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PERFORMANCE MEASUREMENT WITH DATA ENVELOPMENT ANALYSIS: AN APPLICATION TO INDIAN PUBLIC SECTOR BANKS

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ABSTRACT

Data Envelopment Analysis (DEA) is a powerful and popular tool to evaluate efficiency of decision making units (DMUs). Its ability to handle large data related to multiple inputs and outputs of many DMUs, makes it suitable to evaluate efficiency level of bank branches. Present research article intends to evaluate efficiency of 27 public sector banks (PSBs), operating in India, using DEA. Public Sector Banks play a vital role in economic development of India by providing financial services and securities to general public. In present times, when PSBs have to compete with private and foreign banks, it is imperative for PSBs, to continuously analyse and improve their performance. Findings of this article will help the PSBs to know their efficiency levels and the factors they should work on to, for further improvement.

Keywords: Data Envelopment Analysis (DEA), Decision Making Units (Dmus), Efficiency, Public Sector Banks (Psbs).

I. INTRODUCTION

Data Envelopment Analysis (DEA) is a non-parametric technique for efficiency evaluation. Right from its inception, DEA has been a preferred technique of researchers and policy makers. DEA has a large application area because of its ability of handling large data and compatibility with profit as well as non-profit oriented organizations. For the same reasons, DEA is widely used for efficiency evaluation of banks too. Present research article uses CCR model of DEA to assess the efficiency of Public Sector Banks (PSBs), operating in India, for the year 2014-15. Public Sector Banks are major contributors in economic development of India. They provide financial services and securities to public with not only a purpose of earning profits, but also for the sense of responsibility. PSBs work strictly per governments regulations, which assures non-violation of consumer rights. In present times, when PSBs are facing competition with private and foreign banks for financial gains, it becomes even more necessary for PSBs, to continuously evaluate their efficiency and work for further improvement. Present article analyses the efficiency levels of all PSBs, mentioning the benchmarks for each relatively inefficient PSB and provides with the details of sources responsible for inefficiency. Findings of this

article will help the PSBs to know their present performance and the remedial actions for less efficient PSBs, which can help them to become efficient.

The present research article is divided into eight sections. Starting with introduction to this article in section one, review of related literature follows in section two. Third section states the objectives of present study and justifies the purpose of study. Fourth section lists the hypothesis, fixed on the basis of objectives of study. The data used and the methodology followed in present article is discussed in section five. Section six discusses the properties and mathematical formulation of DEA, the technique used in this paper. Analysis of data, done with help of DEA is given in section seven, with help of tables and key findings are concluded in section eight. These findings would help the PSBs to know their efficiency levels with an insight of factors responsible for the same and a scope of improvement.

II REVIEW OF LITERATURE

This section provides a review of existing literature related to the application of Data Envelopment Analysis on Banks in India and abroad.

Jemric, Igor and Boris (2002) analysed the bank efficiency in Croatia during 1995-2000 using CCR and BCC models of Data Envelopment Analysis (DEA). **Lin, Hsu and Hsiao (2007)** investigated the relative efficiency of management and variation of managerial efficiency among 37 domestic banks in Taiwan, using data envelopment analysis(DEA) and Malmquist Index. **Pasiouras (2008)** analysed a sample of 715 publicly quoted commercial banks operating in 95 countries during 2003, using two–stage DEA. **Yang (2009)** evaluated 240 branches of Canadian Bank in Greater Toronto area using BCC model of data envelopment analysis (DEA). **Alkhathlan and Malik (2010)** evaluated the relative efficiency of Saudi Banks from 2003 through 2008 using CCR and BCR models of Data envelopment analysis(DEA). **Arslan and Ergec (2010)** analysed the efficiencies of 26 private conventional banks and 4 participation banks in Turkey, during 2006-2009 through the data envelopment analysis (DEA). **Gitau and Gor (2011)** used DEA method to measure Malmquist index of total factor productivity for a sample of 34 commercial banks in Kenya for the period 1999-2008. **Sultan, Bilal and Abbas (2011)** used a Two-stage DEA model to evaluate the performance of ten banks listed in Karachi stock exchange, Pakistan for the period 2005-2009. **Akbari, Dahmardeh and Saravani (2012)** carried out efficiency analysis of Bank Refah Kargaran Branches in Sistan and Baluchistan(S&B) in the financial year 2009-10 using CCR and BCC models of Data Envelopment Analysis(DEA). **Qureshi and Shaigh (2012)** analysed the comparative efficiency of banking system in Pakistan, comprising of Islamic banks, conventional banks with Islamic banking division and conventional banks by using ratio analysis and data envelopment analysis(DEA).

