Efficiency Evaluation and Ranking of Indian PSBs: An Application of Data Envelopment Analysis

Reshampal Kaur

Associate Professor, Division of Mathematics, UIS, Chandigarh University, Mohali-140413, India, reshampal0304@gmail.com

Abstract.

Efficiency analysis in a relative environment is a requisite for any entity for optimization of sustainable development. Among many other tools available for performance analysis, the most appropriate and preferred tool worldwide is Data envelopment analysis (DEA), with diverse applications in public as well as private sector, in a multiple-input-output environment of Decision-making units (DMUs), in a competitive environment. This paper aims to present a comparative performance analysis of Indian public sector banks (PSBs) using conventional Charnes, Cooper and Rhodes (CCR) DEA model for efficiency evaluation as well as the advanced super-efficiency DEA model for the ranking of DMUs, for the year 2020. Findings from the application of DEA models, reveal that half of the Indian PSBs under study are relatively inefficient. As PSBs contribute majorly in Indian economy, efforts should be made for their efficiency enhancement. Also, it has been found that the results calculated using super-efficiency models are more appropriate and comprehensive for a rigorous efficiency comparison of all DMUs including efficient ones.

Keywords. Data envelopment analysis (DEA), Optimization, Efficiency, Decision making units (DMUs), Performance, Public sector banks (PSBs).

1. INTRODUCTION

For optimization of sustainable development, organizations must use their resources efficiently. Moreover, they need to consistently analyse their performance amongst their peers, to explore their scope of efficiency enhancement, using limited resources available to them. Data envelopment analysis (DEA) is a tool based in the scope of linear programming and has been used abundantly on the global level for an efficiency evaluation in comparative environment, among peer entities, across verticals [1]–[3]. The application areas of DEA include not only governmental entities like schools, military or hospitals, but also in banking, airlines, warehouses, transports, financial markets and stocks [4]–[13]. In the frameworks of DEA, such entities are termed as Decision making units (DMUs), which are peer entities using similar resources, called inputs to produce multiple desired goods or services, called outputs. If required, these input and output variables can be assigned weights, as per their importance. In an analysis dealing with the comparative study in a single time period , non-parametric technique DEA synchronises the inter-relationships of various input-output variables, without any assumption of functional structures [14], for the DMUs under study and identifies the units performing efficiently and further forming the frontier [15]. Also, it identifies comparatively inefficient units along with sources of inefficiency.

Public sector banks (PSBs) play an important role in Indian economy. In present times when there is a tough competition in public, private and foreign banks operating in India, PSBs with limited resources and strict regulations, are facing tough competition for survival as well as for growth. Such circumstances make it desirable to analyse the performance of Indian PSBs, to identify the domains to be improved for enhancement in efficiency.

The present study adopts the non-parametric technique DEA to assess the performance of Indian public sector banks (PSBs) and analyses the comparative inferences regarding efficiency and ranking of these banks, taken as DMUs, using Charnes, Cooper and Rhodes (CCR) DEA model and Super-efficiency DEA model. This paper has been set out as the following. The second section describes the materials and the methods used in this paper along with the details of the data used for the purpose, followed by discussion on results in section three. Further, section four discusses the overall observations of the results followed by a conclusion.

2. MATERIALS AND METHODS

This section describes the approach, techniques and the models used for the analysis, in this study. The description of data and variables used in the study has been provided in the subsection 2.1.

In a framework following Charnes et al. [1], for n DMUs, say DMU1, DMU2, …, DMUn such that the DMUk uses 'm' inputs x_{ik} $(i = 1,2, \dots., m)$ to produce 's' outputs y_{rk} $(r = 1,2, \dots., s)$, in a given time period. All the input and output values considered here are non-negative numbers, using constant returns to scale and following an input-oriented approach.

