

# Measuring Efficiency of Indian Banks: A DEA-Stochastic Frontier Analysis

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**ABSTRACT:** In this study, we employ the efficient frontier methods of Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) to estimate efficiency of Indian commercial banks. Various DEA models have been applied in performance assessing problems and the banks complex production processes have further motivated the development and improvement of DEA techniques. In this study we estimate efficiency of 19 nationalized Indian banks using DEA and stochastic production frontier. The results suggest moderate consistency between parametric and non-parametric frontier methods in efficiency scores rankings, identification of best and worst performing banks, the stability of efficiency scores over time and correlation between frontier efficiency and accounting based performance measures. Also DEA and SFA efficiency estimates are positively and significantly correlated with key financial performance ratios.

**KEYWORDS:** Data Envelopment Analysis, Stochastic Frontier Analysis, Efficiency, Indian Banking.

## I. INTRODUCTION

The performance of any economy to a large extent is dependent on the performance of the banking sector as it being the predominant component of the financial service industry. The changing economic conditions have challenged many organizations to search for more efficient and effective ways to manage their business operations. Only an efficient banking system can contribute towards the formation of capital and implementation of monetary policy of a country. The Indian banking sector went through structural changes since its independence keeping in view its financial linkages with the rest of the economy and to meet the social and economic objectives of development (Kumbhakar and Sarkar, 2005). Facing major economic crisis, the Reserve bank of India (RBI) launched major banking sector reforms in 1991 aimed at creating a more profitable, efficient and sound banking system, based on the recommendations of the first Narasimham committee on financial sector reforms. The purpose of this paper is to propose a methodology based on Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) that addresses to this issue of efficiency using data from Nationalised Indian banks (source RBI Website).

The banking sector in India is characterized by the co-existence of different ownership groups, public and private, and within private, domestic and foreign. The application of quantitative techniques in the area of finance became very popular and especially, assessing Bank performance with the use of advances in Operational Research and SFA. Using a recognized and valid measure of efficiency is critical for managers seeking to increase the effectiveness of their organizations. Over the past two decades, data envelopment analysis (DEA) has become a popular methodology for evaluating the relative efficiencies of decision making units (DMUs) within a relatively homogenous set (e.g. Sun & Lu, 2005). DEA is an approach to estimate the production function of organizations and organizational units and enables the assessment of their efficiency. The comparison of empirical results produced by DEA and SFA is still uncommon in bank efficiency literature. Some studies find inconsistency between DEA and SFA at individual level (Fiorentino et al., 2006; Ferrier and Lovell, 1990). Other studies analyze consistency at industry level and find that the application of these methodologies does lead to similar results (Resti, 1997). Koetter and Meesters (2013) also point out that cost efficiency measures differ depending on the employed technique and suggest the use of multiple benchmarking methods.

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## II. LITERATURE REVIEW

Literature related to efficiency studies can be traced back to Farrell (1957), who treated the production frontier as the basis for efficiency assessment. In 1978, Charnes, Cooper and Rhodes (CCR) described a mathematical programming formulation for the empirical evaluation of relative efficiency of a Decision Making Unit (DMU) on the basis of the observed quantities of inputs and outputs for a group of similar referent DMUs. Banker (1980) and Banker, Charnes and Cooper (1984) (BCC) provided a formal link between DEA and estimation of efficient production frontiers via constructs employed in production economics. Sathye (2003) used DEA to study the relative efficiency of Indian banks in the late 1990's with that of banks operating in other countries. He found that the public sector banks have a higher mean efficiency score as compared to the private sector banks in India, but found mixed results when comparing public sector banks and foreign commercial banks in India.

Kumbhakar and Sarkar (2004) estimated the cost efficiency of public and private sector banks in India by using the stochastic cost frontier model with specification of translog cost function. Seiford and Zhu (1999) examined the performance of the top 55 US banks using a two-stage DEA approach. Results indicated that relatively large banks exhibit better performance on profitability, whereas smaller banks tend to perform better with respect to marketability. Drake and Howcroft (2002) assessed the relative efficiency of UK clearing bank branches using DEA method. This paper utilized the basic efficiency indices and extended the analysis by examining the relationship between size and efficiency. Many of these studies find that state-owned banks are more efficient than private and foreign banks (Bhattacharyya and Pal, 2013; Sharma et al., 2012; Tabak and Tecles, 2010). De (2004) and Debasish (2006) find that foreign banks are actually the most efficient.

