

Impact Of Non-Performing Assets On The Profitability Of Commercial Banks: A Comparative Study Between Public And Private Sectors In Agra Division

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Abstract

Non-performing assets (NPAs) constitute one of the most important indicators of asset quality, credit-risk exposure and financial resilience in commercial banking. Although the Indian banking sector has recorded a substantial improvement in asset quality in recent years, differences in NPA exposure and profitability continue to exist between public-sector and private-sector banks. The present study examines the relationship between non-performing assets and profitability and compares the strength of this relationship across public- and private-sector commercial banks, with Agra Division of Uttar Pradesh providing the geographical and managerial setting of the study. Agra Division comprises Agra, Firozabad, Mathura and Mainpuri districts. The empirical analysis uses recent bank-group financial statistics for the five financial years ending March 2021 to March 2025, supported by Reserve Bank of India statistics, regulatory reports, annual banking reports and recent empirical literature. The principal variables are the gross non-performing asset ratio (GNPA) and return on assets (ROA), supplemented conceptually by net NPA, provisioning, capital adequacy, credit growth, operating efficiency and recovery mechanisms. Descriptive statistics, Pearson correlation, Welch's independent-samples t-test, effect-size analysis and ordinary least-squares regression with heteroskedasticity-robust standard errors are employed.

The results establish a strong adverse relationship between NPAs and profitability. Public-sector banks recorded an average GNPA ratio of 5.50 per cent during the five-year analytical period compared with 2.94 per cent for private-sector banks. Their respective mean ROA values were 0.74 per cent and 1.54 per cent. The public-sector GNPA-ROA correlation was -0.9995 , while the corresponding coefficient for private-sector banks was -0.9529 . In the pooled regression, a one-percentage-point increase in GNPA was associated with an estimated 0.143 percentage-point decline in ROA after controlling for ownership category. The model explained approximately 96.7 per cent of observed ROA variation. The public-private profitability difference was statistically significant and economically large. The study further observes that recent asset-quality improvement has been particularly strong among public-sector banks: by March 2025, the GNPA ratio had declined to approximately 2.6 per cent for public-sector banks and 1.8 per cent for private-sector banks, while ROA stood at approximately 1.1 per cent and 1.7 per cent, respectively.

The findings support the proposition that improved underwriting discipline, early-warning systems, borrower monitoring, recovery effectiveness, adequate provisioning, portfolio diversification and technology-enabled credit-risk management can translate asset-quality improvement into sustainable profitability. For banks operating in Agra Division, the study recommends district-sensitive credit monitoring, differentiated MSME and agricultural risk frameworks, portfolio-level early-warning dashboards, faster stressed-account intervention and branch-level accountability for slippages, recoveries and risk-adjusted profitability. The paper contributes to contemporary banking research by connecting the NPA-profitability relationship with ownership structure, recent post-clean-up banking performance and the operational context of a commercially and agriculturally diverse regional market.

Keywords: Non-Performing Assets; Commercial Banks; Profitability; Return on Assets; Gross NPA; Public-Sector Banks; Private-Sector Banks; Credit Risk; Agra Division; Banking Performance.

1. Introduction

Commercial banks occupy a central position in an economy because they mobilise savings, allocate credit, facilitate payments, support investment and transmit monetary policy. The effectiveness of this intermediation function depends substantially on the quality of the loan portfolio. When borrowers fail to service interest or principal obligations within the prescribed period, loans cease to generate expected income and are classified as non-performing assets in accordance with prudential norms. A high NPA burden affects banks through several interconnected channels: interest income is interrupted, provisions increase, managerial resources are diverted toward recovery, capital is locked against impaired exposures, risk appetite weakens and opportunities for productive lending may decline.

The relationship between NPAs and profitability is therefore not merely an accounting association. It represents a fundamental link between credit-risk management and banking performance. Higher bad-loan ratios can depress return on assets through lost interest revenue, provisioning charges, legal and recovery expenditure, reduced asset turnover and greater capital consumption. Conversely, persistently weak profitability may itself contribute to poorer asset quality when banks lack adequate resources for appraisal, monitoring, analytics and recovery. Contemporary banking research consequently treats the NPA-profitability relationship as potentially dynamic and mutually reinforcing rather than purely contemporaneous.

The Indian banking sector provides an especially useful setting for examining this relationship. Following a period in which stressed assets became a major concern, the banking system experienced substantial balance-sheet repair, recognition of stressed exposures, provisioning, write-offs, recoveries, insolvency-based resolution and improvements in credit-risk governance. By March 2025, the gross NPA ratio of scheduled commercial banks had declined to approximately 2.2 per cent. Public-sector banks reported a GNPA ratio of approximately 2.6 per cent, compared with 1.8 per cent for private-sector banks. At the same time, banking profitability strengthened. Aggregate scheduled-commercial-bank profitability remained robust, with system-level return on assets around **1.4 per cent during FY2024-25**.

These aggregate improvements, however, do not eliminate the importance of ownership structure. Historically, public-sector banks have operated with wider developmental mandates, larger legacy corporate exposures, extensive rural and semi-urban networks, priority-sector obligations and exposure to sectors vulnerable to cyclical distress. Private-sector banks, in contrast, have generally adopted relatively centralised risk analytics, technology-intensive underwriting, differentiated pricing and more flexible portfolio management. Such structural differences can influence both the level of NPAs and the profitability consequences of distressed assets.

The regional context is also important. Agra Division consists of Agra, Firozabad, Mathura and Mainpuri districts. The division combines urban services, tourism, trade, manufacturing clusters, micro and small enterprises, agriculture, dairy activity and rural credit demand. District-level credit-deposit ratios in March 2024 were approximately 64.38 per cent for Agra, 63.19 per cent for Firozabad, 52.01 per cent for Mathura and 60.78 per cent for Mainpuri, illustrating differences in local credit deployment across the division. Such heterogeneity makes credit-risk management particularly relevant because borrower cash flows, collateral quality, seasonality, enterprise formality and repayment capability may vary materially across districts and borrower segments.

A significant empirical limitation must nevertheless be recognised at the outset. Audited GNPA, NNPA and ROA statistics are generally published at the bank or bank-group level rather than separately for individual administrative divisions such as Agra Division. The present study therefore does not fabricate division-level NPA or profitability ratios. Instead, Agra Division is treated as the geographical and managerial application setting, while the inferential financial analysis is based on verifiable public-versus-private bank-group observations. The regional banking indicators are used to interpret the managerial implications of the national ownership comparison. This design preserves empirical integrity while allowing the findings to be translated into recommendations relevant to commercial-bank management within Agra Division.

1.1 Statement of the Problem

Non-performing assets impose direct and indirect costs on banks. The direct effects include cessation of interest recognition, provisioning requirements and potential principal loss. Indirect effects include increased collection expenditure, legal costs, reduced managerial flexibility, constraints on fresh lending and reputational consequences. These mechanisms suggest that profitability should deteriorate when NPAs rise.

