Benchmarking Efficiency in Indian Banking: Insight from a DEA Analysis

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Abstract

This study evaluates the performance of public sector banks in India over a decade, specifically from April 1, 2014, to March 31, 2023, by analyzing efficiency metrics using Data Envelopment Analysis (DEA). The analysis employs two DEA models: the CCR model, which assumes constant returns to scale (CRS) and measures Overall Technical Efficiency (OTE), and the BCC model, which assumes variable returns to scale (VRS) and assesses Pure Technical Efficiency (PTE). The study finds that banks such as Punjab and Sind Bank, State Bank of India, and Bank of Maharashtra demonstrate consistently high efficiency across all metrics, indicating strong and stable performance. In contrast, banks including Bank of Baroda, Canara Bank, and Union Bank of India exhibit notable fluctuations in efficiency, reflecting periods of both high and low performance. Specifically, 2022 was a challenging year for many banks, marked by significant drops in efficiency, but a recovery is evident in 2023. Recommendations include stabilizing operations for banks with high variability, optimizing scale efficiency, and leveraging successful strategies from high-performing banks to foster overall sector improvement.

Keywords: DEA, OTE, PTE, efficiency, banks

JEL Classification: D61; G21; G34

Introduction

The banking sector is a crucial component of any nation's economy, serving as the primary conduit for financial intermediation, capital formation, and economic stability. In India, the banking industry comprises a diverse mix of public, private, and foreign banks, each playing a vital role in supporting the country's economic growth. However, the efficiency of these banks varies significantly, influencing their ability to compete, grow, and contribute effectively to the broader financial system (Kumbhakar and Sarkar, 2003; Bhattacharyya et al., 1997).

With the increasing complexity and competition in the Indian banking sector, understanding and improving efficiency has become a priority for

stakeholders (Fethi and Pasiouras, 2010). Efficiency gaps, which refer to the differences in performance between the most and less efficient banks, can reveal important insights into areas for potential improvement and optimal resource allocation (Kumbhakar and Wang, 2007).

The performance of nationalized banks in India is vital for driving financial inclusion and maintaining economic stability, underscoring the importance of evaluating their effectiveness. As these banks operate in a competitive and evolving financial environment, understanding their efficiency is paramount (Sarkar and Sahu, 2011; Kumar and Singh, 2013). Efficiency in banking, particularly in nationalized banks, goes beyond merely reducing costs; it involves optimizing resource utilization to maximize key outputs like profitability, service quality, and customer satisfaction (Fethi and Pasiouras, 2010).

The Indian government's on-going reforms, including the consolidation of public sector banks, have been aimed at improving the efficiency and financial stability of nationalized banks. The mergers of smaller banks into larger entities, such as the merger of Oriental Bank of Commerce and United Bank of India with Punjab National Bank, have resulted in larger, more resilient banking institutions. Nevertheless, such mergers also bring challenges related to integration, legacy issues, and cultural alignment. However, despite their importance, nationalized banks often face challenges related to operational inefficiencies, which can hamper their ability to compete with private and foreign banks. These inefficiencies, commonly referred to as efficiency gaps, vary widely across the sector, reflecting differences in management practices, technological adoption, and external economic conditions. Addressing these gaps is crucial for enhancing the overall performance and sustainability of nationalized banks in India (Kumar & Singh, 2013; Sarkar & Sahu, 2011; Reddy, 2008; Bhattacharyya et. al 1997). The assessment of bank efficiency, whether at the branch level or the institutional level, has been widely discussed topic in the academic literature on banking and finance (Fethi and Pasiouras, 2010; Berger, 2007; Berger and Humphrey, 1997).

In the context of banking industry, previous research has extensively applied DEA to measure the efficiency of banks globally and in India. For instance, Charnes, Cooper, and Rhodes (1978) introduced DEA as a tool for evaluating the efficiency of decision-making units, which has since been widely adopted in banking efficiency studies. Studies like those by Berger and Humphrey (1997) have used DEA to analyze efficiency trends in the banking sector, while Kumar and Gulati (2008) focused specifically on the Indian context, highlighting the impact of financial reforms on bank efficiency.

This research utilizes the Data Envelopment Analysis (DEA) methodology to evaluate the efficiency of Indian nationalized banks. DEA, a widely recognized non-parametric approach, allows for the assessment of the relative efficiency of decision-making units, providing a comprehensive understanding of where these banks stand in comparison to their peers. Utilising DEA, this research aims to identify the key factors contributing to efficiency gaps and offer insights into areas where improvements are most needed.

The updated efficiency measurements will provide a more accurate and relevant assessment of the performance of Indian nationalized banks in the current economic and regulatory environment. This approach not only helps in understanding where these banks stand today but also provides insights into the strategic areas that need focus to enhance their efficiency further.

The remainder of the present paper is structured as follows: the next section provides a comprehensive overview of previous research relevant to the study, examining key findings and theoretical frameworks. The subsequent section will explore the data sources utilized, outline the research methods employed, and describe the overall framework guiding the analysis. The penultimate section delves into the results obtained from the research, offering a detailed discussion and analysis of the findings. The final section summarizes the research results, drawing conclusions and outlining implications based on the study's findings.

Literature Review

The efficiency of Indian banking industry has garnered substantial research attention, with Data Envelopment Analysis (DEA) frequently utilized as a primary framework

for evaluating their performance. DEA is a non-parametric method that measures the efficiency of decision-making units (such as banks) by comparing the inputs and outputs of each unit relative to the best-performing ones. The application of DEA in evaluating the efficiency of banks has provided valuable insights into the functioning and performance of these banks, especially in the context of economic reforms, technological advancements, and evolving competitive pressures.

