	10	MI & SI

DMUs Efficient (2014)	DMUs Inefficient	Reason(s) for inefficiency	DMUs Efficient (2013)	DMUs Inefficient	Reason(s) for inefficiency	DMUs Efficient (2012)	DMUs Inefficient	Reason(s) for inefficiency	DMUs Efficient (2011)	DMUs Inefficient	Reason(s) for inefficiency	DMUs Efficient (2010)	DMUs Inefficient	Reason(s) for inefficiency
Public banks	Public banks		Public banks	Public banks		Public banks	Public banks		Public banks	Public banks		Public banks	Public banks	
16	12	SI	14	13	MI & SI		10	MI & SI	19	10	SI	19	11	MI & SI
17	13	SI	16	15	MI & SI		11	MI & SI		12	SI	25	12	SI
19	15	MI & SI	17	18	MI & SI		12	SI		13	MI & SI		13	MI & SI
20	18	MI & SI	19	20	MI & SI		13	MI & SI		15	SI		15	SI
22	21	SI		21,22,24	SI		15	SI		17	SI		17	SI
25,26	23,24	MI & SI		23,25,26	MI & SI		17	SI		18	MI & SI		18	MI & SI
Private banks							18	MI & SI		20	MI & SI		20	MI & SI
27	28	SE		25	MI & SI		20	MI & SI		21	SI		21	SI
29	30	SE		26	MI & SI		21	MI & SI		22	SI		22	SI
33	31	MI & SI	Private banks				22	SI		23	SI		23	SI
34	32	SE	27	28	MI & SI		23	MI & SI		24	SI		24	MI & SI
35	36	MI & SI	33	29	SI		24	SI		25	MI & SI		26	SI
37	39	MI	34	30	SI		25	MI & SI	Private banks			Private banks		
38	41	MI & SI	35	31	MI & SI		26	MI & SI	26	28	MI & SI	27	28	MI & SI
40	43	MI & SI	37	32	MI & SI	Private banks			27	29	MI & SI	29	30	SI
42			38	36	MI & SI	27	28	MI & SI	33	30	SI	32	31	MI & SI
44			40	39	MI & SI	29	30	SI	34	31	MI & SI	34	33	SI
45			42	41	MI & SI	33	31	MI & SI	37	32	SI	38	35	MI
46			44	43	MI & SI	34	32	MI & SI	38	35	MI & SI	40	36	MI & SI
			45			37	35	SI	40	36	MI & SI	42	37	SI
			46			38	36	MI & SI	42	39	MI & SI	44	39	MI
						40	39	MI & SI	44	41	MI & SI	45	41	MI & SI
						42	41	MI & SI	45	43	SI	46	43	SI
						43, 44, 45, 46			46					

DMU* Decision Making Unit, MI* Managerial Inefficiency, SI* Scale Inefficiency

Table 4: Results of Statistical Test Performed on Efficiency Scores to Assess Difference between Private and Public Banks

Efficiency measure	p-value of Mann-Whitney U Test	Acceptance/ Rejection of Alternate Hypothesis	Conclusion
2013-14			
OTE	.578	Reject H ₁	Difference is not significant
PTE	.558	Reject H ₁	Difference is not significant
SE	.456	Reject H ₁	Difference is not significant
2012-13			
OTE	.522	Reject H ₁	Difference is not significant
PTE	.722	Reject H ₁	Difference is not significant
SE	.348	Reject H ₁	Difference is not significant
2011-12			
OTE	.046	Accept H ₁	Difference is significant
PTE	.472	Reject H ₁	Difference is not significant
SE	.005	Accept H ₁	Difference is significant

Efficiency measure	p-value of Mann-Whitney U Test	Acceptance/ Rejection of Alternate Hypothesis	Conclusion
2010-11			
OTE	.467	Reject H ₁	Difference is not significant
PTE	.425	Reject H ₁	Difference is not significant
SE	.028	Accept H ₁	Difference is significant
2009-10			
OTE	.486	Reject H ₁	Difference is not significant
PTE	.625	Reject H ₁	Difference is not significant
SE	.023	Accept H ₁	Difference is significant

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