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Ranking Of Public Sector Banks - Two Stage Dea Approach

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Abstract: Indian Banking Sector is comprised of Public, Private and Foreign sector banks. Indian Public Sector Banks account for 73 percent of Commercial Banks' Business. This study aims at ranking the Public Sector Banks basing on the BCC input technical efficiency scores. Since Input super efficiency BCC problems are infeasible in some cases, Super efficiency scores cannot help to improve the discriminatory power of DEA. We have performed two stage DEA analysis and estimated the probabilities of efficient banks to remain efficient. Basing on these probability values the ties among BCC efficient Banks are broken and all the Public Sector Banks are successfully ranked.

Keywords: Public Sector Banks, Data Envelopment Analysis, BCC input technical efficiency, Super efficiency, Binary Regression, Logistic probabilities.

I. INDIAN COMMERCIAL BANKS

Indian commercial banking is constituted by public, private and foreign sector banks. Public Sector Banks share 70 per cent of the bank business. The activities of Public Sector Banks are found wide spread in rural India. Prior to nationalization large banks played the role of financial intermediaries whose prime activities were deposit collection and distribution of advances. These banks functioned with only one motive, namely maximization of profit; credit needs of rural sector and small scale industries were grossly ignored. In 1969 fourteen large banks were nationalized and the spectrum of objectives of the national banks enlarged. In the year 1980 another six banks were nationalized. The environment of public sector banks was greatly influenced by the policies of central government and the regulatory measures of the Central Bank (Reserve Bank of India). Financial repression was manifested in the year 1991. The first stage reforms were implemented in the same year, before this to happen the public sector banks suffered from NPAs growing at an alarming rate.

To improve the functioning of the Commercial Banks, the Central Government and the Central Bank introduced anti-repression policies basing on Narasimham Report in 1991. Another set of reforms (Second stage) were introduced in the year 1998 based on Narasimham Committee Report (II), the consequent deregulation led commercial banks to explore new avenues towards profit maximization. The capital adequacy of Indian commercial banks is beyond international norm, net profits increased, for a while NPAs diminished. After deregulation the public sector banks experienced fierce competition from private sector banks that led to a decline in their Deposits, Investments, Advances and Total Assets.

II. MODELING COMMERCIAL BANKS

A commercial bank may be modelled by the Production Approach, Intermediation Approach, Profit Approach. In Production Approach banks' inputs produce outputs. In this approach labour and capital produce deposits and advances. Production approach is best suited to measure Bank Branch Efficiency (Berger and Humphrey 1997; Camanho and Dyson, 1999).

In Intermediation Approach Banks use Labour, Capital and Deposits to produce advances and other financial products. In Profit Approach inputs are interest expenditure and other expenditure, and outputs are interest income and other income.

The present study models a Commercial Bank by Profit Approach. Interest expenditure and Other expenditure amount to total expenditure, while Interest income and Other income comprise total revenue. These four variables capable of defining profit integrate all the activities of Commercial Banks.

Several researchers studied the performance of Banks and Bank Branches. There is no consensus towards choice the appropriate model nor in the selection of DEA inputs and outputs (Humphrey, 1985; Berg *et al.*, 1991, 1993; Tulkens, 1993; Brockett *et al.*, 1997; Kumbakar *et al.*, 1998; Sathye, 2001; Simar and Wilson, 2007; Banker and Natarajan, 2008; Hakimi *et al.*,2012).

III. RANKING OF COMMERCIAL BANKS

The objective of the study is to rank the Public Sector Banks, employing two stage Data Envelopment Analysis.

A. DATA ENVELOPMENT ANALYSIS

Data envelopment analysis is a linear programming technique initiated by Charnes, Cooper and Rhodes (1978), subsequently extended by Banker, Charnes and Cooper (1984) to account for variable returns to scale. The idea of data envelopment was originally due to Farrell (1957), who formulated an empirical methodology to measure technical, allocative and cost efficiencies of production units. Theoretical building blocks were subsequently provided by R.W. Shephard (1970), whose distance functions of efficiency measurement are inversely related to Farrell's input and output distance functions. But, Shephard could not provide an empirical approach for efficiency measurement.

CCR (1978) formulated fractional programming problems to measure input and output technical efficiencies. Employing Charnes-Cooper transformation these problems can be transformed into linear programming problems. In DEA literature these linear programming problems are called the multiplier problems. The dual problems of multiplier problems are called as the envelopment problems. These can be independently axiomatically obtained.

