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Research Article

A Study on the Financial Outcome of Selected Indian Public Sector Banks: A Data Envelopment Analysis (DEA) Approach

Dr. Dipangshu Dev Chowdhury[1*], Hajir Abdlhussen Abbas[2], Mohammed Shihab Ahmed[3] Ali Saad Alwan[4], Sanpreet Singh Sachdev[5]

[1]Assistant Professor, Faculty of Management and Commerce, ICFAI University Tripura
[2]College of Nursing, University of Baghdad, Baghdad, Iraq, 10011.
Email: haji2.a@conursing.uobaghdad.edu.iq
[3]College of Administration & Economics, University of Wasit, Iraq, Wasit, 52001
Email: mshhab@uowasit.edu.Iq
[4]University of Kut, College of Administration and Economics, Al-Kut, Wasit, 52001, Iraq.
Email: ali.s.al.1musawi@alkutcollege.edu.iq
[5]Department of Oral Pathology and Microbiology, Bharati Vidyapeeth (Deemed to be University) Dental College and Hospital, Navi Mumbai
Email: sunpreetss@yahoo.in
Corresponding Author Dr. Dipangshu Dev Chowdhury
Email: dipangshuchowdhury@gmail.com

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ABSTRACT

The effective functioning of a nation's financial system with banks as primary institutions is crucial for economic development. To assess the efficiency of public sector banks, this study has selected a sample of ten banks out of a total of twelve banks based on market capitalization. Data Envelopment Analysis (DEA) utilizing the CRR model has been employed for assessing efficiency. This study employed input variables such as revenue, expenses, net income, total assets, and liabilities. Conversely, Return on Assets is employed as the output variable. The study's findings suggest that the State Bank of India is the most efficient bank, while UCO bank is the least efficient. The ANOVA analysis indicated a lack of significant variation among the means of the selected public sector banks used in the DEA study.

Keywords: DEA, Efficiency, Public Sector Banks, CRR , ANOVA, Return on Assets.

1.1 Introduction

The banking system, in particular, is a component of the financial services sector, which is among the most intricate industries globally. It is crucial to a nation's economic development because it diversifies the components of growth (Mohamed Shahwan& Mohammed Hassan, 2013). This led regulators to continuously monitor the financial performance as deterioration in performance can have serious impact on economy. Financial performance is considered with how a firm can use its resources and generate income (Filatie,2019). According to Indonesian Institute of Accountants (2016), financial performance is the company's financial condition over a certain period that includes the collection and use of funds measured by several indicators of capital adequacy ratio, liquidity, leverage, solvency, and profitability(Ningrum, 2022). In the context of bank, according to Singh and Milan (2023), financial performance can be measures using parameters like Return on Equity (ROE), Return on Assets (ROA) and Net Interest Margin (NIM). However, other studies used parameters like PELARI (Sebe-Yeboah and Mensah, 2014); CAMEL (Singh & Mialn;2023; Shukla& Singh, 2021; Sangmi&Nazir, 2010). In this study, we tried to focus on measuring the performance of banks using efficiency concept. Efficiency as stated by Drucker (1977),refers to the capacity of an organisation to achieve desired outputs while utilising the least amount of resources. It does not indicate success in the marketplace, but rather measures the level of operational excellence in the process of utilizing resources.When the output of a company is equal to or greater than its input, it is declared efficient.According to Ullah, et.al (2023), the term efficiency, particularly in the banking sector, denotes the optimal

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exploitation of limited resources with minimal cost and greatest output. The examination of efficiency helps to identify how much a bank is efficient and the feasible methods to bridging the gap in this regard.

Kumar and Singh (2014) stated that the presence of an effective banking system significantly enhances the rate of economic expansion within a nation. Therefore, this research on banking efficiency holds significant value for policymakers, industry executives, and numerous stakeholders who depend on the banking sector.

The measurement of bank efficiency can be done with ratios and regression analysis however these traditional have become unsatisfactory because of their inherent limitations. To begin with, regression analysis establishes a comparison between efficiency and average performance as opposed to the best performance (Colbert et al., 2000). Furthermore, regression analysis is a parametric method that necessitates predefining a production function limits the applicability of this paradigm in actual function capture (Sexton, 1986). On the other using financial ratio analysis makes it impossible to determine a single performance score of different multiple ratios objectively (Colbert et al., 2000). Considering the aforementioned factors, the current investigation utilized a prevalent method for assessing efficiency known as Data Envelopment Analysis (DEA). DEA is classified as a non-parametric technique due to its ability to utilize multiple inputs and outputs without necessitating any assumptions about the distribution of residuals or the relative importance of each a component (Mohamed Shahwan& Mohammed Hassan, 2013).

