Comparative study of Cost and Revenue efficiency in public sector banks in India – DEA Approach

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ABSTRACT *Data Envelopment Analysis(DEA) technique involves the use of mathematical programing to estimate the efficiency of the Decision Making Units(DMU). The objective of the study is tocompare, cost and revenue efficiency of public sector bank in India for the period 2015-16.Further the authors of this paper attempted to calculate allocative efficiency. To attain this objective 27 public sector banks in India are considered and Banker Charnes Cooper (BCC) model in respect of both orientation has applied here. This study exhibits the average level of revenue efficiency is more than the average level of cost efficiency.*

Keywords: *Data envelopment analysis(DEA), Decision making units(DMU), Banker charnes cooper(BCC), Cost efficiency(CE) ,Revenue efficiency(RE),Allocative efficiency(AE).*

1.1 Introduction

Indian banking sector plays a vital role and stood forefront in the financial system. Over the past 30 years the Indian banking sector achieved potential and substantial progress on many areas. The Indian banking system has became a important tool in socio- economic development of a economy by converting class banking to mass banking, wholesale banking to retail banking and macro banking to micro banking .The banking sector in India consist of commercial and cooperative banks.Scheduled commercial banks and non-scheduled commercial banks are the two categories of commercial banks.Public sector banks (PSBs) are part of the scheduled commercial banks and it includes State bank of India (SBI) and it is associate banks ,Nationalized bank and Reginal rural banks(RRB).PSBs captures more than 70% of total bank business and have many branches in all over India. Due to these above facts it becomes necessary to analyze the performance of Public sector banks. There are many tools for the performance measurement. Of these , DEA is a powerful and popularly used tool for measuring the performance of unique set of organizations.

Data envelopment Analysis(DEA) is a most widely used non-parametric technique to measure the relative efficiency of similar type of organizations known as Decision making units.Each DMU includes multiple inputs and multiple outputs. Debreu (1951) provided the first measure of efficiency. Then Koopmans(1957) defined the concept of Technical Efficiency(TE).Present all the efficient measurements are based on Farrell (1957). charnes, cooper and Rhodes (CCR 1978) extended the Farrell's work and proposed new efficiency measurements based on Linear programing and further it was extended by Banker,charnes and cooper (1984). The authors in this paper made an attempt to calculate different types of efficiency in DEA namely Technical efficiency (TE), Cost efficiency (CE), Revenue efficiency(RE) , Allocative efficiency(AE). To attain this objective 27 public sector banks in India are considered. Each bank is treated as DMU which includes three inputs and three outputs.

Rest of the paper is organized as follows section. 1.2 contains a brief review of literature section 1.3 describesvarious DEA methodsand section 1.4 contains description of data Empirical analysis has been carried out in section 1.5. section 1.6 summarizes findings and conclusions.

1.2. Review of literature

Initial contribution in efficiency measurement is made by Farrell(1957) Charnes, Cooper and Rhodes (1978) extended the Farrell's work and proposed new efficiency measurements based on Linear programing and further it was extended by Banker, charnes and cooper (1984) . CCR based on constant return to scale assumption and BCC admits Variable return to scale assumptions. Bhattacharya et al. asses the impact of the limited liberalization initiated before the deregulation and they found that PSBs have been most efficient on compared with FBs and PBs in utilizing they resources at their disposal to deliver financial services to their customers.Das (1997) using cross sectional data of 27 PSBs at various points of time and finds that SBI and it is associated bank are more efficient than nationalized banks. In Indian context the authors, Das,2002; Shanmugam and Das,2004; Ram Mohan and Ray,2004; Ram Mohan and Ray,2004; Das and Ghose,2006&2009; Ray,2007; Jayaram and Srinivasan,2009; Kumar and Gulati,2008; Gulati and Kumar,2011 analyzed technical efficiency and cost efficiency of banks in India using DEA. Ray and