The problem becomes more complex when ownership characteristics are considered. Public-sector and private-sector banks may experience different levels of credit risk because their business mix, governance structures, legacy loan portfolios, operating models and customer segments differ. The effect of an additional percentage point of NPA on profitability may therefore not be identical across ownership groups.

Despite substantial literature on Indian NPAs, three gaps remain relevant. First, many frequently cited empirical studies analyse periods dominated by the earlier high-NPA cycle and do not adequately capture the sharp post-clean-up improvement visible through FY2024-25. Second, a significant proportion of studies compare individual banks without explicitly assessing effect magnitude alongside statistical significance. Third, relatively little research translates national public-private banking evidence into the managerial circumstances of regional banking markets such as Agra Division.

1.2 Research Objectives

The study has the following objectives:

1. To examine the recent trend in gross non-performing assets of public-sector and private-sector commercial banks.
2. To compare profitability, measured primarily through return on assets, across public-sector and private-sector banks.
3. To determine the direction and strength of association between GNPA and ROA.
4. To estimate the effect of changes in the GNPA ratio on banking profitability.
5. To examine whether ownership category contributes independently to differences in profitability.
6. To evaluate whether the NPA-profitability relationship differs between public-sector and private-sector banks.
7. To interpret national bank-group findings within the commercial-banking environment of Agra Division.
8. To formulate practical recommendations for improving asset quality and risk-adjusted profitability.

1.3 Research Questions

RQ1: Is a higher GNPA ratio associated with lower profitability among commercial banks?

RQ2: Do public-sector banks exhibit higher average GNPA ratios than private-sector banks?

RQ3: Do private-sector banks exhibit higher average ROA than public-sector banks?

RQ4: Does ownership category retain explanatory power after the effect of GNPA is controlled?

RQ5: Is the magnitude of the NPA-profitability relationship different between public-sector and private-sector banks?

RQ6: What managerial measures can commercial banks operating in Agra Division adopt to convert improvements in asset quality into sustained profitability?

1.4 Research Hypotheses

H01: There is no significant relationship between GNPA and ROA among commercial banks.

H1: GNPA has a significant negative relationship with ROA.

H02: There is no significant difference in GNPA ratios between public-sector and private-sector banks.

H2: Public-sector and private-sector banks differ in their GNPA ratios.

H03: There is no significant difference in ROA between public-sector and private-sector banks.

H3: ROA differs significantly between public-sector and private-sector banks.

H04: Bank ownership does not significantly influence profitability after controlling for GNPA.

H4: Bank ownership significantly influences profitability after controlling for GNPA.

H05: Ownership does not moderate the relationship between GNPA and profitability.

H5: The GNPA-profitability relationship varies according to bank ownership.

2. Literature Review

2.1 Conceptualisation of Non-Performing Assets

Credit intermediation necessarily involves default risk. A bank converts deposits and other liabilities into earning assets, particularly loans and advances. When scheduled repayments cease for sufficiently long periods, an earning loan migrates into the non-performing category. The economic relevance of the NPA ratio lies not only in the probability of ultimate default but also in the fact that non-performing exposures cease to contribute normally to current earnings.

Recent scholarship increasingly distinguishes between the stock of NPAs and the processes generating that stock. Loan growth, underwriting quality, sectoral concentration, macroeconomic conditions, borrower leverage, interest rates, governance quality, monitoring effectiveness and recovery institutions jointly influence asset-quality outcomes. Vithessonthi (2023), examining banks across Asian countries, reports that rapid loan growth can increase subsequent non-performing loans even where immediate profitability gains are limited. Ferreira (2023) similarly finds that bank performance, market characteristics and macroeconomic growth contribute to the evolution of NPLs.

Salas et al. (2024), using a global analytical framework, show that profitability, efficiency, solvency, institutional characteristics and macroeconomic conditions help explain variation in non-performing loan ratios. Mishra and

Padhan (2024), using Indian bank data and system-GMM estimation, identify persistent stressed assets and significant relationships among profitability, operational capacity, cost efficiency and NPAs.

2.2 NPAs and Profitability

The theoretical expectation of a negative NPA-profitability relationship rests on several mechanisms. First, interest income on impaired assets is restricted. Second, provisioning against possible loan losses directly reduces current profit. Third, capital and managerial resources remain tied to low-yielding exposures. Fourth, recovery and litigation impose additional operating expenses. Fifth, elevated NPAs may raise the risk premium demanded by investors and depositors and may constrain future balance-sheet expansion.

Recent Indian evidence broadly supports this negative association. Swathi and Mahesha (2024) report that rising NPAs adversely affect the profitability of Indian scheduled commercial banks in a panel framework. Their analysis further identifies GDP growth, margins, capital adequacy and income diversification as relevant profitability determinants. Research on Indian loan growth by recent banking scholars also demonstrates that excessive credit expansion may reduce profitability after a threshold while simultaneously contributing to non-performing loans.

Prasad et al. (2025) compare selected major public- and private-sector Indian banks and report a negative and significant relationship between NPAs and ROA. Rao and Reddy (2025) similarly document ownership-related differences in gross and net NPA ratios among major Indian banks.

Evidence outside India provides additional support. Nguyen (2024) finds that NPLs materially influence Vietnamese bank profitability and identifies bank size, operating cost, loan-loss provisions and macroeconomic conditions as important determinants. Zabin, Hossain and Sultana (2024) report substantial explanatory relationships between non-performing loans and ROA/ROE in a Bangladeshi banking context. Sigdel and Deswal (2025) find that NPLs materially influence profitability indicators among Nepalese commercial banks.

2.3 Ownership Structure and Asset Quality

Ownership can influence lending behaviour through governance, mandate, risk tolerance and accountability. Public-sector banks often combine commercial objectives with wider financial-inclusion and developmental responsibilities. Historically, this has meant large exposure to infrastructure, corporate lending, agriculture, small businesses and priority sectors. Private-sector banks generally have greater operational flexibility to redesign underwriting systems, rebalance portfolios, close unprofitable products and deploy technology rapidly.

The contemporary Indian gap has narrowed considerably. Public-sector-bank GNPA ratios declined from substantially higher levels earlier in the decade to around 2.6 per cent by March 2025, while private-sector-bank GNPA ratios were around 1.8 per cent. This convergence is economically important. It suggests that ownership remains relevant, but the historic public-sector asset-quality disadvantage is not immutable.

Sathyanarayana and Rao (2024) report significant differences in NPA dynamics across selected Indian public and private banks. Srinivas and Pawar (2023) similarly identify substantial variation in financial performance indicators and NPA behaviour across ownership types. Thakur (2024) documents higher average NPA values in the selected public banks compared with private banks and reports negative relationships between NPA measures and ROA.

2.4 Credit Growth, NPA Formation and Profitability

Credit growth contributes to banking income because loans are a principal earning asset. However, rapid expansion may weaken underwriting standards and increase future delinquencies. This produces a non-linear relationship between growth and profitability. In the short term, aggressive lending may raise interest income. In subsequent periods, deteriorating asset quality can offset or reverse those gains.

