

UNVEILING EFFICIENCY: A COMPREHENSIVE ANALYSIS OF INDIAN PSBs THROUGH DATA ENVELOPMENT ANALYSIS (DEA) AND SCALING TECHNIQUES

Md Nasim Ansari*, Jamaluddeen**

Abstract *In today's highly competitive and complex banking industry, the long-term viability of banks depends on their ability to operate efficiently. This has become of utmost significance in light of globalisation and liberalisation. The importance of efficiency has become even more evident since India began its financial liberalisation process in 1991, followed by a greater focus on globalisation in the 2000s, the global financial crisis of 2008, and the ongoing effects of the COVID-19 pandemic. These events have highlighted the pressing requirement for efficiency. This article evaluates the effectiveness of public sector banks (PSBs) by utilising scaling techniques and DEA assumptions. The assessment is by designated efficiency indicators and takes into account the banks' size. The findings suggest that the interest income efficiencies of the majority of banks are typically near optimal levels. Nevertheless, a considerable proportion of banks demonstrate subpar efficiencies in generating non-interest income, failing to meet satisfactory benchmarks. The difference between the efficiencies of interest and non-interest income has a significant impact on the overall efficiency of banks, which brings it closer to acceptable levels. The panel regression analysis reveals that factors such as cost to income, spread, CASA, income per branch, NPAs, and bank size significantly influence the efficiency of banks.*

Keywords: Sustainability, PSBs, Efficiency, Interest Income, Non-Interest Income, Cost to Income, Spread, NPAs

JEL Classification: D61, G21, G34.

INTRODUCTION

Banks, like the heart of a functioning organism, are dynamic engines fuelling the growth of a burgeoning economy. Their critical significance extends beyond simple financial management; they are the architectures of economic advancement. Banks support businesses, foster innovation, and catalyse investment by providing a strong financial infrastructure. A bank's operational efficiency, a key indicator of their strength, is analogous to the accuracy of a well-choreographed dance, facilitating smooth financial operations. Recent studies, such as the IMF (Gobat, 2017) and the World Bank's Global Financial Inclusion Database, highlight the critical role of banks in economic growth, emphasising the necessity for nimble and responsive

financial institutions to meet the ever-changing demands of a modernising world. Increasing technology and competition highlight the need for a highly efficient banking sector. It underlines the significance of banks' relevant monitoring and performance assessment since this might undermine their overall efficiency and profitability. Globally, performing assets in the banking business are continuously rising, and more considerable assets influence loan prices and interest rates, influencing shareholders, investors' thinking, creditors, and depositors (Dsouza et al., 2022; Hassan et al., 2022). The high interest rate directly impacts the borrowers' decision to take a loan and repay, resulting in the poor recovery of funds and lower bank revenue. Bank's efficiency is critical here, as those with higher efficiency will have a competitive advantage and can create more income by delivering better products and services at a lower cost with additional features

* UGC Senior Research Fellow, Department of Commerce, University of North Bengal, Siliguri, West Bengal, India.
Email: nasimansari70313@gmail.com (Corresponding author)

** Assistant Professor, Department of Commerce, University of North Bengal, Siliguri, West Bengal, India.
Email: qjamaluddeen@gmail.com

(Rabbani et al., 2022; Sun et al., 2020; Singh & Singh, 2015). Banks are challenged to perform efficiently in the highly competitive financial services market. Banks with better efficiency are more likely to survive than banks with lower efficiency. Regarding the supply of credit granted to enterprises in industries that rely on external funding, bank efficiency is recognised as a critical issue (Diallo, 2018). High efficiencies please all stakeholders, whereas low efficiencies may have profound negative implications. This requires bank owners, customers, regulatory authorities, and investors to monitor bank efficiency.

In India, private sector banks were founded to supplement the functions of public sector banks (PSBs), in which the government holds the majority of stakes, intending to improve economic service. There is a consensus among academic literature that private banks consistently outperform their public counterparts across various parameters. For instance, Tamatam et al. (2019) assessed both sectors from 2008 to 2017. They inferred that private banks rank higher in aspects like the banking system, profitability, capital adequacy, management efficiency, income, and liquidity. To emphasise the link between profitability and efficiency, Goel and Rekhi (2013) have shown that PSBs are less profitable than private banks because of operational inefficiency. Hence, studying PSBs' efficiency has become increasingly essential as these banks continue dominating market share, economic effect, number of branches, public perception, and total contribution to the financial system. The current literature needs to include in-depth studies on the efficiency and its determinants of public sector banks in India. This paper, in the Indian context, aims to analyse the technical efficiency of the banks and rank them based on efficiency. Identify the most probable factors influencing the operational efficiency of the public sector banks from 2015 to 2023.

LITERATURE REVIEW

Pradhan et al. (2015) conducted a study to quantify the operational efficiency of public sector banks in India. They discovered that Indian banks are underperforming due to regulatory changes, financial consolidations, competition, and technological advancements. Gulati and Kumar (2017) used a two-stage DEA network separating intermediation and operating efficiency. They used the bootstrapped truncated regression approach to identify the factors influencing both efficiencies. They discovered a difference in the efficiency of PSBs and private banks, with the former being more efficient than the latter at the intermediate and operating stages. More importantly, the regression determined that variations in intermediation efficiency can be associated with variations in bank size, cost of intermediation, etc. In contrast, variations in operating efficiency can be related to profitability and