1.2 Literature Review

The DEA model was first modified by Sherman in order to measure banks' performance in 1984, and since then, was extensively used by banking industry to measure banks' operational efficiency (Sherman&Zhu, 2006). In their study, TuskanandStojanovic (2016) conducted an analysis and comparison of efficiency outcomes in the European banking sector from 2008 to 2012. They utilized two distinct methodologies—the DEA approach and financial indicators—to achieve this. The DEA approach, which utilizes output-oriented DEA models, employs interest income and total operating income as output data and interest expenses and total operating expenses as input data. Efficiency is assessed through the implementation of CRS, VRS, and window analysis within the DEA method. In light of the aforementioned, the profitability approach (bank profit efficiency analysis) is used. The findings from the various approaches to assessing efficiency indicate that the DEA methodology may serve as a valuable supplementary or alternative analytical instrument in identifying preliminary indications of ineffective business strategies. Varias&Sofianopoulou (2012) evaluated the efficiency of Greek commercial banks using DEA and found that 68.42% of the Greek banking sector operates inefficiently. The study concludes that the Greek banking sector is in vulnerable condition and need to inject more funds through Financial Stability Fund to improve efficiency. The DEA window analysis was used by Řepková (2014) in order to examine the efficiency of Czech banking sector during the period 2003–2012.Efficiency has been computed using both constant return to scale and variable return to scale. Findings reveal that the average efficiency under constant return to scale reached 70–78 % and average efficiency under variable return to scale reached 84–89 %. So, it can be concluded that the of Czech banking sector is efficient and the minimal inefficiency that have been found was basically due to excess client deposit in bank balance sheet which affect the net interest income by increasing interest costs of banks.According to Jemric and Vujcic (2002), foreign-owned banks are more efficient. They also found that new banks are more efficient than old ones because old banks have more debts that are not being paid back. They found that small banks work better than big banks regarding size.Kumaradin, et.al (2019) have taken all three aspects of efficiency i.e., cost, revenue and profit with particular emphasis on revenue efficiency which was not been explored in exhaustive manner in the existing DEA literature. The study has taken Malaysian Islamic Banking Sector and found that revenue efficiency domestic Islamic banks is relatively lower as compared to foreign Islamic banks. Fujii, et.al (2014) observed that there are notable variations in the levels of inefficiency between the three ownership structures of Indian banks. They found that foreign banks are closer to efficient frontier as compared to State Public Banks and domestic private banks. Three main reasons attributed for the inefficiency are management of labour forces, other earning assets and Non-Performing Loans. Akhter, et.al (2022) in their recent study have found that public sector banks (PSBs) are the most efficient followed by foreign banks, whereas, the least efficient are the private banks. On the other hand, Maity and Sahu (2022) contradict the results of Akthter, et.al (2022) as the Maity and Sahu (2022)observed that efficiency of foreign banks is significantly higher than that of public and private banks. The

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data suggests that foreign banks operating in India have an efficiency level of 92.53%, while private and public sector banks operate at 90.20 and 86.04%, respectively.

1.3 Objective of the Study

- To analyze the financial performance of the banks on the basis of selected indicators using DEA
- To analyze whether there is any significant difference of performance across selected public sector banks in India

1.4 Hypotheses

Two sets of hypotheses have been identified for the purpose of measurement of financial performance of selected public sector banks of India. The first sets of hypotheses are:

H_{01} = There is no significant difference of performance across selected public sector banks in India
H_{02} = There is no impact of bank specific variables on the financial performance of selected banks

1.5 Methodology

The study is developed using secondary sources of data. Various sources, including Annual Reports of Banks, RBI Reports, and other supplementary materials, are utilized to gather data. Data has been gathered spanning a decade, from the Financial Year 2012-13 to the Financial Year 2021-22. Data Envelopment Analysis will be used for the purpose of measurement of financial performance of selected public sector banks of India. As cited in Patra, et.al. (2023), Data Envelopment Analysis (DEA) has been widely used in Indian banking literature as a means of measuring efficiency. This is mainly because of its simplicity and capacity to handle various inputs and outputs.In total 10 Public Sector Banks are taken for the study out of 12 banks based on market capitalization (Table 1)

Table 1: List of ten banks were taken in this study based on market capitalization:

Serial number	*Public sector banks*	*Market Cap*	*Year of foundation*
1	State Bank of India	489,515 Cr.	1955
2	Bank of Baroda	88,068 Cr.	1908
3	Punjab National Bank	57,147 Cr.	1894
4	Bank of India	32,069 Cr.	1906
5	Canara Bank	53,961 Cr.	1906
6	Central Bank of India	23,612 Cr.	1911
7	Union Bank of India	50,338 Cr.	1919
8	Indian Bank	36,118 Cr.	1907
9	Bank of Maharashtra	18,980 Cr.	1943
10	UCO Bank	32,401 Cr.	1935

Source: Compiled by authors from moneycontrol.com

1.6 Data Analysis Tools and Models:

Data Envelopment Analysis (DEA)-Data Envelopment Analysis (DEA), a non-parametric method, is the most often used tool for evaluating efficiency in the banking industry. The Data Envelopment Analysis model, with the aid of an efficiency score, facilitates the efficient conversion of many inputs into multiple outputs (Ullah, et.al, 2023).DEA measures the relatively efficient production frontier based on the Decision-Making Units (DMUs) which involve multiple outputs that are produced with multiple inputs or undefined relation between inputs and outputs.

The fundamental principle behind employing this approach is to establish a uniform proportion between the weighted total of outputs and the weighted total of inputs for every Decision-Making Unit (Asadi, et.al, 2022).

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DMUs exhibit optimal performance when their efficiency score is equal to one (or when their efficiency value is 100 percent). Conversely, if the efficiency score is less than one, the DMU's performance is considered inefficient (Vaseei, et.al, 2023; Fatimah &Mahmudah, 2017; Aldamak&Zolfaghari, 2017).The initial DEA model created by Charnes et al. (1978), referred known as the CCR model, was founded on the premise of Constant Return to Scale (CRS) to assess the efficiency of decision-making units (DMU). Banker et al. (1984) subsequently improved the CCR model by introducing the Variable Return to Scale (VRS) and creating the BCC model.For the present study, the CCR model is applied.