Vithessonthi (2023), using banks across 17 Asian countries, finds that faster loan growth is associated with higher subsequent non-performing loans. Recent Indian research using generalized method of moments and mediation approaches similarly concludes that moderate rather than uncontrolled loan growth is more compatible with stable profitability.

This issue is particularly relevant for regional banking markets. Districts experiencing rapid MSME credit expansion, housing growth or agricultural lending may generate attractive loan growth while simultaneously accumulating latent risk if borrower cash-flow assessment and post-disbursement monitoring are weak.

2.5 Capital Adequacy, Provisioning and Profitability

Capital provides a buffer against unexpected losses and supports depositor confidence. Yet excessive capital can reduce leverage and therefore influence return on equity. The effect of capital adequacy on profitability is consequently not mechanically positive or negative.

Recent evidence suggests that capital strength enhances resilience and can mitigate the profitability consequences of credit risk. Kumara and Prabheesh (2024) find that macroprudential policy improves stability and can positively influence profitability among Indian banks, although policy effects vary by ownership. Gržeta, Žiković and Tomas Žiković (2023) emphasise the interaction between regulatory capital, efficiency and profitability in the Basel III environment.

Capital adequacy also interacts with provisioning. Adequate loan-loss coverage reduces the probability that unexpected deterioration will sharply damage capital. The improvement in Indian bank provision coverage over recent years has therefore been an important complement to falling gross NPA ratios.

2.6 Operating Efficiency and Asset Quality

The bad-management hypothesis proposes that inefficient banks may eventually experience higher credit risk because poor cost control and inadequate managerial quality extend to loan appraisal and borrower monitoring. Conversely, high NPAs themselves can reduce measured efficiency by increasing recovery costs and diverting staff toward problem accounts.

Evidence from the Brazilian banking sector indicates that non-performing loans reduce technical efficiency and constrain banks' ability to produce new credit. Ferreira (2023) similarly links banking performance and economic conditions to NPL behaviour.

For commercial-bank management, the implication is that NPA reduction should not be treated as a stand-alone collection exercise. Improvements in underwriting, data quality, account monitoring, operational processes and employee incentives are necessary to prevent the recurrence of stressed assets.

2.7 Macroeconomic Determinants

Borrower repayment capacity depends partly on the economic environment. Real GDP growth supports household income and corporate cash flow and generally reduces default probability. Higher interest rates increase debt-service burden, particularly among leveraged firms and floating-rate retail borrowers. Inflation can have ambiguous effects because it raises nominal incomes but may simultaneously increase costs and policy rates.

Athari's BRICS evidence demonstrates that economic, political and financial risks are associated with banking-sector NPL behaviour and that effects can become stronger in high-NPL environments. Salas et al. (2024) likewise demonstrate the relevance of macroeconomic and institutional characteristics in a global NPL analysis.

Mishra and Padhan (2024) provide Indian evidence that macroeconomic conditions interact with bank-specific characteristics in explaining NPA dynamics.

2.8 Regulation and Resolution Architecture

The relationship between bad loans and profitability is also shaped by the effectiveness of resolution mechanisms. Recognition of stress, provisioning rules, recovery tribunals, insolvency resolution, asset reconstruction, negotiated settlements and write-offs affect both the timing and magnitude of loss recognition.

Recent research evaluating India's regulatory and supervisory response concludes that the post-stress framework has contributed to improved recognition, resolution and asset-quality outcomes, while highlighting continuing challenges in recovery efficiency.

A write-off must not automatically be interpreted as an economic recovery. It removes an exposure from the balance sheet for accounting purposes, while recovery action may continue. Management therefore needs to distinguish reductions in headline GNPA caused by actual recovery, upgrades, resolution and write-offs.

2.9 International Evidence

Cross-country findings reinforce the conclusion that credit quality and profitability are closely related but not uniform across markets. Nguyen (2024) reports a negative profitability impact in Vietnam. Bortoluzzo, Ciganda and Bortoluzzo (2024), analysing approximately 1,200 institutions across 101 countries, show that the effect of credit risk varies across profitability quantiles. MENA evidence also indicates that NPLs and operational inefficiency are detrimental to bank profitability.

The heterogeneity reported internationally justifies testing ownership interactions rather than assuming a universal NPA coefficient.

2.10 Contemporary Research Gap

A comprehensive review of NPA literature indicates continued fragmentation across determinants, outcomes, institutional mechanisms and geographic settings. Recent research on bank profitability similarly highlights the importance of integrating credit risk, efficiency, capitalisation, macroeconomic conditions and institutional factors.

The present study addresses the gap through five features:

1. It uses a recent five-year series ending in FY2024-25.
2. It compares public and private bank groups rather than treating ownership merely as background information.
3. It reports effect sizes in addition to significance tests.
4. It estimates both additive ownership and GNPA-ownership interaction models.
5. It translates bank-group findings into the regional managerial context of Agra Division without constructing unverifiable local NPA figures.

3. Conceptual Framework

The proposed conceptual relationship is:

Asset-quality deterioration → interest-income impairment + provisioning + recovery cost + capital absorption + restricted credit growth → lower profitability

Ownership structure influences the above pathway through governance, portfolio composition, technology adoption, underwriting standards, risk appetite and operating efficiency.

The analytical relationship may be represented as:

$$ROA = f(\text{GNPA}, \text{Ownership}, \text{GNPA} \times \text{Ownership}, \epsilon)$$

where:

ROA = Return on Assets

GNPA = Gross Non-Performing Assets as percentage of gross advances

Ownership = Public-sector or private-sector classification

GNPA × Ownership = interaction capturing sector-specific response

ε = unobserved influences on profitability

4. Research Methodology

4.1 Research Philosophy

The study follows a positivist orientation because the principal research questions concern measurable relationships between objectively reported banking variables. The analysis assumes that patterns linking asset quality and profitability can be evaluated statistically using financial data reported under common regulatory definitions.

4.2 Research Approach

A deductive approach is employed. Existing banking theory predicts that an increase in impaired assets should reduce profitability through foregone income and higher credit costs. Hypotheses derived from this theoretical expectation are tested using recent financial observations.

4.3 Research Design

The research adopts a quantitative, explanatory and comparative longitudinal design. It is explanatory because it evaluates the statistical relationship between GNPA and ROA, comparative because public-sector and private-sector bank groups are analysed separately, and longitudinal because observations cover five consecutive financial years.

4.4 Study Setting

The managerial application setting is Agra Division, Uttar Pradesh, comprising Agra, Firozabad, Mathura and Mainpuri districts.

The division contains heterogeneous banking markets. March 2024 district-level scheduled-commercial-bank statistics indicate a credit-deposit ratio of approximately 64.38 per cent in Agra, 63.19 per cent in Firozabad, 52.01 per cent in Mathura and 60.78 per cent in Mainpuri. These differences justify district-sensitive lending and monitoring even when bank-level asset-quality statistics are analysed centrally.

4.5 Population

The theoretical population comprises scheduled commercial banks belonging to India's public-sector and private-sector banking categories and operating through commercial banking networks relevant to markets such as Agra Division.