various sources of income generation for banks. Rezvanian et al. (2008) studied the banks in India from 1998–2003 to observe the influence of ownership on the efficiency of the banks. The study opines that the efficiency of some large PSBs was lesser than that of small-sized banks, and their efficiencies can be improved by scaling up their operations. Recently, research studies have been divided into diverse pathways, resulting in some fascinating DEA applications and advanced methodologies. Raina and Sharma (2013) stated that the significant inefficiency observed among PSBs between 2006 and 2011 was related to the regulatory framework rather than managers' underutilisation of financial resources. Sanjeev (2007) conducted research from 1997 to 2001 and concluded that the size of a bank has no meaningful effect on its efficiency. Kumar and Gulati (2008) conducted their study using 2015 panel data from a selection of banks, producing a matrix of efficiency scores and ROA to examine how it relates to profitability. Kumar (2013) investigated the cost efficiencies of PSBs between 1993 and 2008. He observed that the technical and allocative efficiencies were trending in different directions, with the latter trending downward. Sing and Singh (2015) attempted to analyse the efficiency of public sector banks using the scaling technique, as recommended efficiency metrics of banks, while keeping the bank's size in mind. During the analysis, it was discovered that just a few banks are near high efficiency, with the others falling somewhere near satisfactory level. Bhatia and Mahendru (2015) examined the technological efficiency of reformatory and post-reformatory decades. They discovered a statistically significant difference and concluded that the latter decade outperformed the former, attributing the inefficiency to solely technical and scale inefficiencies. It should be noted that the literature has primarily focused on the efficiency level of Indian public-sector banking by employing various parameters. In contrast, no such extensive work has been done on operational efficiency parameters, except a small amount of work involving one or two parameters (efficiency and profit) of the banking sector. This paper aims to examine the efficiency of public sector banks in various operating areas and to identify the factors influencing them.

METHODOLOGY

Data and Sample

The study is based on secondary data sources and quantitative methods. Data is extracted from the financial annual reports of the selected nationalised public sector banks (PSBs), their official websites, the ACE knowledge portal, and two web-based databases, i.e., www.investing.com and www.moneycontrol.com. We have selected all 12 nationalised

public sector banks (PSBs) in India for the study. Since there was a shift in the government of India from UPA to NDA in 2014, we have taken a sample period from March 2015 to March 2023.

Following the study of Singh and Singh (2015), we employed an average mean of each public sector bank’s numbers over

the previous nine years. Furthermore, each bank has been graded on a scale of poor, satisfactory, better, and excellent. Bank efficiency is measured using variables such as the cost of funds, spread as a proportion of assets, net NPA to net advance, cost to income, and ROAs. These factors are optimal for analysing the bank’s efficiency (Table 1).

Table 1: Sample Description

Determinants of Technical Efficiency of Indian PSBs (Used in DEA)	
Total Interest Income	(Interest/Discount on advances/Bills + Income from investments + Interest on Balance with RBI + Other Interest)
Total Non-interest Income	Total Income – Total Interest Income
Total Operating Expenses (OE)	Interest Expended + Employee costs + Depreciation + operating expenses (excluding employee costs and Depreciation)
Interest Expended (IE)	The cost of debt interest for a specific period
No of Employees and Branch	The number of active members working for a bank and active operating branches for a specific period
Non-interest Expenses	Total Operating Expenses – Interest Expended
Factors Influencing the Efficiency of Indian PSBs (Used in Panel Regression)	
Cost of Fund (COF) (Singh & Singh, 2015)	(Interest paid on borrowings + interest paid on deposits)/(average of current and previous year’s borrowings and deposits)
Cost to income (CI)	It is the percentage of total cost to total revenue.
Spread as a percentage of Total Assets (SPRD) (Singh & Singh, 2015) Spread = Return on Fund – Cost of Fund	The gap in percentage terms between the interest rate on a bank loan and the lender’s cost of funds. In contrast to the net interest margin.
Net Profit per Employee	This depicts the net profit earned per employee. It is calculated by dividing the bank’s earnings after tax by the total number of workers.
Net Profit per Branch	This depicts the net profit earned per branch. It is calculated by dividing the bank’s earnings after tax by the total number of branches.
Bank Size (Vidyarthi, 2020; Lensink et al., 2018)	The firm’s size plays a role in sustainability and efficiency as larger banks benefit from economies of scope. The natural logarithm of total assets measures a bank’s size.
CASA: The CASA ratio, which stands for current account and savings accounts, reflects the proportion of these accounts to total deposits. A higher CASA ratio suggests the availability of low-cost financing, which enhances bank operational efficiency.	
Net Non-Performing Assets (NPAs): The standard asset quality metric is net NPAs as a proportion of net advances (Chawla & Rani, 2021). NPAs have been observed to have a negative impact on Indian banks’ financial performance (Chaudhary & Kumar, 2023; Sahoo & Majhi, 2022), causing banks to actively control their NPAs and operational expenses to boost profitability (Das & Uppal, 2021).	

Abbreviations

- | | |
|-----------------------------|--------------------------------|
| PNB = Punjab National Bank | CBI = Central Bank of India |
| BOM = Bank of Maharashtra | UCO = UCO Bank |
| UBI = Union Bank of India | IOB = Indian Overseas Bank |
| BOB = Bank of Baroda | In B = Indian Bank |
| BOI = Bank of India | P & SB = Punjab and Sindh Bank |
| CB = Canara Bank | SBI = State Bank of India |
| NPA = Non-Performing Assets | CI = Cost to Income |
| COF = Cost of Fund | ROA = Return on Assets |
| SPRD = Spread | |

EMPIRICAL SPECIFICATIONS

Data Envelopment Analysis (DEA)