In the ongoing discourse on banking efficiency, a variety of studies have explored how different factors such as ownership structure, size, and regulatory environment influence performance outcomes. Chen (1998) found that privately-owned banks in Taiwan demonstrated higher efficiency scores compared to their publicly-owned counterparts, highlighting the impact of ownership structure on efficiency. Similarly, Jackson and Fethi (2000) noted that larger and more profitable banks typically operated at higher levels of technical efficiency, underscoring the significance of scale and profitability. Contrary to this, Ariff and Can (2007) found that profit efficiency typically lagged behind cost efficiency in China, with medium-sized banks being more efficient than their smaller or larger counterparts. However, Schmid (1994) observed that in Australia, smaller and very large banks exhibited higher technical efficiency, while regional banks showed lower efficiency, suggesting that size plays a crucial role in efficiency levels. In their 2002 study, Jemric and Vujcic reported that foreign-owned and newer banks outperformed domestic and older banks in Croatia, indicating that new entrants and foreign ownership might enhance efficiency. Conversely, Yildrim (2002) found that state-owned banks in Turkey were more efficient than their privately owned and foreign counterparts, with larger banks also demonstrating higher efficiency. Sathye (2003) used two DEA models to compare bank efficiency in India, finding that public banks were more efficient with Model-A, while foreign banks excelled with Model-B. Barbara and Philip (2003) highlighted the effect of geographic location on bank efficiency, showing that location-related factors can influence operational performance. In their 2005 study, Bonaccorsi di Patti and Hardy observed that deregulation had a positive effect on banking efficiency in Pakistan, emphasizing the role of regulatory changes. Supporting the notion that deregulation enhances performance, Bhattacharyya et al. (1997) findings showed that state-owned banks in India became more efficient post-deregulation. In their 2007 study, Debasish and Mishra observed that foreign banks were typically the most efficient, with emerging banks outperforming older ones burdened by legacy issues. Debnath and Shankar (2008) found that medium-sized banks performed less efficiently compared to large or small banks under variable returns to scale. Gupta et al. (2008) highlighted the efficiency leadership of the State Bank group, followed by private banks, reinforcing the dominance of major public sector banks. Finally, Ketkar and Ketkar (2008) identified foreign banks as the most efficient, followed by private banks, further supporting the impact of ownership structure on efficiency. Shaban et al. (2013) reveal that, during the study period, foreign commercial banks have underperformed compared to both public and private sector banks. Raghoober et al. (2017) suggested that Mauritian banks should focus on efficiency, leveraging technology and training, with blockchain as a potential solution for improvement. Paleckova (2019) found that larger banks with higher liquidity risk and lower net interest margins were more efficient, aligning with DEA model inefficiency findings. Additionally, banks showed high cost efficiency during economic expansion with lower inflation. Fang et al. (2019) found that competition in Chinese banking was strong in 2003–2005 and 2014–2017. Furthermore, the findings reveal that bank size, cost efficiency, profit efficiency, and inflation significantly affect profitability, especially under high risk. Guo et al. (2020) found that, before 2012, state-owned banks were more efficient; post-2012, joint stock banks excelled. Key efficiency factors include non-interest income and cost-to-income ratio. Singh and Thaker (2020) used two-step DEA to assess profit efficiency in Indian banks, finding large public, private, and foreign banks more profitable than smaller ones. Akhtar et al. (2022) find that public banks are more efficient than private and foreign banks but also indicate that Indian banks overall struggle with input management and suggest restructuring for improved performance. Pinto and Tessmann (2023) found that efficient banks vary by segment, with large, public, and new digital banks showing

notable efficiency from a production perspective. Together, these studies provide a comprehensive view of the factors influencing bank efficiency across different contexts and regions.

There are several other studies focusing on the efficiency of public sector banks (PSBs) in India, providing a comprehensive analysis of various aspects and trends that influence their performance. These studies explore multiple dimensions of efficiency, revealing both improvements and ongoing challenges. For instance, Noulas and Ketkar (1996) analyzed technical and scale efficiencies of 18 PSBs, finding that most operated under increasing returns-to-scale, indicating that many banks could benefit from scaling up operations to improve efficiency. Das (1997a, 2000) found that banks within the State Bank of India (SBI) group were more efficient than other nationalized banks, with inefficiencies primarily being technical rather than allocative. However, PSBs improved their allocative efficiency post-liberalization. Nath et al. (2001) used DEA and co-plot to identify five strategic groups among 27 PSBs, noting that efficiency was positively correlated with profitability. Poor performance was linked to low productivity, over-staffing, and ineffective training. In their 2003 study, Kumar and Verma found that technical efficiency in Public Sector Banks (PSBs) was linked to increased profitability, wider branch networks, and higher employee productivity. Mukherjee et al. (2003) observed that PSBs with superior service delivery achieved better performance outcomes, highlighting the importance of effective resource management. Nandy (2007) identified two top performers among PSBs, Indian Overseas Bank and Corporation Bank, suggesting these banks excelled in efficiency. Sanjeev (2007) found no conclusive relationship between efficiency and size in PSBs, indicating that factors other than size might drive efficiency. Kumar (2008) highlighted Corporation Bank and Andhra Bank as ideal benchmarks for both efficiency and profitability, indicating these banks excelled in both dimensions. In their 2008 study, Kumar and Gulati identified key determinants of technical efficiency in Public Sector Banks (PSBs), which included exposure to staff productivity, off-balance sheet activities, market share, and bank size. Tandon (2008) analyzed 19 PSBs from 2003-2006 and found Corporation Bank to be a consistent top performer. Das et al. (2009) observed significant variations in labour-use efficiency among branches of a large PSB, suggesting inconsistencies in performance at the branch level. Kumar and Gulati (2009) found an increase in technical efficiency among PSBs during the post-reforms period and observed a convergence phenomenon, indicating that less efficient banks were catching up with their more efficient counterparts. Biswal and Mishra (2020) observed fluctuating technical efficiency in Nationalized Banks of India, measured by CRS. Chaudhary and Arora (2022) found that only a few banks consistently performed well with minimal variation in efficiency scores.

