Comparative Performance of Public and Private Sector Banks Using Data Envelopment Analysis, India

Dr. Sr. Lalitha Thomas
Jyoti Nivas College Autonomous,
Post Graduate Centre, Bangalore, India

Keywords
Banks, Data Envelopment Analysis, Decision Making Units, Efficiency, Efficiency Variation and Peer Entities

Abstract

Data Envelopment Analysis (DEA) is a data-oriented approach for evaluating the performance of a set of peer entities called Decision Making Units (DMU's) which converts multiple inputs into multiple outputs. DEA application is widely used in evaluating the performance of many kinds of entities engaged in different activities in different contexts. The present study makes use of DEA models to study the efficiency variation among 42 Indian Commercial Banks in which 21 are Public and 21 are Private sector banks. The current study carried out using three inputs three outputs model. The DEA inputs are Number of Employees, Interest Income and Other Income. The DEA outputs are Deposits, Investments and Advances. The data on these variables collected from Reserve Bank of India Bulletin (2017-2018). From the analysis, it is evident that maximum number of public sectors banks are efficient compared to private sector banks and all the inefficient banks should follow the practices of efficient banks.

1. General Introduction

Data Envelopment Analysis is a linear programming-based technique for measuring the performance efficiency of organizational units, which are termed as Decision Making Units. This technique aims to measure how efficiently a decision-making unit uses the resources available to generate a set of outputs. This method has been successfully employed for assessing the relative performance of set of firms that uses a variety of identical inputs to produce a variety of identical outputs.

Generally, the performance of a DMU assessed with DEA by using the concept of efficiency, which is the ratio of weighted sum of outputs to a weighted sum of inputs. Efficiencies obtained by using DEA are relative to the best performance of a virtual DMU. The best performing DMU assigned with an efficiency score of unity and the performance of others varies between zero and one.

The DEA is a mathematical programming technique that finds number of practical applications to measure the performance of similar units, such as a set of hospitals, a set of schools, a set of industries etc. The methodology of DEA depends upon an interesting application of linear programming technique and it was designed initially for performance measurement.

1.1 Efficiency Measurement Concepts

i) Efficiency: The basic efficiency measurement used in DEA is the ratio of total outputs to total inputs which is given by

$$Efficiency = \frac{Total\ outputs}{Total\ inputs}$$

ii) Pure Technical Efficiency: The Pure Technical Efficiency measures how a DMU utilizes the resources under exogenous environments; a low PTE implies that the DMU inefficiently manages its resources.

iii) Scale Efficiency: Scale Efficiency is the potential productivity gain from achieving optimal size of a firm.

iv) Overall Technical Efficiency: The two measures i.e., Pure Technical Efficiency and Scale Efficiency are then combined to provide a measure of Overall Technical Efficiency.

1.2. Input Oriented Measures

Farrell (1957) illustrated his ideas using simple example involving firms with two inputs (X_1 and X_2) to produce a single output (Y), under the assumption of constant returns to scale.

1.3. Output Oriented Measures

Let us consider the case where production involves two outputs (y_1 and y_2) and single input (x_1), under the assumption of constant returns to scale.

The output and input oriented measures will only provide equivalent measures of Technical Efficiency when constant returns to scale exists.

1.4 The Constant Returns to Scale (CRS) Model

Assume there is data on K inputs and M outputs on each of N firms or DMUs. The K x N input matrix X, and the M x N output matrix Y, represent the data of all N DMUs. The purpose of DEA is to construct a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier. Example, an industry where one output produced using two inputs; this is visualized as several intersecting planes forming a tight-fitting cover over a scatter of points in three-dimensional space.

1.5 The Variable Returns to Scale (VRS) Model and Scale Efficiencies

The CRS assumption is only appropriate when all DMUs are operating at an optimal scale (i.e. one corresponding to the flat portion of the LRAC curve). Imperfect competition, constraints on finance, etc. may cause a DMU to be not operating at optimal scale. Banker, Charnes and Cooper suggested an extension of the CRS. DEA model accounts for Variable Returns to Scale (VRS) situations. The use of the CRS specification when not all DMUs are operating at the optimal scale will result in measures of TE, which are confounded by Scale Efficiencies (SE). The use of the VRS specification will permit the calculation of TE devoid of these SE effects.