Efficiency estimates for a set of Decision-Making Units (DMUs) can be generated through various parametric and non-parametric methods found in the efficiency literature. Data Envelopment Analysis (DEA) falls into the non-parametric category, creating a frontier encompassing all efficient units with scores equal to 1. In contrast, relatively inefficient DMUs receive scores below 1. This study and numerous others in the efficiency field opt for DEA over alternative methods for several reasons. DEA allows the selection of inputs and outputs without assigning relative importance to each, and it does not require assumptions about the distribution of efficiencies (Chaluvadi et al., 2018). The two traditional models introduced by Charnes et al. (1978) (CCR) and Banker et al. (1984) (BCC) are built on constant and variable return-to-scale assumptions, respectively. The Data Envelopment Analysis (DEA) model can be used to calculate the efficiencies of Decision-Making Units (DMUs) in any industry, including banking, agriculture, healthcare, manufacturing, hotels/restaurants, etc., by taking into account the respective DMUs, which include banks, agricultural firms, hospitals, manufacturing plants, educational institutions, government institutions, and even individuals. To produce achievable targets, DEA can identify benchmark DMUs for each inefficient DMU (Tamatam et al., 2019). For the computation of the technical efficiency of banks with output bundle y^0 from the input bundle x^0 , the output-oriented variable returns to scale (VRS) DEA model is specified as:

$$\tau_y(x^0, y^0) = \frac{1}{\varphi^*}$$

Where $\varphi^* = \max \varphi$

subject to

$$\sum_{j=1}^N \lambda_j y^j \geq \varphi y^0;$$

$$\sum_{j=1}^N \lambda_j x^j \leq x^0;$$

Where $\sum_{j=1}^N \lambda_j = 1$, and $\lambda_j \geq 0$ (*non - negative*), ($j = 1 \dots \dots \dots N$), φ is unrestricted, x^0 is the input used by the bank under consideration, and y^0 is the output of the bank under consideration $\frac{1}{\varphi}$ is the technical efficiency, λ is the weight, and y is the output (income) of the j^{th} banks.

SET 1 - IIE	SET 2 - NIIE
Total Interest Income (Output)	Total Non-interest Income (Output)
Total Operating expenses (Input 1)	Total Operating expenses (Input 1)
Interest Expended (Input 2)	Interest Expended (Input 2)
Number of Employees (Input 3)	Number of Employees (Input 3)
Number of Branches (Input 4)	Number of Branches (Input 4)
Total Non-interest Expenses (Input 5)	Total Non-interest Expenses (Input 5)

Panel Data Regression

The Lagrange multiplier test indicates that pooled ordinary least square (POLS) is inappropriate for the data. Then, the Hausman test is used to decide the appropriate model for the analysis. The results suggested that the Random Effect Model (REM) is appropriate for both Interest and Non-interest income efficiency models. Thus, our basic model would be:

$$y_{it} = \beta_{1i} + \beta_2 X_{it} + \gamma X_{it} + u_{it}$$

Instead of considering β_{1i} to be fixed, we consider it a random variable with a mean value of β_1 , and an individual company's intercept value may be stated as follows:

$$\beta_{1i} = \beta_1 + \varepsilon_i \quad i = 1, 2, \dots \dots N$$

Where ε_i is the random error term with a mean zero, and σ_ε^2 is variance. We mean that the 12 public sector banks in our sample are drawn from a much larger universe of such institutions and have a standard mean value for the intercept (mean = β_1), with individual differences in intercept values reflected in the error term ε_i .

$$y_{it} = \beta_1 + \beta_2 X_{it} + \gamma X_{it} + \varepsilon_i + u_{it}$$

$$y_{it} = \beta_1 + \beta_2 X_{it} + \gamma X_{it} + w_{it} \quad \text{and} \quad w_{it} = \varepsilon_i + u_{it}$$

Where y_{it} is the dependent variables' vector (Interest-income Efficiency and Non-interest income Efficiency), β_2 and γ are coefficients, and X_{it} is the constitutes of independent and control variables (cost of fund, cost to income, bank size, CASA ratio, spread, income per branch, income per employee, and NPA). W_{it} is the composite error term that consists of two components, i.e., ε_i = cross-section or individual specific error component, and u_{it} = combined error component of time series and cross-section.

DATA ANALYSIS, RESULTS AND FINDINGS

Table 2 represents the descriptive statistics of selected variables influencing the efficiencies and efficiency level of the Indian PSBs. The finding reveals that most banks' interest income efficiencies are generally close to high efficiency (mean = 92.6%). However, a significant number of banks exhibit low non-interest income efficiencies below satisfactory levels (mean = 77.9%). This imbalance between interest income and non-interest income efficiencies significantly impacts the overall efficiency of banks, bringing it closer to just satisfactory levels (mean = 85.2%). The natural logarithm of total assets yields 13.24 as the mean, 10.064 for the lowest, and 15.52 as the maximum value of bank size. When converted into absolute values, the mean, lowest, and maximum values are Rs. 979914.3 crore, Rs.

23484.1 crore, and Rs. 5516978.5 crore, respectively. The average CASA ratio (37.22%) remains low compared to private banks. This might be one of the causes of Indian public sector banks' poor performance. From a banking standpoint, loan performance is often inadequate, with the average non-performing asset (NPA) standing at 5.1%, ranging from 0.25% to 15.33%. The cost of funds for all the PSBs hovers around 5 percent to 6.75 percent, with certain variations among the individual banks. The mean income value per employee and branch is negative because most Indian PSBs were at a loss during the first term of the NDA government (2014 – 2019). The turnaround came post-COVID-19 as the banks performed much better than in the pre-COVID-19 era. The spread-to-assets ratio is comparatively better than other efficiency indicators, with a mean value above 2.2%. The cost-to-income ratio ranges from 22.03% to 82.7%, considered higher for the Indian PSBs.