In data envelopment analysis the unknown production possibility set is approximated by the production possibility set build with the aid of sample production plans. The CCR production possibility set can be obtained under the postulates of inclusion, convexity, free disposability, ray unboundedness and minimum extrapolation. The surface of this PP set is the CCR production frontier that provides bench marks for inefficient production units whose inputs and/or outputs freely disposed off. The CCR production frontier fails to recognize variable returns to scale. This deficiency was removed by BCC (1984) whose PP set was formulated under the axioms of inclusion, convexity, free disposability and minimum extrapolation. The surface of the BCC PP set provides variable returns to scale frontier.

In data envelopment analysis efficient benchmarks are deducted for inefficient production units, solving suitable linear programming problems. For this purpose the inefficient production plans are projected onto the surface of the production possibility set. The CCR and BCC projections are radial, either input or output oriented. Radial measures are called technical efficiency measures, since the projection process retains technique invariant. The input mix of the inefficient production unit and its efficient benchmarks is one and the same in input oriented radial projection. Output mix of the interior production unit and its frontier benchmarks remains to be one and the same in output oriented radial projection.

Radial measures provide short run benchmarks since the characteristic of short run is invariability of input and/or output mix. The DEA methodology initiated by CCR and BCC is known as non-parametric, since the chief tool to measure efficiency score, the production frontier is not parametrically specified. The details of the production frontier are embedded in the liner programming problems. The input efficiency scores are distributed in the interval 0 to 1, while output efficiency scores are found distributed beyond one. Unit efficiency scores correspond the frontier production units. The CCR/BCC DEA problems classify production units into three classes efficient, weak efficient and inefficient.

The CCR/BCC production frontiers are piecewise liner, determined by the extremely efficient production plans. For a given output vector input orientation seeks maximum possible input reduction to attain efficiency. Unit efficiency score and zero slacks place the production unit in the set of efficient production plans. For weak efficient production plan efficiency score emerges with a unit value, with atleast one slack attaining non-zero value. A production plan with less than unit efficiency score is flagged inefficient. Further, for an efficient production plan if the optimal solution is unique it is viewed as extremely efficient.

The CCR/BCC output orientation seeks maximum output expansion for a given input vector. A production plan whose output efficiency score exceeds unity is flagged inefficient.

B. DISCRIMINATORY POWER OF DEA- SUPER EFFICIENCY

DEA suffers from lack of discriminatory power, in the sense that more than one production plans may attain unitary technical efficiency scores. DEA fails to rank such production units. Andersen and Peterson (1993) introduced the concept of super efficiency that is based upon leave-one-out approach, that can be calculated from both input and output orientation perspective. Super efficiency is relevant to efficient decision making units for which the efficiency score is unity and all slacks vanish. To compute either input or output super efficiency of an efficient production plan, its input and output vectors are removed from the reference technology and the relevant CCR liner programming problem is solved. If a production unit is input super-efficient, its efficiency score emerges to be larger than unity. Input super efficiency score of an efficient production plan reveals its ability to remain efficient under input expansion. The output super efficiency score deals with the stability of the production unit to remain efficient under output contraction. Under input orientation such production unit whose super efficiency score above unity is the target is assigned with rank one in ranking analysis of production plans. However, under output orientation such firm whose super efficiency score less than unity is the smallest is considered to be rank-one-production plan. CCR-Super efficiency linear programming problems are always feasible.

The concept of super efficiency can be extended to the BCC linear programming problems. But, these problems are not always feasible. Cook *et al.*, (2009) suggested modifications to the infeasible super efficiency problems to become feasible. Zhu (1996), Dula and Hickman (1997), Seiford and Zhu (1998, 1999) discuss infeasibility of super efficiency problems based on variable returns to scale (BCC) linear programming problems.

C. INPUTS AND OUTPUTS

In Data envelopment analysis choice of too many inputs and too many outputs manifest in too many efficient production units, forcing DEA to loose its discriminatory power. Small number of inputs and outputs mask the truly efficient production plans as inefficient. In the envelopment models degrees of freedom increase with sample size as we notice in statistical theory of estimation. However, degrees of freedom decrease with increase in the number of inputs and/or outputs. A rule of thumb that serves as a guide to select the sample size is,

$n \geq \text{Max}\{mxs, 3(m+s)\}$

where n is the number of firms, m and s are number of inputs and outputs respectively (Cooper *et al.*, 2007).

