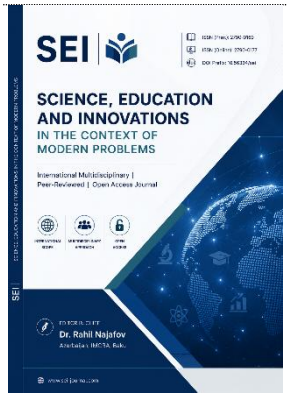

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RESEARCH ARTICLE

Evaluating Human Capital Efficiency and Financial Performance in Indian Private Banks Using the SBM-DEA Model

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Slack-Based Measure (SBM); Data Envelopment Analysis (DEA); Banking Efficiency; Human Resource Efficiency; Employee Expenditure; Financial Performance; Return on Equity (ROE); Return on Assets (ROA); Earnings per Share (EPS); Indian Private Sector Banks.

Abstract

The operational efficiency of the banking sector is a critical determinant of financial stability, institutional competitiveness, and sustainable economic development, particularly within emerging economies such as India. In the context of increasing digitalization, intensified market competition, and evolving regulatory frameworks, the efficient utilization of human resources has become a strategic imperative for banking institutions. Despite the growing significance of human capital in financial intermediation, existing banking efficiency studies have predominantly concentrated on balance-sheet indicators while largely overlooking employee-related dimensions of performance. Addressing this research gap, the present study evaluates the human resource efficiency and financial performance of HDFC Bank and ICICI Bank during the period 2016–2025 by employing the Slack-Based Measure (SBM) model of Data Envelopment Analysis (DEA). The study incorporates employee strength and employee expenditure as input variables, while Net Profit, Return on Equity (ROE), Earnings per Share (EPS), and Return on Assets (ROA) are utilized as output indicators to assess operational and financial efficiency comprehensively. Unlike conventional DEA approaches, the SBM framework captures inefficiencies associated with input and output slacks, thereby providing a more robust and nuanced understanding of resource utilization and managerial effectiveness. Furthermore, the study examines the influence of external shocks and structural changes in the banking environment on institutional efficiency over time. The empirical findings reveal substantial variations in efficiency levels between the two banks across the study period. HDFC Bank consistently operated at or near the efficiency frontier for the majority of the observed years, demonstrating superior human resource management, optimized expenditure allocation, and sustained profitability performance. In contrast, ICICI Bank exhibited significant inefficiencies in input utilization during the earlier years of the analysis, which adversely affected profitability indicators and shareholder value creation. However, the bank recorded notable improvement in efficiency after 2020, eventually achieving full efficiency in 2024 and 2025, reflecting strategic improvements in resource management, operational restructuring, and technological integration. To further validate the comparative efficiency differences between the two banking institutions, the study employed the Mann–Whitney U test. The results confirmed statistically significant differences in efficiency performance between the banks at significance levels of 0.01, 0.05, and 0.10, indicating structural disparities in managerial and operational efficiency. The study contributes to the growing literature on banking efficiency by integrating human capital variables into the SBM-DEA framework and offering empirical evidence from the Indian private banking sector. The findings provide important implications for policymakers, regulators, and banking executives regarding workforce optimization, strategic expenditure management, and long-term institutional sustainability in an increasingly competitive financial environment.

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I. INTRODUCTION

The Indian banking sector has undergone profound structural transformation over the past two decades, driven by financial liberalization, rapid technological advancement, regulatory modernization, and increasing market competition (Sathye, 2003). Within this evolving landscape, private sector banks have emerged as dominant catalysts of innovation and efficiency, fundamentally reshaping customer expectations and operational standards across the industry (Ray, 2010). Among these institutions, HDFC Bank and ICICI Bank have established themselves as leading financial intermediaries, significantly influencing competitive dynamics, digital banking adoption, and sustainable sectoral growth in India.

The assessment of banking efficiency has traditionally relied on financial indicators such as Return on Assets (ROA), Return on Equity (ROE), net profit, and capital adequacy ratios. However, these conventional measures often fail to capture multidimensional operational performance and do not adequately account for inefficiencies associated with resource utilization, employee productivity, or off-balance-sheet activities. In this context, the Slack-Based Measure (SBM) model within the framework of Data Envelopment Analysis (DEA) offers a more comprehensive and empirically robust approach to evaluating banking efficiency. DEA, as a non-parametric linear programming methodology, facilitates the comparative assessment of decision-making units (DMUs) with multiple inputs and outputs by identifying efficiency frontiers and quantifying input-output slacks (Coelli, 2005). Unlike traditional ratio-based techniques, the SBM DEA model provides deeper analytical insights by identifying the precise sources of inefficiency and measuring the extent of excess inputs or deficient outputs.

The present study contributes to the growing body of banking efficiency literature by integrating financial and human resource variables—such as employee strength, employee expenditure, profitability indicators, and return ratios—within an SBM DEA framework. Furthermore, the study incorporates the role of off-balance-sheet exposure, recognizing its increasing significance in determining the financial resilience and operational performance of modern banks. By extending efficiency analysis beyond balance-sheet indicators alone, this research provides a more holistic understanding of bank performance and offers valuable managerial, strategic, and policy-level implications for the Indian banking sector.

Overview of HDFC Bank Limited and ICICI Bank Limited

HDFC Bank has evolved into one of Asia's most prominent private sector financial institutions, particularly following its landmark merger with Housing Development Finance Corporation (HDFC Ltd.) in July 2023. As of FY 2024–25, the bank operated an extensive distribution network comprising more than 9,400 branches and 21,000 ATMs across over 4,150 cities and towns, with outreach extending to approximately 235,000 villages throughout India. The bank reported a balance sheet size exceeding ₹39.1 lakh crore, deposits amounting to ₹27.1 lakh crore, advances of ₹26.2 lakh crore, and a profit after tax of ₹67,347 crore. Its strong financial fundamentals were reinforced by a Gross Non-Performing Asset (GNPA) ratio of only 1.33 percent and a capital adequacy ratio of 19.6 percent, reflecting robust risk management and financial stability.