Table 2: Descriptive Statistics

Variables	Count	Mean	S.D.	Min	Max	Sum
IIE	108	0.92657	0.06851	0.59	1	100.07
NIIE	108	0.7788	0.16446	0.41	1	84.11
Average Efficiency	108	0.85269	0.09589	0.625	1	92.09
CASA	108	37.32	7.43743	21.53	57.85	4030.75
Bank Size	108	13.2486	1.06862	10.064	15.52	1430.84
NPA	108	5.10009	3.12599	0.25	15.33	550.81
Cost of Funds	108	5.17065	1.0025	3.4125	7.8106	558.430
Income/Employee	108	-54537.2	1035492	-3704698	2129775	-5890014
Income/Branch	108	-468076	8377850	-2611286	22420198	-50552219
Spread	108	2.205	0.28716	1.44	2.89	238.14
Cost to Income	108	43.4636	10.6062	22.03	82.77	4694.07
Efficiency Level of Indian PSBs (2015 -2023)						
Efficiency Score	IIE Freq.	NIIE Freq.	Average Efficiency Freq.			
0.00 - 0.50	0	7	0			
0.51 - 0.60	1	10	0			
0.61 - 0.70	0	18	7			
0.71 - 0.80	2	26	20			
0.81 - 0.90	31	20	44			
0.91 - 1.00	74	27	32			

Note: IIE = Interest Income Efficiency; NIIE = Non-interest Income Efficiency.

Table 3 displays the efficiency of the Indian PSBs based on the DEA model (output-oriented variable returns to scale approach). As per the results, the Punjab & Sindh Bank, the State Bank of India, and the Canara Bank are the top 3 most

efficient Indian PSBs. On the other hand, the Central Bank of India, the Indian Overseas Bank, and the UCO Bank are the least efficient PSBs in India.

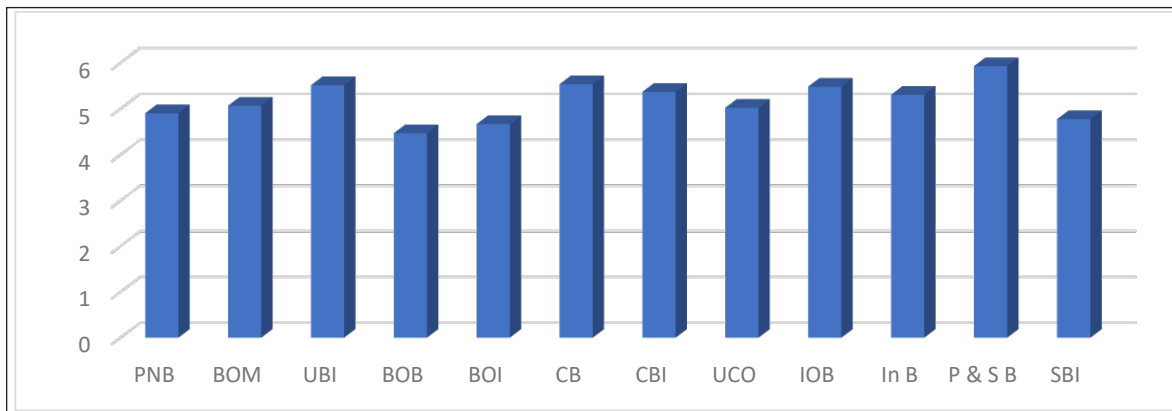
Table 3: Efficiency Scores Based on DEA Model (Output-Oriented VRS)

Sr. No.	Banks	IIE	NIE	Overall Efficiency	Ranks
1	PNB	0.95	0.76	0.85	5
2	BOM	0.93	0.77	0.85	7
3	UBI	0.95	0.77	0.86	4
4	BOB	0.97	0.71	0.84	8
5	BOI	0.91	0.72	0.82	9
6	CB	0.93	0.86	0.90	3
7	CBI	0.86	0.51	0.68	12
8	UCO	0.87	0.76	0.81	10
9	IOB	0.82	0.80	0.81	11
10	In B	0.96	0.74	0.85	6
11	P & S B	0.99	0.97	0.98	1
12	SBI	0.99	0.97	0.98	2

Scaling Technique for Efficiency Analysis

Fig. 1 shows that the cost of funds for all PSBs ranges between 5% and 6.75%, with some variance across banks. This cost has been higher in the cases of Union Bank of India, Canara Bank, and Punjab & Sindh Bank. On the contrary, the Bank of Baroda has the advantage of the lowest cost of funds (4.47%) (consistent with the finding of Singh

& Singh, 2015), while the remaining public sector banks have fared satisfactorily in the cost of funds. It is well known that the cost of funds and spread have an inverse connection, influencing the bank’s total efficiency. To maintain the bank’s efficiency, it appears that a corresponding level of cost of funds and spread is necessary. Individual banks must optimise their financing costs and attain efficiency in the globalised environment.

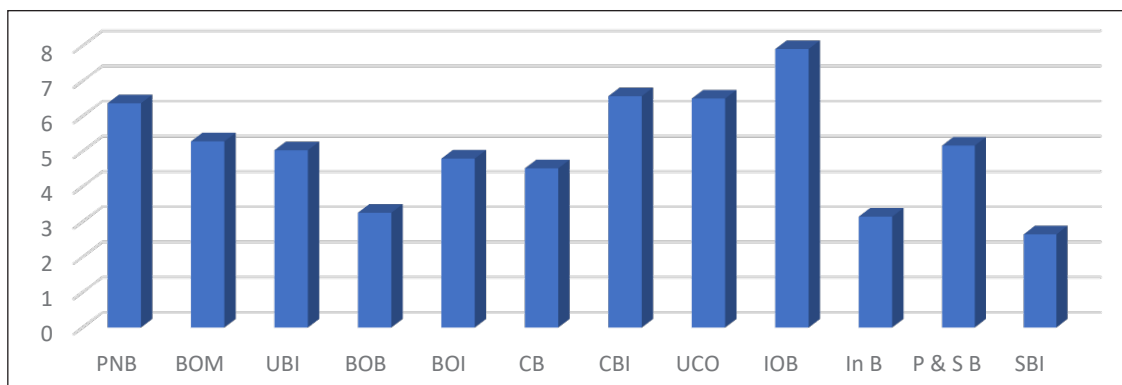


Rank	Poor	Satisfactory	Better	Excellent
Scale	> 5.51	4.1 – 5.5	2.1 – 4.0	0 – 2.0
	UBI, CB, P & SB,	PNB, BOM, BOB, BOI, CBI, UCO, IOB, In B, SBI		

Fig. 1: Cost of Funds (%)

Another crucial indicator for measuring a bank’s efficiency is its amount of NPAs. NPAs have several effects on a bank’s performance. More significantly, it impacts a bank’s earnings since banks do not collect interest on these assets; second, banks must make provision for such assets from current year profits, and bank liquidity is also adversely affected.