Scale efficiency, which measures whether a bank is operating at an optimal size, is another area where nationalized banks have faced challenges. Many nationalized banks in India, due to their large size and extensive branch networks, suffer from scale inefficiencies. Studies such as those by Saha and Ravisankar (2000) have pointed out that these banks often operate under suboptimal conditions, where resources are not utilized to their fullest potential. Overstaffing, underutilization of technology and a focus on fulfilling government mandates rather than optimizing operations are some of the reasons for these inefficiencies.

Ownership structure plays a crucial role in determining the efficiency of nationalized banks. DEA-based studies have consistently found that the ownership model of nationalized banks with the government as the majority shareholder impacts their efficiency. Public ownership often brings with it a set of challenges, including political interference, social obligations, and risk aversion, which can hinder efficient operations. Sensarma (2006) compared the efficiency of state-owned, private, and foreign banks in India and found that public ownership was associated with lower efficiency levels, primarily due to the conflicting objectives of profitability and social welfare. This dual objective often leads to less focus on operational efficiency and more on fulfilling broader economic and social goals, such as financial inclusion and rural banking.

The existing body of research on the efficiency of Indian nationalized banks using DEA provides a comprehensive

understanding of the factors influencing their performance. Despite efforts to improve efficiency through reforms, technological adoption, and better management practices, nationalized banks continue to face significant challenges. These challenges include structural inefficiencies, the dual focus on profitability and social obligations, and the impact of regulatory frameworks. The literature underscores the need for ongoing reforms, greater technological adoption, and a more balanced approach to regulation to enhance the efficiency of nationalized banks. This study aims to build upon this existing body of research by offering a comprehensive analysis of efficiency gaps in Indian banks using recent data.

Data and Methodology

This study employs the Data Envelopment Analysis (DEA) methodology to evaluate the efficiency of Indian nationalized banks. DEA is a non-parametric technique used to assess the relative efficiency of decision-making units (DMUs) by comparing multiple input and output variables. It is particularly suitable for evaluating the performance of organizations like banks, where the goal is to optimize the use of resources to achieve maximum outputs.

Selection of Data

The study aims to evaluate the performance of public sector banks in India over a decade, specifically from April 1, 2014, to March 31, 2023. The sample size of 12 nationalized banks which are currently operating in India for the period of 10 years ranging from 2014 to 2023 are selected for the study. The data has been gathered from the RBI's official website (www.rbi.org.in). The selection of banks is based on their significance in the Indian banking sector, and the period chosen allows for the analysis of efficiency trends over time. By focusing on public sector banks, the study aims to offer a detailed examination of efficiency within a consistent and strategically relevant segment of the Indian banking industry.

The selection of public sector banks for the study is motivated by several important considerations: Public sector banks in India are subject to similar regulatory guidelines and policies set by the government and the Reserve Bank of India (RBI). This regulatory consistency allows for a more accurate and fair comparison of efficiency across these institutions. These banks are owned and controlled by the government, which means they often share similar strategic objectives and operational constraints. This common ownership provides a unified basis for evaluating their efficiency.

Variables

When computing efficiency scores, analysts often find it challenging to select the appropriate input and output variables for modelling bank performance. The literature on banking performance outlines five main approaches for this selection: the Intermediation Approach, the Production Approach, the Value Added Approach, the Asset Approach and the Operating Income Approach (Sharma, 2018). Within the literature the two most common approaches are production and intermediation, each delineating the banking business in distinct ways. The production approach views banking as the creation of deposits, loans, and other financial services through the utilization of labour and capital. In contrast, the intermediation approach portrays banking institutions as intermediaries that connect borrowers with savers, facilitating various financial products and services.

In their 1997 study, Berger and Humphrey suggested that the intermediation approach is more appropriate for assessing bank efficiency, while the production approach is better suited for evaluating the efficiency of bank branches. Supporting the notion, Sharma et al. (2013) considered the intermediation approach as the most effective value-added method for evaluating the technical efficiency of banking units using DEA models. However, as the set of inputs–outputs significantly influences the DEA estimates, choosing an approach to define inputs–outputs is quite important.

In determining the input-output specification pertaining to the Indian banking sector, the Indian banking sector's organisational structure has also been taken into account. This is important because, unlike a strict focus on profit maximization, Indian nationalised banks align their goals with the RBI's overarching objective of fostering economic growth and maintaining the stability of the Indian banking industry (Shanmugam and Das, 2004). Furthermore, in

context of the changes brought about by economic liberalization, Coates (1990) examined the goals of the Indian banking industry, concluding that the production approach is inappropriate for the Indian banking sector. Since there is disagreement over which approach is better, the literature advocates for the use of a combination of approaches to determine the inputs and outputs. Therefore, both the existing literature and the structure of the Indian banking industry have been taken into account for this study. Consequently, this study employs a combination of the intermediation and operating income approaches (Bonin et al., 2005; Becalli et al., 2006; Sensarma, 2006; Barros et al., 2007; Fiordelisi, 2007; Berger et al., 2009).

