EFFICIENCY–INCLUSION NEXUS IN INDIAN BANKING: DEA EVIDENCE FOR ACHIEVING SDG 8

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Abstract
This study investigates the nexus between efficiency of banks and financial inclusion in India in the context of Sustainable Development Goal (SDG) 8. Using a two-stage Data Envelopment Analysis (DEA) under Constant and Variable Returns to Scale models, the efficiency of ten commercial banks—five public and five private—was assessed over the period 2017–2022. Technical Efficiency (TE), Pure Technical Efficiency (PTE), and Scale Efficiency (SE) scores were computed and descriptively aligned with inclusion indicators such as ATM density, PMJDY account penetration, and digital transaction volumes. The results reveal that private sector banks, supported by early digital adoption and lean operating structures, consistently achieved higher efficiency levels, whereas public sector banks continued to dominate in physical outreach. The findings highlight that operational efficiency and financial inclusion are mutually reinforcing, particularly in the post-2020 digital banking environment. By integrating efficiency outcomes with inclusion metrics, this study contributes policy-relevant insights on strengthening India's financial sector to expand access and resilience. The analysis underscores that advancing both efficiency and inclusion is central to achieving SDG Target 8.10 on universal access to financial services.

Keywords: Banking Efficiency, Data Envelopment Analysis (DEA), Financial Inclusion, Public and Private Sector Banks, SDG 8

Introduction
1.1 Role of Banking Efficiency and Inclusive Growth
In a contemporary economy in which digitalisation is taking over the process quickly, the health of banking sector is a key determinant of financial stability, efficient resource utilization, and promotion of inclusive financial system (Mohan & Ray, 2023; Ferretti & Martino, 2025; Yoganandham, 2025). Banks are critical financial intermediaries that enables to pool and transfer the savings of households and corporates and channel them into efficient investments in priority sectors like agriculture, infrastructure, MSMEs, and services, like India a developing nation, where the capital requirement is more than what is available, and where the efficient use of finance is perennial requirement not only for economic development, but also for reducing poverty and inequality (Allen & Santomero, 2001;Prakash et al., 2021; Mahesh et al., 2022).

Technical efficiency (TE) measures the ability of a bank to generate maximize output from the given set of input variables. This study employs the nonparametric DEA approach, widely applied in bank performance research to calculate efficiency across three dimensions: Technical Efficiency (TE), which represents the overall efficiency; Pure Technical Efficiency (PTE), which isolates managerial efficiency; and Scale Efficiency (SE), which is the efficiency of the operational scale (Favero & Papi, 1995; Kumar & Gulati, 2009; Porcelli, 2009; Bodla & Bajaj, 2010). The Banks with higher TE are better able to cut back on operating expenses, shrink interest spreads, and expand reach, all of which are necessary for fostering financial inclusion, especially for the rural and semi-urban areas (Sathye, 2003; Debnath & Shankar, 2008; Ofori-Sasu et al., 2019).

In other words, banking efficiency is not merely a technical benchmark but a need for development. Busy banks are the enablers of inclusive capitalism, in which the gains of financial expansion extend from one area to another and even to all income groups (George & Chattopadhyay, 2012; Ghosh et al., 2014). This study seeks to contribute by assuming that more operationally efficient banks will be better able to fulfil the objectives of inclusive finance (Kumar & Gulati, 2009; Bodla & Bajaj, 2010; Yadav, 2016; Chaluvadi et al., 2018).

1.2 Financial Inclusion's Dynamic in India: 2017–2022

Recognizing that banking efficiency is a vital driver to realize an inclusive growth, from this perspective, evaluating the ever-changing shape of the financial inclusion landscape in India from 2017 to 2022 is indispensable (Sathye, 2003; Kumar & Gulati, 2009; Bello, 2024). In these six years, there was a dramatic shift in the scope and quality of financial inclusion underpinned by a mix of policy mandates, digital breakthroughs, and behavioural changes (Ivatury, 2009; Bodla & Bajaj, 2010; Pazarbasioglu et al., 2022). These steps accelerated the outreach and attempted to introduce operational dynamics that would test the efficiency and health of Indian banks (Bastan et al., 2024; Matlani, 2025; Mahajan et al., 2025).

Previously, it was mainly focused on physical outreach—increasing the number of branches and the reach of ATMs—but India's financial inclusion efforts have now strategically turned, from 2017, to grip digital penetration, usage depth, and quality of service (PwC India, 2021; Hossain, 2023). Aadhaar-enabled services, mobile banking, and UPI have now raised the bar on what we consider inclusion (Bodla & Bajaj, 2010; Deloitte, 2020; World Bank, 2020; Sia Partners, 2022). Banks are not supposed to open accounts anymore; those same institutions are now charged with perpetual engagement, cost-effective operations, and frictionless digital experiences for low-income or first-time users (Bello, 2024; Joshi, 2025; Yoganandham, 2025). Such a changing paradigm exerts enormous pressure on banks' Technical Efficiency (TE) and Scale Efficiency (SE), especially in a country with wide rural-urban and digital divides (Debnath & Shankar, 2008; Kumar & Gulati, 2008; Bodla & Bajaj, 2010; Ghosh et al., 2014).