A defining feature of HDFC Bank's growth trajectory has been its strong emphasis on digital transformation and customer-centric innovation. Approximately 97 percent of the bank's transactions are now conducted through digital channels, demonstrating its leadership in technology-enabled banking services. Simultaneously, the bank has strengthened its commitment to sustainable and socially responsible banking practices. Under its flagship CSR initiative, *Parivartan*, HDFC Bank invested ₹1,068 crore in social development programs, positively impacting more than 100 million lives across areas such as education, rural development, healthcare, and environmental sustainability. Through a combination of financial resilience, technological innovation, governance excellence, and sustainability-oriented initiatives, HDFC Bank continues to reinforce its position as a benchmark institution within the Indian banking industry.

Similarly, ICICI Bank has maintained its status as one of India's leading private sector banks through sustained growth, digital innovation, and prudent financial management. During FY 2024–25, the bank reported total assets of ₹21.18 trillion, supported by deposits of ₹16.10 trillion and net advances of ₹13.42 trillion. The bank achieved a profit after tax of ₹472.3 billion while maintaining a strong Net Interest Margin (NIM) of 4.32 percent and a capital adequacy ratio of 16.55 percent. Asset quality indicators also

demonstrated considerable improvement, with Gross NPAs declining to 1.73 percent and Net NPAs to 0.42 percent, reflecting enhanced credit monitoring and risk mitigation mechanisms.

ICICI Bank has been particularly successful in leveraging digital technologies to expand customer engagement and operational efficiency. Its flagship digital platform, *iMobile*, processed approximately 558 million transactions valued at ₹11.2 trillion, while its business banking platform, *InstaBIZ*, contributed significantly to business banking growth, which expanded by 33.7 percent to ₹2.63 trillion. Beyond financial performance, the bank has also demonstrated strong commitment to corporate sustainability and social responsibility. Through the ICICI Foundation, the bank allocated ₹8.01 billion toward CSR activities, benefiting nearly 18.9 million individuals across India. Additionally, the bank has strengthened its environmental sustainability agenda through the development of five million square feet of IGBC-certified infrastructure and the adoption of a strategic target to achieve carbon neutrality in Scope 1 and Scope 2 emissions by FY 2032. These initiatives collectively underscore ICICI Bank's strategic orientation toward sustainable growth, technological leadership, and long-term institutional resilience.

II. REVIEW OF LITERATURE

Efficiency has long been recognised as a critical determinant of organisational performance, particularly in service-intensive sectors such as banking, where human resources play a central role in value creation. Early studies on organisational efficiency largely relied on traditional financial ratios such as return on assets, return on equity, and profit margins. While these measures provided useful insights into financial performance, they failed to capture the multidimensional nature of efficiency, especially when multiple inputs and outputs were involved. This limitation motivated scholars to adopt more comprehensive techniques capable of assessing relative performance across decision-making units.

Data Envelopment Analysis (DEA), introduced by Charnes, Cooper, and Rhodes, emerged as a powerful non-parametric approach to efficiency measurement. DEA allows simultaneous consideration of multiple inputs and outputs without requiring a predefined functional form. (Coelli, 2005) highlighted DEA's superiority over ratio analysis in evaluating productive efficiency, particularly in sectors where resource allocation decisions are complex. Over time, DEA has been widely applied across banking, healthcare, education, and mutual fund industries to benchmark performance and identify sources of inefficiency.

Within the banking literature, efficiency analysis gained prominence as financial liberalisation, technological advancement, and competitive pressures intensified. (Sathye, 2003) provided early evidence from India, showing that private sector and foreign banks were more efficient than public sector banks, primarily due to better management practices and technological adoption. (Ray & Das, 2010) further demonstrated variations in cost and profit efficiency among Indian banks, emphasising the role of operational strategy and ownership structure in shaping efficiency outcomes.

As DEA applications evolved, researchers began incorporating employee-related variables to better understand the human dimension of efficiency. (Jemric & Vujcic, 2002), in their study of Croatian banks, identified excess labour and fixed assets as major sources of inefficiency, particularly among state-owned banks. Similarly, (Staub et al., 2010) analysed Brazilian banks and found that while technical efficiency was relatively high, inefficiencies stemmed from suboptimal input utilisation, especially labour and capital. These findings underscored that human resources are not merely operational inputs but strategic assets whose efficient deployment significantly influences bank performance.

The development of the Slack-Based Measure (SBM) model by (Tone, 2001) marked a significant advancement in efficiency analysis. Unlike radial DEA models, the SBM approach explicitly accounts for input excesses and output shortfalls, providing a more realistic assessment of inefficiency. This methodological refinement enabled researchers to move beyond efficiency scores and identify the precise magnitude of resource wastage. (Vittal, 2024), applying the SBM model to Indian banks, found that private sector banks outperformed public sector banks, with inefficiencies largely attributed to excessive employee numbers and employee costs.

Parallel evidence from international contexts reinforces these findings. Studies on Malaysian banks by (Kamarudin et al., 2019) revealed that foreign and large banks achieved higher efficiency due to economies of scale and better workforce management. (Fukuyama & Weber, 2015), using a dynamic network DEA approach for Japanese banks, demonstrated that efficiency is closely linked to risk management, capital adequacy, and effective utilisation of labour over time. These studies collectively suggest that efficient human resource deployment is essential for sustaining competitiveness in banking.