Taking input weights as $Iv = (a_{1,} a_{2,\dots,} a_m)$ and output weights as vector $Ov = (b_{1,} b_{2,\dots,} b_s)$, Each DMUk has a LPP to optimize the objective function

$$\text{Maximize } \theta = b_1 y_{1k} + b_2 y_{2k} + \cdots + b_s y_{sk}$$

$$s.t.\ a_1 x_{1k} + a_2 x_{2k} + \cdots + a_m x_{mk} = 1$$

$$\text{and } b_1 y_{1j} + b_2 y_{2j} + \cdots + b_s y_{sj} \le a_1 x_{1j} + a_2 x_{2j} + \cdots + a_m x_{mj}$$

$$for\ every\ j = 1, 2, \dots, n.$$

$$\text{Also, } a_1, a_2, \dots., a_m \ge 0\ and\ b_1, b_2, \dots., b_s \ge 0 \qquad (1)$$

Thus, taking k = 1, 2, …, n, equation (1) above represents 'n' LPPs such that each such LPP can be solved to find most suitable weights for input as well as output variables, corresponding to each DMU.

CCR model of DEA evaluates efficiency scores of the DMUs, this score is a positive value less than or equal to one. The units with efficiency score 'one', are identified as efficient DMUs, which form the frontier. Rest of the units are considered as comparatively inefficient units, with potential scope of improvement, which are assigned with one or more efficient units as benchmarks. These assigned benchmarks and the corresponding inefficient units have same set of variable weights in DEA analysis, thus providing insights for a feasible and achievable target to the inefficient unit, to become efficient.

The conventional CCR DEA model, in which either an input orientation or output orientation can be considered, with constant returns to scale, has numerous extensions. Although there are abundant applications of the basic conventional DEA models, even then these basic models have a shortcoming that they assign efficiency score 'one' to all the efficient DMUs, thus identifying more than one DMU as efficient, which provides similar ranks for many DMUs, hence don't provide the 'most efficient' unit. As a result, not able to provide any information for comparing efficient DMUs.

To resolve this problem, Andersen and Petersen [18] introduced a new DEA model, called Super-efficiency DEA model. In this model, efficiency scores are evaluated by a comparative analysis of efficient units, with respect to a reference technology, which is comprised of rest of the units. As a result, providing non-identical efficiency scores to each of the DMUs and enhanced information on the functioning of units, along with identifying better performing DMU among any pair of DMUs, selected at random.

Present study evaluates the performance of eighteen Indian PSBs, for the year 2020, using the results of the findings of DEA CCR model and DEA Super-efficiency model, considering input-orientation of optimization with constant returns to scale (CRS) of variables.

2.1. Data and Variables

The performance analysis in the present study is based on the eighteen public sector banks of India for the year 2020. The banks under study and the respective symbols are Allahabad bank(B1), Andhra bank(B2), Bank of Baroda(B3), Bank of India(B4), Bank of Maharashtra(B5), Canara bank(B6), Central bank of India(B7), Corporation bank(B8), Indian bank(B9), Indian overseas bank(B10), Oriental bank of commerce(B11), Punjab and Sind bank(B12), Punjab national bank(B13), State bank of India(B14), Syndicate bank(B15), UCO bank(B16), Union bank of India(B17), United bank of India(B18), considered as DMUs for the DEA models.

For the efficiency evaluation using DEA, selection of the variables is the most critical phase, which largely impacts the interpretations. Researchers have varied opinion on the selection and the number of variables selected for the analysis [8], [19], [20]. The present study uses four inputs such as borrowings, owned funds, wage bills and total deposits. Also, there are two output variables, namely total other income and the spread, as shown in a self-sketch figure 1.

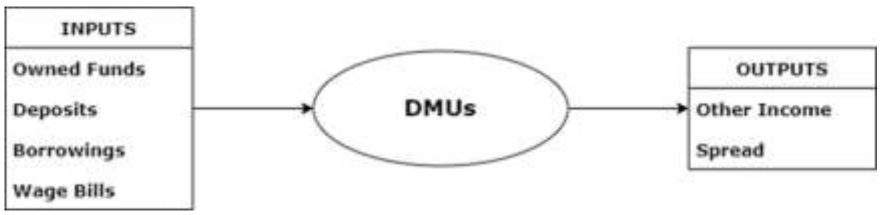

Figure 1. Input and Output Variables Used in DEA Models

The data values related to the DMUs, corresponding to the selected input-output variables, in Million INR, have been sourced from RBI published annual statistical tables. The data values are then normalized and the descriptive statistics like mean and standard deviation, have been calculated, using R programming software. The results thus found have been listed in Table 1.