In conclusion, India's financial inclusion journey from 2017 to 2022 has transitioned from physical outreach to digital usage, and from mere access to sustained service usage (RBI, 2023; NPCI, 2024; PMJDY, 2024). This era underscores the study's main proposition: inclusion is no longer just about coverage—it is about efficiency. By assessing how effectively banks converted inputs into inclusive outputs during this transformative period, the research connects internal performance (TE, PTE, SE) with actual delivery of inclusion on the ground (Bodla & Bajaj, 2010; RBI Supervisory Data, 2023; Bastan et al., 2024).

1.3 Research gap and rationale for integrated analysis

A strong conceptual relationship exists between banking efficiency and financial inclusion: efficiency enables institutions to grow sustainably, while inclusion efforts encourage innovation and operational optimisation (Sarma & Pais, 2011; Ghosh, 2020). Yet, few studies integrate these two dimensions in a single analysis, especially in India (Bodla & Bajaj, 2010; Kumar & Gulati, 2010; Chakrabarty, 2013).

Most DEA-based studies on Indian banks examine Technical Efficiency (TE), Pure Technical Efficiency (PTE), and Scale Efficiency (SE) using traditional inputs and outputs such as deposits, fixed assets, labour, and credit (Bhattacharyya et al., 1997; Ray, 2004; Sathye, 2003; Chen, 2011). However, these works are largely cross-sectional or pre-2020, overlooking disruptions like Aadhaar-linked banking and the surge in digital payments (Chakravarty & Pal, 2013; RBI, 2021).

The 2017–2022 period is a critical window, capturing key developments such as the rise of UPI and mobile payments, expanded PMJDY digital accounts, the launch of RBI's FI-Index in 2021, new digital credit frameworks like the Unified Lending Interface, and operational stress

during COVID-19 (NPCI, 2023; RBI, 2021, 2023; IMF, 2021; KPMG, 2020). Yet, little research has systematically linked bank-level efficiency during this period to financial inclusion outcomes, or compared differences between public and private sector banks (Das & Ghosh, 2009; Subbarao, 2012; Ghosh, 2020).

From a methodological perspective, DEA applications continue to rely mainly on conventional outputs such as loans and interest income, with limited integration of inclusion-sensitive signals like Aadhaar-authenticated transactions or digital transaction intensity (Sharma & Sehrawat, 2014; Zaman et al., 2020; Singh & Kumar, 2021).

This paper addresses two gaps:

- Measure efficiency of Indian public and private banks (2017–2022) using CRS and VRS DEA models (Sathye, 2003; Das & Ghosh, 2009).
- Examine the relationship between efficiency scores (TE, PTE, SE) and inclusion indicators such as PMJDY penetration, UPI usage, ATM/BC density, and FI-Index scores (Chakrabarty, 2011; Ghosh, 2020; RBI, 2021).

By integrating inclusion signals into DEA, the study offers a novel dual framework and a policy-oriented perspective on how bank models can best promote India's inclusive finance agenda (Chattopadhyay, 2011).

1.4 Research Objectives

This study empirically examines how DEA-based efficiency estimates align with banking and financial inclusion performance in India during 2017–2022, a period of accelerated digital transformation and inclusion (Kumar & Gulati, 2008; Ghosh, 2017). The specific objectives are:

- To estimate and compare the technical, pure technical, and scale efficiencies of public and private sector banks in India using DEA under CRS and VRS assumptions (Ray, 2004; Sathye, 2003).
- To analyze the relationship between DEA-based efficiency scores (TE, PTE, SE) and inclusion indicators such as deposit account penetration, ATM/BC density, and digital transaction volume (Chattopadhyay, 2011; Sarma, 2012).
- To benchmark institutional efficiency and inclusiveness across ownership types (Das & Ghosh, 2009; Kumar & Gulati, 2009).
- To suggest a DEA-based framework that incorporates inclusion-oriented outputs for assessing bank efficiency (Sarma & Pais, 2011).

These objectives align with the United Nations Sustainable Development Goal 8 (SDG 8) on "sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" (Bhattacharya et al., 2010; United Nations, 2015). In particular, SDG Target 8.10 emphasizes on strengthening the financial institutions in the country to expand access to banking, insurance, and financial services (Demirguc-Kunt et al., 2018).

By situating bank-level efficiency within this global development agenda, the study highlights how efficient institutions are also essential for inclusive growth, especially in the wake of shocks such as COVID-19 that tested solvency and outreach (RBI, 2021; Beck & Laeven, 2006). Thus, efficiency is not only an institutional performance metric but a developmental imperative for advancing equitable access to finance in India (Chattopadhyay, 2011; Sarma, 2012).

3. Literature Review

Numerous scholars have examined the performance, efficiency, and financial soundness of the Indian banking sector for decades, employing several quantitative methodologies. Data Envelopment Analysis (DEA) is the widely used method (Saha & Ravisankar, 2000; Kaur & Kaur, 2010; Chen, 2011; Gulati & Kumar, 2011). These studies establish DEA as a robust tool

for efficiency analysis, but they largely stop short of linking efficiency with broader developmental goals such as inclusion.