1.6 DEA's Advantages

i. DEA can handle multiple inputs / outputs to generate a set of weights to each input / output.
ii. DEA provides a single comprehensive measure of performance.
iii. It fails to assume any specific functional form relating to inputs & outputs.
iv. DEA provides valuable information for improving the less efficient DMUs. For each inefficient DMU, DEA also provides a peer best practice group for reference.
v. DEA cannot support zero output values.
vi. The sources of inefficiency can be analyzed and quantified. for every evaluated unit.
vii. No need to specify explicitly a mathematical form for the production function.

1.7 DEA Disadvantages

DEA has fewer limitations than other performance measurement approaches in the choice of input and output variables. The efficiency measure obtained by DEA is sensitive to the combination of inputs and outputs.

i. Application of DEA requires solving a separate linear program problem for each DMU. Hence, the application of DEA to various problems that have many DMUs can be computationally intensive. However, this is not a very serious problem, considering the computational power of present-day computers.

ii. Since DEA is an extreme point technique, errors in measurement can cause problems. DEA efficiencies are highly sensitive.
iii. DEA is good at significant
iv. Since DEA is a non-parametric technique, statistical hypothesis tests are difficult.
v. Since a standard formulation of DEA creates a separate function for each DMU, due to which computation of large problems are highly intensive.
vi. It is not easy to explain intuitively the process of DEA in case of more than two inputs and outputs.
vii. DEA designed to compute efficiency scores only when one or more inputs and one or more outputs are used for the analysis. It would be better if the methodology has the flexibility to allow for one or more or even nil outputs or inputs for performance evaluation.
viii. A second problem with DEA is the way in which efficiencies are calculated.

2. Literature Review

In a short span of time, DEA has grown into a powerful quantitative analytical tool for measuring and evaluating performance of a Decision-Making Units (DMUs). The DEA successfully applied to a host of different types of entities engaged in a wide variety of activities in many contents worldwide.

DEA application first applied by Sherman and Gold (1985) for assessing the efficiency of bank branches. It is used as a tool for evaluating relative efficiency; based on efficiency scores one can assign ranks for banks and as a single out driving forces governing efficiency.

In banking industry, DEA model is preferable compared to econometric approach of efficiency measurement because of its advantages such that it can simultaneously analyze several inputs and outputs. Production in the banking industry often involves multiple inputs & outputs and t does not require any assumptions.

DEA is a mathematical programming technique that provides useful insights in locating inefficient units by explicitly considering the mix of services provided and the resources used. DEA can locate inefficient units more powerfully when the number of units in the study exceeds the number of outputs and inputs included in the data set.

DEA most commonly used to evaluate the efficiency of several producers. A typical statistical approach characterized as central tendency approach and it evaluates producers relative to an average producer. DEA can be applied in many cases such as health care, education, banks, manufacturing sector, bench marking management evaluation, fast food restaurants and retails sectors etc.

3. Research Methodology

The DEA model was designed to compare marginal efficiencies of a set of relative homogeneous decision-making units. The non-parametric approach to efficiency measurement is more suitable for policy applications. Since it was more flexible and more data-based policy applications, it generally involved additional constraints. The present study deals with non-parametric approach to the measure of productive efficiency. The various efficiency measures discussed in the present study are Overall Technical Efficiency, Pure Technical Efficiency, Scale Efficiency and Technical Efficiencies of commercial banks in India.

3.1 Statement of the Problem

In Indian banking system profit and returns to investments were its performance indicators. This was the scenario prior to 1969. Subsequently, commercial banks were nationalized adding to their list additional objectives of optimizing social benefit and geographical expansion to meet the growing needs of people. Globalization opened gates to increased competition by the entry of foreign banks. The changes that are taking worldwide continued to give shocks to the banking system, which resulted in an expansion of banking services.

The present study aims at constructing and solving linear programming problems to estimate Overall Technical, Pure Technical, Scale and Technical Efficiencies of Public and Private sector banks in India. The study uses the Data Envelopment Analysis (DEA) to measure bank efficiency.