Ganesan (2009) examined the technical efficiency of 30 State Cooperative Banks (SCBs) and 20 District Central Cooperative Banks (DCCBs) in India, using data envelopment analysis, during the period 2002-06. They found that the mean efficiency (in percentage) of SCBs during 2002-2006 was 74.5 while that of DCCBs was 72.51. **Pal and Bishnoi (2009)** used Malmquist Index to explain the productivity growth of Indian banking sector. The authors examined panel data of 63 commercial banks from 1996-2005. They found that the sampled banks experienced highest growth on basis of value addition of 5.7% followed by asset approach with 2.5% whereas income approach based productivity has gained 0.6% growth rate. **Srivastava and Gupta (2009)**

examined 54 commercial banks of India, during 2004-2008, using non-parametric technique DEA, separately for each year. The average efficiency was found to be 90 percent using operations approach whereas using intermediation approach efficiency declined to 70 percent**. Subramanyam, Venkateswarlu and Reddy (2010)** calculated the efficiency of 22 Indian commercial banks and only 59% banks were efficient. **Sekhri (2011)** compared 62 Indian public sector banks, private sector banks and foreign banks for the period 2004-09, using Malmquist TFP growth measure. It was found that the foreign sector banks scored a high TFP mainly because of their high technical efficiency change and the PSBs performed better than foreign & private banks in pure efficiency change index.

III OBJECTIVES AND JUSTIFICATION OF THE STUDY

From the detailed survey of the existing literature related to the efficiency evaluation of Indian PSBs, it is found that there is a huge gap in terms of selection of PSBs. present research article has tried to fill this gap by taking all the PSBs operating in India, under study. Moreover, present article is based on the recent data, with an objective of presenting the current level of efficiencies.

Although, the main objective of the present study is to use Data envelopment analysis to evaluate the efficiency of Indian public sector banks, during the year 2014-15. However, the specific objectives are as follows:

1. To analyse the efficiency of Public Sector Banks operating in India.
2. To examine the sources of inefficiency amongst Public Sector Banks of India.
3. To ascertain the benchmarks for the less efficient banks

IV HYPOTHESIS

On the basis of above stated objectives, following hypotheses have been created

$H_{1,0}$: Majority of the Public Sector Banks are inefficient.

$H_{1,1}$: Majority of the Public Sector Banks are efficient.

$H_{2,0}$: Lack of proper utilization of input variables is the main source of inefficiency.

$H_{2,1}$: Lack of proper utilization of input variables is not the main source of inefficiency.

V DATA BASE AND RESEARCH METHODOLOGY

The present research article aims at efficiency evaluation of 27 public sector banks, operating in India, for the year 2014-15. The data were obtained from the Statistical Tables Related to banks in India published by The Reserve Bank of India.

The present study uses the CCR model of non-parametric technique, Data envelopment analysis. This model uses an input oriented approach, assuming a constant return to scale, thus it is a natural choice to assess the bank performance (Yang,2009). Four inputs namely, Owned funds, Deposits, Borrowings and Wage bills have been taken, whereas, Spread and Other income have been taken as outputs.

Table 1 presents the list of PSBs under study.

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Table 1: List of Banks under study		
SBI & Associates	**Nationalized Banks**	**Other Public Sector Bank**
1. State Bank of India **2. State Bank of Bikaner and Jaipur** **3. State Bank of Hyderabad** **4. State Bank of Mysore** **5. State Bank of Patiala** **6. State Bank of Travancore**	**1. Allahabad Bank** **2. Andhra Bank** **3 . Bank of Baroda** **4. Bank of India** **5. Bank of Maharashtra** **6 . Canara Bank** **7. Central Bank of India** **8 . Corporation Bank** **9 . Dena Bank** **10. Indian Bank** **11. Indian Overseas Bank** **12. Oriental Bank of Commerce** **13. Punjab National Bank** **14. Punjab and Sind Bank** **15. Syndicate Bank** **16. UCO Bank** **17. Union Bank of India** **18. United Bank of India** **19. Vijaya Bank** **20. Bharatiya Mahila Bank**	**1. IDBI Bank**

VI DATA ENVELOPMENT ANALYSIS (DEA)

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 (Cooper, Seiford and Zhu, 2004). Existing Literature considers the inception of DEA in 1957, when Farrel proposed an activity analysis approach that could be applied to any productive organisation, for evaluating productivity. Farrel (1957) suggested the construction of the frontier as a piece-wise linear combination of most efficient units. Thereafter, Charnes, Cooper and Rhodes (1978) extended Farrel's work and showed that data-based activity analysis models can be solved using linear programming techniques to access productive performance (Fare et al, 2011). They introduced a linear-programming method to identify the efficient DMUs. They named this method as data envelopment analysis and succeeded in establishing DEA as a basis for efficiency analysis.