A strong conceptual relationship exists between banking efficiency and financial inclusion – efficiency enables institutions to grow sustainably and scale services, while inclusion efforts incentivize banks to innovate and optimize operations (Mehrotra & Yetman, 2022; Saha & Sensarma, 2022). Most studies rarely integrate these two dimensions in a single analysis, particularly in the Indian context.

Most of these studies are cross-sectional or based on pre-2020 data (e.g., 2015–2019) and do not factor in recent inclusion-based disruptions such as the exponential growth of digital payments or Aadhaar-linked banking (Kaur & Singh, 2023; Agarwala et al., 2024).

The period 2017–2022 may be considered a vital window for such integrated assessment as it captures several transformational developments: the rise of UPI and mobile payments as primary transaction modes, increased uptake of digital accounts under PMJDY (Beck & Laeven, 2006; RBI, 2022; Chatterjee & Sinha, 2022). Other developments included new digital credit frameworks and banks adapting during COVID-19 (Ghosh & Vinod, 2017; Trivedi & Yadav, 2019).

In the above context, this article aims to cover two interrelated gaps:

- Efficiency of Indian banks (Public and Private sector) for 2017–2022: A study using DEA approach under VRS and CRS assumptions (Kaur & Kapoor, 2022; Sehrawat & Giri, 2022).
- Empirical investigate of the relationship between efficiency scores (TE, PTE, SE) and major inclusivity indicators such as PMJDY penetration, UPI usage, ATM/BC density, and FI-Index quality scores (RBI, 2022; Agarwala et al., 2024).

By addressing these deficiencies, the paper introduces a dual efficiency–inclusion DEA framework with policy relevance for India's inclusive finance agenda (Beck & Laeven, 2006; Chatterjee & Sinha, 2022; Mehrotra & Yetman, 2022). This integrated perspective is where the present study makes its unique contribution.

4. Research Gaps

- Lack of an empirical-composite literature on integrating DEA-based banking efficiency scores (TE, PTE, SE) and financial inclusion indicators — deposit account penetration, ATM/BC density, and UPI transaction volumes (Kaur & Kapoor, 2022; RBI, 2022; Sehrawat & Giri, 2022; Agarwala et al., 2024).
- There is limited evidence from empirical literature beyond 2017 that measures the collective effect of digital financial services, inclusion policy, and institutional effectiveness over several years (Chatterjee & Sinha, 2022; Ghosh, 2022 Mehrotra & Yetman, 2022).
- No DEA models were developed with an output-oriented approach and inclusion-oriented output variables (i.e., Aadhaar authenticated transactions, mobile banking adoption, and digital literacy), which are more critical for inclusive banking (Agarwala et al., 2024; Sehrawat & Giri, 2022).

5. Theoretical Framework: Linking Efficiency and Financial Inclusion

This study follows the ideational assumption that the performance of the banking system is a critical enabler that can enhance the institutional capacity to provide inclusive finance (Morgan & Pontines, 2014; Demirgüç-Kunt et al., 2018).

Adopting ideas from the Resource-Based View (RBV), the model hypothesises that effect the integration of strategic deployment of financial and operational resources enables banks to

reach out farther, more efficiently control risk, and reduce cost-of-service delivery (Barney, 1991; Wernerfelt, 1984; Beck & Laeven, 2006).

At the same time, financial inclusion — by digital modes, rural penetration, or by an Aadhaar-related mechanism —which impels banks to strengthen efficiency for survival in the long run (Ghosh, 2016; Sarma & Pais, 2011). As a result, TE, PTE, and SE are not conceived only as performance indicators but also institutional drivers for inclusive growth (Ray & Das, 2010; Ghosh, 2020; Avkiran, 1999).

This model allows the study not only to link efficiency scores to inclusion measures like PMJDY penetration, UPI transactions, in-built coverage regarding the ATM/BC outlets, and rural coverage, but also to be seen from the perspective of how operational strength helps underpin India's broader inclusive finance agenda (Chakrabarty, 2011; RBI, 2021).

6. Methodology
6.1 Data Overview
Data was compiled from a combination of reliable and official sources, including:
- RBI Annual Reports and Statistical Tables Relating to Banks in India (RBI, 2017–2022)
- Stand-alone annual reports of the respective banks and audited disclosures (Bank Reports, 2017–2022)
- The Financial Inclusion Index (FI-Index) has been released by the RBI since 2021 (Casu et al., 2004; RBI, 2021; RBI, 2022)
- The NPCI databases (Unified Payments Interface reports) (NPCI, 2022; NPCI, 2023)
- Inclusion Metrics Portal (Mehrotra & Yetman, 2015; UIDAI, 2022)