Beyond banking, DEA-based studies in hospitals and universities further highlight the universal relevance of human resource efficiency. (Ersoy et al., 1997) showed that inefficiencies in Turkish hospitals were primarily driven by excess staff and underutilised capacity. (Aziz et al., 2013) found similar patterns in higher education institutions, where inefficient departments employed more staff but produced fewer outputs. These cross-sectoral findings strengthen the argument that labour inefficiency is a persistent challenge across service organisations.

Recent human resource management literature reinforces the strategic importance of employee-related factors. (Fegade & Sharma, 2023) emphasised that employee training and development significantly enhance organisational efficiency, while (Gupta, 2023) argued that optimal workforce size and skill utilisation are critical to performance. (Mehta & Sharma, 2025) further highlighted that employee cost should be viewed as a long-term investment rather than a financial burden, provided it is managed efficiently.

Despite extensive literature on banking efficiency, several research gaps remain. First, relatively few studies in the Indian context explicitly integrate human resource variables into efficiency models. Second, most studies focus on cross-sectional analysis and fail to capture efficiency dynamics across periods of economic disruption. Third, limited attention has been paid to the impact of external shocks such as demonetisation and the COVID-19 pandemic on human resource efficiency in banks.

The present study addresses these gaps by applying the SBM DEA model to examine the human resource efficiency of HDFC Bank and ICICI Bank over a ten-year period. By incorporating employee strength and employee cost as key inputs and analysing efficiency across major economic shocks, the study contributes to both the banking efficiency literature and the growing body of research on strategic human resource management in emerging economies.

1. Relevance of the study

a) Most of the studies found are performed in foreign and a few studies are performed in the Indian context.

b) Very few Studies in the field of Human Resource Management Practices applied Human Resource factor as input and measured efficiency

c) Time-related factors and performance during different times have not been explored in many studies.

2. Objective of the study

I. To study the role of external shocks (COVID-19, Demonetisation) on bank efficiency.

II. To evaluate the efficiency of selected Indian banks using the SBM approach.

III. To analyse the impact of employee-related factors on bank performance.

IV. To compare the performance score of HDFC Bank Limited and ICICI Bank Limited across years.

V. Understand the relation of the efficiency score and economies of scale

III. METHODOLOGY

The present study adopts an analytical research design, as it seeks to evaluate the relationship between the identified variables in a structured manner. The study is based on secondary data collected from annual reports of the selected banks and published databases (ICICI Bank: Number of Employees 2010-2025, IBN, MacroTrends). The sample for the study comprises two major private sector banks in India, namely HDFC Bank and ICICI Bank, selected purposively on the basis of their market share and availability of consistent data. The period of study spans from 2016-2025, which captures the effect of significant economic events such as demonetisation and the COVID-19 pandemic on bank efficiency.

To examine whether significant differences existed in the efficiency performance of the selected banks, the study employed the Mann–Whitney U test, a non-parametric statistical technique suitable for comparing two independent samples. The application of this test was considered appropriate because the SBM efficiency scores exhibited asymmetric distribution and did not satisfy the assumptions of normality required for parametric testing. Accordingly, the hypothesis was evaluated at the 1 percent, 5 percent, and 10 percent levels of significance.

The Slack-Based Measure (SBM) model of Data Envelopment Analysis (DEA), developed by Kaoru Tone, was applied to estimate the efficiency scores of the selected decision-making units (DMUs). Unlike traditional radial DEA models, the SBM approach explicitly incorporates input excesses and output shortfalls into the efficiency measurement framework, thereby providing a more comprehensive and realistic assessment of operational inefficiency.

The SBM efficiency score (ρ^*) for a Decision-Making Unit (DMU) is expressed as:

$$\rho^* = \min \frac{1 - \frac{1}{m}\sum_{i=1}^{m} \frac{s_i^-}{x_{i0}}}{1 + \frac{1}{s}\sum_{r=1}^{s} \frac{s_r^+}{y_{r0}}}$$

Subject to:

$$x_0 = X\lambda + s^-, y_0 = Y\lambda - s^+, \lambda \geq 0,\ s^- \geq 0,\ s^+ \geq 0$$

where:

- ρ represents the SBM efficiency score, ranging between 0 and 1;
- $\rho = 1$ indicates full efficiency with no input or output slacks;
- $\rho < 1$ reflects inefficiency arising from excess inputs and/or insufficient outputs;
- s^- denotes input slack variables;

- s^+denotes output slack variables;
- λrepresents the intensity vector associated with the reference frontier.

The study formulated the following hypotheses:

- **Null Hypothesis (H_0):** There is no statistically significant difference in the SBM efficiency scores of the selected banks.
- **Alternative Hypothesis (H_1):** There is a statistically significant difference in the SBM efficiency scores of the selected banks.

The Mann–Whitney U test results revealed a calculated z-value of –3.604, indicating statistically significant differences in efficiency performance between the selected banks at conventional significance levels. The findings therefore support the rejection of the null hypothesis and confirm the existence of structural variations in operational efficiency and resource utilization between the banking institutions under investigation.

IV. Data Analysis and result

Table 1. Descriptive statistics of HDFC Bank

Descriptive Statistics of HDFC Bank					
Variables	Number of Years	Minimum	Maximum	Mean	Std. Deviation
Number of Employees	10	84325	206000	130246.50	44569.350
Employees cost	10	6306.00	183894.20	58111.1330	64354.64416
Net Profit in Crore	10	12817.33	73440.17	35145.0490	20860.35797
ROE in percentage	10	14.56%	18.22%	16.8840%	1.10603%
EPS (RS)	10	50	96	70.70	15.812
ROA	10	2	2	2.00	.000
Valid N (listwise)	10				

Source: Computed by the authors using R Studio software.