Due to infeasibility of BCC super efficiency problems, the Public Sectors cannot be ranked basing on BCC efficiency/Super efficiency scores. However, via two stage DEA approach one can enhance the discriminatory power of DEA, consequently the PSBs can be ranked.

D. TWO STAGE DEA

(i) In stage one the BCC input efficiency scores are obtained solving,

$$\theta^{BCC} = \text{Min}\,\theta$$

$$\text{Such that } \sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{ij_0}, \quad i \in M \qquad (3.1)$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{rj_0}, \quad r \in S$$

$$\sum_{j=1}^{n} \lambda_j = 1 \qquad \lambda_j \geq 0, \quad j \in N$$

where test bank is Bank_{j_0}

x_{ij} : i^{th} input of j^{th} bank

y_{rj} : r^{th} output of j^{th} bank

λ_j : Intensity parameter of j^{th} bank

$$0 < \theta^{BCC} \leq 1$$

GRAPHICAL ILLUSTRATION

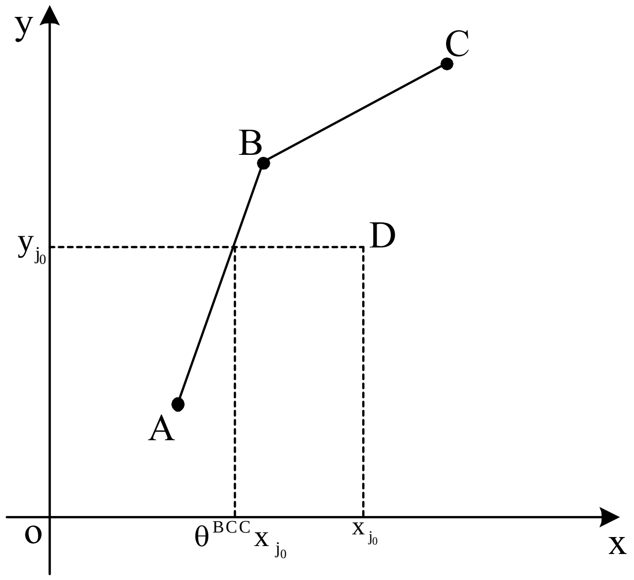

Figure 1

In the figure above input and output are measured along horizontal and vertical axes. The line segments AB and BC constitute BCC frontier. To attain input technical efficiency the inefficient bank D shall contract its input from x_{j_0} to $\theta^{BCC} x_{j_0}$. The input contraction is radial.

(ii) In the second stage DEA, an attempt is made to explain interbank differences by regression analysis.

Mitchell and Anvural (1996), Miller and Noulas (1996), Goldberg and Rai (1996), Berger and Mester (1997), Sathey (2001), Simar and Wilson (2007), Hoff (2007), Kumar and Gulati (2008), Banker and Natarajan (2008), Mcdonald (2009), and Hakimi *et al.*,(2012) performed second stage DEA analysis to examine the impact of environmental variables on efficiency scores.

The choice of regression model to explain interbank differences reflected by the efficiency scores is not trivial, since the efficiency scores are fractional.

$$0 < \theta_{CCR}, \theta_{BCC} \leq 1$$

The alterative regression models are linear probability regression, latent variables regression, Logit Regression, Probit regression, fractional regression (Papke and Wooldridge, 1996), Generalized Fractional Regression (Ramalho *et al.*, 2010), Stochastic Frontier Regression (Banker and Natarajan, 2008), Bootstrap Regression (Simar and Wilson, 2007).

In the present study we employed Binary Regression, whose disturbance term follows Standard Logistic Distribution.

Due to data constraints, Non-performing Assets (NPAs), Bank Size measured by total assets and income from Off Balance Sheet (OBS) business are chosen as environmental variables. It is hypothesized that the variation in the pure technical efficiency scores can be explained by these environmental variables. The binary regression equation specified is as follows:

$$y_j = \beta + \beta_N z_{Nj} + \beta_S z_{Sj} + \beta_O z_{Oj} + \varepsilon_j, \quad (3.2)$$

j=1, 2,……n

where $y_j = 1$ if $\theta_{BCC} = 1$

$= 0$ if $\theta_{BCC} < 1$

z_N, z_S and z_O respectively measure net NPAs, size and income from Off Balance Sheet Business (OBS).

To fit (3.2) we have used SPSS.