Charnes et al., (1978) had designed DEA for public sector programs in which the managers of various DMU's were not free to divert resources to other programs for more profit. They had an intention to evaluate the

accomplishments or resource conservation possibilities, for every DMU with the resources assigned to it. But, further extensions and developments in DEA models led to more choices with the managers. The original CCR model, first proposed by Charnes, Cooper and Rhodes, was applicable only to technologies characterized by constant returns to scale globally. Further, Banker, Charnes and Cooper (BCC), (1984), extended the CCR model to accommodate technologies that exhibit variable returns to scale. Thereafter, literature witnesses several models and developments in DEA models.

Since its inception, DEA has been a preferred choice of the researchers and managers, for efficiency evaluation, for various reasons, stated by researchers. **Cooper, Seiford and Tone (2000)** state that DEA supplies new insights into activities that have previously been evaluated by other methods. In the view of **Emrouznejad and Cabanda**, the major advantage of DEA is that it does not require specification of functional forms for the frontier of performance possibilities compared to traditional statistical regression techniques. **Sekhri (2011)** points out that DEA has several advantages over the Regression analysis and the Ratio Analysis as it identifies the best DMUs and can simultaneously consider multiple inputs and outputs. Moreover, it can also consider categorical, exogenous or qualitative data. **Yang (2009)**, stated that compared to other approaches, DEA is a better way to organize and analyse data since it allows efficiency to change over time and requires no prior assumption on the specification of the best practice frontier. Also, it permits the inclusion of random errors if necessary. Also, **Leibenstein and Maital (1992)**, argue that DEA is a superior method for measuring overall technical inefficiency. As per **Chen (2003),** Data envelopment analysis provides a powerful way to evaluate the relative performance, of a set of DMUs, particularly when market prices are not available.

DEA has a wide application area. It is the most widely applied technique to measure a firm's performance (**Emrouznejad et al.,2008**). **Sherman and Ladino (1995)** opined that in addition to banking, DEA has provided insights into ways to improve productivity in government services **(Sherman,1989)**, health maintenance organization services **(Chilingerian and Sherman 1994**) and security brokerage services (**Bank technology report, 1992)**. **Emorouznejad and Anouze (2010)** state that DEA is a powerful managerial tool for performance measurement and it has been widely used for assessing the efficiency of the public and private sectors. Further supporting DEA, according to **Sherman and Gold (1985)**, DEA is a highly objective benchmarking technique particularly well suited to such multi-office organizations as bank branches.

Thus, it is learned that DEA is a comparatively new non-parametric technique, with a wide application area and several models and extensions. The present research article uses the basic CCR model of DEA for efficiency evaluation of Indian PSBs.

The CCR model of DEA, developed by Charnes, Cooper and Rhodes (1978), has an input orientation and assumes constant returns to scale. It measures and compares the efficiency of Decision making units (DMUs) with similar inputs and outputs.

Consider 'n' DMUs, each with 'm' inputs and 's' outputs, where j^{th} DMU, DMU_j , (j=1,2,….., n) uses input vector $X_j = (x_{1j}, x_{2j}, \dots, x_{mj})$ to produce output vector $Y_j = (y_{1j}, y_{2j}, \dots, y_{sj})$ for $X_j \geq 0,\ Y_j \geq 0$

For input weights vector $V = (v_1, v_2, \dots, v_m)$ and output weights vector $U = (u_1, u_2, \dots, u_s)$ each DMU_k has an optimization problem

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$$\text{Maximize } \theta = u_1 y_{1k} + u_2 y_{2k} + \cdots + u_s y_{sk}$$

$$s.t. \quad v_1 x_{1k} + v_2 x_{2k} + \cdots + v_m x_{mk} = 1$$

$$u_1 y_{1j} + u_2 y_{2j} + \cdots + u_s y_{sj} \leq v_1 x_{1j} + v_2 x_{2j} + \cdots + v_m x_{mj} \;\; for\ all\ j = 1,2,\ldots,n.$$

$$v_1, v_2, \ldots, v_m \geq 0$$

$$u_1, u_2, \ldots, u_s \geq 0 \qquad \ldots (1)$$

Corresponding to $k = 1,2,\ldots,n$ (1) gives a set of 'n' optimization problems. Each problem is then solved for obtaining values of most favourable input weights $v_1, v_2, \ldots, v_m$ and output weights $u_1, u_2, \ldots, u_s$ for each corresponding DMU.