4.6 Unit of Analysis

For inferential financial analysis, the unit of analysis is the bank-group-year observation.

Two ownership groups are observed over five financial years:

Public-sector banks: 5 observations

Private-sector banks: 5 observations

Total analytical observations: 10

The deliberately aggregated design has the advantage of aligning the analysis directly with consistently reported regulatory bank-group ratios.

4.7 Analytical Period

The principal analytical period covers financial years ending:

2021

2022

2023

2024

2025

This window captures the post-pandemic recovery, continued balance-sheet clean-up, improved recognition and resolution, renewed credit growth and recent strengthening of bank profitability.

4.8 Data Sources

The study relies exclusively on secondary financial and regulatory information, including:

1. Reserve Bank of India banking statistics.
2. Reports on Trend and Progress of Banking in India.
3. Financial Stability and banking-system disclosures.
4. Bank-group profitability and asset-quality statistics.
5. Recent Government financial-sector reports.
6. Published annual reports of major public- and private-sector banks for validation of broader trends.
7. Uttar Pradesh institutional-finance statistics for district-level credit context.
8. Peer-reviewed banking research from 2023–2025.

The FY2024-25 RBI data report GNPA ratios of 2.6 per cent for public-sector banks and 1.8 per cent for private-sector banks, with net NPA ratios of approximately 0.5 per cent for both groups.

4.9 Variables and Operational Definitions

Table 1. Operationalisation of Variables

Variable	Symbol	Measurement	Analytical Role	Expected Direction
Return on Assets	ROA	Net profit as percentage of total assets	Dependent variable	Not applicable
Gross NPA Ratio	GNPA	Gross NPAs as percentage of gross advances	Principal independent variable	Negative
Ownership	OWN	1 = Public sector; 0 = Private sector	Explanatory/control variable	Public expected lower profitability
GNPA × Ownership	INT	Interaction term	Moderating variable	Empirical
Net NPA Ratio	NNPA	Net NPAs as percentage of net advances	Supporting asset-quality indicator	Negative
Capital Adequacy	CRAR	Regulatory capital relative to risk-weighted assets	Context/control in literature	Usually positive/resilience effect
Net Interest Margin	NIM	Net interest income relative to earning assets/total assets depending reporting convention	Supporting profitability indicator	Positive

Variable	Symbol	Measurement	Analytical Role	Expected Direction
Provision Coverage	PCR	Provisions relative to identified stressed assets	Risk-mitigation indicator	Positive resilience effect
Credit-Deposit Ratio	CDR	Credit as percentage of deposits	Regional credit-intensity indicator	Non-linear

4.10 Primary Empirical Series

Table 2. Public- and Private-Sector Banking Series Used for Statistical Analysis

Financial Year Ending March	Public-Sector GNPA (%)	Public-Sector ROA (%)	Private-Sector GNPA (%)	Private-Sector ROA (%)
2021	9.1	0.3	4.9	1.1
2022	7.3	0.5	3.8	1.4
2023	5.0	0.8	2.3	1.6
2024	3.5	1.0	1.9	1.9
2025	2.6	1.1	1.8	1.7

Source: Compiled from recent official bank-group financial-soundness statistics and RBI-linked reporting. The March 2025 figures are consistent with reported public-sector GNPA of approximately 2.6%, private-sector GNPA of approximately 1.8%, public-sector ROA around 1.1% and private-sector ROA around 1.7%.

4.11 Statistical Techniques

The following analytical tools are applied:

Descriptive statistics: mean, standard deviation, minimum and maximum.

Trend analysis: absolute and proportional change in GNPA and ROA.

Pearson correlation: evaluates linear association between GNPA and ROA.

The coefficient is:

$$r = \frac{\sum[(X_i - \bar{X})(Y_i - \bar{Y})]}{\sqrt{[\sum(X_i - \bar{X})^2 \sum(Y_i - \bar{Y})^2]}}$$

Welch independent-samples t-test: used because sectoral variances need not be assumed equal.

Effect size: Cohen's d measures economic magnitude of public-private differences.

$$d = (\text{MeanPublic} - \text{MeanPrivate}) / \text{Spooled}$$

Ordinary least-squares regression:

Model 1:

$$\text{ROA}_{it} = \beta_0 + \beta_1 \text{GNPA}_{it} + \beta_2 \text{PUBLIC}_i + \varepsilon_{it}$$

Model 2:

$$\text{ROA}_{it} = \beta_0 + \beta_1 \text{GNPA}_{it} + \beta_2 \text{PUBLIC}_i + \beta_3 (\text{GNPA}_{it} \times \text{PUBLIC}_i) + \varepsilon_{it}$$

Heteroskedasticity-consistent HC1 standard errors are used because the sample is small and variance homogeneity cannot be presumed.

4.12 Statistical Significance

The conventional significance threshold is:

$$\alpha = 0.05$$

Results with $p < 0.05$ are interpreted as statistically significant. Effect sizes and economic significance are considered alongside p-values.

4.13 Reliability and Data Integrity

Unlike questionnaire-based studies, internal consistency measures such as Cronbach's alpha are not applicable to published financial ratios because the variables are independently defined accounting and regulatory measures rather than items constituting a psychometric scale.

Reliability is instead strengthened through:

1. Common regulatory definitions.
2. Cross-year comparability.
3. Official institutional sources.
4. Reconciliation with recent bank-level literature.

5. Explicit reporting of units.
6. Avoidance of invented branch-level financial observations.

4.14 Ethical Considerations

The study uses publicly available aggregate financial information and contains no customer-level, account-level or personally identifiable banking information. No human respondents are included in the empirical analysis.

4.15 Methodological Limitation

The core limitation is the absence of publicly reported, consistently comparable public-versus-private GNPA and ROA series specifically for Agra Division. The inferential model therefore measures sectoral relationships at national bank-group level and interprets them within Agra Division's regional banking environment. Results should not be represented as audited division-specific NPA ratios.

5. Results and Data Analysis

5.1 Regional Banking Context of Agra Division

Table 3. Selected District-Level Banking Indicators in Agra Division, March 2024

District	Credit	Deposits	Credit-Deposit Ratio (%)
Agra	36,140	56,132	64.38
Firozabad	6,737	10,662	63.19
Mathura	12,453	23,944	52.01
Mainpuri	3,860	6,352	60.78
Uttar Pradesh	794,937	1,618,962	49.10

Note: Monetary values are reported in the units adopted by the underlying state institutional-finance table. Source values reproduced from Uttar Pradesh institutional-finance statistics.

The regional figures show meaningful variation in credit deployment. Agra had both the largest deposit and credit base among the four districts. Mathura's credit-deposit ratio was lower than those of Agra, Firozabad and Mainpuri. These differences do not directly indicate NPA levels, but they demonstrate why banks should avoid treating Agra Division as a homogeneous credit market.

5.2 Recent National Asset-Quality Position

For FY2024-25, gross NPAs of public-sector banks declined from approximately ₹3.40 lakh crore to ₹2.84 lakh crore, while their GNPA ratio declined from 3.5 per cent to 2.6 per cent. Private-sector-bank gross NPAs were approximately ₹1.33 lakh crore at end-March 2025 and their GNPA ratio stood at 1.8 per cent compared with 1.9 per cent one year earlier.