Fig. 2 shows that all the Indian PSBs performed miserably in this operating efficiency parameter. All were ranked in the poor category except SBI, whose NPA (%) is below 3%. IOB, CBI, UCO, and PNB are the worst-hit banks on this parameter.

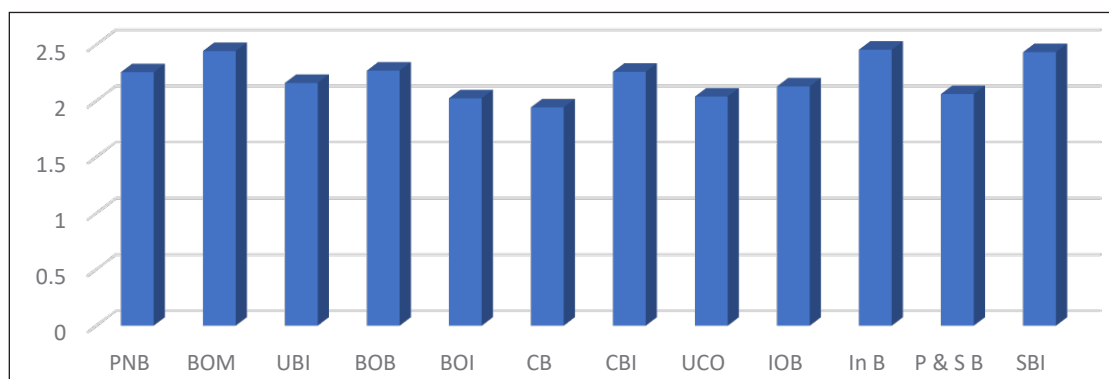


Rank	Poor	Satisfactory	Better	Excellent
Scale	> 3.0	1.5 – 2.99	1.01 – 1.49	0 – 1.0
	PNB, BOM, UBI, BOB, BOI, CB, CBI, UCO, IOB, In B, P & SB, SBI			

Fig. 2: NPA (%)

Fig. 3 shows that the spread-to-assets ratio is much better than other criteria, indicating that the bank is efficient and profitable. The spread, on the other hand, is the difference between the assets’ cost and return. Individual banks can choose between spreads ranging from 1.44% to 2.89%. According to the rating of PSU banks, three banks, namely Bank of India, Canara Bank, and UCO Bank, performed

inefficiently (less than 2% spread as a proportion of assets). The Indian Bank, on the other hand, had the highest (2.5%), and the Central Bank had the lowest (1.9%) spread on assets. The remaining banks have fared better (between 2 and 3 percent). The data also shows that spread is an effective indication of operational efficiency.

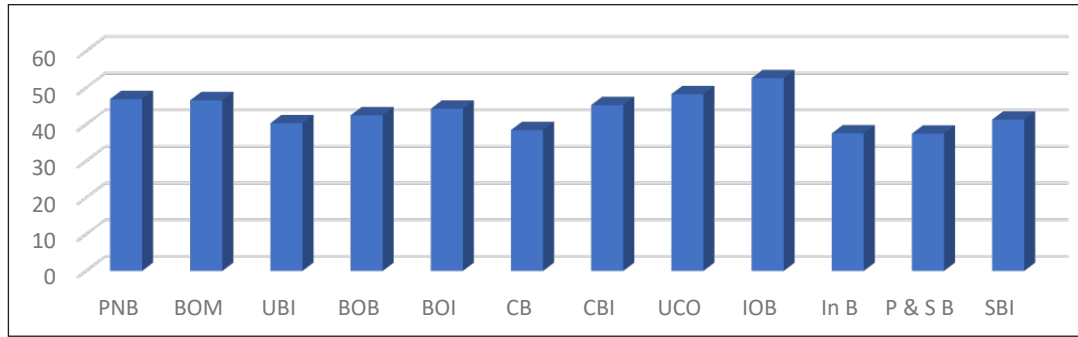


Rank	Poor	Satisfactory	Better	Excellent
Scale	0.0 – 1.0	1.1 – 2.0	2.1 – 3.0	> 3.1
		BOI, CB, UCO	PNB, BOM, UBI, BOB, CBI, IOB, In B, P & SB, SBI	

Fig. 3: Spread (%)

Fig. 4 displays the cost-to-income ratio for the Indian PSBs. It is assumed that the higher the percentage, lower the profitability. Our finding shows that the Indian Overseas Bank had the highest percentage (more than 50%); conversely, the Canara Bank, Indian Bank, and the Punjab & Sindh Bank enjoyed the lowest (31%-40%) cost-to-income ratio. While a lower cost-to-income ratio is typically preferred, the perfect

ratio will vary based on the bank’s business strategy, market circumstances, and strategic objectives. Furthermore, a low ratio may raise concerns about the bank’s capacity to invest in vital infrastructure and innovation. As a result, long-term success requires a balanced and deliberate approach to controlling the cost-to-income ratio.