6.2 Stage 1 – DEA- Analysis of Efficiency
At first, we measure the technical efficiency of each bank with DEA. (Charnes et al., 1978; Ray and Das, 2010).
- Efficiency indices were calculated using the DEAP 2.1 (Coelli, 1996). An input-oriented model was chosen as Indian banks face regulatory pressure to reduce costs and improve asset quality. (Seiford & Thrall, 1990; Casu et al., 2004; Coelli et al., 2005).
- Both CRS and VRS models (Banker et al., 1984) were applied; Scale Efficiency (SE) derived as their ratio (Coelli et al., 2005)

$$\text{SE} = \frac{TE(CRS)}{PTE\ (VRS)}$$

❖ Input Variables:
1. Fixed Assets– proxy for infrastructure and branch-level investments (Sathye, 2003)
2. Number of Employees – an indicator of labor resource deployment (Saha & Ravisankar, 2000)
3. Loanable Funds– sum of deposits and borrowings available for credit creation (Bhattacharyya et al., 1997; Bhala, 2015)

❖ Output Variables:
1. Advances– loans and credit extended by the bank (Sinha, 2020; Mukherjee et al., 2002)
2. Investments– SLR and market instruments representing asset deployment (Kaur & Kaur, 2010; Sharma et al., 2014)
3. Non-Interest Income– service charges, fees, commissions, and diversified income streams (Das et al., 2004; Prasad & Ghosh, 2005)

DEA models were run year-wise (2017–2022) to track efficiency trends across PSBs and PVBs (Kaur and Kaur, 2010; Ray and Das, 2010)

6.3 Stage 2 – Inclusion and Performance Variables

❖ DEA results were contextualized with inclusion and performance indicators (Das & Ghosh, 2009). These ratios now contribute to shaping an institutional profile of each bank according to how far they are in terms of inclusion, outreach, and operational soundness without modifying the DEA model itself (Mandira & Chakrabarty, 2013; Sarma, 2015; Ghosh, 2021; Avkiran, 1999).

❖ **Financial Inclusion Indicators:**

1. **Deposit Accounts** gauges the depth of savings account penetration, especially in inclusion schemes such as PMJDY (Chattopadhyay, 2011; Sarma & Pais, 2011; Ghosh, 2013). Higher values imply better financial access (Demirgüç-Kunt et al., 2018; Sarma, 2020). However, separate PMJDY data points were not available, and the PMJDY mocks serve as a broad proxy for all PMJDY and non-PMJDY accounts pooled, representing each bank's aggregate deposit outreach (Chakrabarty, 2013; CRISIL, 2020; RBI, 2021; Avkiran, 1999).

2. **Loan Accounts**—This is a proxy for formal credit access by an individual (Sarma & Pais, 2008; Ghosh, 2021). It reflects a greater level of community financial deepening and banking activity (Das & Ghosh, 2009; Chattopadhyay, 2011; Bhala, 2015).

3. **ATMs Density:** This map shows the geographical distribution of bank branch locations (Kaur & Kaur, 2010; RBI, 2022). Higher ATM density means more exhaustive coverage, especially in rural and semi-urban areas of the country (Barros et al., 2007; Sarma, 2020).

4. **Digital Transactions** gives an understanding of how much people use digital means for financial transactions (Bhala, 2015; Chavan, 2020; NPCI, 2022). The rise in transaction volumes reflects actions pushed through digital platforms such as UPI, mobile banking, and online services (KPMG, 2021; NPCI, 2023; RBI, 2023).

❖ **Financial Performance Indicators:**

1. Capital Adequacy Ratio (CAR) indicates the proportion of a bank's capital strength and ability to absorb risk, a key measure of financial health and regulatory compliance (Barros et al., 2007; Kaur & Kapoor, 2015; RBI, 2020).

2. Return on Assets (ROA) reflects profitability by indicating how efficiently a bank utilizes its assets to generate earnings (Kumbhakar & Sarkar, 2003; Das & Ghosh, 2009; Gulati & Kumar, 2011).

3. Cost-to-The cost-to-income (CIR) represents the operational net efficiency of the ratio, which indicates better cost management (Berger & Humphrey, 1997; Saha & Ravisankar, 2000).

4. The log of Total Assets is included to represent the size of the bank and provide context to its operational scale, particularly when comparing large public banks with leaner private banks (Berger & Humphrey, 1997; Bhala, 2015; Kaur & Kapoor, 2015).

All data for these indicators were sourced from the Reserve Bank of India and banks' annual reporting databases, such as the FI-Index and NPCI dashboards. (CRISIL, 2021; NPCI, 2023; RBI, 2023). Indicators were standardized and cross-verified to ensure consistency and accuracy across the six-year study period (Das & Ghosh, 2009; Sarma, 2020; Ghosh, 2021; Avkiran, 1999).

6.4 Analytical Strategy

The analysis adopts a descriptive and comparative framework to support interpreting DEA-based efficiency results (Das & Ghosh, 2009; Saha & Ravisankar, 2000; Gulati & Kumar, 2016). The following steps were carried out:

1. Descriptive Summary

A bank-wise and year-wise descriptive summary of all inclusion and performance indicators was compiled. This provided a reference point for the study period (2017–22) and to compare performance in efficiency with levels of digital outreach, physical access, and financial health (RBI, 2022).