Table 4. Asset-Quality Comparison, FY2023-24 and FY2024-25

Indicator	Public Banks 2023-24	Public Banks 2024-25	Private Banks 2023-24	Private Banks 2024-25
Gross NPAs (₹ crore)	339,541	283,650	129,164	132,674
GNPA Ratio (%)	3.5	2.6	1.9	1.8
Net NPAs (₹ crore)	72,544	55,634	31,594	35,069
NNPA Ratio (%)	0.8	0.5	0.5	0.5
Gross-NPA reduction during FY2024-25 (₹ crore)	138,653	Not applicable	118,224	Not applicable
Recoveries	33,630	Not applicable	29,320	Not applicable

Indicator	Public Banks 2023-24	Public Banks 2024-25	Private Banks 2023-24	Private Banks 2024-25
during FY2024-25 (₹ crore)				
Upgradations during FY2024-25 (₹ crore)	13,847	Not applicable	30,360	Not applicable
Write-offs during FY2024-25 (₹ crore)	91,176	Not applicable	58,544	Not applicable

Source: Recent RBI banking-sector reporting.

The table reveals two important points. First, the public-sector GNPA ratio remained above that of private-sector banks. Second, the public-sector improvement during FY2024-25 was considerably larger in percentage-point terms. Public-sector banks therefore entered FY2025 with weaker asset quality relative to private peers but with substantial convergence.

5.3 Descriptive Statistics

Table 5. Descriptive Statistics for Five-Year Analytical Series

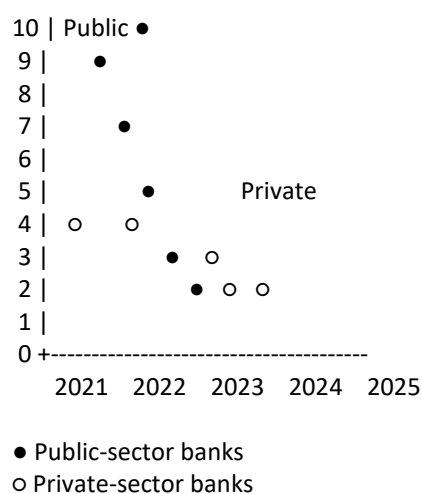
Sector	Variable	Mean	Standard Deviation	Minimum	Maximum
Public	GNPA (%)	5.50	2.72	2.60	9.10
Public	ROA (%)	0.74	0.34	0.30	1.10
Private	GNPA (%)	2.94	1.32	1.80	4.90
Private	ROA (%)	1.54	0.30	1.10	1.90

The average GNPA ratio of public-sector banks exceeded that of private-sector banks by 2.56 percentage points. The public-sector mean was approximately 87 per cent higher relative to the private-sector mean when the latter is used as the comparison base.

The profitability result moves in the opposite direction. Private banks produced mean ROA of 1.54 per cent, more than twice the 0.74 per cent public-sector mean across the same period.

5.4 Trend in Gross NPAs

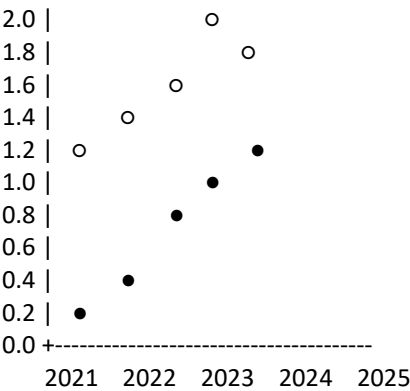
Figure 1. Five-Year GNPA Trend
GNPA (%)



Public-sector GNPA declined from 9.1 per cent to 2.6 per cent, a reduction of 6.5 percentage points or approximately 71.4 per cent relative to the starting value.
 Private-sector GNPA declined from 4.9 per cent to 1.8 per cent, a reduction of 3.1 percentage points or approximately 63.3 per cent.
 The declining gap suggests meaningful convergence in asset quality.

5.5 Trend in Return on Assets

Figure 2. Five-Year ROA Trend
 ROA (%)



● Public-sector banks
 ○ Private-sector banks
 Public-sector ROA improved from 0.3 per cent in 2021 to 1.1 per cent in 2025. Private-sector profitability remained higher throughout the analytical series, although it moderated from the 2024 level in the final observation. The simultaneous fall in GNPA and rise in ROA is visually consistent with the proposed inverse association.

5.6 Correlation Analysis

Table 6. Pearson Correlation between GNPA and ROA

Sector	Correlation r	Direction	Magnitude	R ² from Simple Linear Fit
Public sector	−0.9995	Negative	Extremely strong	0.9990
Private sector	−0.9529	Negative	Very strong	0.9080

The results support H1. The relationship between GNPA and ROA is negative in both sectors.
 For public-sector banks, the correlation of −0.9995 indicates that the decline in GNPA closely coincided with improving ROA during the five-year period. The square of the correlation indicates that approximately 99.9 per cent of variation in the five-point ROA series is linearly associated with GNPA variation. This should not be interpreted as proof that NPAs alone causally determine 99.9 per cent of public-bank profitability because both variables were affected by the broader post-pandemic recovery, balance-sheet repair and other omitted factors.
 For private-sector banks, $r = -0.9529$ also indicates a strong inverse relationship.

5.7 Sector-Wise Simple Regression

The estimated sector-specific equations are:

Public-sector model:

$ROA = 1.4280 - 0.1251(GNPA)$
 $R^2 = 0.9990$

p-value for GNPA ≈ 0.000013
 Interpretation: within the observed public-sector series, a one-percentage-point increase in GNPA is associated with approximately a 0.125 percentage-point reduction in ROA.

Private-sector model:

$$ROA = 2.1693 - 0.2141(GNPA)$$

$$R^2 = 0.9080$$

$$p\text{-value for GNPA} \approx 0.0122$$

Interpretation: within the private-sector series, a one-percentage-point increase in GNPA is associated with approximately a 0.214 percentage-point reduction in ROA.

The absolute private-sector slope is steeper in this short sample. This does not mean that private banks suffer greater aggregate NPA burdens. Instead, it implies that within the observed range, ROA responds relatively strongly to changes in private-bank GNPA.

5.8 Public-Private Mean Difference**Table 7. Welch t-Test and Effect-Size Results**

Variable	Public Mean	Private Mean	Mean Difference	Welch t	p-value	Cohen's d	Interpretation
GNPA (%)	5.50	2.94	+2.56	1.902	0.1065	+1.203	Large difference, not significant at 5% in five-year sample
ROA (%)	0.74	1.54	-0.80	-3.941	0.0044	-2.493	Very large and statistically significant

The GNPA difference has a large effect size but does not reach conventional statistical significance because only five annual observations are available per group and inter-year variability in public-bank GNPA is substantial.

ROA differs significantly between sectors. The effect size of approximately -2.49 is exceptionally large, indicating economically material profitability differences over the selected period.