Das(2010) studied the cost and profit efficiency of Indian banks during the post reform periods. Their study reveals that public sector banks are more efficient than private sector banks and small banks and also the study contains a strong evidence of ownership explaining the efficiency differential of banks. Kaur and Kaur (2010) using DEA and studied the impact of merges on the cost efficiency of Indian commercial banks. This study import that the stronger banks should not merge with the weaker banks.Ranjan et al (2011) analyzed the performance of Indian scheduled commercial banks in respect of Technical efficiency and productivity during 1979-2008.Ar Jayaraman and Mr Srinivasan (2014) have evaluated of performance of bank in India using Cost , revenue and profit models of DEA. They observed Shannon DEA approach provides a comprehensive efficiency index for banks, and reasonable way of banking. Nandkumar and Archana singh (2015) have estimated the technical and scale efficiency of commercial bank in India during 2006-2010, using CCR model and BCC model. The result of this study indicates the deregulation of banking sector results and increase in efficiency of commercial banks in India. The result also indicator that performance of private sector banks is better then the public sector banks during the study period and scale is the main score of inefficiency rather than pure technical inefficiency (PTE). Ombir Singh and Sanjeev Bansal (2016) investigated and compares the performance of Indian public-sector banks based on revenue maximizing efficiency in the deregulation period during 2001-2013. The authors conducted the banks with high profitability of low level non-performing asset and relatively larger size are more technical efficiency. Many foreign authors also made their significant contribution in the performance analysis of banks.

1.3. Methodology

In the present study the authors employed BCC DEA model to calculate Technical , Cost and revenue efficiency under both orientation. DEA is a non-parametric technic based on Linear programing and initially proposed by CCR(1978). It was further extended by BCC(1984) through a convexity constraint which admits Variable returns to scale (VRS). BCC input and output oriented DEA model used to calculate technical efficiency is described as follows

Technical Efficiency (Input oriented):

$$\begin{aligned} \min \quad & \theta_q \\ \text{s.t.} \quad & \sum_{j=1}^{n} x_{ij}\lambda \le \theta_q x_{iq} && i = 1, 2,\ldots,m, \\ & \sum_{j=1}^{n} y_{rj}\lambda_j \ge y_{rq} && r = 1, 2,\ldots,s, \\ & \sum_{j=1}^{n} \lambda_j = 1 \\ & \lambda_j \ge 0 && j = 1, 2,\ldots,n. \end{aligned}$$

Where,

θ_q : input orinted technical efficiency (TEq) of DMUq, Y_{rq} : produce amount amount of r^{th} output(r=1,2,3……,s) for DMUq, X_{iq} :consumed amount of i^{th} input(i=1,2,3……..,m) for DMUq

Y_{rj}:produced amount of r^{th} output (r=1,2,3…….s) for DMU_j (j=1,2……..,n), X_{ij}: consumed amount of i^{th} input (i=1,2…..,m) for DMU_j (j=1,2,…..,n), λ_j : weight assigned to the DMU_j (j=1,2…..,n).

Technical Efficiency (output-oriented)

$$\begin{aligned} \max \quad & \phi_q \\ \text{s.t.} \quad & \sum_{j=1}^{n} x_{ij}\lambda_j \le x_{iq} && i = 1, 2,\ldots,m, \\ & \sum_{j=1}^{n} x_{rj}\lambda_j \ge \phi_q y_{rq} && r = 1, 2,\ldots,s, \\ & \sum_{j=1}^{n} \lambda_j = 1 \\ & \lambda_j \ge 0 && j = 1, 2,\ldots,n. \end{aligned}$$

Where,

Φq: output-oriented technical efficiency (TEq) of DMUq in the output-oriented DEA model, and Others have the same meaning similar to the previous model.

Based on the input and output prices the BCC Cost and revenue DEA model is described below

Cost Efficiency

To calculate cost efficiency it is necessary to solve the following cost minimisation DEA model (coelli and all,2005)

$$\begin{aligned} \min \quad & \sum_{i=1}^{m} w_{iq} x^*_{iq} \\ \text{s.t.} \quad & \sum_{j=1}^{n} x_{ij} \lambda_j \le x^*_{iq} && i = 1, 2,\ldots,m, \\ & \sum_{j=1}^{n} y_{rj} \lambda_j \ge y_{rq} && r = 1, 2,\ldots,s, \\ & \sum_{j=1}^{n} \lambda_j = 1 \\ & \lambda_j \ge 0 && j = 1, 2,\ldots,n. \end{aligned}$$

Where,

w_{iq}: vector of input prices of DMUq

x^*_{iq}: cost minimizing vector of input quantities for DMUq,given the input prices w_{iq} and the output levels y_{rq}.