2. Comparative Analysis

Comparisons were drawn between the inclusion and performance indices in PSBs and PVBs to emphasize sector-wise variation on operational thrusts towards inclusion outreach and resource deployment (Kaur & Kaur, 2010; Chattopadhyay, 2011; Gulati & Kumar, 2016). Such comparisons, in addition to DEA results, enrich the interpretative depth of efficiency evaluations (Kumar & Gulati, 2008). Having outlined the DEA framework, variables, and comparative approach, the next section presents the efficiency results and discusses patterns across public and private banks.

7. Analysis and Results

7.1 Overview of DEA Efficiency Scores (CRS and VRS Models)

The efficiency of selected Indian banks has been analyzed using the DEA (Data Envelopment Analysis) approach, with two return-to-scale assumptions: Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) (Banker et al., 1984; RBI, 2022). In the CRS model, Technical Efficiency (TE) measures overall efficiency, ensuring managerial skills and scale economies are accounted for (Saha & Ravisankar, 2000; Chen, 2011; Gulati & Kumar, 2011).

CRS Model (TE):

The TE scores show how effectively banks converted inputs into outputs during 2017–2022 (Kumar & Gulati, 2008). Figures X and Y present year-wise TE trends for five public and five private banks.
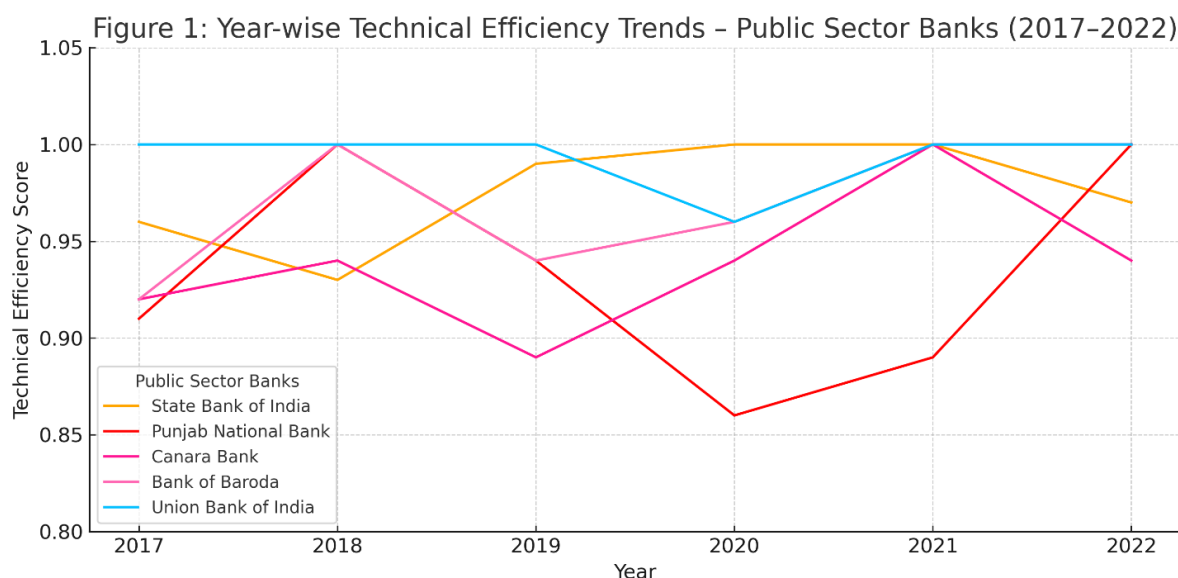

Figure 1: Year-wise Technical Efficiency Trends – Public Sector Banks (2017–2022)

Source: Author's calculation using DEAP 2.1 software.

This figure presents DEA-based Technical Efficiency Scores of the five largest Public Sector banks, SBI and Union Bank. Improvements are relatively steady, but in the case of Punjab National Bank and Canara Bank, the frequency of increased efficiency patterns is more prominent (Das & Ghosh, 2009; Kaur & Kapoor, 2015; RBI, 2022; Bastan et al., 2024).
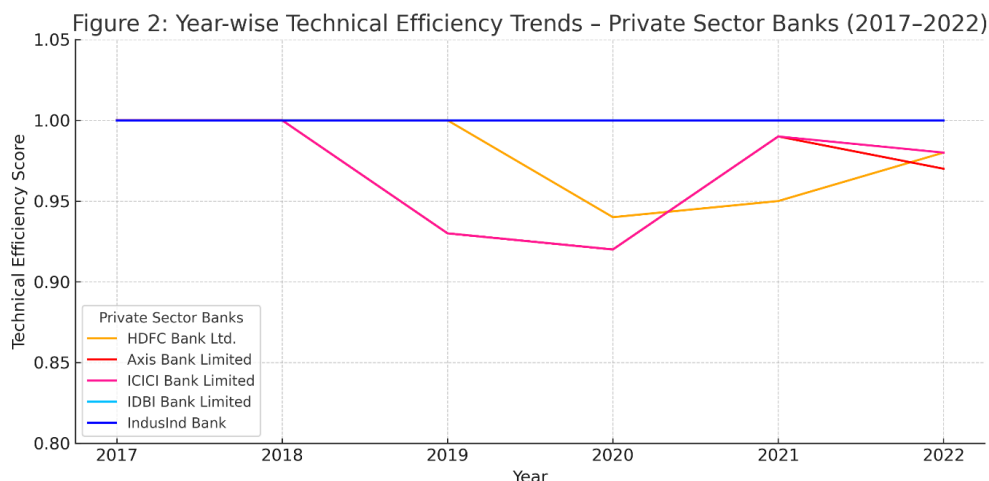
Figure 2: Year-wise Technical Efficiency Trends – Private Sector Banks (2017–2022)

Source: Author's calculation using DEAP 2.1 software.