## III. OBJECTIVE OF THE STUDY

The main objective of this paper to assesses efficiency of Indian banks using DEA technique and SFA techniques. To measure and compare the financial performance of Nationalised Banks of India using BCC model of Data Envelopment Analysis and SFA production frontier estimate.

## IV. METHODOLOGY & DATA

### IV. 1 DATA ENVELOPMENT ANALYSIS

Data Envelopment Analysis is a linear programming procedure for a frontier analysis of inputs and outputs. The input-oriented DEA model under the assumption of variable return to scale can be used for calculation of input-oriented technical efficiency. In this study, we estimate the model proposed by Banker et al. (1984), which allows for variable returns to scale. The input-oriented VRS model can be written as:

$$\begin{aligned}
 & \text{Min } \phi \\
 & \phi, z \\
 & \text{s.a } -q_i + Q \lambda_j \geq 0 \\
 & \quad \phi x_i - X \lambda_j \geq 0 \\
 & \quad \sum_{i=1}^n \lambda_i = 1 \\
 & \quad \lambda_i \geq 1
 \end{aligned} \tag{1}$$

Where  $\phi$  is technical efficiency,  $q_i$  are the outputs for firm  $i$ ,  $Q$  and  $X$  are matrices of outputs and inputs for all firms, respectively,  $x_i$  is the vector of inputs for the  $i$ -th firm and  $\lambda_i$  is a vector of weights.

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## IV.2 STOCHASTIC FRONTIER ANALYSIS

The stochastic frontier approach was proposed by Meeusen and Van den Broek (1977) and Aigner et al. (1977). The main differences between DEA and SFA as DEA is deterministic and non-parametric, SFA assumes a stochastic relationship between input and output and is it is a parametric approach.

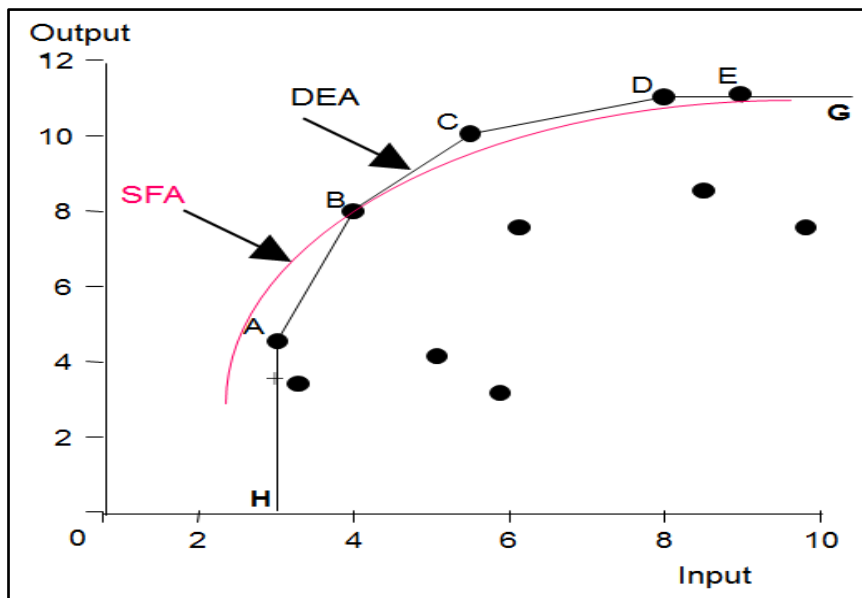


Fig 1 DEA Vs SFA estimator

Consider the stochastic production frontier model,

$$\ln y_{it} = \beta_0 + \sum_{p=1}^m \beta_p \ln x_{itp} + v_{it} - u_{it} \tag{2}$$

Where  $y_{it}$  denotes the output of firm produced at time  $t$ ,  $x_{it}$  be the collection of  $m$  inputs consumed for the purpose of producing  $y_{it}$ ,  $v_{it}$  is the random error assumed to be standard normal  $N(0, \sigma_v^2)$ ,  $u_{it}$  represents the inefficiency effect, which is non-negative and often assumed to follow a half-normal distribution (Coelli et al., 2005; Kumbharkar and Lovell, 2003).