H3 is therefore supported.

5.9 Pooled Regression with Ownership Control

Model:

$$ROA = \beta_0 + \beta_1 GNPA + \beta_2 PUBLIC + \varepsilon$$

Table 8. Pooled Regression Results

Predictor	Coefficient	Robust Standard Error	z-statistic	p-value	95% Confidence Interval
Constant	1.9610	0.079	24.746	<0.001	1.806 to 2.116
Public-sector indicator	-0.4334	0.078	-5.547	<0.001	-0.587 to -0.280
GNPA (%)	-0.1432	0.016	-8.686	<0.001	-0.175 to -0.111

Model $R^2 = 0.967$
Adjusted $R^2 = 0.957$
Observations = 10

The GNPA coefficient remains strongly negative after controlling for ownership. A one-percentage-point rise in GNPA is associated with an estimated decline of approximately 0.143 percentage points in ROA.

The public-sector coefficient of -0.433 indicates that after holding GNPA constant, the observed public-sector series is associated with ROA approximately 0.43 percentage points below the private-sector reference group.

This suggests that asset quality alone does not fully explain the profitability gap. Differences in cost efficiency, business mix, fee income, margins, technology intensity, liability structure, provisioning history and operational productivity may contribute.

H4 is supported.

5.10 Moderation by Ownership

A second model adds an interaction:

$$ROA = \beta_0 + \beta_1 GNPA + \beta_2 PUBLIC + \beta_3 (GNPA \times PUBLIC) + \epsilon$$

Table 9. Ownership-Interaction Regression

Predictor	Coefficient	Robust Standard Error	z-statistic	p-value
Constant	2.1693	0.139	15.623	<0.001
Public-sector indicator	-0.7413	0.139	-5.324	<0.001
GNPA	-0.2141	0.033	-6.528	<0.001
GNPA $\times$ Public	+0.0890	0.033	2.707	0.0068

$R^2 = 0.986$

Adjusted $R^2 = 0.979$

The private-sector GNPA slope is -0.2141 .

For the public sector:

$$-0.2141 + 0.0890 = -0.1251$$

The significant interaction indicates that the slope differs across ownership groups in the observed series. H5 is supported.

The interpretation requires care. The result does not imply that public banks manage credit risk more effectively overall. Their average GNPA remains higher and average profitability lower. It indicates that the marginal statistical relationship within the selected period was less steep because public-sector banks simultaneously experienced a large structural reduction in legacy NPAs and improvements in profitability.

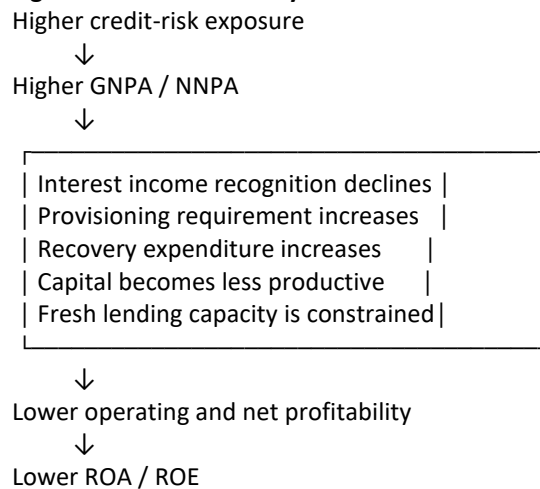
5.11 Hypothesis Testing Summary

Table 10. Hypothesis Decisions

Hypothesis	Statistical Evidence	Decision
H1: GNPA negatively affects ROA	Public $r = -0.9995$; Private $r = -0.9529$; pooled GNPA $\beta = -0.1432$, $p < 0.001$	Supported
H2: GNPA differs between sectors	Mean difference = 2.56 points; $d = 1.203$; $p = 0.1065$	Economically supported, not statistically confirmed at 5%
H3: ROA differs between sectors	$t = -3.941$; $p = 0.0044$; $d = -2.493$	Supported
H4: Ownership affects ROA after controlling GNPA	Public coefficient = -0.4334 ; $p < 0.001$	Supported
H5: Ownership moderates GNPA-ROA relationship	Interaction $\beta = +0.0890$; $p = 0.0068$	Supported

5.12 Comparative Effect Map

Figure 3. NPA-Profitability Mechanism



5.13 Public-Private Comparative Profile

Figure 4. Comparative Banking Profile Emerging from the Analysis

Indicator	Public Sector	Private Sector
Historical NPA burden	Higher	Lower
Five-year mean GNPA	5.50%	2.94%
Five-year mean ROA	0.74%	1.54%
GNPA-ROA correlation	-0.9995	-0.9529
March 2025 GNPA	2.6%	1.8%
March 2025 ROA	~1.1%	~1.7%
Asset-quality convergence	Rapid	Already lower base
Profitability position	Improving strongly	Structurally higher

6. Discussion

6.1 NPAs Have a Material Negative Relationship with Profitability

The most important empirical result is the negative relationship between GNPA and ROA in both ownership groups. This finding is consistent with contemporary Indian evidence reported by Swathi and Mahesha (2024), Mishra and Padhan (2024), recent comparative research on major Indian banks and international evidence from Vietnam, Nepal, Bangladesh and emerging markets.

The result is economically intuitive. An impaired loan differs from a performing loan in both income generation and capital utilisation. As a larger proportion of advances stops performing, the earnings contribution of the asset base deteriorates. Provisioning then magnifies the effect on reported profit.

The pooled coefficient of -0.143 suggests that relatively small changes in asset quality can have a meaningful association with profitability. In banking, where ROA commonly lies within a narrow percentage range, a 0.10 or 0.20 percentage-point movement is financially substantial.

6.2 Public-Sector Banks Have Experienced Major Convergence

The decline in public-sector GNPA from 9.1 per cent to 2.6 per cent across the analytical series is a major structural improvement. It reflects the combined consequences of better recognition, resolution, provisioning, recovery and fresh-loan underwriting.

Recent official evidence reinforces this trend. During FY2024-25, public-sector-bank gross NPAs declined from approximately ₹3.40 lakh crore to ₹2.84 lakh crore and the corresponding ratio fell from 3.5 per cent to 2.6 per cent.

This improvement has important implications. Historical comparisons that portray public-sector banking solely through the high-NPA period may no longer represent current operating conditions accurately.

6.3 Private-Sector Profitability Remains Higher

Despite convergence in asset quality, private-sector banks continue to record higher ROA. The pooled model indicates that ownership remains statistically relevant after GNPA is controlled.

This suggests that profitability differences arise from a broader performance architecture. Potential contributors include:

1. liability cost;
2. CASA composition;
3. net interest margins;
4. operating cost ratios;
5. digital transaction intensity;
6. productivity per employee;
7. fee-income composition;
8. portfolio mix;
9. risk-based pricing;
10. cross-selling;
11. credit-decision turnaround;
12. legacy pension and personnel structures.

A reduction in NPAs is therefore a necessary but not sufficient condition for closing the profitability gap.