The study aims to evaluate the operational efficiency of the Indian nationalized banks by focusing on minimizing inputs to achieve a specified level of output, considering that banks exert greater control over their inputs than their outputs. The inputs and outputs used in the DEA model are selected based on their relevance to banking operations and their availability in the data sources. The chosen variables for this analysis include Deposits, Interest Expenses, Non-Interest Expenses, and Personnel Expenses as inputs, and Advances, Interest Income, and Non-Interest Income as outputs.

DEA Model Specification

Data Envelopment Analysis (DEA) is a linear programming-based methodology designed to evaluate the relative efficiency of decision-making units (DMUs) that utilize multiple inputs to produce multiple outputs. DEA constructs an efficiency frontier composed of the most efficient DMUs, serving as benchmarks or "best practices". Each DMU is then assessed relative to this frontier, with its efficiency quantified by the extent to which it deviates from the best-practice frontier. The non-efficiency of a DMU is measured by comparing its performance against this frontier, providing insights into potential improvements and operational adjustments needed to achieve efficiency. This approach allows for a comprehensive assessment of performance across diverse operational contexts and organizational structures.

The Farrell (1957) model, pioneering in efficiency analysis, introduced the concept of measuring the relative efficiency of decision-making units (DMUs) using the ratio of observed output to the maximum achievable output with given inputs. This foundational work laid the groundwork for subsequent DEA models by highlighting the importance of efficiency measurement. Building on Farrell's ideas, the CCR model (Charnes, Cooper, and Rhodes, 1978) formalized this approach within a linear programming framework, introducing the concept of constant returns to scale (CRS). The CCR model assesses efficiency by comparing a DMU's input-output ratios to those of a convex combination of other DMUs, thereby setting a benchmark for evaluating performance under the assumption that scale effects are constant. In response to the limitation of the CRS assumption, the BCC model (Banker, Charnes, and Cooper, 1984) extended the CCR framework by incorporating variable returns to scale (VRS). This model allows for the assessment of efficiency without assuming constant returns, thus offering a more flexible and realistic approach to efficiency evaluation by recognizing that different DMUs might operate at different scales of production. Together, these models provide a comprehensive toolkit for analyzing and benchmarking the efficiency of various organizations and processes.

In the present study, we utilize two DEA models – CCR (Charnes, Cooper, and Rhodes, 1978) and BCC (Banker, Charnes, and Cooper, 1984) – to analyze efficiency measures under different assumptions about returns to scale. The CCR model, which assumes constant returns to scale (CRS), is used to derive what are commonly known as overall technical efficiency (OTE) scores. These OTE scores reflect a DMU's efficiency in transforming inputs into outputs but include the effects of scale efficiency. In contrast, the BCC model assumes variable returns to scale (VRS) and yields what are referred to as pure technical efficiency (PTE) scores. PTE scores isolate the efficiency related solely to the management and operational practices of a DMU, excluding any influences from scale inefficiencies.

To evaluate the overall technical efficiency (OTE) scores, CCR input oriented DEA model is considered, and is presented as follows:

$$Maximise \sum_{r=1}^{t} u_r y_{ir} \quad (1)$$

Subject to

$$\sum_{r=1}^{t} u_r y_{jr} - \sum_{r=1}^{s} v_s x_{js} \leq 0, \quad j = 1,...,n \quad (2)$$

$$\sum_{s=1}^{m} v_s x_{is} = 1 \quad (3)$$

$$u_r, v_s \geq \varepsilon \quad (4)$$

Where, *n* represents the total number of Decision Making Units (DMUs), *t* denotes the number of outputs, and *m* indicates the number of inputs. The variable x_{is} refers to the input value *s* for the DMU_i while y_{ir} signifies the output value *r* for the DMU_i. The term h_i is the efficiency score of the DMU_i (generally, index *0* is used to indicate the DMU being assessed in the models), u_r indicates the relative importance of the output *r*, v_s represents the relative importance of the input *s*, and ε is a small positive real number.

To evaluate pure technical efficiency (PTE) scores, second DEA model which is a variant of the preceding one, known as the BCC model, with variable return to scale is considered:

$$Maximise \sum_{r=1}^{t} u_r y_{ir} - u_0 \quad (5)$$

Subject to

$$\sum_{r=1}^{t} u_r y_{jr} - \sum_{s=1}^{m} v_s x_{js} - u_0 \leq 0, \quad j = 1,...,n \quad (6)$$

$$\sum_{s=1}^{m} v_s x_{is} = 1 \quad (7)$$

$$u_r, v_s \geq \varepsilon \quad (8)$$

The DEA models facilitate the identification and quantification of inefficiency scores through the conversion of the CCR and BCC models into their corresponding dual models. To illustrate, the dual model corresponding to the CCR input-oriented approach is presented as follows:

$$Minimise\ \theta = z_0 - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{t} s_r^+\right) \quad (9)$$

Subject to

$$x_{ij0} z_0 - \sum_{j=1}^{n} \lambda_j x_{ij} - s_i^- = 0, \quad i = 1,...,m \quad (10)$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_i^+ = y_{rj0}, \quad r = 1,...,t \quad (11)$$

$$\sum_{j=1}^{n} \lambda_j = 1 \quad (12)$$

In the equations, the parameters λj (j = 1,… , n) identify the benchmark Decision Making Units (DMUs) and define an envelope for the evaluated DMU_0; θ_0 represents the efficiency ratio of the evaluated DMU_0; z_0 denotes the proportion of inputs, for an inefficient DMU, needed to produce outputs equivalent to its benchmark DMUs; and s_i^- and s_r^+ correspond to the slacks associated with the inputs *i* and the outputs *r*, respectively. In a similar manner, the duality of the BCC input-oriented model is obtained by adding the following convexity constraint to the CCR dual input-oriented model.