## V. DATA SOURCE & RESULTS

There is a mathematical approach to DEA that can be adopted which is illustrated using Linear Programming technique. In this paper, we have taking 19 Nationalised Indian Banks (except IDBI Bank) for FY 2011-12. Data has been collected from RBI website for evaluation and data has been shown in Table 1.

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TABLE 1-DATA FOR FINANCIAL YEAR 2011-12-

Sr No	DMU's	Input		Output
		Interest expended	Operating expenses	Interest income
1	Allahabad Bank	103606	26914	155233
2	Andhra Bank	75794	18042	113387
3	Bank of Baroda	193567	51587	296737
4	Bank of India	201672	49407	284807
5	Bank of Maharashtra	46969	16425	72140
6	Canara Bank	231613	46737	308506
7	Central Bank of India	139809	37490	191495
8	Corporation Bank	98709	17836	130178
9	Dena Bank	46931	11547	67941
10	Indian Bank	78133	21870	122313
11	Indian Overseas Bank	128809	31631	178971
12	Oriental Bank of Commerce	115991	23155	158149
13	Punjab and Sind Bank	49734	11585	64745
14	Punjab National Bank	230136	70028	364280
15	Syndicate Bank	101833	28141	152684
16	UCO Bank	107303	20562	146324
17	Union Bank of India	142354	39875	211443
18	United Bank of India	54819	13833	79611
19	Vijaya Bank	60846	12010	79881

**Note-Amount in Million**

In this study we use the VRS input-orientation model of DEA and SFA production frontier model. We have used two input measure such as interest expended, operating expenses and one output measures as Interest income. Table2 shows the DEA & SFA efficiency score of Nationalised Indian banks for FY 2011-12.

TABLE 2-DEA & SFA RESULT USING R SOFTWARE –

Sr No	DMU	DEA Efficiency	SFA Efficiency	TEM SFA Efficiency
1	Allahabad Bank	0.98	0.99	1.00
2	Andhra Bank	1.00	1.00	1.00
3	Bank of Baroda	1.00	1.00	1.00
4	Bank of India	0.96	0.98	0.99
5	Bank of Maharashtra	1.00	0.98	0.99
6	Canara Bank	1.00	0.98	0.99
7	Central Bank of India	0.89	0.96	0.96
8	Corporation Bank	1.00	0.99	1.00
9	Dena Bank	1.00	0.99	1.00
10	Indian Bank	1.00	1.00	1.00
11	Indian Overseas Bank	0.93	0.98	0.98
12	Oriental Bank of Commerce	0.99	0.99	1.00
13	Punjab and Sind Bank	1.00	0.96	0.97
14	Punjab National Bank	1.00	0.99	1.00
15	Syndicate Bank	0.96	0.99	1.00
16	UCO Bank	1.00	0.99	1.00
17	Union Bank of India	0.95	0.98	1.00
18	United Bank of India	0.98	0.99	1.00
19	Vijaya Bank	1.00	0.98	0.99

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Table 3 indicate descriptive Statistics of DEA & SFA including Statistical significant 2-sample t test result. Also we compute a rank correlation of 59.6 % between DEA and SFA efficiency scores, which is statistically significant.