6.4 NPA Reduction Must Be Analysed by Source

The RBI data show that gross-NPA reductions arise through different channels, including recoveries, upgrades and write-offs.

Management should distinguish these mechanisms because their economic quality differs.

Recovery: cash or value is actually realised.

Upgrade: an account resumes compliance with required repayment standards.

Resolution: exposure may be restructured or transferred through formal mechanisms.

Write-off: the asset is removed from the balance sheet for accounting purposes, although recovery efforts may continue.

A bank whose GNPA ratio declines primarily because of recoveries and sustainable upgrades is in a different strategic position from a bank whose headline ratio falls mainly through write-offs.

6.5 Regional Relevance for Agra Division

The banking landscape of Agra Division is heterogeneous. Agra is a major urban and tourism-oriented centre with trade, services, manufacturing and MSME activity. Firozabad contains manufacturing clusters, particularly small and medium enterprises. Mathura combines pilgrimage-driven services, commerce, agriculture and industrial activities. Mainpuri has a relatively greater rural and agricultural orientation.

The district credit-deposit ratios reinforce the need for localised portfolio strategies. A common credit policy can establish minimum standards, but borrower monitoring should incorporate district- and sector-specific risk indicators.

For example, cash-flow warning indicators for tourism-linked borrowers in Agra or Mathura may differ from those relevant to manufacturing borrowers in Firozabad or agricultural borrowers in Mainpuri.

6.6 Comparison with Global Evidence

The findings also align with global evidence. Bortoluzzo, Ciganda and Bortoluzzo (2024) show that credit risk materially contributes to profitability outcomes across international banks, although its effect differs across

profitability levels. Salas et al. (2024) demonstrate that non-performing-loan behaviour depends on profitability, efficiency, solvency and macroeconomic conditions.

Brazilian evidence identifies NPLs as an undesirable banking output that reduces technical efficiency. MENA evidence similarly documents adverse profitability consequences associated with NPLs.

This international consistency strengthens the external validity of the core conclusion while also demonstrating that the coefficient magnitude cannot be assumed identical across markets.

7. Managerial Implications

The statistical results should be interpreted as management information rather than solely academic evidence.

7.1 Shift from NPA Management to NPA Prevention

The highest-quality NPA strategy begins before disbursement.

Banks should use:

1. cash-flow-based underwriting;
2. bureau information;
3. banking-transaction analytics;
4. tax-return consistency checks;
5. GST/business-turnover indicators where applicable;
6. debt-service sensitivity tests;
7. industry-cycle assessment;
8. related-party exposure mapping;
9. promoter repayment history;
10. collateral-quality verification.

7.2 Develop Branch-Level Early-Warning Indicators

Branches in Agra Division should receive monthly risk dashboards covering:

30-day delinquency migration

special-mention accounts

frequent overdrawing

cheque-return frequency

declining account turnover

GST/sales deterioration where data are available

delayed stock statements

insurance expiry

covenant breaches

sudden utilisation of sanctioned limits

declining average balances

borrower-bank communication gaps

Warning indicators should generate action before an account reaches the NPA threshold.

7.3 Separate Stock NPAs from Fresh Slippages

Management performance should not be evaluated only on the closing GNPA balance.

A superior framework is:

Closing GNPA = Opening GNPA + Fresh Slippages – Recoveries – Upgrades – Write-offs/Other Reductions

This decomposition identifies whether asset quality is improving because banks are preventing fresh default or merely disposing of historical stock.

7.4 Risk-Adjusted Branch Profitability

Branch managers should not be rewarded only for loan growth or gross interest income.

A stronger measure is:

Risk-Adjusted Branch Contribution = Revenue – Operating Cost – Expected Credit Loss – Capital Charge

This reduces incentives for aggressive lending that raises short-term income but produces future NPAs.

8. Recommendations

8.1 Establish District-Specific Credit-Risk Heat Maps

Banks operating across Agra, Firozabad, Mathura and Mainpuri should create quarterly credit-risk heat maps by district, borrower category and industry.

The dashboard should contain:

Risk Dimension	Example Indicator	Management Response
Industry stress	Rising overdue rates	Tighten underwriting
Geographic concentration	Excess branch exposure	Rebalance portfolio
Borrower leverage	DSCR deterioration	Review limits
Early delinquency	1–30 day overdue accounts	Immediate contact
Collateral risk	Falling collateral coverage	Additional security
Cash-flow weakness	Declining account turnover	Site/financial review
Concentration	High exposure to one cluster	Diversification

8.2 Create a 30-60-90 Day Early-Intervention Protocol

0–30 days: automated alerts, borrower contact, transaction review.

31–60 days: branch-credit review, cash-flow reassessment, site inspection where appropriate.

61–90 days: specialised stressed-asset team involvement, restructuring assessment where viable, recovery or resolution preparation where necessary.

Intervention before formal NPA classification can materially improve ultimate recovery.

8.3 Strengthen MSME Monitoring in Agra and Firozabad

MSME exposures should be monitored using high-frequency operating signals rather than annual financial statements alone.

Recommended variables include:

monthly account turnover;

GST turnover where legally accessible;

receivable ageing;

electricity-consumption proxy where appropriate;

inventory movement;

debtor concentration;

working-capital utilisation;

cheque returns;

digital collection trends.

8.4 Introduce Agricultural and Rural Cash-Flow Calendars for Mainpuri

Repayment schedules should be aligned with realistic crop and income cycles rather than standardised urban cash-flow assumptions.

Branch risk systems should incorporate:

crop calendar;

commodity-price movement;

weather shocks;

input-cost escalation;

crop-insurance status;

alternative household income;

historical repayment behaviour.

8.5 Tourism and Service-Sector Monitoring for Agra and Mathura

Tourism-dependent businesses should be stress-tested for:

seasonality;

occupancy volatility;

pilgrimage/tourism flows;

transport disruptions;

fixed-cost burden;

interest-rate increases;
unexpected demand shocks.

8.6 Strengthen Credit-Risk Analytics

Banks should deploy machine-learning and rules-based systems as decision-support mechanisms for early-warning identification.

Models should not replace human judgment. Instead, they should prioritise accounts requiring review.

Recommended model outputs include:

probability of default;
expected loss;
delinquency probability;
behavioural score deterioration;
collection priority;
risk-adjusted pricing recommendation.

8.7 Measure Recovery Quality

A recommended recovery scorecard is:

Recovery Quality Index = Weighted score of cash recovery + sustainable upgrades + resolution value – haircut cost – recovery delay

This prevents management from focusing only on gross reduction in NPA balances.

8.8 Link Management Incentives to Fresh Slippage

Branch and regional performance scorecards should assign negative weight to new NPAs generated from recent sanctions.

Recommended performance indicators:

fresh-slippage ratio;
recovery ratio;
upgrade sustainability;
collection efficiency;
risk-adjusted ROA;
expected-credit-loss variance;
SMA migration rate.

