Performance Efficiency of Selected Private Sector Banks in India Using Data Envelopment Analysis

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Abstract:
Liberalization of banking sector in India was noticed in early 1990 s when India adopted a new economic policy for the development of nation. The banking reform package was based on the recommendations proposed by the Narasimham Committee Report (1992) that advocated a move to a more market oriented banking system, which would operate in an environment of prudential regulation and transparent accounting, expecting banks to usher overall efficiency, to improve the profitability and overall financial health in the banks. This re energized Indian Banking Sector with rapid economic growth and strong contribution from all sectors of banks – public banks, private banks and foreign banks. The emergence of private sector banks in India has developed tough competition among them in terms of interest rates, wide range of products and services, customer service etc. Research studies focusing on the efficiencies of private sector banks are essential in today, s scenario where the competition is very vulnerable. The study focuses on analyzing the performance efficiencies of selected private sector banks using Data Envelopment Analysis (DEA). DEA was used to analyse the relative efficiency of banks for the year 2012 -13. Cross efficiency matrix was used to identify the most efficient bank.

Keywords: Data Envelopment Analysis (DEA), Private Sector banks, Performance Efficiency

1. Introduction

Financial intermediation plays a vital role in the economic growth of a country. In India commercial banks play significant role in the process of financial intermediation. Indian banking sector has seen incredible changes and substantially grown over the past few decades. Banking in India originated in the last decades of the 18th century and travelled various phases witnessing significant structural and dimensional changes over a period of time. After independence the Banking Regulation Act was passed in 1949 providing the legal framework for regulating banking system, by the Reserve Bank of India (RBI). With the objective of growth, reduction in imbalance of economic activity, extending banking facilities to the rural and semi urban areas and to bring the large area of economic activity under organised banking system, 14 major Indian scheduled commercial banks were nationalized on 19th July 1969 and on 15th April 1980 six more private sector banks were nationalized . The rapid growth of the Indian banking system gave rise to several problems like low operational efficiency, low profitability, unsatisfactory customer service etc. Liberalization of banking sector in India was noticed in early 1990 s when India adopted a new economic policy for the development of nation. This re energized Indian Banking Sector with rapid economic growth and strong contribution from all sectors of banks – public banks, private banks and foreign banks.

Banking in India was dominated by public sector banks since when all major banks were nationalized by the Indian government. Because of liberalization in government banking policy, old and new private sector banks have re – emerged. Private sector banks are split into two groups by the financial regulators in India, old and new. The banks, which were not nationalized at the time of bank nationalization are known to be old private sector banks. They were not nationalized, because of their small size and regional focus. The banks, which came into operation after 1991, with the introduction of financial sector reforms are called as new private sector banks. They have grown faster and bigger over the past two decades using latest technology and providing contemporary innovations. Private sector banks in India have successfully capitalized on the growth of Indian economy. They have a market share of 20 percent

in deposits and advances.[1] More than acquiring market share the private sector banks has transformed the way of banking is done in India.

Deregulation of interest rates and adoption of technology infused completion among banks. Several measures were taken to strengthen the supervisory functions to ensure the implementation of prudential regulation and focus on customer service. Because of the intense competition within the banking industry and from non banks and capital market, banks started seeking new sources of income by offering variety of services. Ownership and governance of banks assume greater importance as they deploy large amounts of public funds. The private banking sector now operates in a more competitive environment with relatively large volume of financial flows and more innovative products. In such a scenario analyzing the efficiency of these private sector banks is essential to know their effective utilization of their resources.

2. Problem Statement

The emergence of private sector banks in India has developed tough competition among them in terms of interest rates, wide range of products and services, customer service, etc. These banks are striving to achieve their maximum efficiency by utilizing their resources effectively. In the interest of the economy and also to improve efficiency of these banks, it is necessary to study their performance efficiency and find ways to enhance their efficiency. The concept of efficiency has many dimensions and there are several measures of efficiency in use, from simple output/input ratio to factor productivity. A commercial bank is an entity where it plays a role of intermediating funds between savers and investors, wherein the inputs of the bank are essentially financial capital (i.e. the deposits collected and the funds borrowed), and outputs are measured by the volume of advances and investments. A bank is said to be technically efficient if it produces more outputs using less input resources. To achieve maximum efficiency banks should have effective utilization of their resources. Thus the bank management requires planning, continuous monitoring and evaluation. Identification and implementation of appropriate strategies is imperative to enhance their performance. Adoption of technology and innovations in banking sector had produced intense competition and tremendous growth in the past decade. Several research studies focused on the Indian banking sector dealt about analyzing their financial performance based on ratios and other empirical analysis. Research studies focusing on the efficiencies of private sector banks are essential in today, s scenario where the competition is very vulnerable. The study focuses on analyzing the performance efficiency of selected private sector using Data Envelopment Analysis.

3. Objectives of the Study

    i.   To study the performance efficiency of selected private sector banks in India for the year 2012 – 13,using Data Envelopment Analysis

    ii.   To identify the most efficient bank for the year 2012 -13

4. Review of Literature

- RBI Publications (2013)[2] on "Analysis of efficiency in the Indian banking Sector using the data envelopment analysis" the trend in improvement in efficiency in the Indian banking Sector was estimated using DEA. Here DEA is based on Intermediation approach. Under this approach, banks are regarded as financial intermediaries that use a certain set of inputs to create a set of outputs. Accordingly, inputs have been taken as deposits, borrowings and operating expenses to produce earning assets (comprising loans and investments) as outputs. The period of analysis is from 2000 to 2013 capturing the high growth phase and current phase of slowdown in macroeconomic and banking sector activity.