Table 2. Descriptive Statistics of ICICI Bank

Descriptive Statistics of ICICI Bank					
Variables	N	Minimum	Maximum	Mean	Std. Deviation
Number of Employees	10	97132	187765	135497.60	30947.651
Employees cost	10	6912.2900	23629.9400	12514.969000	5365.0272253
Net Profit in Crore	10	5689.1600	54418.7100	22831.767000	16767.9713094
ROE in percentage	10	4.00%	19.00%	12.2000%	5.05085%
EPS (RS)	10	7	72	31.70	22.598
ROA	10	0	2	1.30	.675
Valid N (listwise)	10				

Source: Computed by the authors using R Studio software.

Table 3. Efficiency Score of HDFC Bank Limited and ICICI Bank Limited

DMU OF HDFC LIMITED	**Input-Oriented Efficiency Score**	**Output-Oriented Efficiency Score**	**DMU OF ICICI LIMITED**	**Input-Oriented Efficiency Score**	**Output-Oriented Efficiency Score**
HDFC 2016	1	1	ICICI 2016	0.90	0.54
HDFC 2017	1	1	ICICI 2017	0.80	0.48
HDFC 2018	1	1	ICICI 2018	0.76	0.32

HDFC 2019	1	1	ICICI 2019	0.70	0.16
HDFC 2020	0.99	0.88	ICICI 2020	0.61	0.32
HDFC 2021	0.74	0.91	ICICI 2021	0.80	0.57
HDFC 2022	0.63	0.91	ICICI 2022	0.89	0.71
HDFC 2023	1	1	ICICI 2023	0.94	0.87
HDFC 2024	1	1	ICICI 2024	1	1
HDFC 2025	1	1	ICICI 2025	1	1

Source: Computed by the authors using R Studio software.

From Table 1.3, it is found that HDFC Bank Limited is continuously maintaining high level of efficiency throughout the study period. The bank achieved a perfect efficiency score (1.00) in both input- and output-oriented models for maximum years, except for 2020-22, where minor inefficiencies were observed (input-oriented efficiency dropping to 0.63 in 2022). This indicates that during these years, HDFC Bank faced slight inefficiencies in utilizing its inputs to generate optimal outputs, possibly due to the pandemic-induced economic slowdown.

On the other side, ICICI Bank Limited showed significant inefficiency during the starting years of the study. Its input-oriented efficiency score was as low as 0.61 in 2020, and output-oriented efficiency dropped sharply to 0.16 in 2019, suggesting poor output utilization relative to inputs. However, from 2023 onward, ICICI Bank showed a remarkable improvement, achieving full efficiency (score = 1) in both orientations in 2024 and 2025.

The results thus indicate that HDFC Bank has demonstrated higher operational consistency, while ICICI Bank has shown a strong efficiency recovery trend in the latter years of the period.

Table 4. Input oriented Slack of HDFC Limited and ICICI Limited

DMU OF HDFC LIMITED	**Number of employees-oriented Slack (In Number)**	**Employees Cost-oriented Slack (In Crore)**	**DMU OF ICICI LIMITED**	**Number of employees-oriented Slack (In Number)**	**Employees Cost-oriented Slack (In Crore)**
HDFC 2016	0.0	0.0	ICICI 2016	9577.0	606.1500
HDFC 2017	0.0	0.0	ICICI 2017	20416.0	1587.1200
HDFC 2018	0.0	0.0	ICICI 2018	24805.0	2027.3900
HDFC 2019	0.0	0.0	ICICI 2019	29785.0	3119.1200
HDFC 2020	0.0	107.7607	ICICI 2020	4377.0	4850.6100
HDFC 2021	0.0	30001.0477	ICICI 2021	37364.581	1231.6791
HDFC 2022	1960.242	41613.9241	ICICI 2022	23647.783	433.8868
HDFC 2023	0.0	0.0	ICICI 2023	16703.470	0.0
HDFC 2024	0.0	0.0	ICICI 2024	0.0	0.0
HDFC 2025	0.0	0.0	ICICI 2025	0.0	0.0

Source: Computed by the authors using R Studio software.

The slack values reveal that HDFC Bank has maintained near-optimal input utilisation across the years, with minimal or zero slacks in most periods. This indicates that the bank efficiently allocated its workforce and employee-related expenditures relative to its outputs.

Conversely, ICICI Bank shows substantial input slack from 2016 to 2022, especially in the "number of employees" and "employee cost" categories. For instance, in 2019, ICICI Bank had an employee slack of 29,785 and a cost slack of 3,119.12 crore, implying significant potential to reduce input resources without compromising output. These high slack values align with the bank's low efficiency scores during the same period.

Table 5. Input and Output Variables Used in the SBM-DEA Framework

Variable Category	Variables	Measurement Unit	Expected Role in Efficiency Assessment	Theoretical Justification
Input Variables	Number of Employees	Total Workforce Strength	Represents human capital deployment and operational labour intensity	Human resources constitute a primary productive input in banking operations
	Employee Expenditure	₹ Crore	Reflects investment in workforce compensation and administrative efficiency	Employee-related costs significantly influence operational productivity and cost efficiency
Output Variables	Net Profit	₹ Crore	Measures profitability and financial performance	Indicates the bank's ability to convert operational resources into earnings
	Return on Equity (ROE)	Percentage (%)	Captures shareholder value generation	Reflects managerial effectiveness in utilizing shareholders' funds
	Earnings per Share (EPS)	Indian Rupees (₹)	Represents market-oriented profitability performance	Indicates wealth creation for equity investors
	Return on Assets (ROA)	Percentage (%)	Measures asset utilization efficiency	Evaluates the bank's capacity to generate income from total assets

Source: Developed by the authors based on the SBM-DEA efficiency framework and banking performance literature.