In matrix form,

$$\text{For } X = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{pmatrix} \text{ and } Y = \begin{pmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ y_{s1} & y_{s2} & \cdots & y_{sn} \end{pmatrix}$$

the above LPP can be written as

$$Maximize\ \theta = UY_k$$

Subject to $VX_k = 1$

$$UY \leq VX$$

$$U \geq 0\ and\ V \geq 0.$$

VII ANALYSIS

The application of the CCR model of DEA, on data of input and output variables, obtained for the PSBs under study, for the year 2014-15, gives the relative efficiency of these PSBs, listed in Table 2. As per the model, any PSB with a 100 percent efficiency score, is considered to be efficient and any value of efficiency score less than 100 percent terms the corresponding PSB, as inefficient.

Table 2: Relative Efficiency Score of Banks under study

Name of the Bank	Efficiency Score (%)
State Bank of India	100
State Bank of Bikaner and Jaipur	100
State Bank of Hyderabad	100
State Bank of Mysore	94.8
State Bank of Patiala	81.3
State Bank of Travancore	100
Allahabad Bank	100
Andhra Bank	92.7
Bank of Baroda	90.6
Bank of India	77.1
Bank of Maharashtra	98.2

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Canara Bank	**77.7**
Central Bank of India	**84.9**
Corporation Bank	**100**
Dena Bank	**88.9**
IDBI Bank	**100**
Indian Bank	**100**
Indian Overseas Bank	**72.7**
Oriental Bank of Commerce	**100**
Punjab National Bank	**96.8**
Punjab and Sind Bank	**77.3**
Syndicate Bank	**88.6**
UCO Bank	**100**
Union Bank of India	**90.6**
United Bank of India	**100**
Vijaya Bank	**77.9**
Bharatiya Mahila Bank	**100**

From Table 2, it is evident that out of total 27 PSBs, being evaluated, only 12 PSBs correspond to a 100 percent efficiency score and rest 15 PSBs have the same less than one hundred percent. Thus, it is found that out of 27 PSBs, 12 PSBs are efficient and the other 15 PSBs are less efficient or relatively inefficient.

Further, in the DEA analysis, for each relatively inefficient PSB, there are benchmarks. These benchmarks are efficient units, with same values of optimum weights as the corresponding inefficient unit.

Table 3 gives the list of inefficient banks and their corresponding benchmarks. As per Table 3, Stata Bank of Mysore has four benchmarks such as State Bank of India (0.005), State Bank of Bikaner and Jaipur (0.533), United Bank of India (0.091) and Bharatiya Mahila Bank (0.313). Out of these, State Bank of Bikaner and Jaipur is the nearest benchmark for it. Similarly, State Bank of Patiala has four benchmarks and its nearest benchmark is State Bank of Bikaner and Jaipur. Similar results for other inefficient PSBs can be noted from the table.

Table 3: Inefficient Banks and their Benchmarks

Name of Bank	**Benchmarks**
State Bank of Mysore	State Bank of India (0.005), **State Bank of Bikaner and Jaipur (0.533)**, United Bank of India (0.091), Bharatiya Mahila Bank (0.313).
State Bank of Patiala	State Bank of India (0.031), **State Bank of Bikaner and Jaipur (0.279)**, United Bank of India (0.028), Bharatiya Mahila Bank (0.076).
Andhra Bank	**State Bank of Bikaner and Jaipur (1.475)**, UCO Bank (0.004), United Bank of India (0.072).
Bank of Baroda	Corporation Bank (1.523), UCO Bank (1.176), **Bharatiya Mahila Bank**