- Eken (2013)[3] evaluated the efficiency of Turkish banks using SBM (Slacks based Model) of DEA, where inputs are selected to be risks and outputs are profitability ratios, the risk efficiency of 20 Turkish commercial banks is benchmarked under four alternative models. The results indicate that profitability of banks is not necessarily in parallel with their risk-taking preferences. While the profitability of one bank may be better than that of others, the risk efficiency may not be the same. By comparing a bank's risk efficiency with its competitors, it can be determined whether the profitability of the bank is reasonable compared to its risk levels. DEA is an effective benchmarking tool for such a comparison.

- Ar and Kurtaran (2013)[4] measured the relative efficiency of 13 commercial banks in Turkey for the year of 2011 with an integrated approach includes Analytic Hierarchy Process and Data Envelopment Analysis. It uses two inputs (personnel expenditures and number of branch) and four outputs (deposits-national currency, deposits-foreign currency and precious metal, cash loans, and non-cash loans) in terms of production approach. According to empirical result, state-owned commercial banks are efficient in both CCR (Charnes-Cooper-Rhodes) and BCC (Banker-Charnes-Cooper) model. However, foreign-owned commercial banks have the lower efficiency scores than both state-owned and private-owned commercial

[1] Priya (2014). "An Analysis of Profitability Position of Private Sector Banks In India" ,International Journal of Business and Management Invention,3(2):45-53

[2] Reserve Bank of India (2013). "Analysis of Efficiency in the Indian Banking Sector using the Data Envelopment Analysis". Report on trend and Progress of banking in India 2012 -13:Chapter IV:64

[3] Mehmet H. Eken (2013). "Evaluating the Efficiency of Turkish Banks: A Risk and Profitability Approach", JCC: The Business and Economics Research Journal, 6(1):53-68

[4] Ilker Murat and Ahmet Kurtaran (2013). "Evaluating the Relative Efficiency of Commercial Banks in Turkey: An Integrated AHP/DEA Approach", International Business Research, 6(4):129-146

banks. The results also suggest that inefficient banks should especially improve their non-cash loans and should focus on their annual personnel expenditure. Moreover, more than half of the commercial banks are scale inefficiency. The results of the study may be useful for the bank managers in assessing their performance.

- Sekhri (2011)[5] compared the efficiency and productivity of public sector banks relative to private banks and foreign banks. This comparison is attempted over a six-year period (2004-09). The results of this study have been calculated both year-wise and sector-wise. While comparing banks on a year-wise basis, it has been found that the TFP index of the foreign banks was low compared to the private and the public sector banks between the period 2004-05 and 2005-06, but the TFP index of the foreign banks has increased after 2006. The main reason being that the technical productivity of the foreign banks has increased over the years as compared to private and public sector banks. This has also been the reason for the better performance of foreign banks when the banks were compared sector-wise. The other reason for the better performance of foreign banks is that the scale index of foreign banks and private banks has increased but that of the public sector banks has fallen down slightly. But contrary to the thinking, the public sector banks have fared well than their private and foreign counterparts in pure efficiency change index. The pure efficiency index of private and foreign banks has fallen over the years but that of public sector banks has increased because of the steps taken by the public sector banks to improve the quality of their services and technological advancements. The foreign sector banks have grown faster than the public sector banks and the private banks over the last few years.

- Akhtar (2010)[6] assessed the efficiency of commercial banks across Pakistan for the years from 2001 to 2006 by using Data Envelopment Analysis (DEA). The average efficiency scores of banks across Pakistan appear to be low. Foreign banks tend to perform better than those of the local banks in Pakistan, both private and public. However, private local banks perform better than those of their counterparts in the public sector. Furthermore, findings of the research say that foreign banks appear to be overcoming the cross-border disadvantages. This might be surfacing out of their superior investment strategies, advanced management techniques, and better-quality services to their clients. On the contrary, Pakistani commercial banks fail to support the home field, where local banks are expected to perform more efficiently than those from abroad. This might be due to concentrating on servicing the retail markets only, existence of competition in the banking industry, rising interest rates, higher levels of non-interest and administrative expenses, pursuing less sophisticated investment strategies, and providing less competitive managerial services to their clients.

- Lin (2009)[7] took 117 branches of a certain bank in Taiwan in 2006 as the research subject and introduces data envelopment analysis (DEA) to evaluate the operating performances of business units of this bank to provide the reference for a bank's managers in determining operation strategies. The result indicates that, in overall technical efficiency, the case bank has many inefficient branches distinctly; the average overall technical efficiency of branches is 54.8% and the average pure technical efficiency of branches is 67%, which was probably because of lower loan-to-deposit ratio, leading to excessive input waste. The average scale efficiency of the case bank during the sample period is 82%. The ratio of resource waste due to technical inefficiency is 45.2%, of which 55.03% is due to pure technical inefficiency

- Liang (2008)[8] used a cross efficiency evaluation as a extension of DEA, which not only provides a ranking among the DMUs but also eliminates unrealistic DEA weighting schemes without requiring a prior information on weight restrictions. A factor that possibly reduces the usefulness of the cross-efficiency evaluation method is that the cross-efficiency scores may not be unique due to the presence of alternate optima. As a result, it is recommended that secondary goals be introduced in cross-efficiency evaluation.