To determine scale efficiency (SE), which measures the extent to which a DMU's efficiency is affected by its scale of operation, we use the ratio of the OTE score to the PTE score for each DMU (Banker et al. 1984). This is mathematically expressed as:

SE=OTE/PTE

Here, SE indicates how much of the overall inefficiency captured by the OTE score is attributable to scale effects. An SE score close to 1 implies that the DMU is operating at an optimal scale, while a lower SE score suggests that scale inefficiencies contribute to the DMU's overall inefficiency. By analyzing OTE, PTE, and SE, we gain a comprehensive understanding of both the technical and scale-related aspects of efficiency for each DMU.

Analysis and Interpretations

Table 1 provides a detailed descriptive statistics of key financial metrics for various banks over the period from 2014 to 2023. These metrics include advances, interest income, non-interest income, deposits, interest expenses, non-interest expenses, and personnel expenses. The State

Bank of India and Punjab National Bank exhibit the highest averages across most metrics, indicating large-scale operations. In contrast, smaller banks, such as Bank of Maharashtra and Punjab and Sind Bank, show lower averages but demonstrate more consistent performance. Larger banks experience greater variability in their metrics, suggesting challenges in maintaining stable performance. Conversely, smaller banks generally exhibit lower variability, reflecting their more stable but smaller-scale operations. Additionally, larger banks like the State Bank of India face higher expenses and greater variability, underscoring the complexities associated with managing large-scale operations. Smaller banks, on the other hand, incur lower expenses and exhibit less variability, frequently attributable to their simpler operational structures.

Table 1: Descriptive Statistics of Bank Inputs and outputs during the period (2014-2023)

Banks	Measures	Advances	Interest Income	Non-interest income	Deposits	Interest expenses	Non-Interest expenses	Personnel expenses
BANK OF BARODA	Mean	560292.56	56753.17	7833.44	611783.62	35188.61	6613.83	7400.46
	Std. Dev.	200778.19	17981.44	3098.34	213439.25	8258.13	2970.34	3723.86
	Min.	383259.22	38939.71	4402.00	476974.05	26974.36	2997.34	4139.72
	Max.	940998.27	89588.54	12933.97	1203687.79	48532.37	11165.66	13352.66
BANK OF INDIA	Mean	382212.71	40997.76	5784.08	170480.19	27619.00	4082.90	5871.69
	Std. Dev.	43920.56	3028.44	1476.95	78312.39	2148.48	838.71	1245.38
	Min.	341005.94	37910.10	3652.54	116803.09	24013.73	2708.32	3991.15
	Max.	485899.64	47647.72	7878.73	381839.59	32086.25	5590.34	8391.84
BANK OF MAHARASHTRA	Mean	105072.88	12396.47	1669.07	581040.68	7944.27	1241.84	1811.74
	Std. Dev.	27221.28	1438.90	648.90	286218.51	854.78	352.95	240.08
	Min.	82666.21	10849.60	894.19	94336.93	6971.07	800.99	1540.98
	Max.	171220.67	15898.46	2652.48	1086409.25	9174.29	1863.56	2255.21
CANARA BANK	Mean	471275.54	52882.03	9242.70	299547.51	36888.96	4749.46	7506.31
	Std. Dev.	185546.53	15622.47	5396.65	37675.57	7684.89	2065.40	3951.89
	Min.	301067.48	39547.61	3932.76	240068.99	29088.76	2408.63	3672.38
	Max.	830672.55	84424.78	18762.20	355855.99	52989.49	8737.65	13743.83
CENTRAL BANK OF INDIA	Mean	166710.59	24269.60	2747.12	276061.85	16497.82	2407.33	4202.44
	Std. Dev.	20232.37	1363.48	742.92	156583.33	2108.47	492.34	591.57
	Min.	139398.77	22638.57	1894.23	162274.82	13314.88	1641.93	3537.01
	Max.	202984.31	26408.78	4083.71	593617.81	19161.71	3282.77	5603.97
INDIAN BANK	Mean	224169.06	24399.33	3403.77	221662.68	15207.20	2261.37	3506.45
	Std. Dev.	125879.55	11688.98	2285.81	31817.35	5771.20	1419.94	2343.55
	Min.	122208.99	15249.21	1363.36	141980.16	10850.09	904.71	1742.59
	Max.	449296.73	44942.21	7143.06	262158.92	24716.75	4570.68	7527.23
INDIAN OVERSEAS BANK	Mean	148539.35	19590.63	3609.21	103856.69	13785.92	1886.99	3161.65
	Std. Dev.	21287.84	2797.51	1136.43	35134.25	3084.21	353.75	531.52
	Min.	121333.41	16729.87	2138.60	84730.16	10418.73	1386.30	2362.61
	Max.	178052.57	23938.33	5559.02	202135.35	18554.38	2590.78	4099.05
PUNJAB AND SIND BANK	Mean	63890.44	7997.79	702.24	647282.56	5788.39	600.24	1183.57
	Std. Dev.	5926.93	588.90	223.03	310093.76	819.42	165.81	298.19
	Min.	57239.07	6973.91	427.28	70641.50	4444.50	391.09	856.23
	Max.	76819.43	8744.34	959.38	1146218.45	6909.35	918.98	1688.07