TABLE 1: DESCRIPTIVE STATISTICS OF INPUT AND OUTPUT VARIABLES

Variables	N	Mean	S.D.	Median	Skewness	Kurtosis
Owned funds	18	36273.67	52300.45	17874.36	2.88	7.94
Total Deposits	18	502689.99	720579.37	245167.06	3.02	8.63
Borrowings	18	39432.20	72776.31	14912.32	2.98	8.40
Wage Bills	18	6391.32	10020.24	3521.32	3.33	10.19
Other Income	18	6562.04	9991.97	3336.07	3.18	9.47
Spread	18	13788.77	21938.63	7079.66	3.12	9.14

Source: Authors own calculations; All data values in Crores of INR.

3. RESULTS

This section includes the results of the tools, used in this study. The performance of each DMU, as per the findings received from CCR and Super-efficiency models of DEA, has been given in Table 2.

TABLE 2: EFFICIENCY SCORES OF DMUS FROM CCR AND SUPER-EFFICIENCY DEA MODELS

DMUs	CCR DEA	Super-eff CRS	Rank
B1	0.89888	0.898878202	16
B2	1	1.201578921	4
B3	1	1.04029503	8
B4	0.92399	0.923989726	12
B5	1	1.264321665	3
B6	0.90562	0.905617061	15
B7	0.91107	0.91107119	14
B8	1	1.756742858	1
B9	1	1.071503337	7
B10	0.91672	0.916722592	13
B11	0.86109	0.861085027	17
B12	0.81198	0.811975669	18
B13	0.95522	0.955217477	11

B14	0.99015	0.990147412	10
B15	1	1.026979216	9
B16	1	1.105953206	6
B17	1	1.142041177	5
B18	1	1.374446839	2

The findings of the DEA CCR model, as efficiency scores, with an input orientation and using a constant return to scale, have been given in Table 2, column 2. As analyses from these results, nine DMUs namely, Andhra bank(B2), Bank of Baroda(B3), Bank of Maharashtra(B5), Corporation bank (B8), Indian bank(B9), Syndicate bank(B15), UCO bank(B16), Union bank of India(B17), United bank of India(B18) are efficient with efficiency score equal to one whereas remaining nine DMUs are relatively inefficient in performance, with efficiency score less than one.