- Nenovsky (2008)[9] analyzed the efficiency of Bulgarian banking system and the study covers only the period of 1999-2006 because of the lack of consistent available data prior 1999. During the analyzed period the impact on the bank efficiency of the following factors is studied: change in property, penetration of the foreign commercial banks on the local banking market, competition, structure of bank assets and liabilities, central bank policy in respect to credit activity, etc. Different specifications of DEA like intermediation and operating approaches were applied to separate groups and sub-groups. The results show that the foreign banks perform better than domestic and state-owned banks because of the technological and managerial improvements and the large banks are more efficient than the small banks due to decreasing operating costs and scale economies.

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[5]Vidya Sekhri (2011). "A DEA and Malmquist Index Approach to Measuring Productivity and Efficiency of Banks in India", The IUP Journal of Bank Management, 10(3):49 - 63

[6] Mohammad Hanif Akhtar (2010). "X-Efficiency Analysis of Pakistani Commercial Banks", International Management Review, 6(1):12-23

[7] Tyrone T. Lina,Chia-Chi Leeb and Tsui-Fen Chiua (2008). "Application of DEA in analyzing a bank's operating performance", Expert Systems with Applications,36(5):8883–8891

[8] L. Lianga, J. Wua, W.D. Cook and J. Zhu (2008). "Alternative secondary goals in DEA cross-efficiency evaluation", International Journal of Production Economics, 113(2):1025-1030

[9] Nikolay Nenovsky, Petar Chobanov, Gergana Mihaylova and Darina Koleva (2008). "Efficiency of the Bulgarian Banking System: Traditional Approach and Data Envelopment Analysis", Working Paper Series, Agency for Economic Analysis and Forecasting, 2008

- Chen, Skully, and Brown (2005)[10] examine the cost, technical and allocative efficiency of 43 Chinese banks over the period 1993 to 2000. The goal of this analysis is to identify the change in Chinese banks' efficiency following the program of deregulation initiated by the government in 1995. Results show that the large state-owned banks and smaller banks are more efficient than medium sized Chinese banks. In addition, technical efficiency consistently dominates the allocative efficiency of Chinese banks. The financial deregulation of 1995 was found to improve cost efficiency levels including both technical and allocative efficiency.

5. Research Methodology

The Exploratory research design was adopted due to the nature of the study. The main purpose of such studies is that of formulating a problem for more precise investigation or of developing the working hypotheses from an operational point of view. The major emphasis in such studies is on the discovery of ideas and insights. As such the research design appropriate for such studies must be flexible enough to provide opportunity for considering different aspects of a problem under study.[11] The study is based on the secondary data which is collected from the annual publications of RBI "A Profile of Banks" and CMIE Prowess 4.The study is covered for nine years from the year 2004 - 05 to 2012 - 2013.

Commercial banking in India has three important segments namely Public Sector banks, Private Sector banks and Foreign banks. For the purpose of study Private Sector banks in India is chosen for the reason that after liberalization the growth of these banks were rapid and they face several risks with deregulation, competition and customer service. At present in India there are 20 private sector banks operating out of which 13 banks are categorized as Old Private Sector and 7 come under the category of New Private Sector banks. The Old private sectors banks are Catholic Syrian Bank Ltd, City Union Bank Ltd , Dhanalakshmi Bank Ltd, Federal Bank Ltd, ING Vysya Bank Ltd, Jammu & Kashmir Bank Ltd, Karnataka Bank Ltd, Karur Vysya Bank Ltd, Lakshmi Vilas Bank Ltd, Nainital Bank Ltd, Ratnakar Bank Ltd, South Indian Bank Ltd, Tamilnad Mercantile Bank Ltd and New Private Sector Banks are Axis Bank Ltd, Development Credit Bank Ltd, HDFC Bank Ltd, ICICI Bank Ltd, IndusInd Bank Ltd, Kotak Mahindra Bank Ltd and Yes Bank Ltd.[12] The judgement sampling technique was adopted for drawing the banks to be dealt with for the purpose of this study. In this type of sampling, the items for the sample are selected deliberately by the researcher; his choice concerning the items remains supreme.[13] From 20 private sector banks 9 banks were selected whose total of input and output variables are neither too low nor too high.
 The purpose of the study to analyse the performance efficiencies of selected private sector Banks in India using Data Envelopment Analysis (DEA). DEA is applicable to any Decision Making Units (DMUs) but these banks are selected because they are in the growing phase and play a critical role in the development of the country.

6. Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a relatively new "data oriented" approach for evaluating the performance of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs. It is based upon application of linear programming technique used in evaluating the performances of different kinds of entities such as hospitals, Air Force wings, Universities, Business firms, Banks etc. that perform same function in terms of resources they use and outputs they produce. In banks they accept deposits, provide loans and all facilities to customers related to their basic functions.