The above graph shows the efficiency trends of private sector banks. HDFC, ICICI, and IndusInd consistently high TE scores signify strong digital capabilities accompanied by lean operating models (Bhala, 2015; Gulati & Kumar, 2016; PwC, 2020; Ghosh, 2021).

Key Findings from the TE Analysis:

- HDFC Bank maintained a perfect TE score of 1.000 each year, operating on the efficiency frontier (CRISIL, 2021; NPCI, 2023).
- Canara Bank improved steadily from 0.9097 in 2017 to 1.000 in 2022, reflecting rationalized operations (RBI, 2023).
- Bank of Baroda also improved efficiency post-merger (PwC, 2020).
- Axis and ICICI started at full efficiency but showed slight declines by 2022, indicating minor scale inefficiencies (KPMG, 2021).

Overall, TE patterns suggest that technology adoption and portfolio restructuring contributed significantly to efficiency improvements.

- **VRS Model: Pure Technical Efficiency (PTE)**

The VRS model isolates managerial efficiency (Banker et al., 1984). PTE scores from 2017–2022 indicate that most banks, especially private ones, consistently optimized internal processes (Ghosh, 2021). Gains are linked to digitization, governance reforms, and investments in staff capabilities (EY, 2021; RBI, 2023).

Bank Name	**Average TE**	**Average PTE**	**Average SE**
Axis Bank Limited	0.98	1	0.98
Bank of Baroda	0.96	0.98	0.98
Canara Bank	0.92	1	0.92
HDFC Bank Ltd.	1	1	1
ICICI Bank Limited	0.97	0.97	0.99
IDBI Bank Limited	1	1	1
IndusInd Bank	1	1	1
Punjab National Bank	0.97	1	0.97
State Bank of India	1	1	1
Union Bank of India	0.99	1	1

Table 1: Average DEA Efficiency Scores of Public and Private Sector Banks (2017–2022)
Source: Author's calculations based on DEA results generated using DEAP 2.1 software.

The table highlights that HDFC, SBI, IDBI, and IndusInd achieved full efficiency across TE, PTE, and SE, while PSBs like Canara lagged in scale efficiency despite strong managerial performance (Das & Ghosh, 2009).

7.2 Sector-Wise Comparison: Public vs. Private Banks

Ownership differences reveal a clear efficiency divide.

- **Private Banks (PVBs):** Higher TE and SE, driven by technology adoption, lean structures, and quick decision-making (EY, 2019; McKinsey, 2020). HDFC, ICICI, and Axis consistently leveraged digital platforms and analytics for efficiency gains.
- **Public Banks (PSBs):** Despite strong outreach and inclusion roles (e.g., PMJDY), their wider physical footprint and legacy structures reduced operational efficiency (Das & Ghosh, 2009; RBI, 2020). However, VRS results show that managerial efficiency at branch and mid-level remains sound (NPCI, 2023).

In conclusion, PSBs balance social obligations with efficiency trade-offs, while PVBs focus on commercial efficiency via tech-driven models. Reforming PSBs through modernization and digital integration is essential for narrowing the performance gap (McKinsey, 2022; RBI, 2023).

7.3 Descriptive Alignment Between Efficiency Scores and Inclusion Indicators

Efficiency scores were compared with four inclusion indicators — deposit accounts per 1,000 adults, loan accounts per 1,000 adults, ATM density, and mobile transactions (RBI, 2019; World Bank, 2022).
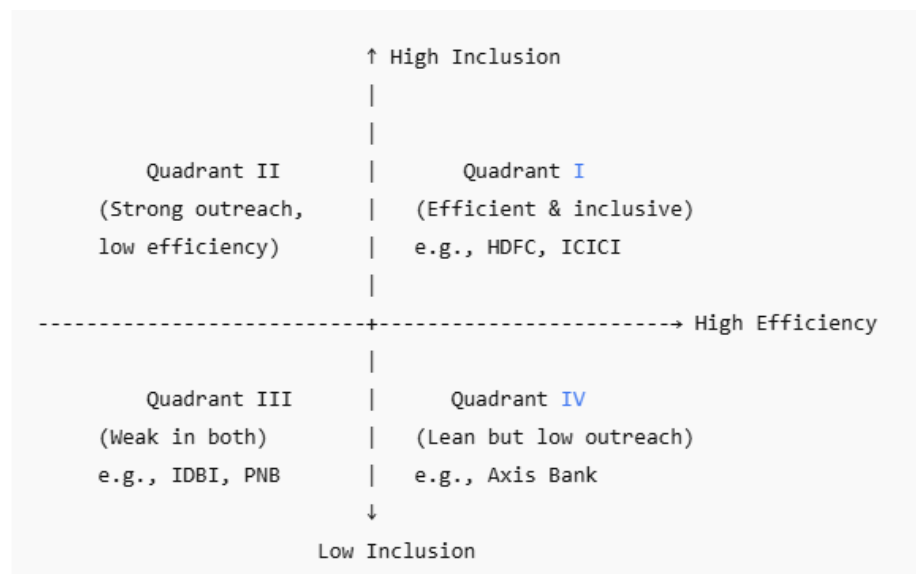
Bank Name	Deposit A/cs / 1000	Loan A/cs / 1000	ATM Density	Mobile Transactions
Axis Bank Limited	1980.2	242.4	75.1	16989.8
Bank of Baroda	1980.2	242.4	75.1	16989.8
Canara Bank	1980.2	242.4	75.1	16989.8
HDFC Bank Ltd.	1980.2	242.4	75.1	16989.8
ICICI Bank Limited	1980.2	242.4	75.1	16989.8
IDBI Bank Limited	1980.2	242.4	75.1	16989.8
IndusInd Bank	1980.2	242.4	75.1	16989.8
Punjab National Bank	2029.4	274.1	75.1	16989.8
State Bank of India	1980.2	242.4	75.1	16989.8
Union Bank of India	1980.2	242.4	75.1	16989.8