CCR model- Charnes, Cooper and Rhodes(CCR)(1978a, 1979) introduced a ratio definition of efficiency, also called the CCR ratio definition of efficiency, which generalizes the single-output to single-input classical engineering-science ratio definition to multiple outputs and inputs without requiring reassigned weight.Consequently,the efficiency can be defined as:

$$efficiency = \frac{\text{weighted sum of outputs}}{weighted\ sum\ of\ inputs} \quad \text{---------- (1)}$$

The CCR model is of the following form:

$$Maximize\ \Theta = \frac{\Sigma_{r=1}^{s} U_r Y_{r_0}}{\Sigma_{i=1}^{m} V_i X_{i_0}} \quad \text{---------- (2)}$$

$$\text{subject to } \frac{\Sigma_{r=1}^{s} U_r Y_{r_j}}{\Sigma_{i=1}^{m} V_i X_{i_j}} \leq 1 \quad j = 1, \ldots n \quad \text{---------- (3)}$$

where,

Θ = relative efficiency of the DMU

s = number of outputs produced by the DMU

m = number of inputs employed by the DMU $Y_{r_j} > 0$represent output data for DMU

$X_{i_j} > 0$ represent input data for DMU

U_r = output weights

V_i = input weight

Followingthe Charnes-Cooper transformation (1962), one can select a representative solution (u, v) for which

$$\sum_{i=1}^{m} V_i X_{i_0} = 1$$

To obtain a linear programming problem that is equivalent to the linear fractional programming problem. Thus, denominator in the above efficiency measure Θ is set to equal one and the transformed linear problem for DMU_0 can be written:

$$Max\ Z_0 = \Sigma_{r=1}^{s} U_r Y_{r_0} \quad \text{---------- (a)}$$

subject to

$$\Sigma_{r=1}^{s} U_r Y_{r_j} - \Sigma_{i=1}^{m} V_i X_{i_j} \leq 0 \quad \text{---------- (b)}$$

$$\Sigma_{i=1}^{m} V_i X_{i_0} = 1 \quad \text{---------- (c)}$$

r = 1, 2, ...s ;i = 1, 2, ...m

Profitability measure tools:

The most standard technique to evaluate the profitability of banks are Return on Assets (ROA) and Return on Equity (ROE). These ratios are globally applied in financial analysis and favourable for evaluating the profitability

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and the efficiency of bank performance under a given period of time and compare to other market participants. The main advantages of financial tools are feasibility of data, simplicity and globally of applications.

Return on asset ratio is an indicator of the profitability of an organization. It is relatively connected to assets and shows how superiorly they are utilizing their assets for gaining profit. The ROA ratio can be calculated by dividing an organization's net income by its total assets and it is shown as a percentage form.

Data description of inputs used in DEA estimations:

- **Revenue:**In accounting, turnover is the gross income generated from the sale of goods and services related to a company's primary activities.
- **Expenses:**An expense is an item that generally requires an outflow of money or some form of property to another person or group in payment for an item, service, or other category of expense.
- **Net Income:**Net income is the total amount earned by an individual or business over a period of time, less taxes, expenses and interest.

  Net Income = Revenue – Expenses
- **Total Assets:**Total assets are the sum of liabilities and shareholders' funds. We can also calculate a combination of current assets and fixed assets.
- **Total Liabilities:**Gross liability refers to the sum of all liabilities for which an individual or entity is liable.

Data description of outputs used in DEA estimations:

Return on Assets (ROA): Return on Assets (ROA) is net income divided by total assets. This is a measure of efficiency that indicates how well a company is using its assets.

1.7 Data Analysis and Interpretation

To analyses the efficiency level among all selected public sector banks (i.e. ten DMUs) the DEA was applied and the results showing the technical efficiencies are presented in the following table. Here, the DEA was applied with five inputs namely Revenues, Expenses, Net Income, Total Assets and Total Liabilities.

Serial number	*Public sector banks*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
1	State Bank of India	1	1	1	1	1	1	1	1	1	1
2	Bank of Baroda	0.935	0.921	0.869	0.941	0.933	0.939	0.994	0.966	0.975	0.88
3	Punjab National Bank	0.864	0.939	0.783	0.982	0.937	0.96	1	0.984	0.985	0.912
4	Bank of India	0.755	1	0.715	0.743	0.753	0.896	0.916	0.889	0.896	0.82
5	Canara Bank	0.701	0.784	0.688	0.794	0.718	0.858	0.722	1	0.747	0.862
6	Central Bank of India	1	1	1	1	1	0.927	1	0.653	0.801	1
7	Union Bank of India	0.607	0.726	0.707	0.948	0.687	1	0.713	0.633	1	1
8	Indian Bank	0.523	0.7	0.586	0.813	0.617	0.815	0.605	0.639	0.698	0.885
9	Bank of Maharashtra	0.496	0.651	0.55	0.645	0.355	0.812	0.516	0.55	0.606	0.834

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10	UCO Bank	0.423	0.588	0.487	0.618	0.366	0.736	0.509	0.486	0.514	0.768
	Mean	0.73	0.831	0.739	0.848	0.737	0.894	0.797	0.78	0.822	0.896