The estimated measures of efficiency are proposed to reveal the effective utilization of their resources at the unit or maximizing the output without any additional resources in the inputs. The efficiencies assessed are relative because they reflect the scope for resource conservation or output maximization at one unit relative to other comparable units. In the past DEA has been extensively used to assess many profit making institutions which are considered as the primary goal of any business. But these days other factors have also gained importance for assessing the performance of any unit. DEA is used widely as a technique to assess the relative efficiency and find the most the efficient bank based on the efficiency scores. The bank that attains the efficiency scores of 1lie in the efficient frontier otherwise the bank lie below the efficient frontier.

The basic efficiency measure in DEA is the ratio of total outputs to total inputs both in money values

        Efficiency = Output/ Input

By convention, x and y represent vectors of inputs and outputs, respectively. The subscripts i and j represent particular inputs and outputs respectively. Thus x_i represents the ith input, and y_j represents the jth outputs of a decision making unit. The total number of inputs and outputs be represented by I and J respectively, where I, J>0.

In DEA, multiple inputs and outputs are linearly aggregated using weights. Thus the virtual input (because of aggregating/ adding dissimilar inputs e.g. no of staffs, floor size of the bank etc) of a firm is obtained as the linear weighted sum of all its inputs.

$$\sum_{i=1}^{I} u_i x_i$$

…………………………………………….(1)

Where $u_i$is the weight assigned to input x_i during th aggregation. Similarly, the virtual output of a firm is obtained as the linear weighted sum of all its outputs.

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[10] Chen, Skully and Brown (2005). "Banking efficiency in China: Application of DEA to pre- and post-deregulation eras: 1993–2000", China Economic Review, 16:229–245

[11] C.R. Kothari (2011). Research Methodology: Methods and Techniques",(New Age International): 35-36

[12]Department of financial services, Ministry of Finance, Government of India
http://financialservices.gov.in/banking/ListofPrivateSectorBanks.asp?pageid=1

[13] C.R. Kothari (2011). Research Methodology: Methods and Techniques",(New Age International): 59

$$\sum_{j=1}^{J} v_j\, y_j$$

………………………………………………(2)

Where v_j is the weight assigned to output y_j during the aggregation. Given these virtual inputs and outputs, the efficiency of the DMU in converting the inputs to outputs can be defined as the ratio of outputs to inputs.

Efficiency = Virtual Output/ Virtual Input

$$E = \frac{\sum_{j=1}^{J} v_j y_j}{\sum_{i=1}^{I} u_i x_i} = R_{ij}$$

………………………………… (3)

Where R_{ij} is the ratio of total output to total input in value terms.

Obviously, the most important issue at this stage is the assignment of weights, and there is no unique set of weights. The weight for a DMU is determined using mathematical programming, as those weights that maximize its efficiency subject to the condition that the efficiencies of other DMUs (calculated using the same set of weights) are restricted to values between zero and one. The DMU for which the efficiency is maximized is normally termed as the reference or base DMU or the DMU under the assessment.

6.1. Selection of Inputs and Outputs

The Selection of inputs and outputs for the application of DEA is a challenging task. The criteria for selecting the inputs and outputs are quite subjective. There is no specific rule in determining the procedure for selection of inputs and outputs and for the present study the selection of inputs and outputs is based on the review of literature. Inputs are defined as the resources utilized by the DMUs and the outputs are the benefits generated as the result of their operation.

From the literature the prior researchers in such analysis prefer the intermediation approach is best suited for analyzing bank level efficiency.[14] In the existing studies relating to measurement of efficiency of banks, intermediation approach has been widely adopted when compared to other approaches. Banks are viewed as intermediaries in intermediation approach. Each output is measured in value and not in number of transactions. Therefore, banks are seen as primarily intermediating funds between savers and investors. There is no unique recommendation on what should be considered the proper set of inputs and outputs.[15]

Intermediation approach is selected for the present study, under this approach; banks are regarded as financial intermediaries that use a certain set of inputs to create a set of outputs. Accordingly, inputs have been taken as deposits, borrowings and operating expenses to produce earning assets (comprising advances and investments) as outputs.[16]

The following variables were used for the study

6.2. Inputs Variables

Deposits

Borrowings

Operating Expenses

6.3. Output Variables

Investments

Advances

6.4. Cross Efficiency

Cross efficiency methods evaluate the performance of DMUs with the respect of optimal input and output weights (v_j and u_i) of the other DMUs. The resulting evaluations can be aggregated in a Cross Efficiency Matrix (CEM).In the CEM, the element in the ith row and j[th] column represents the efficiency of DMU_i when evaluated with the optimal weights of DMU_j. A DMU which is a good overall performer should have several high cross efficiency scores in its row. On the other hand the poorly performing DMU would have low scores in its row. The row means can be computed to effectively differentiate between good and poor performers.[17]

7. Results and Discussion

Based on the total of input and output variables nine banks were selected for analysis. The selection of banks was based on the total of input and output variables of the banks. The below table 1 and 2 depicts the details

[14] Berger, A.N., Hanweck, G.A., Humphrey, D.B., (1987). "Competitive viability in banking Scale, Scope and Product Mix Economies". Journal of Monetary Economics (20): 501-520.

[15] Roberta B. Stauba, Geraldo da Silva Souzab and Benjamin M. Tabak (2010). "Evolution of bank efficiency in Brazil: A DEA approach", European Journal of Operational Research,202(1):204–213

[16] Reserve Bank of India (2013). "Analysis of Efficiency in the Indian Banking Sector using the Data Envelopment Analysis". Report on trend and Progress of banking in India 2012 -13

[17] A. Boussofiane, R.G. Dyson and E. Thanassoulis (1991). "Applied data envelopment analysis". European Journal of Operational Research, 52(1):1-15.