Table 6. Summary of Efficiency Trends and Managerial Implications of Selected Indian Private Sector Banks (2016–2025)

Bank	Efficiency Trend	Major Observations	Key Sources of Inefficiency	Strategic Interpretation
HDFC Bank	Consistently High Efficiency	Operated at or near the efficiency frontier during most years of the study period	Minor inefficiencies observed during the COVID-19 period (2020–2022)	Strong digital infrastructure, effective workforce utilization, and superior managerial practices contributed to sustained operational efficiency
ICICI Bank	Gradual Efficiency Improvement	Significant inefficiencies observed during 2016–2020 followed by substantial recovery after 2020	High employee-related slack, operational restructuring challenges, and external economic shocks	Post-pandemic restructuring, digital transformation, and cost optimization improved efficiency performance and enabled full efficiency by 2024–2025
Comparative Findings	HDFC Outperformed ICICI	Mann–Whitney U test confirmed statistically significant differences in efficiency performance	Structural differences in operational strategy and resource allocation	Efficiency performance in Indian private banking is strongly associated with workforce optimization, technological adaptation, and strategic cost management

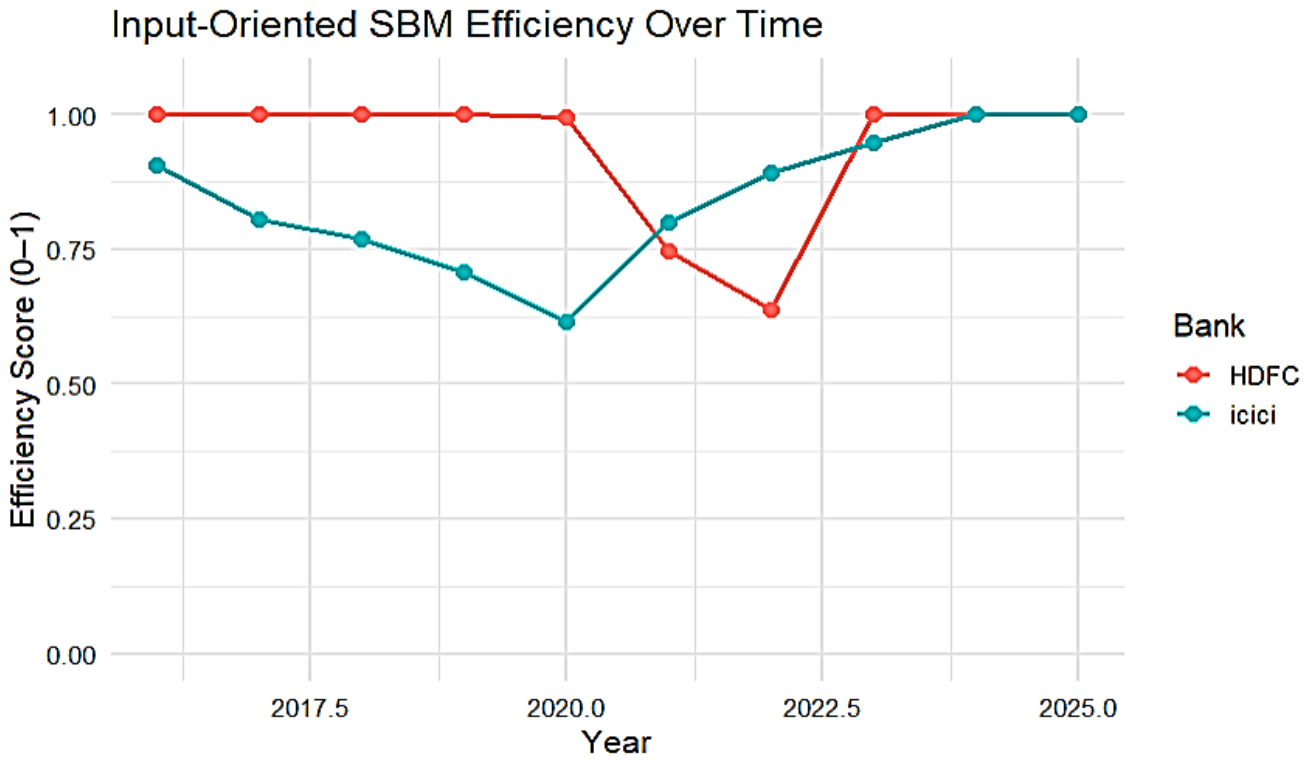
Source: Compiled and interpreted by the authors based on SBM-DEA results and statistical analysis.

The year 2023 marks a turning point for ICICI Bank, with both employee and cost slacks declining to zero by 2024-2025, indicating a transition toward full efficiency. This improvement could be attributed to better cost control, digitalisation, and operational restructuring in the post-pandemic era.

From the above figure, it can be seen that the efficiency of both banks varies over the period of time. From 2016 to 2020, HDFC Bank was operating at the full efficiency frontier, which means there was no effect of Demonetisation and the Covid pandemic. It may be due to better utilisation of technology and online banking services provided by the Bank. Demonetisation in India in 2016 compelled Banks and consumers to use cashless transactions. On the other side efficiency of ICICI Bank is showing a continuous decrease from 2016 to 2020. As ICICI Bank is a leading corporate bank, it is working in infrastructure-related businesses. Demonetisation in India