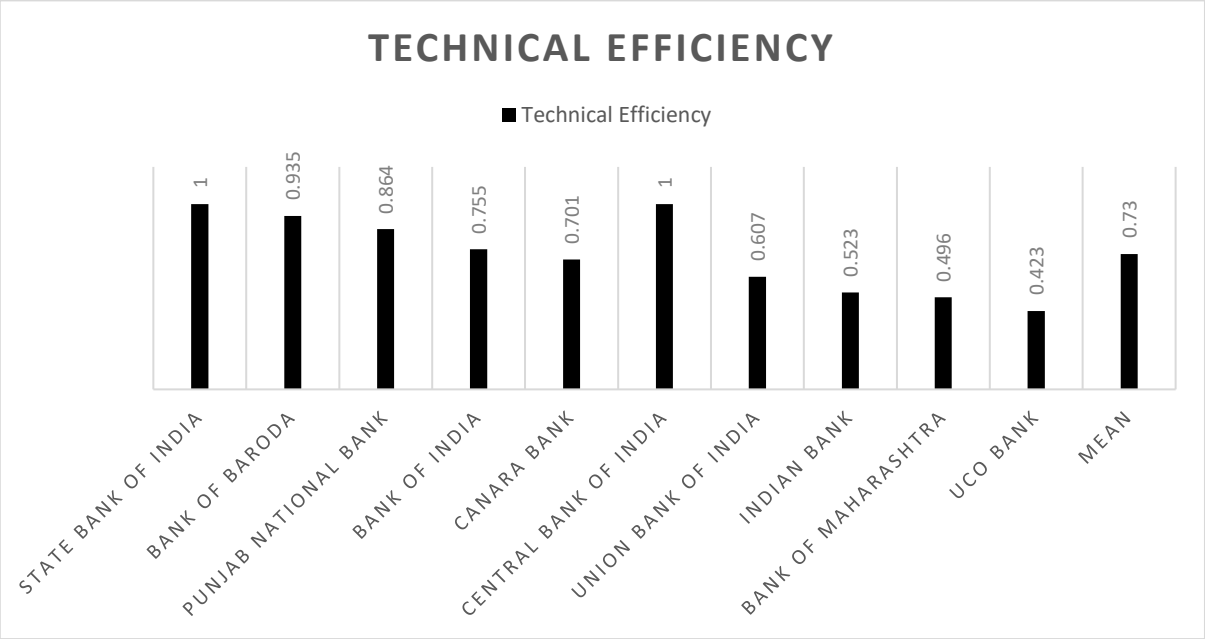
Source: Computed from secondary data of selected banks (estimated by DEAP 2.1)

Technical Efficiency of the banks are obtained through the application of DEAP or Data Envelopment Analysis Program where Revenues, Expenses, Net Income, Total Assets and Total Liabilities are inputs and Return on Assets or ROA is the output.

From the table we can understand that State Bank of India has been performing the best among all the selected 10 public sector banks, maintaining a technical efficiency of 1 throughout the span of 10 years from 2013 to 2022 followed by Central Bank of India. A value of 1 in technical efficiency means the bank is fully efficient in converting its inputs to outputs and a score below 1 indicates how much it lags in efficiently doing the same.

Graphical presentation of the technical efficiency values in the form of bar graphs are provided below:

Technical Efficiency of Public Sector Banks for the 1st year i.e. 2013



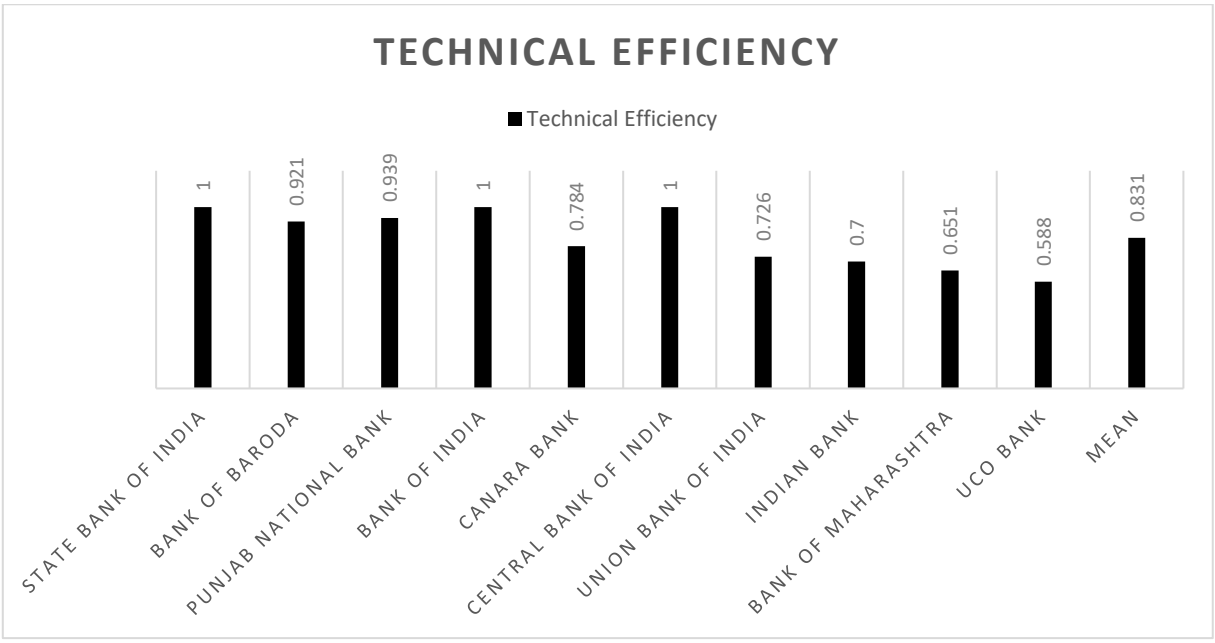
Inference: Both State Bank of India and Central Bank of India are having equal and full technical efficiency of 1 followed by Bank of Baroda with 0.935. UCO Bank with 0.423 has the lowest value.