To apply DEA and to find the most efficient DMU the sample size of DMUs should be comparable in size. DEA analyst should be cautious not to increase the number of units very large and make the analysis too wide.[18] The number of DMUs is expected to be larger than the product of number of inputs and outputs in order to discriminate effectively between efficient and inefficient DMUs. But there are many reviews stating DEA used with small sample sizes.[19]

From 20 private sector banks 9 banks were selected whose total of inputs and outputs were neither too low nor too high. The total ranges from Rs 20110 Crores to Rs 908611 Crores since the magnitude of their business is too wide and vary largely.

Rs In Crores			
Bank	Total Inputs	Total Outputs	Total
Development Credit Bank Ltd	10165	9945	20110
Ratnakar Bank Ltd	11305	11948	23253
Catholic Syrian Bank Ltd	12873	12153	25025
Dhanalakshmi Bank Ltd	13134	12462	25595
Nainital Bank Ltd	3811	22588	26399
Lakshmi Vilas Bank Ltd	16437	16027	32464
Tamilnad Mercantile Bank Ltd	20893	21604	42497
City Union Bank Ltd	24524	20513	45036
Karnataka Bank Ltd	38302	38640	76942
Karur Vysya Bank Ltd	43415	43317	86732
South Indian Bank Ltd	46314	44339	90653
ING Vysya Bank Ltd	49118	50050	99168
Federal Bank Ltd	63981	65251	129233
IndusInd Bank Ltd	65333	63975	129307
Jammu & Kashmir Bank Ltd	66285	64941	131226
Kotak Mahindra Bank Ltd	73649	77342	150992
Yes Bank Ltd	89212	89976	179188
Axis Bank Ltd	303479	310704	614182
HDFC Bank Ltd	340490	351334	691824
ICICI Bank Ltd	446968	461643	908611

Table 1: Total of Input and Output Variables

Rs In Crores			
Bank	Total Inputs	Total Outputs	Total
Karnataka Bank Ltd	38302	38640	76942
Karur Vysya Bank Ltd	43415	43317	86732
South Indian Bank Ltd	46314	44339	90653
ING Vysya Bank Ltd	49118	50050	99168
Federal Bank Ltd	63981	65251	129233
IndusInd Bank Ltd	65333	63975	129307
Jammu & Kashmir Bank Ltd	66285	64941	131226
Kotak Mahindra Bank Ltd	73649	77342	150992
Yes Bank Ltd	89212	89976	179188

Table 2: Banks Selected based on Input and Output Variables

8. Data Envelopment Analysis

DEA is the tool used to assess the relative efficiency of units; in this study relative efficiency of nine private sector banks is analysed. The variables stated above are used for the study. As the first step, the efficiency of the banks is arrived at using DEA taking each bank amongst the group of banks as the reference bank.

Initially Federal bank was taken as reference bank and found that IndusInd bank and Kotak Mahindra bank attained efficiency score of 1 along with Federal bank. Yes bank and Jammu & Kashmir attained a score of 0.79 and 0.85 respectively which is less when compared to their other banks. The same scores were attained by all banks when IndusInd bank and Kotak Mahindra bank taken as

[18]Suresh Kumar (2009). "Data Envelopment Analysis to evaluate Performance of a Private Sector Commercial Bank" Ph.D., Thesis (Unpublished), Department of Management Studies and Research, Coimbatore Institute of Management and Technology, Coimbatore
[19]Ali F. Darrat, Can Topuz, TarikYousef (2002). " Assessing Cost and Technical Efficiency of Banks in Kuwait". ERF's 8th Annual Conference in Cairo, ERF, Cairo, Egypt. http://www.erf.org.eg/CMS/uploads/pdf/1194082688_Assessingcost-Darrat&Yousef.pdf

reference bank. Tables 3, 4 and 9 show the efficiency scores of all banks when Federal bank, IndusInd bank and Kotak Mahindra bank taken as reference banks

Bank	Output (Rs in Crores)		Input (Rs in Crores)			Analysis Results			
Federal Bank	21154.59	44096.71	57614.86	5186.99	1179.5	1.00	1.00	1.00	0.00
IndusInd Bank	19654.17	44320.61	54116.72	9459.56	1756.4	1.01	1.01	1.00	0.00
ING Vysya Bank	18278.23	31772.03	41334	6511.26	1272.8	0.72	0.76	0.95	-0.04
Jammu & Kashmir Bank	25741.06	39200.41	64220.62	1075	989	0.89	1.05	0.85	-0.16
Karnataka Bank	13432.48	25207.68	36056.22	1579.76	666	0.57	0.60	0.95	-0.03
Karur Vysya Bank	13837.25	29480.12	38652.97	3999.34	762.2	0.67	0.68	0.99	-0.01
Kotak Mahindra Bank	28873.43	48468.98	51028.77	20410.62	2209.7	1.10	1.10	1.00	0.00
South Indian Bank	12523.47	31815.54	44262.3	1284.55	767.2	0.72	0.73	0.98	-0.01
Yes Bank	42976.04	46999.57	66955.58	20922.15	1334.5	1.07	1.35	0.79	-0.28
Weight	0	2.26774E-05	1.59687E-05	1.25763E-05	1.24899E-05				