PUNJAB NATIONAL BANK	**Mean**	515868.39	57818.71	8733.61	2373039.69	37193.24	5325.49	8761.44
	Std. Dev.	165813.06	15938.36	2782.59	1141271.38	8611.97	2375.39	3128.30
	Min.	349269.12	43223.25	4576.71	391560.06	27077.28	2827.78	5420.72
	Max.	830833.98	85144.11	12319.96	4051534.12	50652.47	9295.40	14810.01
STATE BANK OF INDIA	**Mean**	2037341.43	222166.70	35170.80	302796.44	136076.95	25725.00	38338.26
	Std. Dev.	657908.05	63449.61	9318.63	316415.38	32545.15	9282.02	13988.02
	Min.	1209828.72	136350.80	18552.92	181849.28	87068.63	13221.57	22504.28
	Max.	3199269.30	332103.06	45221.48	1202739.57	187262.56	40451.29	57561.99
UCO BANK	**Mean**	124053.21	16303.88	2157.40	473787.90	11092.85	1175.32	2333.37
	Std. Dev.	20554.68	1989.67	792.81	277951.84	1869.51	231.62	856.29
	Min.	99313.84	14020.13	1121.00	173431.05	8508.39	891.67	1547.53
	Max.	155870.18	19358.99	3424.17	1032392.63	13796.54	1638.17	3872.74
UNION BANK OF INDIA	**Mean**	395315.47	44779.25	6856.79	624279.78	29805.63	4716.12	5567.95
	Std. Dev.	196086.74	19511.61	4340.73	205746.24	10067.94	2700.78	3557.30
	Min.	229104.43	29349.39	2821.54	263761.57	21470.07	2174.99	3150.93
	Max.	761845.46	80743.34	14633.15	966996.93	47978.00	9541.63	12389.71

Data Source: Obtained and compiled from the Official website of the Reserve Bank of India (www.rbi.org.in)

Table 2: Annual Overall Technical Efficiency, Pure Technical Efficiency and Scale Efficiency of Nationalised Banks

Year	Measures	OTE	PTE	SE	Year	Measures	OTE	PTE	SE
2014	**Mean**	0.938	0.984	0.952	**2019**	**Mean**	0.947	0.977	0.966
	Std. Dev.	0.093	0.039	0.073		**Std. Dev.**	0.112	0.050	0.077
	Min.	0.771	0.882	0.811		**Min.**	0.674	0.830	0.791
	Max.	1.000	1.000	1.000		**Max.**	1.000	1.000	1.000
2015	**Mean**	0.887	0.938	0.937	**2020**	**Mean**	0.953	0.988	0.963
	Std. Dev.	0.179	0.100	0.115		**Std. Dev.**	0.092	0.040	0.068
	Min.	0.530	0.711	0.706		**Min.**	0.718	0.860	0.830
	Max.	1.000	1.000	1.000		**Max.**	1.000	1.000	1.000
2016	**Mean**	0.988	0.997	0.991	**2021**	**Mean**	0.966	0.983	0.983
	Std. Dev.	0.028	0.009	0.024		**Std. Dev.**	0.048	0.039	0.032
	Min.	0.919	0.968	0.919		**Min.**	0.885	0.897	0.896
	Max.	1.000	1.000	1.000		**Max.**	1.000	1.000	1.000
2017	**Mean**	0.870	0.903	0.955	**2022**	**Mean**	0.678	0.875	0.735
	Std. Dev.	0.212	0.188	0.067		**Std. Dev.**	0.340	0.180	0.289
	Min.	0.431	0.500	0.838		**Min.**	0.139	0.562	0.233
	Max.	1.000	1.000	1.000		**Max.**	1.000	1.000	1.000
2018	**Mean**	0.968	0.989	0.979	**2023**	**Mean**	0.950	0.958	0.990
	Std. Dev.	0.046	0.027	0.032		**Std. Dev.**	0.094	0.081	0.023
	Min.	0.858	0.912	0.909		**Min.**	0.751	0.787	0.939
	Max.	1.000	1.000	1.000		**Max.**	1.000	1.000	1.000

Table 2 provides an in-depth look at the annual efficiency metrics of nationalized banks from 2014 to 2023, focusing on Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE), and Scale Efficiency (SE).

Overall Technical Efficiency (OTE), which measures how well banks convert inputs into outputs, shows a generally high mean value, indicating robust performance. However, there is noticeable variability, with a peak efficiency in 2016 (0.988) and a significant drop in 2022 (0.678), reflecting possible challenges or inefficiencies during that period. The recovery in 2023 (0.950) suggests improvements or adjustments were made to address prior

issues. This can also be observed in Figure 1.

Pure Technical Efficiency (PTE) assesses the banks' ability to produce the maximum output from given inputs, excluding scale effects. PTE values are consistently high, peaking at 0.997 in 2016, which implies that when adjusting for scale, the banks performed near optimally. The decline in 2022 to 0.875 highlights a period of reduced efficiency, but PTE improved to 0.958 in 2023, suggesting a return to higher performance levels.