Technical Efficiency of Public Sector Banks for the 2nd year i.e. 2014

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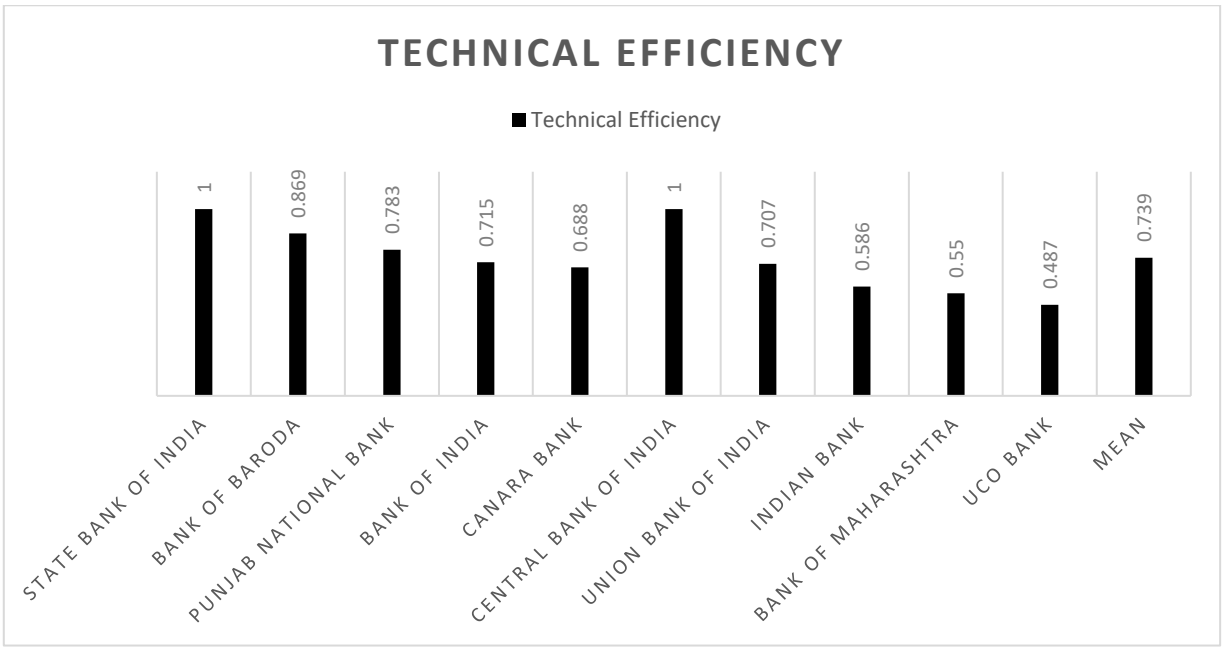
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Inference: Again we can see State Bank of India and Central Bank of India are performing excellently with Bank of India joining them followed by Punjab National Bank and Bank of Baroda.

Technical Efficiency of Public Sector Banks for the 3rd year i.e. 2015



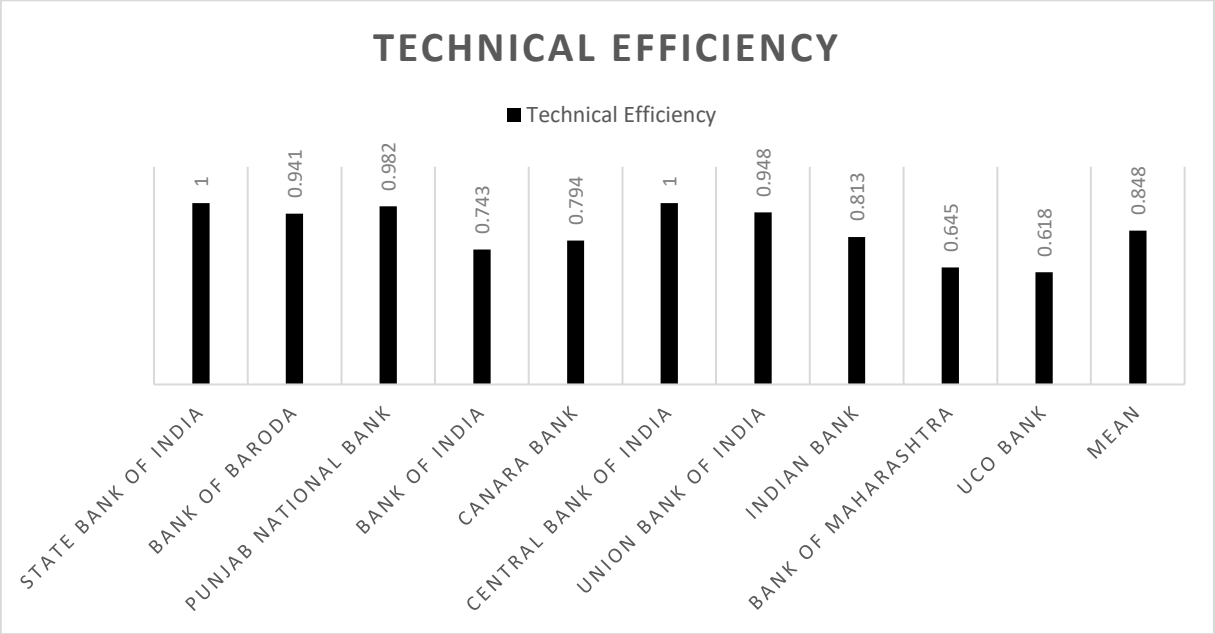
Inference: SBI and CBI are performing spectacularly with BoB in the second position having a technical efficiency of 0.869. UCO Bank with 0.487 has the least.