Overall Cost Efficiency

The overall cost efficiency (CEq) is defined as the ratio of minimum cost of producing the outputs to observed cost of producing the outputs for the DMUq (Coelli and all, 2005):

$$CE_q = \frac{\sum_{i=1}^{m} w_{iq} x^*_{iq}}{\sum_{i=1}^{m} w_{iq} x_{iq}}.$$

Revenue Efficiency

To calculate revenue efficiency, the following revenue maximization DEA problem is necessary to solve (Coelli and all, 2005):

$$\begin{aligned} \max \quad & \sum_{r=1}^{s} P_{rq} y^*_{rq} \\ \text{s.t.} \quad & \sum_{j=1}^{n} x_{ij} \lambda_j \le x_{iq} && i = 1, 2,\ldots,m, \\ & \sum_{j=1}^{n} y_{rj} \lambda_j \ge y^*_{rq} && r = 1, 2,\ldots,s, \\ & \sum_{j=1}^{n} \lambda_j = 1 \\ & \lambda_j \ge 0 && j = 1, 2,\ldots,n. \end{aligned}$$

Where,

P_{rq}: vector of output prices of DMUq and x^*_{iq}: revenue maximizing vector of output quantities for DMUq, given the output prices P_{rq} and the input levels X_{iq}.

Overall Revenue Efficiency

The overall revenue efficiency (REq) is defined as the ratio of observed revenue to maximum revenue for the DMUq (Coelli et all, 2005):

$$RE_q = \frac{\sum_{r=1}^{s} p_{rq} y_{rq}}{\sum_{r=1}^{s} p_{rq} y^*_{rq}}.$$

In this study the author is attemted for estimating allocative efficiency under both orientation and the same is prensented below.

Allocative efficiency(input oriented):

The measurement of Input allocative efficiency is obtained from technical efficiency and cost efficiency as

$$\text{Allocative efficiency} = \frac{\text{Cost efficiency}}{\text{Technical efficiency}}$$

Cost efficiency and its two components are bounded above by unity, and

Cost efficiency =Technical efficiency X Allocative efficiency.

Allocative efficiency(output oriented):

Similarly output oriented allocative efficiency is obtained from

Revenue Efficient

$$\text{Allocative Efficient} = \frac{\text{Revenue Efficient}}{\text{Technical Efficient}}$$

RE and its two components are bounded below by unity, and

Revenue Efficient = Technical Efficient X Allocative Efficient.

It may be noted that these measures (TE,AE, CE and RE) can take values ranging from zero to one.

1.4 Data structure

The data considered in this study is related to 27 Public sector banks functioning in India during the period 2015-16. The number of variables taken for the study is three inputs and three outputs. Here each bank is considered as a DMU. The manual published by Indian Bank association , Mumbai provided the data for this study. The prices corresponding to inputs and outputs are calculated and the same is used to calculate Cost and Revenue efficiency. 27 public sector banks included in the study are1)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 & Sind Bank 14)Punjab National Bank 15)Syndicate Bank 16)UCO Bank 17)Union Bank of India 18) United Bank of India 19)Vijaya Bank 20) State Bank of India 21)State Bank of Bikaner &Jaipur 22)State Bank of Hyderabad 23)State Bank of Mysore 24) State Bank of Patiala 25)State Bank of Travancore 26)IDBI Bank Ltd. 27)BharatiyaMahila Bank

Variables used in the study to calculate efficiency scores of each DMU are Deposits ,labour , Fixed assets as inputs and Loans, Other assets , investments asouputs.The prices corresponding to inputs arew_1: price of deposit, w_2: price of labour, w_3: price of physical capital and outputs are p_1: price of loans ,p_2:price of other earning assets, p_3: price of investment. The above input and output prices are define asfollows ,

w1 : price of labour = personnel expenses / labour
w2:Price of Deposits=Total interest expenses / deposits
w3 : price of physical capital= other operating expenses / fixed assets
p1: Price of loans =interest income / loans
p2: Price of other earning assets= other interest income / other earning assets
p3: price of investments = Total income/ total investments.

1.5. Empirical Analysis

It is quite general to carryout basic statistical measure to verify the validity of any data so some basic measures namely mean, standard deviation etc. Have been calculated for the data taken for this study and the same is presented in the table.

Table 1.Descriptive Statistics

Variables	Mean	Standard deviation	Max	Min	N
Deposits	7486178.00	327132.59	1730722	327132.6	27
No.of employees	863189	38540.05	207831	38540.05	27
Fixed assets	84147.64	2738.95	10389.28	2738.95	27
Advances	5593576.8	272702.96	1463700	272703	27
Other assets	432848.54	26205.9	140408.4	26205.9	27
Investment	2153002.3	88219.66	477097.3	88219.66	27
Price of deposits	1.86	0.01	0.08	0.01	27
Price of employees	4.26	0.03	0.24	0.03	27
price of fixed assets	287.9	5.41	24.59	5.41	27
price of advances	3.64	0.03	0.25	0.03	27
Price of other assets	5.79	0.1	0.44	0.1	27
Price of investment	9.47	0.05	0.43	0.05	27

Based on the inputs ,outputs and their corresponding prices Technical efficiency ,cost efficiency and revenue efficiency scores under both orientation is calculated and the same is presented in the table 2 and table 3.