Scale Efficiency (SE) evaluates how well banks operate at their optimal scale. The SE mean values are generally high, indicating effective scale management. However, SE dropped in 2022 to 0.735, reflecting potential scale inefficiencies or operational misalignments. The subsequent rise in 2023 to 0.990 signifies a return to more effective scale management.

Overall, the data indicate that nationalized banks generally maintained high levels of efficiency but faced significant challenges in 2022. The variations in OTE, PTE, and SE suggest that while the banks were largely efficient, they encountered specific issues that affected performance, particularly in 2022. The recovery in 2023 indicates effective measures taken to address and rectify these inefficiencies, culminating in improved operational efficiency.

These trends indicate varying efficiency in the nationalized banks' operations over the years, influenced by multiple factors, possibly including changes in regulations, economic conditions, or internal management practices.

Table 3: Overall Technical Efficiency, Pure Technical Efficiency and Scale Efficiency for the Banks over the period of study (2014-2023)

Banks	Measures	OTE	PTE	SE	Banks	Measures	OTE	PTE	SE
BANK OF BARODA	Mean	0.886	0.946	0.914	INDIAN OVERSEAS BANK	Mean	0.926	0.985	0.939
	Std. Dev.	0.252	0.119	0.203		Std. Dev.	0.124	0.032	0.111
	Min.	0.234	0.642	0.364		Min.	0.624	0.912	0.663
	Max.	1.000	1.000	1.000		Max.	1.000	1.000	1.000
BANK OF INDIA	Mean	0.895	0.944	0.944	PUNJAB AND SIND BANK	Mean	1.000	1.000	1.000
	Std. Dev.	0.143	0.075	0.101		Std. Dev.	0.000	0.000	0.000
	Min.	0.626	0.808	0.706		Min.	1.000	1.000	1.000
	Max.	1.000	1.000	1.000		Max.	1.000	1.000	1.000
BANK OF MAHARASHTRA	Mean	1.000	1.000	1.000	PUNJAB NATIONAL BANK	Mean	0.791	0.894	0.874
	Std. Dev.	0.000	0.000	0.000		Std. Dev.	0.247	0.163	0.195
	Min.	1.000	1.000	1.000		Min.	0.281	0.500	0.371
	Max.	1.000	1.000	1.000		Max.	1.000	1.000	1.000
CANARA BANK	Mean	0.818	0.882	0.919	STATE BANK OF INDIA	Mean	1.000	1.000	1.000
	Std. Dev.	0.191	0.156	0.083		Std. Dev.	0.000	0.000	0.000
	Min.	0.448	0.535	0.746		Min.	1.000	1.000	1.000
	Max.	1.000	1.000	1.000		Max.	1.000	1.000	1.000
CENTRAL BANK OF INDIA	Mean	0.914	0.986	0.926	UCO BANK	Mean	0.979	1.000	0.979
	Std. Dev.	0.152	0.044	0.139		Std. Dev.	0.044	0.000	0.044
	Min.	0.579	0.860	0.579		Min.	0.893	1.000	0.893
	Max.	1.000	1.000	1.000		Max.	1.000	1.000	1.000
INDIAN BANK	Mean	0.905	0.947	0.946	UNION BANK OF INDIA	Mean	0.861	0.927	0.902
	Std. Dev.	0.180	0.138	0.085		Std. Dev.	0.269	0.136	0.238
	Min.	0.423	0.562	0.753		Min.	0.139	0.598	0.233
	Max.	1.000	1.000	1.000		Max.	1.000	1.000	1.000

Figure 1: Annual Efficiency Metrics of Nationalized Banks (2014-2023) and Efficiency Metrics Bank-wise