Technical Efficiency of Public Sector Banks for the 4th year i.e. 2016

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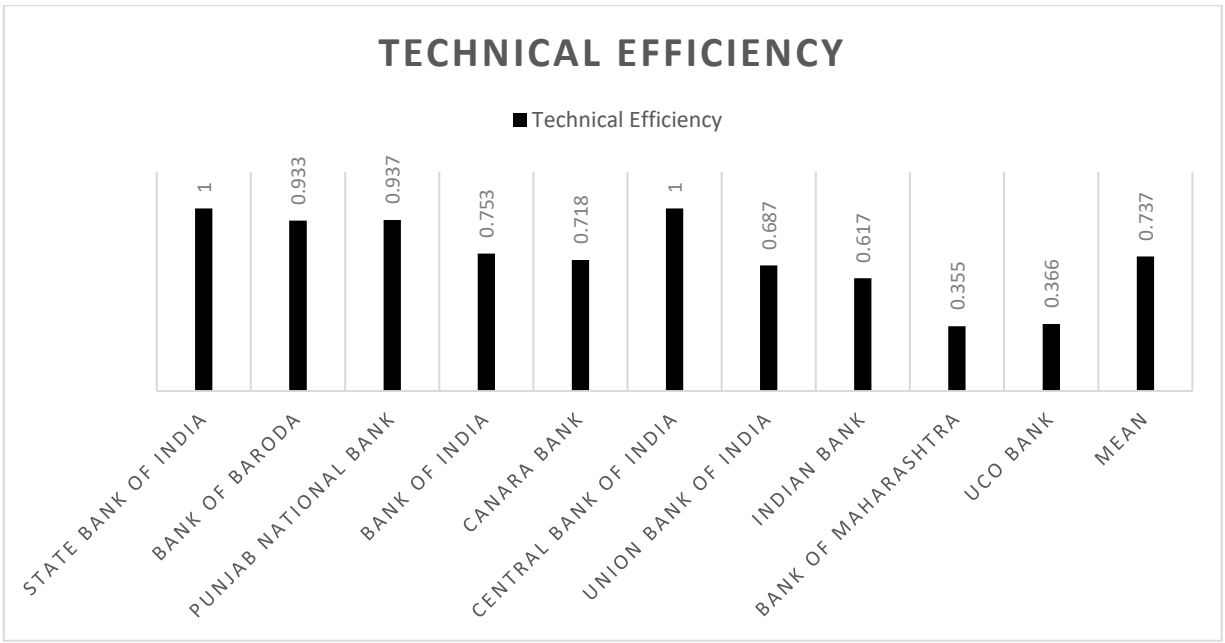
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Inference: SBI and CBI jointly in the first position followed by Punjab National Bank in the second. UCO Bank has the lowest score in technical efficiency here.

Technical Efficiency of Public Sector Banks for the 5th year i.e. 2017



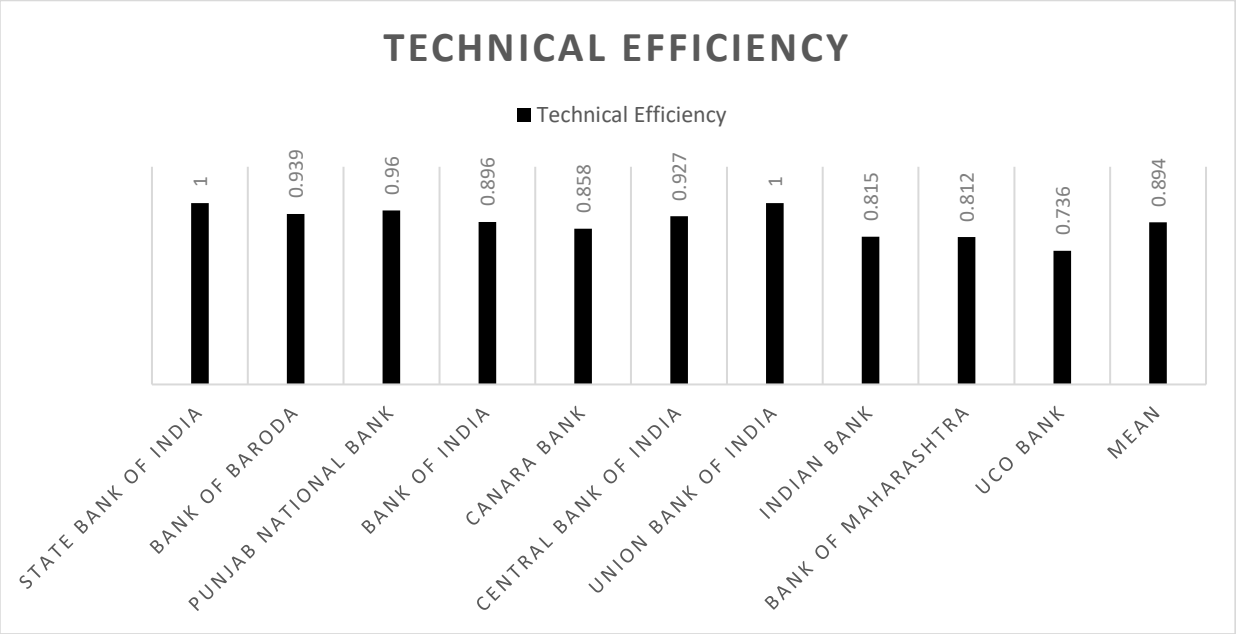
Inference: SBI and CBI jointly achieving full technical efficiency with BoB in the second and Bank of Maharashtra at last position.