Table 3: Year : 2012 - 13: Reference Bank - Federal Bank Ltd

Bank	Output (Rs in Crores)		Input (Rs in Crores)			Analysis Results			
Federal Bank	21154.59	44096.71	57614.86	5186.99	1179.5	0.99	0.99	1.00	0.00
IndusInd Bank	19654.17	44320.61	54116.72	9459.56	1756.4	1.00	1.00	1.00	0.00
ING Vysya Bank	18278.23	31772.03	41334	6511.26	1272.8	0.72	0.75	0.95	-0.04
Jammu & Kashmir Bank	25741.06	39200.41	64220.62	1075	989	0.88	1.05	0.85	-0.16
Karnataka Bank	13432.48	25207.68	36056.22	1579.76	666	0.57	0.60	0.95	-0.03
Karur Vysya Bank	13837.25	29480.12	38652.97	3999.34	762.2	0.67	0.67	0.99	-0.01
Kotak Mahindra Bank	28873.43	48468.98	51028.77	20410.62	2209.7	1.09	1.09	1.00	0.00
South Indian Bank	12523.47	31815.54	44262.3	1284.55	767.2	0.72	0.73	0.98	-0.01
Yes Bank	42976.04	46999.57	66955.58	20922.15	1334.5	1.06	1.34	0.79	-0.28
Weight	0	2.25629E-05	1.5888E-05	1.25127E-05	1.24268E-05				

Table 4: Year : 2012 - 13: Reference Bank - IndusInd Bank Ltd

Karnataka bank and Kotak Mahindra bank attained efficiency score of 1when ING Vysya bank was taken as reference bank Federal bank, Jammu & Kashmir bank and Yes bank show a score of 0.99 which is close to efficiency. Following table 5 shows the scores of banks when ING Vysya bank taken as reference banks.

Bank	Output (Rs in Crores)		Input (Rs in Crores)			Analysis Results			
Federal Bank	21154.59	44096.71	57614.86	5186.99	1179.5	1.29	1.30	0.99	-0.01
IndusInd Bank	19654.17	44320.61	54116.72	9459.56	1756.4	1.26	1.33	0.94	-0.08
ING Vysya Bank	18278.23	31772.03	41334	6511.26	1272.8	1.00	1.00	1.00	0.00
Jammu & Kashmir Bank	25741.06	39200.41	64220.62	1075	989	1.31	1.32	0.99	-0.01
Karnataka Bank	13432.48	25207.68	36056.22	1579.76	666	0.77	0.77	1.00	0.00
Karur Vysya Bank	13837.25	29480.12	38652.97	3999.34	762.2	0.85	0.88	0.97	-0.03
Kotak Mahindra Bank	28873.43	48468.98	51028.77	20410.62	2209.7	1.55	1.55	1.00	0.00
South Indian Bank	12523.47	31815.54	44262.3	1284.55	767.2	0.86	0.93	0.93	-0.06
Yes Bank	42976.04	46999.57	66955.58	20922.15	1334.5	1.86	1.88	0.99	-0.03
Weight	2.36E-05	1.78891E-05	2.01908E-05	2.54074E-05	0				

Table 5: Year : 2012 - 13: Reference Bank - ING Vysya Bank Ltd

When Jammu & Kashmir bank taken as reference bank it is found that ING Vysya bank, Karnataka bank and Yes bank attained efficiency of 1 along with reference bank. Federal bank and Kotak Mahindra bank attained a score of 0.99 which is close to efficiency. The following table 6 shows the scores of other banks

Bank	Output (Rs in Crores)		Input (Rs in Crores)			Analysis Results			
Federal Bank	21154.59	44096.71	57614.86	5186.99	1179.5	0.97	0.98	0.99	-0.01
IndusInd Bank	19654.17	44320.61	54116.72	9459.56	1756.4	0.94	1.01	0.93	-0.07
ING Vysya Bank	18278.23	31772.03	41334	6511.26	1272.8	0.76	0.76	1.00	0.00
Jammu & Kashmir Bank	25741.06	39200.41	64220.62	1075	989	1.00	1.00	1.00	0.00
Karnataka Bank	13432.48	25207.68	36056.22	1579.76	666	0.58	0.58	1.00	0.00
Karur Vysya Bank	13837.25	29480.12	38652.97	3999.34	762.2	0.64	0.67	0.96	-0.03
Kotak Mahindra Bank	28873.43	48468.98	51028.77	20410.62	2209.7	1.18	1.19	0.99	-0.01
South Indian Bank	12523.47	31815.54	44262.3	1284.55	767.2	0.65	0.70	0.92	-0.05
Yes Bank	42976.04	46999.57	66955.58	20922.15	1334.5	1.44	1.44	1.00	0.00
Weight	1.99E-05	1.24571E-05	1.52356E-05	2.00573E-05	0				