Table 2: Average Financial Inclusion Indicators of Banks (2017–2022)
Source: Author's compilation based on Reserve Bank of India data (2017–2022).

Findings:

- **PSBs** (e.g., SBI, PNB) dominate physical outreach, with high deposit and loan account penetration under schemes like PMJDY (RBI, 2020).
- **PVBs** (e.g., HDFC, ICICI) score higher on digital inclusion through UPI, mobile banking, and internet transactions, aligning with their high TE and PTE (NPCI, 2022).

```
                        ↑ High Inclusion
                        |
                        |
        Quadrant II     |      Quadrant I
        (Strong outreach,|    (Efficient & inclusive)
        low efficiency) |    e.g., HDFC, ICICI
                        |
------------------------+----------------------→ High Efficiency
                        |
        Quadrant III    |      Quadrant IV
        (Weak in both)  |    (Lean but low outreach)
        e.g., IDBI, PNB |    e.g., Axis Bank
                        ↓
                  Low Inclusion
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Figure 3: DEA–Inclusion Alignment Matrix (Conceptual Layout)

Source: Author's conceptual framework based on DEA results and financial inclusion indicators (RBI, 2021; World Bank, 2021).

The descriptive empirical evidence was synthesized in a conceptual 2×2 alignment matrix figure (Figure 3). This model classifies selected banks across two intersecting points: their average Technical Efficiency (TE) scores from DEA analysis and a composite Financial Inclusion Index (drawn from indicators such as deposit account penetration and digital transaction volumes) (Sathye, 2003; Banker et al., 2004).

Quadrant I: Banks that are efficient AND inclusive — banks like HDFC or ICICI in the private sector who have managed to leverage digital and tech at scale (Sathye, 2003; RBI, 2021; World Bank, 2021). Banks falling under **Quadrant II:** (Punjab National Bank, SBI) have a wide physical presence but relatively lower efficiency and are intensive in operational cost (RBI, 2021).

Quadrant III includes banks that face challenges of low inclusion and low efficiency (e.g., IDBI) (Banker et al., 2004). **Quadrant IV** includes efficient banks with weak inclusion footprint (e.g., Axis Bank, IndusInd) (World Bank, 2021).

This framework, adapted from Banker et al. (2004) and Sathye (2003), provides a strategic lens to analyse the inclusion–efficiency nexus in Indian banking.

7.4 Efficiency Trends and Digital Push (Post-2020)

Post-2020, efficiency gains accelerated with India's digital banking surge.

- PVBs: HDFC retained full efficiency; Axis and ICICI improved TE significantly through digital delivery and reduced cost structures (Dey et al., 2022; RBI, 2023).
- PSBs: PNB's TE rose from 0.8551 in 2020 to 0.9681 in 2022, and Bank of Baroda achieved 1.000 in 2022 post-merger integration (ICRA, 2021; Deloitte, 2020). Canara also reached full efficiency by 2022.

These improvements reflect RBI's EASE reforms and government-supported digital initiatives (DFS, 2021; Ministry of Finance, 2022).

Overall, the post-2020 digital push has narrowed the efficiency gap between PSBs and PVBs, marking a turning point in India's banking sector (Joshi & Kansal, 2021; World Bank, 2021).

7.5 Inclusion–Efficiency Nexus: Insights for SDG 8

The findings highlight a strong linkage between financial inclusion and efficiency, aligning with SDG 8, particularly Target 8.10, which emphasizes strengthening domestic financial

institutions to provide universal access to financial services (United Nations, 2015; RBI, 2022a; World Bank, 2021b; Ghosh, 2022).

Private Sector Banks (PVBs) demonstrate how operational efficiency can drive scalable inclusion. Through digital innovations such as UPI, mobile apps, and internet banking, they deliver services at low cost while maintaining high Technical Efficiency (TE) and Scale Efficiency (SE). HDFC Bank and ICICI Bank exemplify this model, consistently scoring high efficiency and leading in digital transactions (Narayanasamy, 2020; Kumar & Singh, 2022; NPCI, 2021; RBI, 2022b; KPMG, 2020; Deloitte, 2020; Sathye, 2003; Banker et al., 2004).

In contrast, Public Sector Banks (PSBs) have traditionally advanced financial inclusion through physical outreach in rural and semi-urban regions, often under government mandates such as PMJDY and social security schemes (Nair, 2019; Singh & Sekhar, 2021; RBI Financial Inclusion Index, 2021; World Bank Global Findex, 2021). While impactful, this model raises operating costs and reduces efficiency (Das & Ghosh, 2009; Kumar & Sahu, 2020). To remain viable, PSBs must accelerate digital integration, process automation, and workforce upskilling (EY, 2021; PwC India, 2021).