Technical Efficiency of Public Sector Banks for the 6th year i.e. 2018

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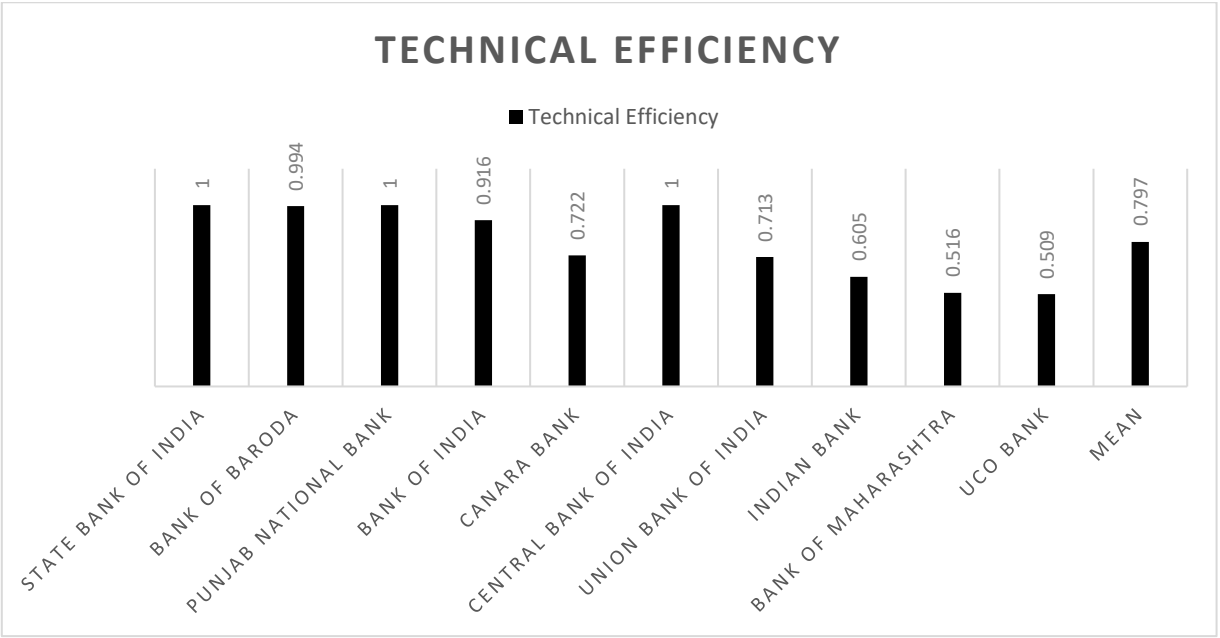
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Inference: SBI and Union Bank of India scored full efficiency with Bank of Baroda at second and UCO Bank at last rank.

Technical Efficiency of Public Sector Banks for the 7th year i.e. 2019



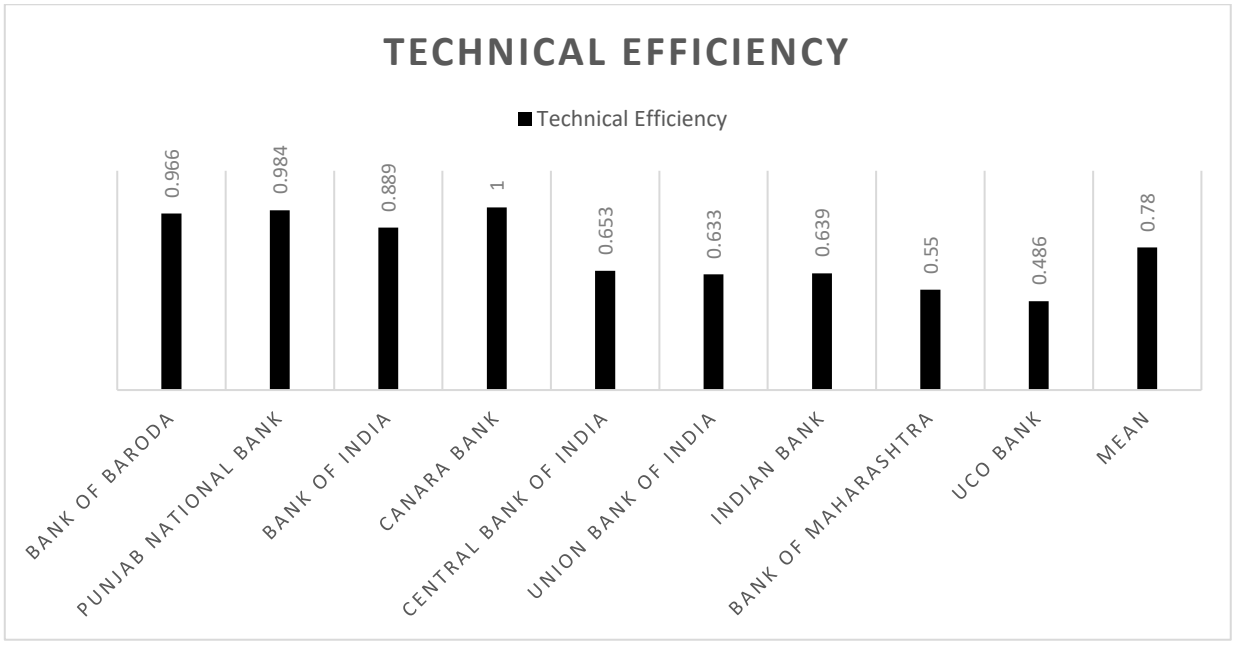
Inference: SBI, PNB and CBI all achieving full efficiency followed by Bank of Baroda in the second rank.

Technical Efficiency of Public Sector Banks for the 8th year i.e. 2020

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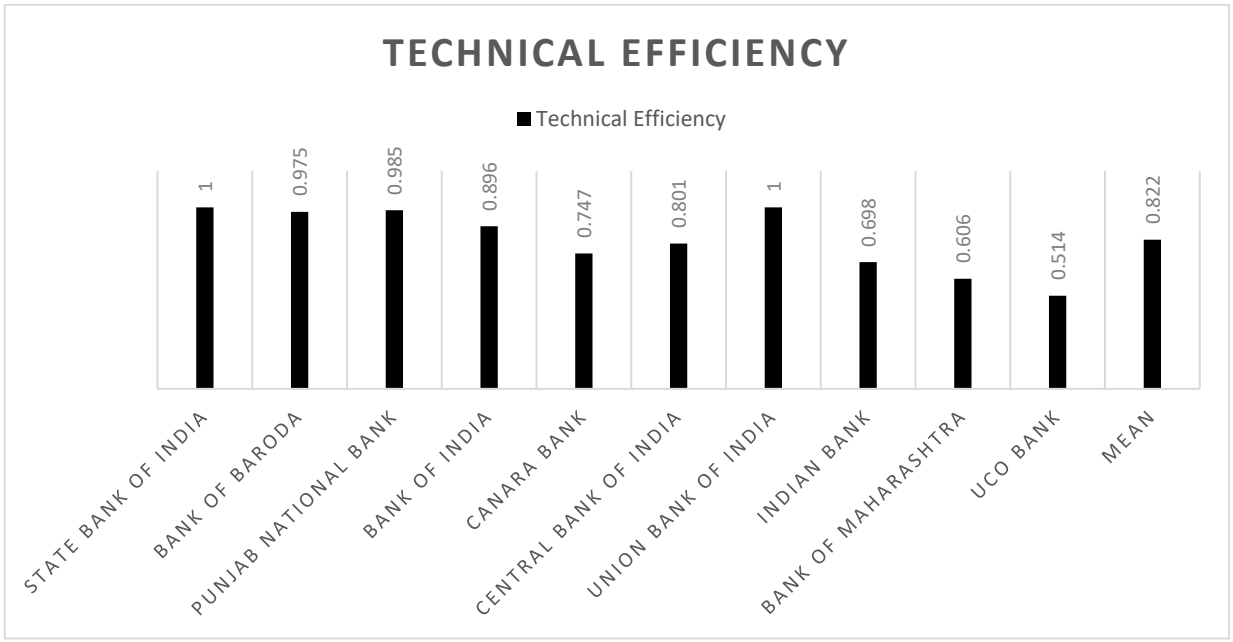
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Inference: SBI and Canara Bank having maximum technical efficiency here followed by PNB in second and UCO Bank at last position.