3.2 Objectives of the Present Study

The main aim of the present study is to measure the efficiency of public and private sector commercial banks in India by using three inputs and three outputs.

1. To estimate Overall Technical, Pure Technical, Scale and Technical Efficiencies of Public and Private sector banks in India
2. To evaluate the performance of these banks through efficiency measures.

3.3 Type of Research – Analytical Research

3.4 Data Source

The data relevant to 21 Public and 21 Private sector Banks for the present study collected from Reserve Bank of India Bulletin (2017-2018). The current study failed to evaluate Commercial Banks efficiency scores for the period 2018 – 2019, due to unavailability of the data for the financial year 2018 - 2019. The variables considered for the study are:

Input variables: Number of Employees, Interest Income and Other Income.

Output variables: Deposits, Investments and Advances.

3.5 Tools Used for Analysis – DEA, Mean, Standard Deviation and t-test

4. Data Analysis & Interpretation

The present study makes use of Data Envelopment Analysis models to study the efficiency variation among 42 Indian Commercial Banks. The current study uses the data on three DEA inputs and the three DEA outputs. The data on the selected variables collected from Reserve Bank of India Bulleting (2017-2018).

Table 4.1: Public Sector Banks – Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE) & Scale Efficiency (SE)

S. No.	Public Sector Banks	OTE	PTE	SE
1	ALLAHABAD BANK	0.995	1.00	0.995
2	ANDHRA BANK	0.950	1.00	0.95
3	BANK OF BARODA	1.00	1.00	1
4	BANK OF INDIA	1.00	1.00	1
5	BANK OF MAHARASHTRA	0.921	0.992	0.998
6	CANARA BANK	0.945	0.946	0.998
7	CENTRAL BANK OF INDIA	0.918	1.00	0.918
8	CORPORATION BANK	1.00	1.00	1
9	DENA BANK	0.882	0.902	0.977
10	IDBI BANK LIMITED	1.00	1.00	1
11	INDIAN BANK	0.045	0.046	0.978
12	INDIAN OVERSEAS BANK	0.841	0.842	0.998
13	ORIENTAL BANK OF COMMERCE	0.985	1.00	0.985
14	PUNJAB AND SIND BANK	1.00	1.00	1
15	PUNJAB NATIONAL BANK	0.976	1.00	0.976
16	STATE BANK OF INDIA	1.00	1.00	1
17	SYNDICATE BANK	1.00	1.00	1
18	UCO BANK	1.00	1.00	1
19	UNION BANK OF INDIA	0.999	1.00	0.99
20	UNITED BANK OF INDIA	1.00	1.00	1
21	VIJAYA BANK	0.981	1.00	0.981

From the above table it is evident that, the following public sector banks are efficient based on OTE – Bank of Baroda, Bank of India, Corporation Bank, IDBI Bank Limited, Punjab and Sind Bank, State Bank of India, UCO Bank and United Bank of India. These banks emanated with 100% OTE

score, the other remaining banks realized input losses. The bank falling at the bottom is Indian Bank. The overall technical efficiency of the Public sector banks distributed over the interval 0.045 ≤ OTE ≤ 1.000.

From the above table, 16 public sector banks out of 21 are Pure Technical Efficient. This indicates that 76% are Pure Technical Efficient attaining 100% efficiency score. The remaining five banks have input losses due to PTE. The PTE of the public sectors banks distributed over the interval of 0.046 ≤ PTE ≤ 1.00. From the above table, it is evident that eight public sector banks out of 21 banks, found scale efficient and other remaining banks experienced decreasing returns to scale. Bank of Baroda, Bank of India, Corporation Bank, IDBI Bank Limited, State Bank of India, Syndicate Bank, UCO Bank and United Bank of India achieves cent percent Scale Efficiency. The scale efficiency of the public sector banks distributed over the interval 0.918 ≤ SE ≤ 1.