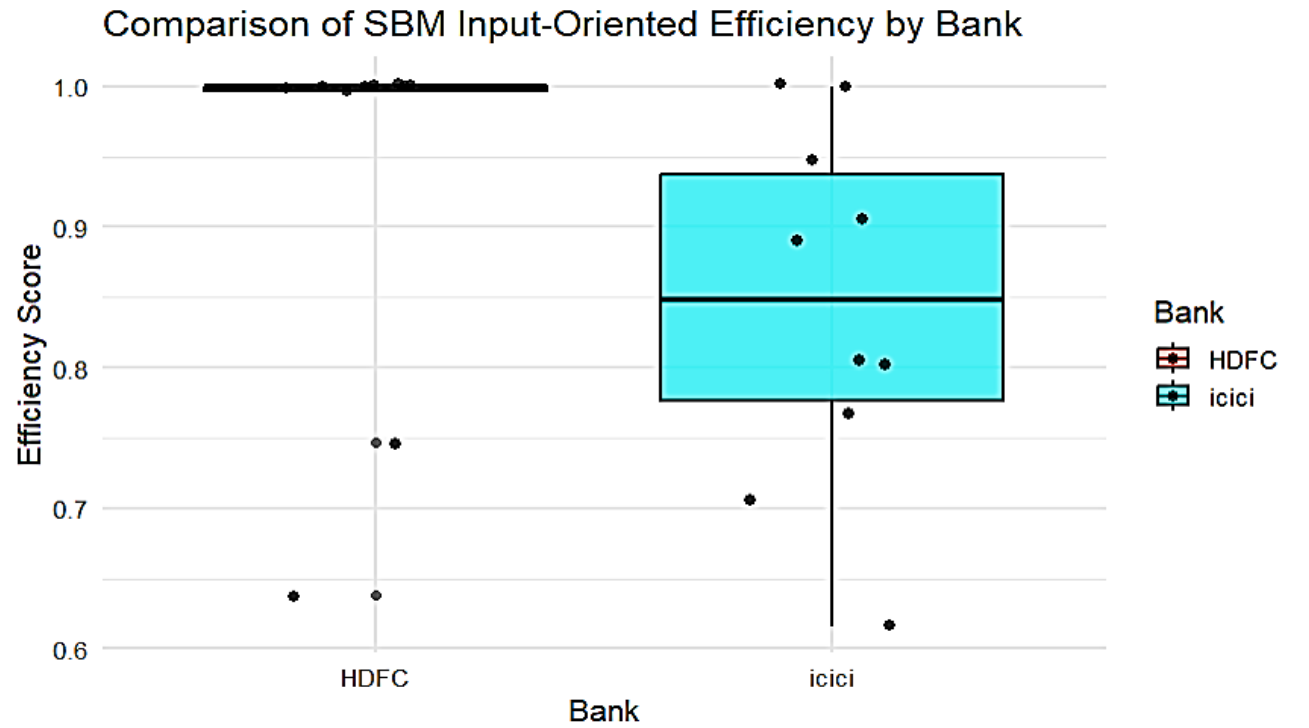
and the Covid pandemic had adversely affected the GDP of the Nation, so the same may be the reason for the inefficiency of the bank. After 2020, ICICI Bank's performance has been continuously showing improvement and achieving full efficiency by 2024.

Figure 1. Trend of SBM Efficiency Scores of HDFC Bank and ICICI Bank (2016–2025)



Source: Computed by the authors using R Studio software.

Figure 2. Comparative Distribution of Input-Oriented SBM Efficiency Scores



Source: Computed by the authors using R Studio software.

The boxplot comparison of SBM input-oriented efficiency scores clearly reveals that HDFC Bank continuously outperformed ICICI Bank over the period of study. The efficiency values of HDFC are clustered very close to the value of 1, indicating that the bank operated near the efficiency level with minimum deviations, reflecting efficient utilisation of its resources by the management. In contrast, ICICI Bank shows wider inefficiency, with a lower median and several downward outliers, particularly around the 0.70–0.75 range. Such dispersion demonstrates may be due to the time frame of 2016- 2020, as already discussed about the Demonetisation event in India and the COVID-19 pandemic. More efficient performance of HDFC Bank could be due to Economies of Scale, large market capture as compare to ICICI Bank.

V. Statistical Significance of Differences in Performance of Both the Banks

Table 7.

Bank	N	Mean Rank	Sum of Rank
HDFC Bank	20	26.85	537.00
ICICI Bank	20	14.14	283.00
Total	40		

Source: Computed by the authors using R Studio software.

A z-test was performed to assess the significance of the difference between the sample and population means. The analysis yielded a z-value of −3.604 (p = 0.00032), indicating a highly significant difference at the 0.001 level. This implies that the observed variation is not due to random chance, and the null hypothesis was rejected.

Table 8.

Test Statistics	SBM Efficiency Score
Mann–Whitney U	73.000
Wilcoxon W	283.000
Z	-3.604
Asymp. Sig. (2-tailed)	0.000
Result	Significant at 0.05 level

Source: Computed by the authors using R Studio software.

Figure 3. Mann–Whitney U Test Distribution of SBM Efficiency Scores

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of SBM_Score is the same across categories of Bank.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Source: Computed by the authors using R Studio software.

As is already known, the SBM model of efficiency measurement is based on a non-parametric method of measurement, and after checking the distribution of efficiency scores of these two banks, we found that the efficiency scores were showing asymmetric distribution of data therefore we applied Mann-Whitney U Test to determine whether a significant difference exists in the SBM efficiency scores between HDFC Bank and ICICI Bank. The test result (p = 0.000 < 0.05) indicates that the difference is statistically significant. Hence, the null hypothesis stating that "the distribution of SBM scores is the same across categories of banks" is rejected.

This implies that the SBM efficiency levels of the two banks are not homogeneous, and HDFC Bank Limited demonstrates superior efficiency performance compared to ICICI Bank Limited.

Findings of the Study

The findings of the present study provide substantial empirical evidence regarding the role of human resource efficiency in determining the financial and operational performance of Indian private sector banks. By applying the Slack-Based Measure (SBM) model under the Data Envelopment Analysis (DEA) framework, the study demonstrates that efficient utilization of employee-related resources significantly influences profitability, operational sustainability, and institutional competitiveness within the banking industry. Similar conclusions regarding the importance of managerial and operational efficiency in banking institutions have been reported in earlier DEA-based studies conducted across both developed and emerging economies (Berger & Humphrey, 1997; Sathye, 2003; Fukuyama & Weber, 2015).