Technical Efficiency of Public Sector Banks for the 9th year i.e. 2021



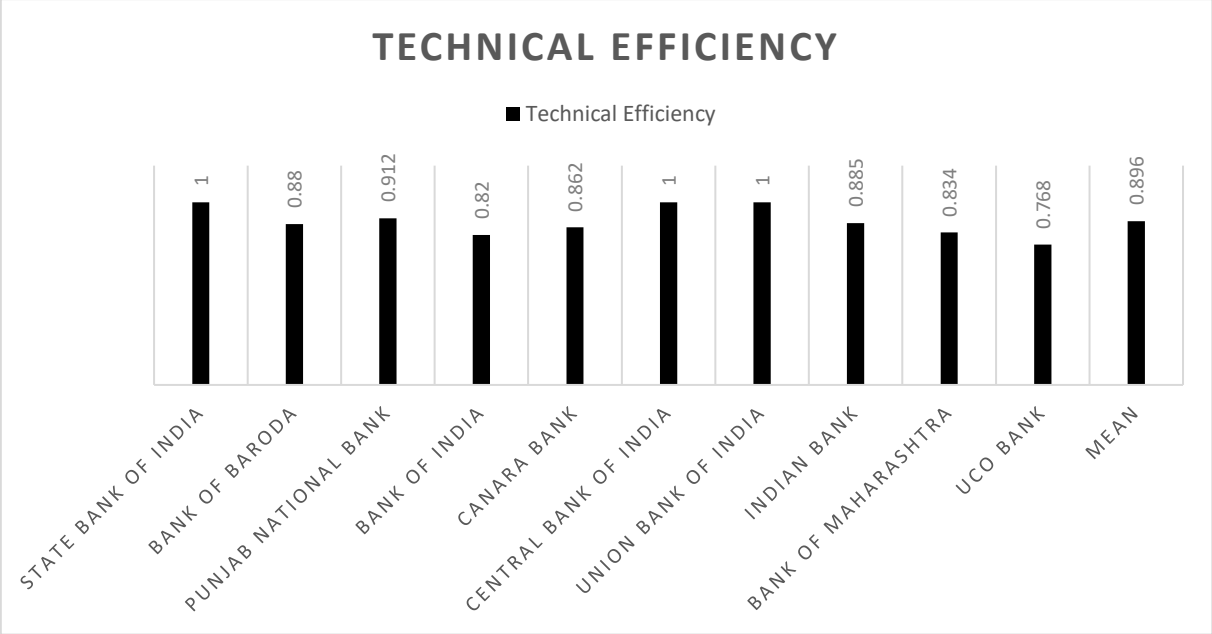
Inference: SBI and Union Bank of India achieving perfect technical efficiency while Punjab National Bank follows in the second position and UCO Bank yet again at last rank.

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Technical Efficiency of Public Sector Banks for the 10th year i.e. 2022



Inference: SBI, CBI and UBI maintaining the maximum efficiency here followed by PNB in second rank.

1.8 Findings

ANOVA Test

An ANOVA test is a way to find out if survey or experiment results are significant in variation.In other words, they help you to figure out if you need to reject the null hypothesis or accept the alternate hypothesis.

ANOVA Results

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1050.076	10	262.5191	1.832976	0.162087	2.866081
Within Groups	2864.402	30	143.2201			
Total	3914.479	39				

In the following section single factor ANOVA was applied to analyses if there is significant variation across ten chosen public sector banks on the basis of average values of ROA. The results obtained from ANOVA shows that the calculated F value is 1.832 and it is lesser than tabulated or critical value (2.866081). Therefore, null hypothesis is accepted with the conclusion that there is no significant difference for average values of ROA for selected ten public banks.

Conclusion and Recommendations

Out of all the public sector banks selected for the DEA analysis, SBI has been constantly achieving topmost technical efficiency throughout the span of 10 years which only indicates its superb capability and functioning .Central bank of India is a close second in terms of efficiency among the banks considered for the analysis.UCO Bank has been the least technically efficient firm, usually placed in the last position .The application of ANOVA test results in the acceptance of null hypothesis which verifies the absence of any significant variation among the means of all the selected public sector banks considered for DEA analysis .It must be observed that the financial sector and banking sector totally depends on market, global phenomenon, RBI guidelines and Macroeconomic Policy Change

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of any economy. The study is with very limited scope and time still it identifies some policy recommendations: that includes hiking ROA through downsizing fictitious assets .Another suggestion would be for the Operating expenses to be reduced.

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