Overall, the study underscores that efficiency and inclusion must reinforce rather than undermine each other (Chattopadhyay, 2019; Reddy & Prasad, 2020). Sustainable inclusion requires PSBs to become digitally capable and performance-driven, while PVBs must balance efficiency with broader outreach. With appropriate policy and regulatory support, India's banking system can deliver inclusive growth consistent with SDG 8's vision of productivity, resilience, and equitable development (UNDP, 2020; Sharma & Kaushik, 2022; OECD, 2021; IMF, 2022; Bodla & Bajaj, 2010; World Bank, 2021a; UN, 2022).

8. Policy and Managerial Implications

The research results of this study present several key insights to policymakers and the banking industry. For one, there is an obvious requirement to make it worthwhile for private banks to upgrade their digital infrastructure, especially across rural and semi-urban areas (Bose & Ghosh, 2020; NCAER, 2020).

Second, PTE— which captures managerial and staff productivity — continues to remain weak, especially for PSBs (Claessens & Kose, 2013; Das & Senapati, 2019; Dey & Kar, 2021). Therefore, policymakers must accord priority to capacity-building programs such as digital training, process reengineering, and performance-linked incentives to boost these institutions' human capital (World Economic Forum, 2021; EY, 2022).

Third, scale inefficiencies (SE) in both sets of public and private sector banks indicate that optimal scaling strategies need to be prioritized (CRISIL, 2022; Reserve Bank of India, 2022c). That means rationalizing physical overlap without excluding underserved regions. Logic is an enabler for this reach without replicating physical models (Claessens & Kose, 2013; UNESCAP, 2021; NITI Aayog, 2022).

Moreover, the study recommends that DEA-derived performance indices be part of financial inclusion policy-making decisions (Charnes et al., 1978; Coelli et al., 2005; Bodla & Bajaj, 2010). Banks that continually fall short of TE, PTE, or SE figures should be markers for operational audits and selective interventions (Ray, 2004; Claessens & Kose, 2013; Emrouznejad & Yang, 2018). Equally, inclusion subsidies or incentives (under PMJDY, for example, or UPI onboarding) should be designed based on the banks' proven performance concerning the delivery of services at efficiency and scale (Mehrotra & Yetman, 2015; Ghosh, 2016). Such a governance model can ensure that financial inclusion is both extensive and viable. These findings argue for hybrid models of digital efficiency and physical access in how future banking policy approaches can balance outreach with sustainability (Claessens & Kose, 2013; Narayan & Rao, 2022; Singh, 2023).

9. Conclusion

The objective of this study was to analyze the efficiency performance of Indian public and private sector banks for the period 2017–2022, and to determine whether such performance is consistent with major financial inclusion indicators in the light of SDG 8, notably Target 8.10 (United Nations, 2015; RBI, 2022). These scores were aligned descriptively with inclusion indicators such as deposit accounts density, ATM penetration, and mobile transaction volume. The results reinforce the private sector's ongoing dominance in scale and operational efficiency, confirming they have more streamlined operations with advanced use of digital technology, continuous cost discipline, and an excellence mindset. Post-2020, many public sector banks showed improvements, albeit scale-related inefficiencies have continued to afflict these undertakings, which nonetheless remained dominant in outreach and inclusion (World Bank, 2021; RBI, 2022). This underscores the link between greater digital inclusion and larger scale efficiency, particularly for banks such as HDFC and ICICI that have been leading the way, highlighting that technology is a key enabler of what can be both an inclusive and commercially viable implementation of financial services.

However, the research is not without its limitations. The analysis was performed with a small sample of just ten banks, which might not capture the entire diversified landscape of Indian banking. In addition, although the study covers six years, the empirical results are descriptive, with no use of panel regression or causal estimation models.

Future research could extend the sample to RRBs and SFBs and employ econometric models such as Tobit regression or enhanced DEA frameworks incorporating financial inclusion–specific outputs. Moreover, including variables such as Aadhaar-linked transactions, digital onboarding rates, or rural mobile penetration in future DEA models might better capture inclusion scenarios emerging in India.

Therefore, this study shows that inclusion and efficiency are not mutually exclusive objectives but two interconnected aspects of a banking transformation. Policymakers must balance efficiency and accessibility when designing future banking reforms so that financial institutions can support both economic growth and equitable access, advancing the vision of SDG 8.

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