Table 4.2: Private Sector Banks – Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE) & Scale Efficiency (SE)

S. No.	Private Sector Banks	OTE	PTE	SE
1	AXIS BANK LIMITED	1.00	1.00	1
2	BANDHAN BANK LIMITED	0.648	0.685	0.945
3	CATHOLIC SYRIAN BANK LTD	0.968	0.982	0.986
4	CITY UNION BANK LIMITED	1.00	1.00	1
5	DCB BANK LIMITED	0.890	0.973	0.914
6	FEDERAL BANK LTD	1.00	1.00	1
7	HDFC BANK LTD.	1.00	1.00	1
8	ICICI BANK LIMITED	1.00	1.00	1
9	IDFC BANK LIMITED	1.00	1.00	1
10	INDUSIND BANK LTD	0.866	0.867	0.998
11	JAMMU & KASHMIR BANK LTD	1.00	1.00	1
12	KARNATAKA BANK LTD	1.00	1.00	1
13	KARUR VYSYA BANK LTD	0.881	0.885	0.995
14	KOTAK MAHINDRA BANK LTD.	0.924	0.939	0.984
15	LAKSHMI VILAS BANK LTD	0.998	1.00	0.998
16	NAINITAL BANK LTD	1.00	1.00	1
17	RBL BANK LIMITED	0.951	0.965	0.986
18	SOUTH INDIAN BANK LTD	1.00	1.00	1
19	TAMILNAD MERCANTILE BANK LTD	0.913	0.993	1
20	THE DHANALAKSHMI BANK LTD	1.00	1.00	1
21	YES BANK LTD.	1.00	1.00	1

From the above table it is evident that, the following private sector banks are efficient based on OTE – Axis Bank, City Union Bank Limited, Federal Bank, HDFC Bank Limited, ICICI Bank Limited, IDFC Bank, Jammu & Kashmir Bank Ltd, Karnataka Bank Ltd, Nainital Bank Ltd, South India Bank Ltd, Dhanalakshmi Bank Ltd and Yes Bank Ltd. These banks emanated with 100% OTE score, the other remaining banks realized input losses. The bank falling at the bottom is Bandhan Bank. The overall technical efficiency of the Private sector banks distributed over the interval 0.648 ≤ OTE ≤ 1.000.

From the above table it is evident that out of 21 private sector banks, 13 banks are Pure Technical Efficient, and the remaining eight banks experienced input losses. The pure technical efficiency of the Private sector banks distributed over the interval 0.685 ≤ OTE ≤ 1.000.

Axis Bank, City Union Bank Limited, Federal Bank, HDFC Bank Limited, ICICI, IDFC, Jammu & Kashmir Bank, Nainital Bank, South Indian Bank, Tamilnad Mercantile Bank and Dhanalakshmi Bank achieves cent percent Scale Efficiency. The scale efficiency of the private sector banks distributed over the interval 0.914 ≤ SE ≤ 1.

Table 4.3: Hypothesis testing using Two Sample t-test

H_0: There is no significant difference in the performance of Public and Private sector banks with respect to overall technical efficiency/pure technical efficiency/scale efficiency

H_1: There is a significant difference in the performance of Public and Private sector banks with respect to overall technical efficiency/pure technical efficiency/scale efficiency.

t-Test: Two-Sample Assuming Equal Variances						
	Public Sector Banks (OTE)	*Private Sector Banks (OTE)*	*Public Sector Banks (PTE)*	*Private Sector Banks (PTE)*	*Public Sector Banks (SE)*	*Private Sector Banks (SE)*
Mean	0.93	0.95	0.94	0.97	0.99	0.99
Variance	0.04	0.01	0.04	0.01	0.00	0.00
Df	40.00		40.00		40.00	
t Stat	-0.59		-0.55		-0.45	
P(T<=t) two-tail	**0.56**		**0.58**		**0.65**	
t Critical two-tail	2.02		2.02		2.02	

It is evident that the result is not significant at 5% level of significance. The OTE estimates obtain from the above table reveals that 16 out of 21 public sector banks have consistently shown the OTE above to the average OTE whereas the remaining five banks registered its OTE's below to the average of OTE. In case of Private sector banks, 14 have shown OTE above to the average OTE and the remaining seven banks registered the OTE below to the average OTE.

From the hypothesis testing, it is evident that the difference between Public and Private sector banks under Pure Technical Efficiency is not significant at 5% level. Eighteen Public sector banks out of 21 banks consistently shown that their PTE is above to the average public sector PTE. Whereas when it comes to Private sector, 16 banks PTE above the concerned average.