The empirical results reveal that HDFC Bank maintained consistently higher efficiency scores throughout the study period compared with ICICI Bank. HDFC Bank operated at or near the efficiency frontier in most years under both input-oriented and output-oriented SBM models, indicating superior workforce utilization, efficient expenditure management, and strong digital operational capability. These findings are consistent with previous studies arguing that private sector banks with stronger technological integration and better managerial practices tend to achieve higher operational efficiency (Ray & Das, 2010; Das & Ghosh, 2006; Vittal, 2024).

In contrast, ICICI Bank exhibited comparatively lower efficiency during the initial years of analysis, particularly between 2016 and 2020. The study identified substantial input slacks associated with employee strength and employee expenditure, indicating inefficiencies in resource allocation and operational management. Similar patterns of labour-related inefficiency have been observed in international banking studies conducted in Croatia, Brazil, and Malaysia, where excess workforce utilization and ineffective cost management adversely affected banking productivity (Jemric & Vujcic, 2002; Staub et al., 2010; Kamarudin et al., 2019). However, the findings also demonstrate that ICICI Bank achieved significant improvement after 2020, eventually reaching full efficiency during 2024 and 2025. This transition reflects the positive effects of operational restructuring, digital transformation, cost optimization strategies, and improved managerial adaptability during the post-pandemic recovery period.

The study further reveals that external economic shocks, particularly demonetisation and the COVID-19 pandemic, exerted varying effects on the operational efficiency of the selected banks. While HDFC Bank showed relatively greater resilience due to its stronger retail banking orientation and advanced digital banking infrastructure, ICICI Bank experienced greater efficiency deterioration because of its comparatively higher exposure to infrastructure and corporate lending activities. These findings align with previous research emphasizing that technological adaptability and diversified banking operations enhance institutional resilience during periods of economic uncertainty (Altunbas et al., 2001; Havrylchyk, 2006; Wheelock & Wilson, 1999).

Another important finding of the study relates to the strategic role of employee-related expenditures. The results suggest that employee cost should not merely be interpreted as an operational burden, but rather as a long-term strategic investment capable of improving productivity, profitability, and institutional performance when managed efficiently. Similar conclusions have been highlighted in recent human resource management studies emphasizing the relationship between workforce development, employee training, and organizational efficiency (Fegade & Sharma, 2023; Gupta, 2023; Mehta & Sharma, 2025). The findings therefore reinforce the growing recognition that human capital represents a critical intangible asset within modern banking institutions.

The Mann–Whitney U test confirmed statistically significant differences in SBM efficiency scores between the two banks at multiple significance levels. This indicates that the efficiency performance of the banks is structurally heterogeneous and influenced by differences in managerial strategy, operational scale, technological integration, and workforce utilization practices. Earlier DEA literature similarly reported that institutional efficiency in banking is significantly shaped by ownership structure, economies of scale, managerial capability, and strategic resource allocation (Banker et al., 1984; Sherman & Gold, 1985; Coelli et al., 2005).

Furthermore, the findings validate the practical applicability of the SBM-DEA framework as an effective methodological tool for identifying operational inefficiencies in banking institutions. Unlike conventional financial ratio analysis, the SBM approach successfully quantified input excesses and output deficiencies, thereby providing a deeper understanding of inefficiency sources and managerial performance. These findings support the methodological arguments advanced by Tone (2001), who emphasized that slack-based efficiency models provide more realistic and policy-relevant assessments than traditional radial DEA approaches.

Overall, the study concludes that sustainable competitiveness in the Indian banking sector increasingly depends upon strategic workforce optimization, technological modernization, digital banking expansion, and efficient resource management. Banks capable of integrating human capital efficiency with innovation-driven operational models are more likely to maintain long-term financial resilience and competitive advantage in rapidly evolving financial environments.

VI.CONCLUSION

The present study examined the human resource efficiency and financial performance of HDFC Bank and ICICI Bank by employing the Slack-Based Measure (SBM) model within the framework of Data Envelopment Analysis (DEA). The findings clearly demonstrate that efficient utilization of employee-related resources plays a critical role in enhancing operational productivity, profitability, and long-term institutional sustainability in the Indian banking sector. By incorporating employee strength and employee expenditure as key input variables, the study extends the traditional banking efficiency literature beyond balance-sheet-oriented analysis and provides a more comprehensive understanding of organizational performance.

The empirical analysis revealed that HDFC Bank consistently maintained higher efficiency levels throughout most of the study period, reflecting effective workforce management, superior digital integration, optimized operational expenditure, and stronger managerial capability. In contrast, ICICI Bank exhibited comparatively lower efficiency during the earlier years due to substantial input slacks and operational inefficiencies. However, the bank demonstrated significant recovery after 2020 and achieved full efficiency in 2024 and 2025, indicating the positive impact of restructuring strategies, technological advancement, and improved cost management practices.

The study also confirms that external economic disruptions, including demonetisation and the COVID-19 pandemic, had differentiated impacts on the selected banks. HDFC Bank displayed greater operational resilience due to its diversified retail banking model and advanced digital infrastructure, whereas ICICI Bank experienced stronger efficiency fluctuations because of its greater exposure to infrastructure and corporate lending segments. These findings highlight the importance of technological adaptability, diversified operational structures, and strategic workforce planning in ensuring banking resilience during periods of economic uncertainty.

Furthermore, the Mann–Whitney U test established statistically significant differences in efficiency performance between the two banks, confirming that banking efficiency is strongly influenced by variations in managerial effectiveness, strategic orientation, operational scale, and human capital utilization. The study therefore validates the practical relevance of the SBM-DEA approach as an effective analytical tool for identifying inefficiencies, measuring operational performance, and supporting strategic decision-making in financial institutions.