IV. DATA

The Data are collected from Reserve Bank of India Bulletins (2016).

INPUTS: Interest Expenditure (x_1)

Other Expenditure (x_2)

OUTPUTS: Interest Income (y_1)

Other Income (y_2)

ENVIRONMENTAL VARIABLES

Net NPAs (z_N)

Bank size (z_S) = Total Assets.

Income from Off Balance Sheet Business (z_O)

(Money values are expressed in crores of rupees)

NPAS: The Indian commercial banks, in particular the Public Sector Banks experience non-performing assets which vary from one bank to another. NPAs indicate the health of a bank. The public sector banks of India face the problem of mounting NPAs from year to year. NPAs need provisions which bring down the profitability of banks. Therefore, to improve the efficiency and profitability of Public Sector Banks, NPAs are to be reduced as well as controlled. The inputs we have considered in this study estimate the cost of the bank and the outputs give revenue of the bank. The difference between revenue and cost is the profit. Therefore, it is appropriate to choose net NPAs as an environmental variable, to explain efficiency variation.

SIZE OF THE BANK: Size of a bank is measured by its total assets. Size relates with returns to scale. Large banks often suffer from decreasing returns to scale, while small banks enjoy increasing returns to scale. An organization is scale efficient, if and only if, its returns to scale are constant. Size of the bank is chosen as an environmental variable capable of explaining variation in the efficiency scores.

OFF BALANCE SHEET BUSINESS (OBS): Off Balance Sheet business sharply increased since 2011 in Indian commercial banks. The business grew at the rate of 32 per cent from year to year. The off balance sheet business activities constitute, forward contracts of clients, bank guarantees, and Bankers' acceptances. These activities earn fee income. The rise in off balance sheet business heavily contributes to other in come. An RBI report, "Trends and progress of Banking in India" reveals a one percent rise in off balance sheet business exposure leads to 0.08 per cent increase in other income.

This study chooses OBS as an environmental variable to explain the variation in efficiency scores.

V. EMPIRICAL RESULTS

Predicted probabilities can be calculated for efficient banks using the following formula.

$$P\left[y_j = 1/z\right] = \frac{e^{x\hat{\beta}}}{1+e^{x\hat{\beta}}} \quad (5.1)$$

where $j \in D_0$

For $j_1, j_2, \in D_0$,

$$P\left[y_{j_1} = 1/z\right] \geq P\left[y_{j_2} = 1/z\right] \quad (5.2)$$

$\Rightarrow \text{Bank}_{j_1}$ is superior to Bank_{j_2}

$\hat{\beta}$ can be obtained fitting the binary regression model.

The binary logistic regression implemented refers to input pure technical efficiency scores, where the binary dependent variable y is defined as,

$$y = \begin{cases} 1 \text{ if DMU is pure technical efficient} \\ 0 \text{ other wise.} \end{cases}$$

$$y = \beta + \beta_N z_N + \beta_S z_S + \beta_O z_O + \varepsilon \quad (5.3)$$

is the binary regression model. The fit emerged to be in appropriate. (5.3) is estimated augmenting only two explanatory variables. The consequent regression fits were found unimpressive.

Finally, regression fits were examined with single explanatory variable

$$y = \beta + \beta_S z_S + \varepsilon \quad (5.4)$$

emerged to be a meaningful regression model for which $\hat{\beta}_s$ is found to be significant at 8 percent level of significance. For fitting logistic regression SPSS is used*.

$$P\left(y = 1/z_s\right) = \frac{e^{\hat{\beta}+\hat{\beta}_s x_3}}{1+e^{\hat{\beta}+\hat{\beta}_s x_3}}$$

- ✓ The Nagelkerke R^2 is about 26 percent
- ✓ $\hat{\beta}_s = 0.000045$ is significant at 8 percent
- ✓ $\hat{\beta} = -2.005$ is significant at 2 percent
- ✓ R^2 count = 77.8 percent.