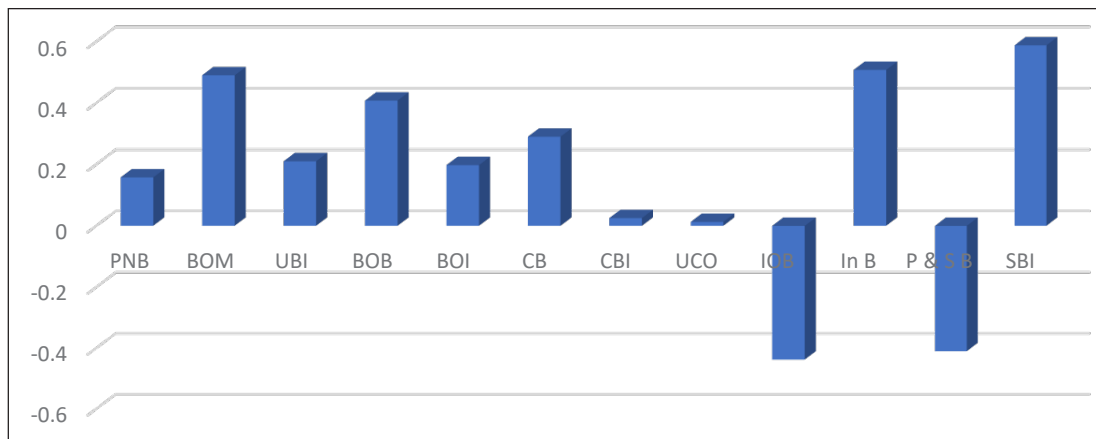


Rank	Poor	Satisfactory	Better	Excellent
Scale	> 50	41 – 50	31 – 40	< 30
	IOB	PNB, BOM, UBI, BOB, BOI, CBI, UCO, SBI	CB, In B, P & SB	

Fig. 4: Cost to Income (%)

The study of Fig. 5 on ROAs (percent) shows how effectively a public sector bank’s assets are leveraged to create profits. If the ratio is higher, total asset returns will be higher, and vice versa. Individual banks’ ROAs range from -0.4375 percent to 0.5875 percent on average. According to the available data, the State Bank of India, Indian Bank, Bank of Maharashtra, and Bank of Baroda performed satisfactorily in terms of return on assets (ROA), ranging from 0.41 to 0.80 percent,

whereas all other PSBs performed below the satisfaction level in terms of ROAs. Therefore, a higher ROA for a bank indicates efficient asset utilisation, improved profitability, effective risk management, and competitive advantage, all of which are critical considerations for operational efficiency and long-term success in the banking business. It is also evident that a bank’s ROAs and cost of funds are inversely related.



Rank	Poor	Satisfactory	Better	Excellent
Scale	< 0.40	0.41 – 0.80	0.81 – 1.20	1.21 – 1.60
	PNB, UBI, BOI, CB, CBI, UCO, IOB, P & SB	BOM, BOB, In B, SBI		

Fig. 5: ROA (%)

From the above analysis, it has been observed that only a few PSBs went above the satisfactory level in 2 out of 5 parameters, and most of the banks either performed at a satisfactory level or below the satisfactory level. We have assigned ranks to the PSBs based on the above scaling technique. The most efficient bank has been assigned rank 1, and the least efficient bank has been given rank 12. Hence,

the lowest average scorer will be the most efficient bank, and the highest scorer will be the least efficient PSB. Table 4 indicates that the State Bank of India, the Indian Bank, and the Bank of Baroda are the top 3 efficient Indian PSBs. In contrast, the Indian Overseas Bank, UCO Bank, and the Central Bank of India are the least efficient PSBs in India.

Table 4: Ranks of PSBs Based on Efficiency Parameters (Scaling Technique)

Banks	NPA	COF	SPRD	CI	ROA	Average Score	Overall Rank
PNB	9	4	6	10	8	7.4	8
BOM	8	6	2	9	3	5.6	4
UBI	6	9	7	4	6	6.4	5
BOB	3	1	4	6	4	3.6	3
BOI	5	2	11	7	7	6.4	6
CB	4	11	12	3	5	7	7
CBI	11	8	5	8	9	8.2	10
UCO	10	5	10	11	10	9.2	11
IOB	12	10	8	12	12	10.8	12
In B	2	7	1	2	2	2.8	2
P & S B	7	12	9	1	11	8	9
SBI	1	3	3	5	1	2.6	1

Selection among POLS, FEM, or REM

Lagrange multiplier tests (Breusch-Pagan) serve as the pivotal tool for model selection among POLS, FEM, or REM analyses (Mahali & Ansari, 2024; Gujarati, 2022). Table 5 displays the outcomes of these Lagrange multiplier tests (Breusch-Pagan). These tests reveal less than 5% probabilities for interest and non-interest income efficiency

models. Consequently, this leads us to reject both models' null hypothesis. The results show that one-way cross-section effects are present in both interest and noninterest income models, but there are no temporal effects. As a result, POLS is deemed inappropriate for both datasets, necessitating a selection between the fixed effect model (FEM) and the random effect model (REM).

Table 5: Lagrange Multiplier Tests for Random Effects

Null hypotheses: POLS is appropriate

Alternative hypotheses: POLS is not appropriate (Go for FEM/REM)

Model 1 Interest Income Efficiency			
	Cross Section	Time	Both
Breusch-Pagan Prob.	53.98792 (0.0000) **	0.035524 (0.8505)	54.02345 (0.0000) **
Honda	7.347647 (0.0000) **	-0.188477 (0.5747)	5.062298 (0.0000) **
King-wu	7.347647 (0.0000) **	-0.188477 (0.5747)	4.624374 (0.0000) **
Model 2 Non-Interest Income Efficiency			
Breusch-Pagan	70.30296 (0.0000) **	0.259835 (0.6102)	70.56280 (0.0000) **
Honda	8.384686 (0.0000) **	0.509740 (0.3051)	6.289309 (0.0000) **
King-wu	8.384686 (0.0000) **	0.509740 (0.3051)	5.828557 (0.0000) **

Note: ** Represents significance at 0.05.