Scale efficiency difference between public and private sector banks are not significant at 5% level of significance. Fourteen banks out of 21 public sector banks consistently shown that their SE is above to the average SE whereas in case of private sector banks 16 banks SE's is above to the average SE.

4.1 Efficient Peer Banks

Relatively inefficient DMU imitates the management style of its Peer. An appropriate efficient peer is the best practices performer in the sample that is like the inefficient unit in some respect and can lend insights useful for inefficient unit to improve.

Table 4.4: Public Sector Banks – Efficient Peers

S.No	Public Sector Banks	Peers			
1	ALLAHABAD BANK	United Bank of India	Bank of Baroda	UCO Bank	State Bank of India
2	ANDHRA BANK	UCO Bank	Bank of Baroda	Corporation Bank	
3	BANK OF BARODA	Bank of Baroda			
4	BANK OF INDIA	United Bank of India	Bank of Baroda	Punjab and Sind Bank	UCO Bank
5	BANK OF MAHARASHTRA	United Bank of India	Bank of Baroda	UCO Bank	Punjab and Sind Bank
6	CANARA BANK	Bank of Baroda			
7	CENTRAL BANK OF INDIA	United Bank of India	UCO Bank		
8	CORPORATION BANK	Corporation Bank			
9	DENA BANK	State Bank of India	United Bank of India	UCO Bank	Bank of Baroda
10	IDBI BANK LIMITED	IDBI Bank Limited			
11	INDIAN BANK	United Bank of India			
12	INDIAN OVERSEAS BANK	Bank of Baroda			
13	ORIENTAL BANK OF COMMERCE	United Bank of India			
14	PUNJAB AND SIND BANK	UCO Bank	Bank of Baroda	Corporation Bank	IDBI Bank Limited
15	PUNJAB NATIONAL BANK	Punjab and Sind Bank			
16	STATE BANK OF INDIA	Bank of Baroda	United Bank of India	State Bank of India	
17	SYNDICATE BANK	State Bank of India			
18	UCO BANK	Syndicate Bank			
19	UNION BANK OF INDIA	Bank of Baroda	Corporation Bank	IDBI Bank Limited	
20	UNITED BANK OF INDIA	United Bank of India			
21	VIJAYA BANK	Bank of Baroda	Punjab and Sind Bank	Syndicate Bank	

For majority of inefficient banks Bank of Baroda and IDBI Bank Limited are efficient peers. These two banks serve as role models for Andhra Bank, Bank of Baroda, Bank of Maharashtra, Punjab and Sind Bank, Union Bank of India and Vijaya Bank. The normal practices of efficient peer banks are the best practices of the inefficient bank.

Table 4.5: Private Sector Banks – Efficient Peers

S. No	Private Sector Banks	Peers				
1	AXIS BANK LIMITED	Axis Bank Limited				
2	BANDHAN BANK LIMITED	Yes Bank Ltd	Federal Bank Limited			
3	CATHOLIC SYRIAN BANK LTD	Dhanalakshmi Bank Limited	Jammu and Kashmir Bank Limited			
4	CITY UNION BANK LIMITED	City Union Bank Limited				
5	DCB BANK LIMITED	Yes Bank Ltd	Federal Bank Limited			
6	FEDERAL BANK LTD	Federal Bank Limited				
7	HDFC BANK LTD.	HDFC Bank Limited				
8	ICICI BANK LIMITED	ICICI Bank Limited				
9	IDFC BANK LIMITED	IDFC Bank Limited				
10	INDUSIND BANK LTD	ICICI Bank Limited	Federal Bank Limited	Axis Bank Limited	Yes Bank Ltd	
11	JAMMU & KASHMIR BANK LTD	Jammu and Kashmir Bank Limited				
12	KARNATAKA BANK LTD	Yes Bank Ltd				
13	KARUR VYSYA BANK LTD	IDFC Bank Limited	Federal Bank Limited	Dhanalakshmi Bank Limited	Karnataka Bank Limited	
14	KOTAK MAHINDRA BANK LTD.	Federal Bank Limited	ICICI Bank Limited	Yes Bank Ltd	IDFC Bank Limited	
15	LAKSHMI VILAS BANK LTD	IDFC Bank Limited	Federal Bank Limited	South Indian Bank Ltd	Nainital Bank Limited	Dhanalakshmi Bank Limited
16	NAINITAL BANK LTD	Nainital Bank Limited				
17	RBL BANK LIMITED	Yes Bank Ltd	Federal Bank Limited	ICICI Bank Limited	IDFC Bank Limited	
18	SOUTH INDIAN BANK LTD	South Indian Bank Ltd				
19	TAMILNAD MERCANTILE BANK LTD	IDFC Bank Limited	Karnataka Bank Limited	Dhanalakshmi Bank Limited	Federal Bank Limited	
20	THE DHANALAKSHMI BANK LTD	Dhanalakshmi Bank Limited				
21	YES BANK LTD.	Yes Bank Ltd				