WALD Statistic Follows χ^2- distribution with one degree of freedom

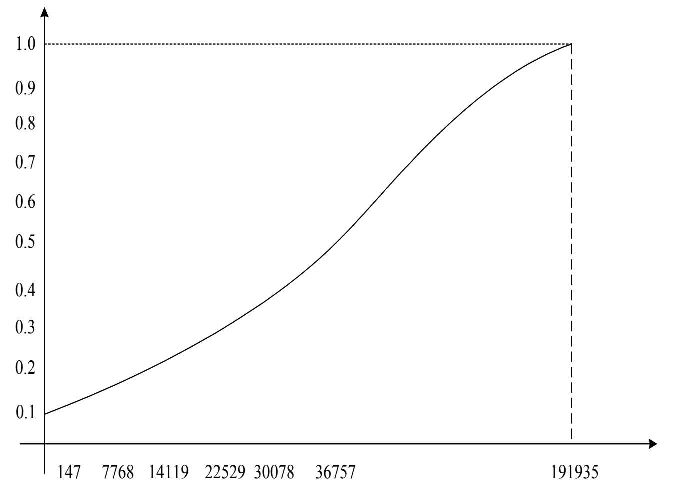

Figure 2

The above figure represents logistic distribution. Total assets are measured along horizontal axis, $p(y=1/z_s)$ is measured along vertical axis. Total assets and pure technical efficiency are positively related. Public sector banks grow stronger by assets' expansion.

S. No.	Name of the Bank	$p(y=1/z_S)$
1.	SB of Bikaner and Jaipur	0.1722
2.	SB of Hyderabad	0.2077
3.	State Bank of India	0.9989(*)
4.	State Bank of Mysore	0.1598
5.	State Bank of Patiala	0.1846
6.	State Bank of Travancore	0.1780
7.	Allahabad Bank	0.2693
8.	Andhra Bank	0.2293
9.	Bank of Baroda	0.7481(*)
10.	Bank of India	0.6628
11.	Bank of Maharashtra	0.2027
12.	Bharatiya Mahila Bank Ltd	0.1194(*)
13.	Canara Bank	0.5832(*)
14.	Central Bank of India	0.3427
15.	Corporation Bank	0.2691(*)
16.	Dena Bank	0.1928
17.	IDBI Bank Limited	0.3861(*)
18.	Indian Bank	0.2406
19.	Indian Overseas Bank	0.3222
20.	Oriental Bank of Commerce	0.2707
21.	Punjab and Sind Bank	0.1719
22.	Punjab National Bank	0.6435(*)
23.	Syndicate Bank	0.3194
24.	UCO bank	0.2863(*)
25.	Union Bank of India	0.4131
26.	United Bank of India	0.1904(*)
27.	Vijaya Bank	0.2018

Table 1

The 'starred' scores refer to efficient banks, of which the strongest appears to be State Bank of India, followed by Bank of Baroda, Punjab National Bank, Canara Bank, IDBI Bank Ltd, UCO Bank, Corporation Bank, United Bank of India and Bharatiya Mahila Bank Ltd.

To improve the discriminator power of DEA, we advice ranking of efficient decision making units basing on logistic probability scores $p[x=1/z_s]$. Larger is this probability for an efficient decision making unit greater is its rank.

Ranking of efficient decision making units, based on their logistic probability scores.

S. No	Name of the Bank	Rank
1.	SB of Bikaner and Jaipur	10
2.	SB of Hyderabad	12
3.	State Bank of India	1
4.	State Bank of Mysore	17
5.	State Bank of Patiala	22
6.	State Bank of Travancore	26
7.	Allahabad Bank	11
8.	Andhra Bank	14
9.	Bank of Baroda	2
10.	Bank of India	15
11.	Bank of Maharashtra	13
12.	Bharatiya Mahila Bank Ltd	9
13.	Canara Bank	4
14.	Central Bank of India	21
15.	Corporation Bank	7
16.	Dena Bank	23
17.	IDBI Bank Limited	5
18.	Indian Bank	16
19.	Indian Overseas Bank	24
20.	Oriental Bank of Commerce	18
21.	Punjab and Sind Bank	25
22.	Punjab National Bank	3
23.	Syndicate Bank	19
24.	UCO bank	6
25.	Union Bank of India	20
26.	United Bank of India	8
27.	Vijaya Bank	27

Table 2

VI. CONCLUSIONS

- ✓ The Public Sector banks are found to be highly efficient.
- ✓ Second stage DEA results reveal BCC efficiency and size of the bank are positively related.
- ✓ The logistic distribution probabilities are used to improve the discriminatory power of DEA, consequently the BCC – efficient banks were ranked on the basis of these probabilities.
- ✓ State Bank of India, Bank of Baroda and Punjab National banks respectively attained first, second and third ranks.

Punjab and Sind Bank, State Bank of Travencore and Vijaya bank secured 25th, 26th and 27th ranks.

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