Fixed Effect Model (FEM) or Random Effect Model (REM)

We have two possibilities after rejecting the POLS model: FEM or REM. We employed Hausman’s (1978) specification test to select the best model. The test reveals that a probability value of less than 5% resembles the Fixed Effect Model (FEM), while a probability value of more than 5% indicates that the Random Effect Model is acceptable. Thus, Table 6 reveals that the probability value for both models is greater than 5%, meaning that the Random Effect Model is appropriate.

Table 6: Correlated Random Effects – Hausman Test

Test cross-section random effects

Model 1 Interest Income Efficiency			
Test Summary	Chi-sq. Statistics	Chi-sq. d. f.	Prob.
Cross-section random	8.185615	8	0.4156
Model 2 Non-interest Income Efficiency			
Cross-section random	7.004302	8	0.5362

Random Effect Model (REM) Results

Table 7 demonstrates the results for the models discussed in the previous section using Panel EGLS (REM). In Model 1, where the dependent variable is IIE, the cost to income, CASA, and NPA coefficients are significantly negative, implying that these variables adversely impact the Indian

PSBs’ efficiency. An increase in these variables might reduce the efficiency of public sector banks (PSBs) in India. It might lead to lower profits, capital loss, and challenges in fulfilling regulatory and stakeholder requirements. Addressing these difficulties frequently necessitates strategic initiatives such as better risk management, reducing costs, and attracting low-cost deposits. On the other hand, the positive coefficient of spread indicates that a rise in spread to total asset ratio will enhance the Indian PSBs efficiency. A positive spread to total assets can improve the efficiency of Indian public sector banks (PSBs) by reflecting their capacity to produce money from interest-earning assets such as loans and investments that surpass the cost of capital. This surplus can help PSBs meet operational expenditures, maintain capital adequacy, and promote overall financial stability.

In Model 2, where the dependent variable is NIIE, the coefficients of CASA, income per branch, spread, NPA, and bank size are significant. The positive coefficients of CASA, income per branch, and bank size indicate that the ability of PSBs in India to earn more non-interest income efficiently increases as the proportion of low-cost CASA deposits, income per branch, and the bank’s overall size rises. The negative significant coefficients of spread and NPA suggest that higher spread and higher NPA relate to increased inefficiency in producing non-interest income. This might be seen as a negative indicator of the institution’s financial health, showing that improved management of interest-related elements is connected to higher efficiency in producing money from interest rather than non-interest sources.

Table 7: Dependent Variables Interest Income Efficiency (IIE) and Non-Interest Income Efficiency (NIIE); Method: Panel EGLS (Cross-Section Random Effects)

Variable	Model 1 IIE		Model 2 NIIE	
	Coefficient	Prob.	Coefficient	Prob.
Constant	1.068663	0.0000 **	0.420498	0.3705
Cost to Income	-0.004178	0.0446 **	0.000350	0.9388
Cost of Fund	-0.009923	0.4133	-0.002565	0.9252
CASA	-0.001994	0.0885 *	0.009885	0.0104 **
Income/Branch	8.64E-10	0.7726	1.01E-08	0.0950 *
Income/Employee	-3.43E-08	0.1498	-2.82E-08	0.5618
Spread	0.088793	0.0078 **	-0.131676	0.0582 *
NPA	-0.614297	0.0874 *	-0.003505	0.005706 **
Bank Size	0.787834	0.9487	0.420498	0.028632**
R-squared	0.396466		R-squared	0.346732
Adjusted R-Squared	0.347696		Adjusted R-Squared	0.293942
S. E. of regression	0.055333		S. E. of regression	0.100232
F- statistics	8.129239		F- statistics	6.568211
Prob (F-statistics)	0.000000 **		Prob (F-statistics)	0.000001 **
Mean dependent var	0.926574		Mean dependent var	0.172612
S. D. dependent var	0.068511		S. D. dependent var	0.119285
Akaike info criterion	-2.871233		Akaike info criterion	0.994591

Note: ** Represents significance at 0.05, and * represents significance at 0.10 levels.

CONCLUSION

As observed in the literature survey, there is a paucity of detailed efficiency analyses of Indian PSBs utilising the most recent available data. In this light, this work adds to the current literature by conducting a complete and in-depth relative efficiency analysis of the Indian public sector banking business using DEA. It also examines the efficiencies of banks by analysing several efficiency metrics based on the scaling approach. Further, this study identifies the factors influencing interest and non-interest efficiencies of Indian PSBs. According to the DEA model (VRS), the top three most efficient Indian PSBs are Punjab & Sindh Bank, State Bank of India, and Canara Bank. The Central Bank of India, Indian Overseas Bank, and UCO Bank, on the other hand, are India's least efficient PSBs. The scaling technique reveals that only a few PSBs fared above the satisfactory threshold in two of the five categories, with most banks performing at or below the satisfactory level. Based on the aforesaid scaling approach, we awarded rankings to the PSBs. The most efficient bank is ranked first, while the least efficient bank is ranked twelve. Table 4 indicates that the State Bank of India, the Indian Bank, and the Bank of Baroda are the top 3 efficient Indian PSBs. In contrast, the Indian Overseas Bank, UCO Bank, and the Central Bank of India are the least efficient PSBs in India. The study also reveals some significant factors influencing the efficiency of Indian PSBs, such as cost of funds, cost to income, spread, NPAs, income per branch, bank size, etc.

In the modern Indian banking business, there is concern about the future of regulatory requirements, competition, rising cost to income, cost of funds, growing NPAs, quickly changing client tastes with unusually fast-growing technology and automation, escalating rivalry, and profitability constraints. In such a circumstance, efficiency management becomes more critical in banking. Only an up-to-date examination of the bank's performance relative to its competitors can ensure such development in efficiency, profits, and market value. This timely analysis regarding the bank's efficiency compared to the benchmark best feasible efficient banks gets the attention of the bank's decision-makers. Government officials and managers can go further into the reasons for inefficiency and develop internal skills to replicate the most outstanding performers by the Indian PSBs.