For majority of inefficient banks Federal Bank, Yes Bank, IDFC Bank and Dhanalakshmi Bank Limited are efficient peers. These four banks serve as role models for Bandhan Bank, Catholic Syrian Bank, DCB, IndusInd Bank, Karur Vysya Bank, Kotak Mahindra Bank, RBL and Tamilnad Mercantile Bank Ltd., The normal practices of efficient peer banks are the best practices of the inefficient bank.

5. Summary & Conclusion

DEA successfully applied to a host of different types of entities engaged in wide variety of activities in many contexts worldwide. It has grown into a powerful quantitative analytical tool for measuring and evaluating the performance. In banking Industry, DEA model is preferable to econometric approach of efficiency measurements because of its advantages. As we know efficiency in banking system contributes an extensive way for higher economic growth in any country, studies in this nature are very important for policy makers, industrialist and many others who are reliant on the banking sector. The present study aims at constructing and solving linear programming problems to estimate Technical, Pure Technical and Scale Efficiency of Public and Private sector banks in India. During the period 2017 – 2018, the following public and private sector banks are efficient based on all the three estimates. They are Bank of Baroda, Bank of India, Corporation Bank, IDBI, Punjab and Sind Bank, SBI, UCO Bank and United Bank of India from public sector commercial banks; when it comes to private sector Axis Bank, City Union Bank, Federal Bank, HDFC Bank, ICICI Bank, IDFC Bank, Jammu and Kashmir Bank, Karnataka Bank, Nainital Bank, SIB, Dhanalakshmi

Bank and Yes Bank outperformed based on their efficient scores from all the three estimates. Based on Peer weights - Bank of Baroda, IDBI Bank, Federal Bank, Yes Bank, IDFC Bank and Dhanalakshmi Bank served as a role model in Banking Sector for the other remaining 35 banks. Normal practices followed by these six banks are the best practices for the other inefficient banks.

6. Research Limitations & Directions for Further Research:

Limitations of the Study

1. The study is restricted to the financial year 2017 – 2018 due to time constraint.

2. The current research failed to evaluate the performance of Indian Commercial Banks for the year 2018 – 2019, due to unavailability of the data.

The current study is limited to India, the research can be extended by considering samples across the world. The study can further diversified with different combinations of Input-Output models i.e, one input – two outputs or two inputs – two output models etc., the current study can enlarge by considering five years data relevant to public and private sector banks and evaluate the level of consistency in the efficiency scores. Research can further magnify by evaluating efficiency of banks before and after the demonetization and its impact on Indian economic growth.

References

Banker R D, Charnes and W W Cooper (1984), "Models for the Estimation of Technical and Scale Inefficiencies in a Data Envelopment Analysis", Management Science, Vol. 30, PP. 1078 – 1092

Coelli T J (1996), "A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program, CEPA Working Paper", ISSN: 1327 – 435X, The University of New England.

Farrell M J (1957), "The Measurement of Productive Efficiency", Journal of Royal Statistical Society, Series A, Vol. 120, pp. 253 – 281.

Sherman, Lawrence M and Franklin Gold (1985), "Branch Operating Efficiency: Evaluation with Data Envelopment Analysis", Journal of Banking and Finance, Vol. 9, pp. 2917 – 315.

Sueyoshi T (2001), "Extended DEA Discriminate Analysis", European Journal of Operational Research, Vol. 131, pp. 324 – 352.