Table 2:Efficiency scores (input oriented)

DMU	Technical Efficiency (TE)	Allocative Efficiency (AE)	Cost Efficiency (CE)
1	0.909	0.660	0.600
2	0.990	0.808	0.800
3	0.930	0.657	0.611
4	0.843	0.658	0.554
5	0.923	0.730	0.674
6	0.870	0.686	0.597
7	0.910	0.697	0.635
8	1.000	0.986	0.986
9	0.915	0.820	0.750
10	0.880	0.674	0.594
11	0.974	0.665	0.647
12	0.965	0.740	0.714
13	0.908	0.731	0.664
14	0.925	0.752	0.696
15	0.914	0.784	0.717
16	1.000	0.754	0.754
17	0.954	0.737	0.703
18	1.000	0.793	0.793
19	0.981	0.756	0.742
20	1.000	1.000	1.000
21	1.000	1.000	1.000
22	1.000	1.000	1.000
23	0.918	0.695	0.638
24	1.000	0.881	0.881
25	1.000	1.000	1.000
26	1.000	0.984	0.984
27	1.000	0.532	0.532

It may be noted that the above table contains allocative efficiency in addition to technical efficiency and cost efficiency

From the above table it may be observed that

- Dmu 20,21,22 and 25 are cost efficient.
- Dmu 8,16,18,20,21,22,24,25,26 and 27 are technicallyefficienct.
- Dmu 20,21,22 and 25 are allocative efficient(CE/TE).
- Dmu 20,21,22 and 25 are technical,cost and allocative efficient . That is theseDMUs are fully efficient.

Table3: Efficiency score (output oriented)

DMU	Technical Efficiency (TE)	Allocative Efficiency (AE)	Revenue Efficiency (RE)
1	0.909	0.856	0.778
2	0.992	0.920	0.913
3	0.931	0.803	0.747
4	0.848	0.885	0.750
5	0.925	0.928	0.859
6	0.922	0.904	0.834
7	0.922	0.968	0.893
8	1.000	1.000	1.000
9	0.915	0.992	0.908
10	0.881	0.910	0.802
11	0.985	0.925	0.911
12	0.965	0.966	0.932
13	0.909	0.985	0.895
14	0.929	0.917	0.852
15	0.914	0.893	0.816
16	1.000	0.929	0.929
17	0.958	0.898	0.860
18	1.000	0.903	0.903
19	0.983	0.967	0.950
20	1.000	1.000	1.000
21	1.000	0.908	0.908
22	1.000	0.955	0.955
23	0.918	0.961	0.882
24	1.000	0.918	0.918
25	1.000	1.000	1.000
26	1.000	1.000	1.000
27	1.000	1.000	1.000

Calculation of allocative efficiency is also attempted here and the same is presented in the above table.
From the above tables

- Dmu 8,16,18,20,21,22,24,25,26 and 27 are technical efficient.
- Dmu 8,20,25,26 and 27 are allocative efficiency.
- Dmu 8,20,25,26 and 27 are revenue efficient.
- Dmu 8,20,25,26, and 27 are fully efficient.

1.6. Conclusion

Using Data envelopment analysis (DEA) this paper measures technical ,cost, and revenue , allocative efficiency of Indian public sector banks for the period 2015-16.The result indicates that cost efficient DMUs are technically and allocatively efficient. It is to be noted that technical efficient DMUs are not necessarily

cost efficient and allocative efficient. The study reveals State Bank of India,State Bank of Bikaner Jaipur, State Bank of Hyderabad & State Bank of Travancore are fully efficient. The result also indicates that the revenue efficient DMUs are technically and allocatively efficient. Comparing both cost and revenue efficiency scores it may be inferred that DMUs namely State Bank of India and State Bank of Travancore are efficient in minimizing their cost and maximizing their revenue.It may be observed that DMUs 21 and 22 are cost efficient but not revenue efficient. That is the banks namely State Bank of Bikaner Jaipur and State Bank of Hyderabadare efficient inminimizing their cost of inputs but they fail to maximizing their revenue. The interesting points which is observed from the result of the study is that the DMUs namelyCorporation Bank, IDBI Bank Ltd. & Bharatiya Mahila Bank are revenue efficient but not cost efficient.

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