Conflict of Interest: The authors do not have any conflict of interest.

REFERENCES

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in

- data envelopment analysis. *Management Science*, 30(9), 1078-1092.
- Bhatia, A., & Mahendru, M. (2015). Assessment of technical efficiency of public sector banks in India using data envelopment analysis. *Eurasian Journal of Business and Economics*, 8(15), 115-140.
- Chaluvadi, S., Raut, R., & Gardas, B. B. (2018). Measuring the performance efficiency of banks in a developing economy: The case study of Indian public sector vs private sector. *Benchmarking: An International Journal*, 25(2), 575-606.
- Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision-making units. *European Journal of Operational Research*, 2(6), 429-444.
- Chaudhary, P., & Kumar, A. (2023). Impact of credit risk on the performance of Indian banks. *Journal of Commerce and Accounting Research*, 12(1), 29-38.
- Chawla, S., & Rani, S. (2021). Investigating the determinants of non-performing assets: The case of the Indian banking sector. *Journal of Commerce and Accounting Research*, 10(4), 64-75.
- Das, S. K., & Uppal, K. (2021). NPAs and profitability in Indian banks: An empirical analysis. *Future Business Journal*, 7(1), 1-9.
- DSouza, S., Rabbani, M. R., Hawaldar, I. T., & Jain, A. K. (2022). Impact of bank efficiency on the profitability of the banks in India: An empirical analysis using panel data approach. *International Journal of Financial Studies*, 10(4), 93.
- Gobat, J. (2017, June 15). Banks: At the heart of the matter. *International Monetary Fund (IMF)*. <https://www.imf.org/en/Publications/fandd/issues/Series/Back-to-Basics/Banks#:~:text=Although%20banks%20do%20many%20things,whom%20the%20bank%20lends%20money>
- Goel, C., & Rekhi, C. B. (2013). A comparative study on the performance of selected public sector and private sector banks in India. *Journal of Business Management & Social Sciences Research*, 2(7), 46-56.
- Gujarati, D. N. (2022). *Basic econometrics*. Prentice Hall.
- Gulati, R., & Kumar, S. (2017). Analyzing banks' intermediation and operating efficiencies using the two-stage network DEA model: The case of India. *International Journal of Productivity and Performance Management*, 66(4), 500-516.
- Hassan, M. K., Rabbani, M. R., Brodmann, J., Bashar, A., & Grewal, H. (2023). Bibliometric and scientometric analysis on CSR practices in the banking sector. *Review of Financial Economics*, 41(2), 177-196.

- Kumar, S. (2013). Banking reforms and the evolution of cost efficiency in Indian public sector banks. *Economic Change and Restructuring*, 46, 143-182.
- Kumar, S., & Gulati, R. (2008). An examination of technical, pure technical, and scale efficiencies in Indian public sector banks using data envelopment analysis. *Eurasian Journal of Business and Economics*, 1(2), 33-69.
- Lensink, R., Mersland, R., Vu, N. T. H., & Zamore, S. (2018). Do microfinance institutions benefit from integrating financial and nonfinancial services? *Applied Economics*, 50(21), 2386-2401.
- Mahali, M., & Ansari, M. N. (2024). Income diversification and financial sustainability of Indian microfinance institutions (MFIs): An empirical study. *International Journal of Banking, Risk & Insurance*, 12(1), 40-19. doi:<https://doi.org/10.21863/ijbri/2024.12.1.005>
- Pradhan, A. K., Sonaje, V. H., & Desai, S. P. (2015). Measuring technical efficiency: An application of data envelopment analysis to select public sector banks in India. *Asia-Pacific Finance and Accounting Review*, 3(1), 107.
- Rabbani, M. R., Kayani, U., Bawazir, H. S., & Hawaldar, I. T. (2022). A commentary on emerging markets banking sector spillovers: COVID-19 vs. GFC pattern analysis. *Heliyon*, 8(3).
- Raina, D., & Kumar Sharma, S. (2013). Determinants of cost efficiency of commercial banks in India: DEA evidence. *IUP Journal of Bank Management*, 12(2).
- Rezvanian, R., Rao, N., & Mehdian, S. M. (2008). Efficiency change, technological progress and productivity growth of private, public and foreign banks in India: Evidence from the post-liberalization era. *Applied Financial Economics*, 18(9), 701-713.
- Sahoo, M. K., & Majhi, M. (2022). Non-performing assets management of commercial banks in India - A literature review. *Journal of Commerce and Accounting Research*, 11(4), 62-73.
- Sanjeev, G. M. (2006). Does banks' size matter in India? *Journal of Services Research*, 6(2), 135-144.
- Singh, P., & Singh, K. (2015). Efficiency assessment parameters of public sector banks in India. *Global Business Review*, 16(6), 1112-1126.
- Sun, H., Rabbani, M. R., Ahmad, N., Sial, M. S., Cheng, G., Zia-Ud-Din, M., & Fu, Q. (2020). CSR, co-creation and green consumer loyalty: Are green banking initiatives important? A moderated mediation approach from an emerging economy. *Sustainability*, 12(24), 10688.
- Tamatam, R., Dutta, P., Dutta, G., & Lessmann, S. (2019). Efficiency analysis of Indian banking industry over the period 2008-2017 using data envelopment analysis. *Benchmarking: An International Journal*, 26(8), 2417-2442. doi:<https://doi.org/10.1108/BIJ-12-2018-0422>
- Vidyarthi, H. (2020). Dynamics of income diversification and bank performance in India. *Journal of Financial Economic Policy*, 12(3), 383-407.