Table 6: Year : 2012 - 13: Reference Bank - Jammu & Kashmir Bank Ltd

Efficiency scores when Karnataka bank taken as reference bank in below table 7

Bank	Output (Rs in Crores)		Input (Rs in Crores)			Analysis Results			
Federal Bank	21154.59	44096.71	57614.86	5186.99	1179.5	1.68	1.68	1.00	0.00
IndusInd Bank	19654.17	44320.61	54116.72	9459.56	1756.4	1.65	1.73	0.95	-0.08
ING Vysya Bank	18278.23	31772.03	41334	6511.26	1272.8	1.30	1.30	1.00	0.00
Jammu & Kashmir Bank	25741.06	39200.41	64220.62	1075	989	1.69	1.72	0.98	-0.04
Karnataka Bank	13432.48	25207.68	36056.22	1579.76	666	1.00	1.00	1.00	0.00
Karur Vysya Bank	13837.25	29480.12	38652.97	3999.34	762.2	1.12	1.15	0.97	-0.03
Kotak Mahindra Bank	28873.43	48468.98	51028.77	20410.62	2209.7	2.01	2.01	1.00	0.00
South Indian Bank	12523.47	31815.54	44262.3	1284.55	767.2	1.14	1.21	0.94	-0.07
Yes Bank	42976.04	46999.57	66955.58	20922.15	1334.5	2.36	2.44	0.97	-0.08
Weight	2.76E-05	2.49492E-05	2.63081E-05	3.25543E-05	0				

Table 7: Year : 2012 - 13: Reference Bank - Karnataka Bank Ltd

Federal bank, Karnataka bank and Kotak Mahindra bank established their consistency when Karnataka bank taken as reference bank and ING Vysya bank also attained efficiency of 1 and confirmed its consistency in its performance.

Bank	Output (Rs in Crores)		Input (Rs in Crores)			Analysis Results			
Federal Bank	21154.59	44096.71	57614.86	5186.99	1179.5	1.50	1.50	1.00	0.00
IndusInd Bank	19654.17	44320.61	54116.72	9459.56	1756.4	1.50	1.56	0.96	-0.06
ING Vysya Bank	18278.23	31772.03	41334	6511.26	1272.8	1.08	1.18	0.92	-0.10
Jammu & Kashmir Bank	25741.06	39200.41	64220.62	1075	989	1.33	1.58	0.84	-0.25
Karnataka Bank	13432.48	25207.68	36056.22	1579.76	666	0.86	0.91	0.94	-0.06
Karur Vysya Bank	13837.25	29480.12	38652.97	3999.34	762.2	1.00	1.00	1.00	0.00
Kotak Mahindra Bank	28873.43	48468.98	51028.77	20410.62	2209.7	1.64	1.64	1.00	0.00
South Indian Bank	12523.47	31815.54	44262.3	1284.55	767.2	1.08	1.11	0.97	-0.03
Yes Bank	42976.04	46999.57	66955.58	20922.15	1334.5	1.59	1.80	0.88	-0.21
Weight	0	3.39212E-05	2.12676E-05	4.87571E-06	0.000207879				

Table 8: Year : 2012 - 13: Reference Bank - Karur Vysya Bank Ltd

As per the efficiency scores of banks from the above table when Karur Vysya bank attained efficiency as reference bank again Kotak Mahindra bank and Federal bank represented their reliability by achieving the score of 1.

When South Indian bank taken as reference bank only Federal bank attained efficiency along with reference bank and yes bank which had a stable performance previously show 0.75 which is less than other banks scores.

The following table 9 and 10 show the scores of banks when Kotak Mahindra bank and South Indian bank taken as reference banks respectively

Bank	Output (Rs in Crores)		Input (Rs in Crores)			Analysis Results			
Federal Bank	21154.59	44096.71	57614.86	5186.99	1179.5	0.91	0.91	1.00	0.00
IndusInd Bank	19654.17	44320.61	54116.72	9459.56	1756.4	0.91	0.91	1.00	0.00
ING Vysya Bank	18278.23	31772.03	41334	6511.26	1272.8	0.66	0.69	0.95	-0.03
Jammu & Kashmir Bank	25741.06	39200.41	64220.62	1075	989	0.81	0.96	0.85	-0.15
Karnataka Bank	13432.48	25207.68	36056.22	1579.76	666	0.52	0.55	0.95	-0.03
Karur Vysya Bank	13837.25	29480.12	38652.97	3999.34	762.2	0.61	0.62	0.99	-0.01
Kotak Mahindra Bank	28873.43	48468.98	51028.77	20410.62	2209.7	1.00	1.00	1.00	0.00
South Indian Bank	12523.47	31815.54	44262.3	1284.55	767.2	0.66	0.67	0.98	-0.01
Yes Bank	42976.04	46999.57	66955.58	20922.15	1334.5	0.97	1.23	0.79	-0.26
Weight	0	2.06317E-05	1.45282E-05	1.14418E-05	1.13632E-05				

Table 9: Year : 2012 - 13: Reference Bank - Kotak Mahindra Bank Ltd

Bank	Output (Rs in Crores)		Input (Rs in Crores)			Analysis Results			
Federal Bank	21154.59	44096.71	57614.86	5186.99	1179.5	1.39	1.39	1.00	0.00
IndusInd Bank	19654.17	44320.61	54116.72	9459.56	1756.4	1.39	1.41	0.99	-0.02
ING Vysya Bank	18278.23	31772.03	41334	6511.26	1272.8	1.00	1.06	0.94	-0.06
Jammu & Kashmir Bank	25741.06	39200.41	64220.62	1075	989	1.23	1.43	0.86	-0.20
Karnataka Bank	13432.48	25207.68	36056.22	1579.76	666	0.79	0.83	0.96	-0.04
Karur Vysya Bank	13837.25	29480.12	38652.97	3999.34	762.2	0.93	0.94	0.98	-0.02
Kotak Mahindra Bank	28873.43	48468.98	51028.77	20410.62	2209.7	1.52	1.61	0.95	-0.08
South Indian Bank	12523.47	31815.54	44262.3	1284.55	767.2	1.00	1.00	1.00	0.00
Yes Bank	42976.04	46999.57	66955.58	20922.15	1334.5	1.48	1.97	0.75	-0.49
Weight	0	3.14312E-05	2.18962E-05	2.39955E-05	0				