Overall, the study concludes that sustainable competitiveness in the Indian banking industry increasingly depends on the integration of human capital efficiency, technological innovation, digital banking capabilities, and strategic cost optimization. Banks that successfully align workforce productivity with innovation-driven operational strategies are more likely to achieve long-term financial resilience, profitability, and institutional sustainability in an increasingly competitive financial environment.

Recommendations

Based on the empirical findings of the study, the following recommendations are proposed for banking institutions, policymakers, and financial regulators:

Managerial Recommendations

1. Strengthening Human Resource Efficiency. Banks should prioritize efficient workforce planning and employee productivity management to reduce operational slack and improve institutional performance. Strategic deployment of human capital can significantly enhance profitability and operational sustainability.
2. Investment in Digital Banking Infrastructure. Banking institutions should expand investments in digital technologies, artificial intelligence, automation, and online banking services to improve operational efficiency and reduce dependence on traditional cost-intensive banking models.
3. Optimization of Employee Expenditure. Employee-related expenditure should be managed strategically as a long-term investment rather than merely as an operational cost. Performance-based compensation systems, continuous training programs, and skill development initiatives can improve workforce effectiveness and productivity.
4. Diversification of Banking Operations. Banks with excessive exposure to infrastructure and corporate lending should diversify toward retail banking and digital financial services to minimize vulnerability during periods of economic instability and external shocks.
5. Regular Efficiency Monitoring Using SBM-DEA Models. Banking institutions should conduct periodic SBM-DEA-based efficiency evaluations to identify areas of inefficiency, optimize resource allocation, and strengthen operational decision-making processes.

Policy Recommendations

6. Encouraging Technological Modernization. Financial regulators and policymakers should encourage banks to accelerate digital transformation initiatives by providing supportive regulatory frameworks and innovation incentives.
7. Human Capital Development Policies. Regulatory authorities should promote sector-wide employee development programs focused on digital banking skills, financial analytics, risk management, and technological adaptability to improve the overall efficiency of the banking sector.
8. Risk Diversification and Crisis Preparedness. Policymakers should encourage banks to adopt diversified operational models and strengthen crisis management mechanisms to reduce the negative effects of future economic disruptions similar to demonetisation and the COVID-19 pandemic.
9. Integration of Efficiency-Based Performance Evaluation. Regulatory institutions may incorporate efficiency-based indicators, including DEA and SBM models, into broader banking performance assessment frameworks to support evidence-based financial supervision.

Recommendations for Future Research

10. Expansion of Sample Size. Future studies should include a larger number of public and private sector banks to provide broader comparative insights into banking efficiency across India.
11. Incorporation of Additional Human Resource Variables. Further research may integrate variables such as employee training hours, workforce diversity, technological competency, employee satisfaction, and managerial quality to deepen the analysis of human capital efficiency.
12. Application of Advanced DEA Models. Future researchers may employ dynamic DEA, network DEA, fuzzy DEA, or Malmquist productivity index approaches to capture efficiency changes over time and provide more sophisticated efficiency analysis.
13. Cross-Country Comparative Studies. Comparative international studies involving emerging and developed economies may provide broader understanding regarding the relationship between human capital efficiency and banking performance across different financial systems.

VII. DECLARATIONS

Policy and Managerial Implications

- The study shows that HDFC Bank functions with higher efficiency than ICICI Bank, probably due to different field of operations of the banks, ICICI Bank should also focus on retail Banking services to carb the maximum potential of its Business.
- ICICI Bank needs to focus on reduction of operational slack, especially in administrative and non-interest expenses, to enhance overall efficiency.
- External shocks show more effect on infrastructure related sectors as compare to retail sector, so for the purpose of anticipation of such shocks, diversified field of operation should be adopted by banks
- Banks management team should regularly conduct SBM-based evaluations to identify inefficiency areas and improve input–output balance.

Future Scope of Research

- More private Bank with long period of time can be studied to get more accurate result of performance efficiency of Banks
- Future work may incorporate additional input areas such as employees training hours, proportion of Male and Female employees in Banking sectors.
- Expanding the time frame of analysis can help identify efficiency trends and the long-term impact of digitalization.
- Further studies may explore public-private banks to assess the overall competitiveness of India's banking system.

VIII. Limitations of the Study

i. The study is limited to Two Private Sector banks (HDFC and ICICI), so results cannot be generalised to all Indian banks.
ii. The analysis covers 2016-2025, which may not reflect long-term structural changes in the banking sector.
iii. The study uses Secondary Data, which may contain minor reporting inconsistencies.
iv. The SBM Model focuses only on operational efficiency, excluding profitability and risk factors.
v. Selected inputs and outputs may not capture all qualitative aspects of banking performance.

Ethical Approval and Consent to Participate

This study is based exclusively on secondary data collected from publicly available annual reports, financial statements, and published institutional records of Indian private sector banks. The research did not involve human participants, personal data, clinical experimentation, or animal subjects. Therefore, ethical approval and informed consent were not required for the conduct of this study.

Availability of Data and Materials

The data utilized in this study were obtained from publicly accessible annual reports, financial disclosures, and official publications of HDFC Bank and ICICI Bank covering the period 2016–2025. The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that they have no known financial, institutional, professional, or personal competing interests that could have influenced the outcomes or interpretation of this research.

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Authors' Contributions

- Rohit Kumar Sahu contributed to conceptualization, data collection, methodology design, statistical analysis, interpretation of results, and manuscript drafting.
- Dr. Utkarsh Kumar supervised the research process, contributed to theoretical development, critical revision, and overall academic guidance.
- Jitendra Patel contributed to data organization, literature review, statistical validation, and editing of the manuscript.

All authors reviewed and approved the final manuscript.

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