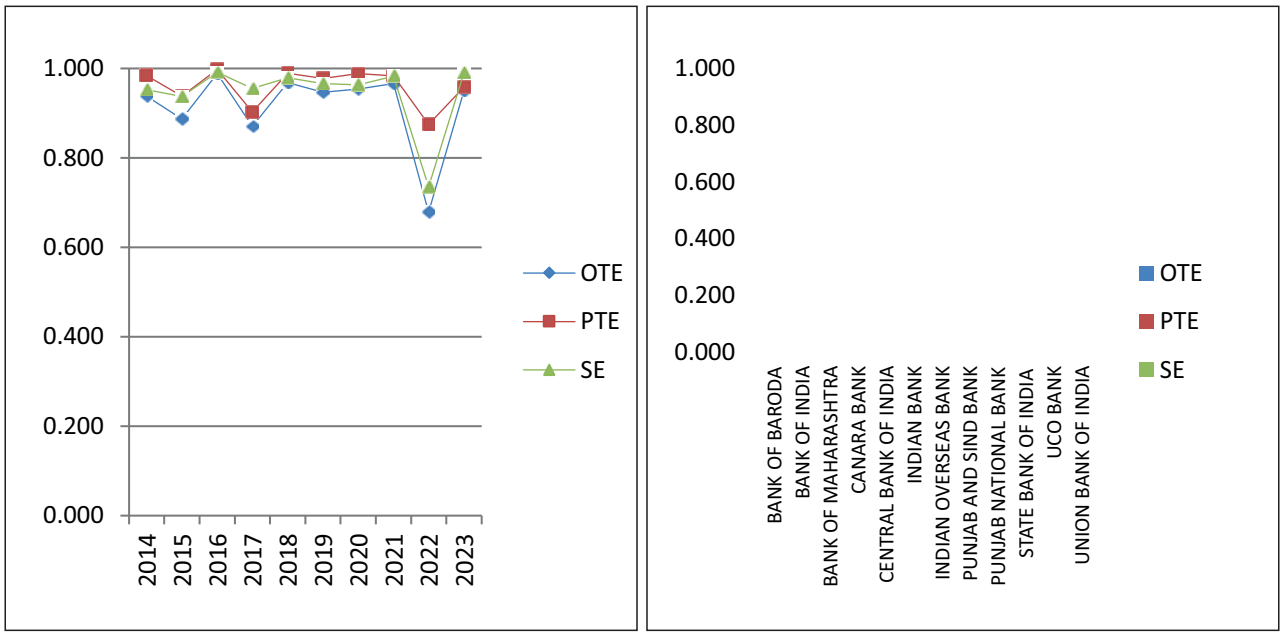

Table 3 presents an analysis of Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE), and Scale Efficiency (SE) highlighting distinct performance patterns among nationalized banks from 2014 to 2023. This analysis provides insights into how effectively these banks utilize their resources and manage their operations.

In the competitive landscape of the Indian nationalized banks, Punjab and Sind Bank, State Bank of India and Bank of Maharashtra stand out as consistent high performers in all the metrics of OTE, PTE and SE indicating exceptional and consistent efficiency across all dimensions. This suggests that Punjab and Sind Bank excels at converting inputs into outputs, operates at an optimal scale, and achieves pure technical efficiency. The perfect scores reflect a robust management system, effective resource utilization, and sound operational practices that maintain high efficiency regardless of external conditions. This can also be observed in Figure 1.

The consistent performance of State Bank of India could be attributed to its scale, financial strength, and comprehensive management strategies that ensure high efficiency. The absence of variability indicates effective and stable operations, likely supported by advanced systems and processes that optimize performance across various parameters.

Additionally, the findings suggest that the Bank of Maharashtra has effectively aligned its operations with best practices, ensuring high efficiency in both technical and scale aspects. Such consistency is typically the result of strong strategic planning, efficient resource management, and successful implementation of best practices.

In the analysis, it is evident that Bank of Baroda, Canara Bank and Union Bank of India exhibit notable fluctuations in their performance metrics. The OTE of Bank of Baroda, with a Mean of 0.886, coupled with high variability (Std. Dev.: 0.252) indicates significant fluctuations in overall efficiency. The wide range (Min: 0.234, Max: 1.000) points to inconsistent performance, likely attributable to varying operational practices, management challenges, or external factors affecting performance. Periods of low efficiency may indicate operational disruptions or strategic misalignments, while high scores highlight the potential for strong performance during peak periods.

The OTE of Canara Bank with a Mean of 0.818, coupled with substantial variability (Std. Dev.: 0.191) reveals inconsistent overall efficiency. The broad range in

efficiency values suggests that the bank experiences fluctuations due to internal inefficiencies, changes in operational strategy, or external market conditions impacting performance. The variability in PTE and SE further indicates challenges in maintaining consistent operational excellence and scale management.

The OTE of Union Bank of India with a Mean of 0.861, coupled with high variability (Std. Dev. 0.269) suggests significant swings in performance. This variability may arise from factors such as inconsistent management practices, fluctuating operational strategies, or external economic pressures. While the bank can achieve high efficiency, its performance is not stable, indicating room for improvement in operational consistency and strategic alignment.

Among the nationalized banks with lower efficiency metrics are Punjab National Bank, Bank of Baroda, Canara Bank, Union Bank of India and Indian Bank, these banks exhibit lower average scores in Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE), and Scale Efficiency (SE).

The reasons for low efficiency may result from operational inefficiencies, inconsistent management practices, or scale mismanagement such as suboptimal branch locations, over-expansion, or underutilization of resources, all of which can adversely affect performance. External factors like economic downturns, regulatory changes, and market fluctuations can also impact bank performance. Additionally, poor strategic decisions or a lack of alignment between strategy and operations can lead to inefficiencies, such as a poor product mix, inadequate customer service, or ineffective risk management.

Conclusion and Suggestions

The analysis of efficiency metrics (Overall Technical Efficiency, Pure Technical Efficiency, and Scale Efficiency) across nationalized banks from 2014 to 2023 reveals diverse performance levels. Banks such as Punjab and Sind Bank, State Bank of India, and Bank of Maharashtra consistently achieve high efficiency across all metrics, indicating robust and stable performance. In contrast, banks like Bank of Baroda, Canara Bank, and Union Bank of India exhibit significant fluctuations in efficiency, reflecting periods of both high and low performance. These inconsistencies suggest varying degrees of operational and strategic challenges.

The findings underscore that while some banks excel with stable high efficiency, others face notable variability in performance. High-performing banks benefit from effective management practices and optimal scale operations, whereas banks with lower and more variable efficiency metrics encounter operational inefficiencies, inconsistent management, and scale mismanagement. The variability observed in several banks indicates potential areas for improvement in achieving consistent performance.

Banks with high variability need to focus on stabilizing their operations. Implementing standardized processes, improving management practices, and adopting robust performance monitoring systems can help reduce fluctuations. For banks showing inconsistent scale efficiency, optimizing scale operations to ensure they operate at or near optimal scale can improve overall performance. This may involve adjusting their operational scale or adopting strategies to better align with their operational capacities. Conversely, banks performing consistently well should continue leveraging their successful strategies and consider sharing best practices with others to foster overall sector improvement.

Overall, while some banks demonstrate outstanding and stable performance, others exhibit significant variability. Addressing the factors contributing to these fluctuations can lead to enhanced consistency and overall efficiency across the banking sector.

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