Table 10: Year: 2012 - 13: Reference Bank - South Indian Bank Ltd

Yes bank attained efficiency when it was taken as reference bank along with Federal bank, Karnataka bank and Kotak Mahindra bank. Following table 11 shows the scores of other banks.

Bank	Output (Rs in Crores)		Input (Rs in Crores)			Analysis Results			
Federal Bank	21154.59	44096.71	57614.86	5186.99	1179.5	0.71	0.71	1.00	0.00
IndusInd Bank	19654.17	44320.61	54116.72	9459.56	1756.4	0.69	0.73	0.94	-0.04
ING Vysya Bank	18278.23	31772.03	41334	6511.26	1272.8	0.55	0.55	0.99	0.00
Jammu & Kashmir Bank	25741.06	39200.41	64220.62	1075	989	0.71	0.72	0.99	-0.01
Karnataka Bank	13432.48	25207.68	36056.22	1579.76	666	0.42	0.42	1.00	0.00
Karur Vysya Bank	13837.25	29480.12	38652.97	3999.34	762.2	0.47	0.48	0.98	-0.01
Kotak Mahindra Bank	28873.43	48468.98	51028.77	20410.62	2209.7	0.84	0.84	1.00	0.00
South Indian Bank	12523.47	31815.54	44262.3	1284.55	767.2	0.48	0.51	0.94	-0.03
Yes Bank	42976.04	46999.57	66955.58	20922.15	1334.5	1.00	1.00	1.00	0.00
Weight	1.22E-05	1.01598E-05	1.06809E-05	1.21712E-05	2.26363E-05				

Table 11: Year : 2012 - 13: Reference Bank - Yes Bank Ltd

DEA analysis for the year 2012 - 13 gives an idea about the efficiency scores of banks and the steadiness of their performance. It was found that federal bank, Kotak Mahindra bank and Karur Vysya bank attained maximum efficiency scores. The next step is finding the most efficient bank among them. Cross Efficiency matrix was constructed to do the same.

8.1. Cross Efficiency
An array of efficiencies can be calculated for each bank by altering the reference bank. This can be employed to solve the problem of multiple banks reaching the maximum efficiency of one and thereby confirming the possibility of selecting the most efficient bank and ranking the banks based on their efficiencies.

Bank	Cross Efficiency Measure (Ratio) Bank used as Reference for DEA									Descriptive Statistics		
	Federal Bank	IndusInd Bank	ING Vysya Bank	Jammu & Kashmir Bank	Karnataka Bank	Karur Vysya Bank	Kotak Mahindra Bank	South Indian Bank	Yes Bank	Average Cross Efficiency (Ratio)	Standard Deviation	Rank
Federal Bank	1	1	0.99	0.99	1	1	1	1	1	0.9978	0	1
IndusInd Bank	1	1	0.94	0.93	0.95	0.96	1	0.99	0.94	0.9678	0.0287	5
ING Vysya Bank	0.95	0.95	1	1	1	0.92	0.95	0.94	0.99	0.9667	0.031	6
Jammu & Kashmir Bank	0.85	0.85	0.99	1	0.98	0.84	0.85	0.86	0.99	0.9122	0.0744	8
Karnataka Bank	0.95	0.95	1	1	1	0.94	0.95	0.96	1	0.9722	0.0286	4
Karur Vysya Bank	0.99	0.99	0.97	0.96	0.97	1	0.99	0.98	0.98	0.9811	0.012	3
Kotak Mahindra Bank	1	1	1	0.99	1	1	1	0.95	1	0.9933	0.0172	2
South Indian Bank	0.98	0.98	0.93	0.92	0.94	0.97	0.98	1	0.94	0.9600	0.0282	7
Yes Bank	0.79	0.79	0.99	1	0.97	0.88	0.79	0.75	1	0.8844	0.105	9
Foot note: i. Each Column represents the results of DEA with the selected reference branch ii. Each Row represents the efficiency of a Single branch computed with different Reference Branches												

Table 12: Cross Efficiency Table for Ranking Banks - (Year 2012 -13)

From the average cross efficiency ratio and ranks based on the ratio it is found that federal bank and Kotak Mahindra achieved the maximum score of 0.99. There is only very minimum variation between Federal bank and Kotak Mahindra bank. But based on the standard deviation of both the banks federal bank can be considered as the most efficient bank.

9. Conclusion

The study is taken up with the above stated objectives with an aim of analyzing the efficiency of selected private sector banks in India. Performance of commercial banks in India were analysed using various tools earlier by many researchers. In this study DEA is used as an effective tool to study the efficiency of selected private sector banks and to identify the most efficient bank. DEA was used to analyse the relative efficiency of banks for the year 2012 -13. Using Cross efficiency matrix and ranking of banks federal bank was identified as the most efficient bank.

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