**TABLE 3-DESCRIPTIVE STATISTICS OF DEA & SFA EFFICIENCY USING R SOFTWARE -**

```
summary(te)
Summary of efficiencies
The technology is vrs and input orientated efficiency
Number of firms with efficiency==1 are 10
Mean efficiency: 0.981
---
Eff range  #  %
0.8<= E <0.9  1  5.3
0.9<= E <1    8  42.1
E ==1         10 52.6
  Min. 1st Qu.  Median  Mean 3rd Qu.  Max.
0.8897 0.9722 1.0000 0.9814 1.0000 1.0000

> summary(te SFA)
  Min. 1st Qu.  Median  Mean 3rd Qu.  Max.
0.9620 0.9807 0.9875 0.9840 0.9895 1.0000

> summary(teM SFA)
  Min. 1st Qu.  Median  Mean 3rd Qu.  Max.
0.9627 0.9881 1.0000 0.9927 1.0000 1.0000

Here teM as Efficiencies estimates using the conditional mean approach Jondrow et al. (1982, 235)

Two-sample T for x1 vs x2

  N  Mean  StDev  SE Mean
x1 19 0.9814 0.0305 0.0070
x2 19 0.9850 0.0102 0.0023

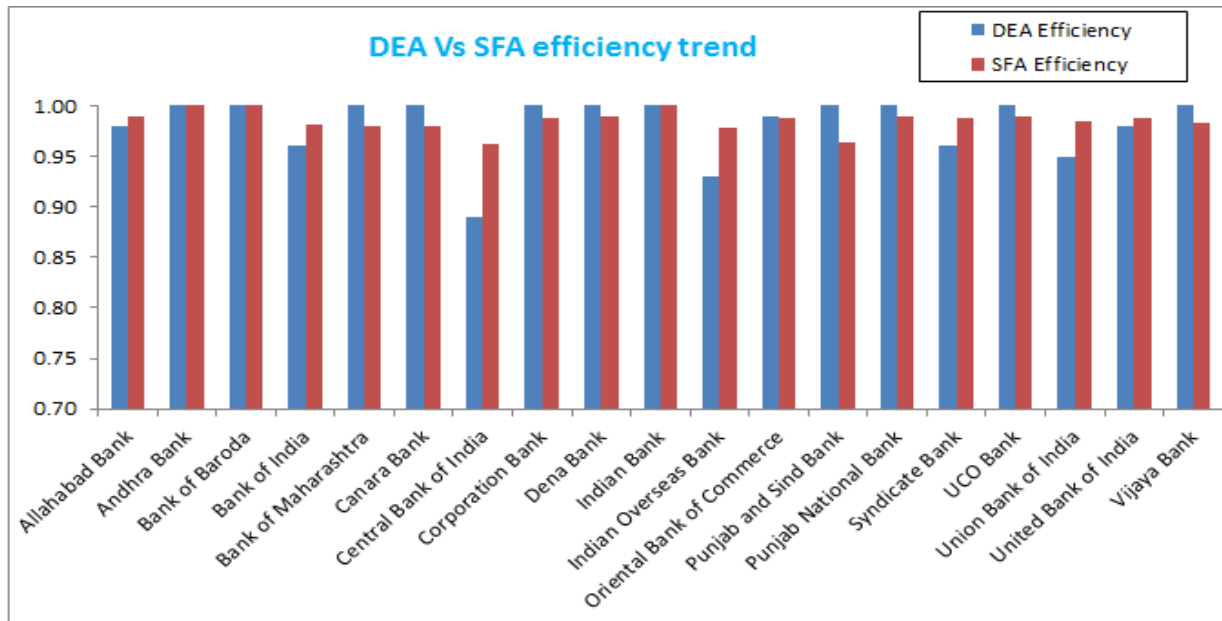
Difference = mu (x1) - mu (x2)
Estimate for difference: -0.004368
95% CI for difference: (-0.019690, 0.010953)
T-Test of difference = 0 (vs not =): T-Value = -0.59 P-Value = 0.560 DF = 22
```

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### BANK WISE PERFORMANCE GRAPH-



Above Figure plots the efficiency scores obtained by SFA and DEA for all bank-observations.

### VI. CONCLUSION

This paper presents a unique approach of DEA & SFA production frontier for evaluating Indian banks performance. A sample of 19 Nationalised Indian Banks has been analyzed for effectiveness using DEA & SFA. The analysis provides the precise corrective figure for every output and input in order to improve their efficiency of an inefficient bank. We have investigated the performance of Indian banks by using BCC based DEA model & SFA production frontier (Table 2). As per shown 2-sample t test summary result, they are statistically significant. This means that results produced by both data envelopment analysis and stochastic frontier approach suggest Indian banks have operated in the same level of efficiency. This means that DEA and SFA efficiency estimates are positively and significantly correlated with key financial performance ratios. It is in the hands of managers to skillfully using these results as a support for decision-making. This study provides scope for further research using larger sample size and panel data with different sets of input and outputs to test the robustness of the results.

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