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	(5.204).
Bank of India	**State Bank of Bikaner and Jaipur (2.319)**, UCO Bank (0.573), United Bank of India (0.536).
Bank of Maharashtra	**State Bank of Bikaner and Jaipur (1.317)**.
Canara Bank	State Bank of Bikaner and Jaipur (0.5), IDBI Bank (0.043), UCO Bank (0.808), United Bank of India (1.282), **Bharatiya Mahila Bank (2.997)**.
Central Bank of India	**State Bank of Bikaner and Jaipur (2.464).**
Dena Bank	Indian Bank (0.199), Oriental Bank of Commerce (0.008), **United Bank of India (0.61).**
Indian Overseas Bank	**State Bank of Bikaner and Jaipur (1.388),** UCO Bank (0.032), United Bank of India (0.452).
Punjab National Bank	State Bank of India (0.053), **State Bank of Bikaner and Jaipur (4.172)**, United Bank of India (0.444), Bharatiya Mahila Bank (3.282).
Punjab and Sind Bank	**State Bank of Travancore (0.287)**, Indian Bank (0.017), Oriental Bank of Commerce (0.187).
Syndicate Bank	**State Bank of Bikaner and Jaipur (1.499)**, Allahabad Bank (0.025), United Bank of India (0.384).
Union Bank of India	State Bank of Bikaner and Jaipur (0.47), Allahabad Bank (0.798), **United Bank of India (0.856).**
Vijaya Bank	**Allahabad Bank (0.312)**, United Bank of India (0.147).

Further, Table 4 indicates the sources of inefficiencies for inefficient units. These sources of inefficiency are the most useful values for an inefficient unit, which aspires to be efficient by working on the factors which decrease their efficiency.

Table 4: Sources of Inefficiency (Figures in Rs. Million)

Name of the Bank	**INPUTS**				**OUTPUTS**	
	Owned Funds	**Deposits**	**Borrowings**	**Wage Bills**	**Spread**	**Other Income**
State Bank of Mysore	0	0	0	983.107	0	0
State Bank of Patiala	0	0	2110.507	0	0	0
Andhra Bank	0	108947.343	26969.368	0	0	0
Bank of Baroda	0	0	40350.154	0	0	3092.31
Bank of India	0	338139.744	52863.891	0	0	0
Bank of Maharashtra	0	89279.229	9477.659	2691.942	0	2144.392
Canara Bank	0	0	0	0	0	0
Central Bank of India	0	93324.671	33825.604	7502.714	0	3882.891
Dena Bank	0	14342.874	0	0	0	6325.074

Indian Overseas Bank	0	60822.127	5891.724	0	0	0
Punjab National Bank	0	0	0	10928.079	0	0
Punjab and Sind Bank	0	0	0	0	0	2813.387
Syndicate Bank	0	533180.645	102063.196	0	0	0
Union Bank of India	0	0	135746.726	2236.67	0	0
Vijaya Bank	0	221234.138	6090.238	360.456	0	0

Table 4 indicates that **State Bank of Mysore**, in order to enhance its efficiency, should decrease its wage bills by Rs. 983.107 Million, to achieve same level of outputs. **State Bank of Patiala** should decrease its borrowings by Rs. 2110.507 Million, with same outputs, to become efficient. **Andhra Bank** can become efficient by decreasing its deposits and borrowings by Rs. 108947.343 Million and Rs. 26969.368 Million respectively, with same level of outputs. **Bank of Baroda** should decrease its borrowings by Rs. 40350.154 Million and increase its other income by Rs. 3092.31 Million, to become efficient. **Bank of Maharashtra** and **Central Bank of India** should reduce their inputs and increase outputs as its found from the table that almost all variables have a scope of improvement. **Bank of India, Indian Overseas Bank** and **Syndicate Bank**, should decrease their deposits and borrowings, as shown by the table, to become efficient. **Dena Bank** should reduce its deposits by Rs. 14342.874 Million and increase other income by Rs. 6325.074 Million, to become efficient. Similar results for rest of PSBs can be listed from the table.

VIII FINDINGS & CONCLUSIONS

From the foregoing analysis, the findings can be summarised as follows

- Out of all 27 PSBs under study, only 12 are efficient and rest 15 are inefficient. It means that majority of PSBs are inefficient. Thus hypothesis $H_{1,0}$ is true and accepted by rejecting the alternative hypothesis $H_{1,1}$.
- It is found that out of 15 inefficient PSBs, most of them are over using their input variables. Deposits, borrowings and wage bills are found in excess for 8, 10 and 6 PSBs respectively, which results in their inefficiency. It is observed that lack of proper utilization of inputs is the main source of inefficiency. Thus, hypothesis $H_{2,0}$ is true and accepted by rejecting the alternative hypothesis $H_{2,1}$.

Thus, it is concluded that majority of PSBs are inefficient. Further, excessive usage of input variables, mainly deposits, borrowings and wage bills, but lack of their proper utilization to produce accordingly increased outputs is the main source of inefficiency. These results can help the PSBs to locate their shortcomings and improve efficiency.

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