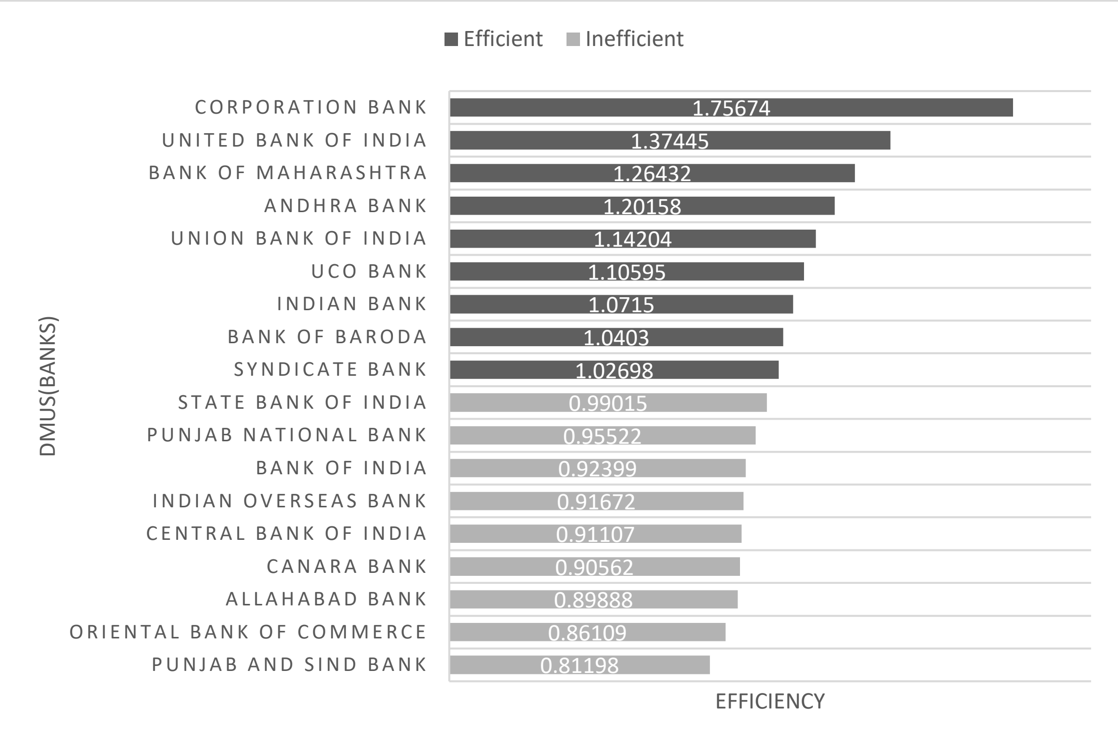

Figure 2. Performance Analysis Using DEA Models

It has been observed from the findings that all efficient DMUs have score equal to one, which makes it difficult to assign benchmarks to these units, for identification of further efficiency improvement. To overcome this problem, DEA super-efficiency model has been used. The findings of this model have been provided in Table 2, column 3. In addition to the identification of efficient and inefficient DMUs, as given by CCR model, this model also evaluates distinct efficiency score to each efficient DMU, providing a clear efficiency ranking of all DMUs, as given in Table 3, column 4, for an easy comparison of performance and benchmarking. Figure 2 represents the identification of efficient and inefficient DMUs as well as the rank wise efficiency scores of DMUs, using Super-efficiency DEA model.

It has been observed from the results that among efficient DMUs, Corporation bank(B8) is leading with rank 1, followed by United bank of India(B18) on rank 2, Bank of Maharashtra(B5) on rank 3, Andhra bank(B2) on rank 4, Union bank of India(B17) on rank 5, UCO bank(B16) on rank 6, Indian bank(B9) on rank 7, Bank of Baroda(B3) on rank 8 and Syndicate bank(B15) on rank 9. Further lower ranks have been obtained by inefficient DMUs.

4. CONCLUSION

Data envelopment analysis (DEA) is an efficient tool, which can be applied for a comparative efficiency evaluation, in a multiple input-output framework. In spite of a vast application areas, conventional DEA models have some shortcomings, like these conventional models provide efficiency score 'one' to all efficient DMUs, thus do not provide any parameter to further compare these DMUs for their comparative performance analysis. This shortcoming can be improved by using Super-efficiency model of DEA, which provides non-repeated efficiency scores to the DMUs, thus helping in identification of better performing DMU among any pair of DMUs selected at random. These results further can be helpful for benchmarking also, for a targeted improvement in efficiency.

Present study uses conventional CCR and the advanced Super-efficiency models of DEA, to analyse the efficiency of eighteen Indian public sector banks (PSBs), for the year 2020. Findings reveal a poor performance of Indian PSBs under study, where only half of the banks under study are efficient. Top five rankers are Corporation bank, United bank of India, Bank of Maharashtra, Andhra bank and Union bank of India.

It is required to further analyze the inefficient banks and explore the causes of their low efficiency. Also, for efficiency enhancement of these relatively inefficient PSBs, they should be assigned with efficient benchmarks, to provide an easy-to-follow targets, which can help the low performing unit to have guiding factor for an efficiency enhancement.

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Biographies

Reshampal Kaur received the post-graduation degree in Mathematics from Punjab University, Chandigarh. She is CSIR-NET qualified and did her PHD from Punjab Technical University, in Operations Research. She is currently working as an Associate Professor at Department of Mathematics, Chandigarh University. Her research areas include mathematical modelling, multivariate data analysis and optimization.