8.9 Public-Sector Banks: Convert Balance-Sheet Repair into Structural Profitability

Because public-sector-bank asset quality has improved considerably, the next stage should focus on:

operating cost efficiency;
digital servicing;
fee-income growth;
risk-based pricing;
staff productivity;
data-led monitoring;
portfolio optimisation.

The objective should shift from repairing legacy assets to preventing recurrence and increasing risk-adjusted return on performing assets.

8.10 Private-Sector Banks: Avoid Complacency at Low NPA Levels

Private-sector banks should not interpret relatively low GNPA ratios as justification for aggressive credit expansion.

The Asian evidence indicates that excessive loan growth may later increase non-performing loans. Private banks should therefore retain underwriting discipline, especially in unsecured retail, SME and high-growth loan categories.

8.11 Portfolio Diversification

Exposure limits should consider correlation among borrowers rather than only individual borrower quality.

A bank with individually acceptable borrowers can still face concentration risk when all are exposed to the same local industry, commodity or seasonal demand pattern.

8.12 Strengthen Provisioning Discipline

Banks should preserve adequate coverage during good periods rather than allowing declining headline NPAs to create excessive optimism.

Forward-looking provisioning provides a buffer against the credit cycle and reduces future profit volatility.

8.13 Develop a Regional Stressed-Asset Command Centre

Large banks with material exposure in the division could establish a specialised regional monitoring mechanism covering:

large SMA accounts;

high-risk MSMEs;

restructured exposures;

legal recovery;

collateral enforcement;

fraud indicators;

branch slippage trends.

9. Practical Action Matrix for Banks in Agra Division

Table 11. Recommended Implementation Framework

Action	Responsibility	Frequency	Principal KPI	Expected Outcome
District risk heat map	Regional credit office	Quarterly	Sectoral GNPA/SMA	Earlier identification
SMA dashboard	Branch + risk team	Weekly	Migration rate	Lower fresh slippages
High-risk borrower review	Credit committee	Monthly	Exposure reviewed	Improved monitoring
Recovery war-room	Recovery team	Monthly	Cash recovery	Higher resolution
Vintage analysis	Analytics team	Quarterly	NPA by sanction year	Identify underwriting weakness
Risk-adjusted profitability	Finance/risk	Quarterly	RAROA/RAROC	Better capital allocation
Portfolio stress test	Risk team	Half-yearly	Expected loss	Improved resilience
Employee credit training	HR/risk	Half-yearly	Certification rate	Stronger underwriting
Early-warning model validation	Model-risk team	Quarterly/annual	Precision/recall	Better alerts
Board/regional review	Senior management	Quarterly	GNPA, NNPA, PCR, ROA	Stronger governance

10. Conclusion

This study examined the impact of non-performing assets on commercial-bank profitability through a recent comparison of public-sector and private-sector banking performance, with Agra Division serving as the regional managerial setting.

The evidence demonstrates a strong inverse relationship between gross non-performing assets and return on assets. Public-sector banks recorded higher average NPAs and lower average profitability over the five-year analytical period, although their asset quality improved dramatically. Private-sector banks maintained lower NPA ratios and higher ROA, but the analysis confirms that their profitability also responds negatively to increases in credit impairment.

The pooled regression indicates that a one-percentage-point rise in GNPA is associated with an estimated 0.143 percentage-point decline in ROA after ownership is controlled. Bank ownership independently contributes to profitability variation, demonstrating that differences in NPAs do not fully explain the public-private profitability gap.

The findings should not be interpreted as evidence that ownership mechanically determines performance. Instead, ownership captures a wider combination of governance, portfolio structure, operating efficiency, historical exposures, liability composition and institutional mandates.

Recent developments are especially encouraging for India's public-sector banks. Their GNPA ratio fell to approximately 2.6 per cent by March 2025, while private-sector banks stood around 1.8 per cent. The narrowing asset-quality gap demonstrates that sustained regulatory reform, recognition, resolution and improved credit practices can materially change banking outcomes.

For Agra Division, the principal implication is that NPA prevention must become more granular. Agra, Firozabad, Mathura and Mainpuri have different commercial and credit characteristics. A uniform regional strategy is therefore inferior to portfolio monitoring based on district, industry, borrower and loan-vintage characteristics.

Commercial banks should move from retrospective NPA management toward predictive credit-risk management. Early-warning analytics, cash-flow-based underwriting, rapid intervention, risk-adjusted pricing, portfolio diversification, adequate provisioning, recovery quality and branch-level slippage accountability should form the core of this transition.

Ultimately, sustainable profitability does not result from loan growth alone. It arises when credit growth generates performing assets whose risk-adjusted income exceeds funding, operating, provisioning and capital costs. The quality of assets is therefore inseparable from the quality of profits.

11. Limitations and Scope for Future Research

The study has several limitations.

First, the statistical sample consists of aggregated public- and private-sector bank-group observations over five years. Future research may extend the design to individual banks and use panel fixed-effects, random-effects, dynamic-GMM or panel-quantile estimation.

Second, publicly available audited financial statistics do not provide a consistent division-level GNPA-ROA series for Agra Division. Future research may collaborate with banks or obtain authorised branch-level data for Agra, Firozabad, Mathura and Mainpuri.

Third, ROA is the principal profitability variable. Future studies should include ROE, NIM, operating profit to assets, risk-adjusted return on capital and cost-to-income ratio.

Fourth, future studies may model GNPA formation using macroeconomic and local variables including GDP growth, inflation, lending rates, unemployment, agricultural conditions and industry concentration.

Fifth, borrower-level longitudinal data could permit survival analysis, hazard models or machine-learning default prediction.

Sixth, future research may test whether digital lending and automated underwriting reduce or increase subsequent NPA formation.

Seventh, the impact of write-offs, actual cash recoveries and upgrades should be estimated separately because these mechanisms have different economic implications.

12. Extended Statistical Appendix

Appendix A. Input Dataset

Observation	Year	Sector	GNPA (%)	ROA (%)
1	2021	Public	9.1	0.3
2	2022	Public	7.3	0.5
3	2023	Public	5.0	0.8
4	2024	Public	3.5	1.0
5	2025	Public	2.6	1.1
6	2021	Private	4.9	1.1
7	2022	Private	3.8	1.4
8	2023	Private	2.3	1.6
9	2024	Private	1.9	1.9
10	2025	Private	1.8	1.7

Appendix B. Key Statistical Results

Test	Statistic	Result
Public GNPA-ROA correlation	-0.9995	Strong negative
Private GNPA-ROA correlation	-0.9529	Strong negative
Public simple-regression slope	-0.1251	Negative
Public simple-regression R ²	0.9990	Very high
Private simple-regression slope	-0.2141	Negative
Private simple-regression R ²	0.9080	High
ROA Welch t-statistic	-3.941	Significant
ROA Welch p-value	0.0044	Reject H03
ROA Cohen's d	-2.493	Very large
GNPA Welch t-statistic	1.902	Not significant at 5%
GNPA Welch p-value	0.1065	Do not reject H02
GNPA Cohen's d	1.203	Large
Pooled regression R ²	0.967	High
Interaction-model R ²	0.986	High

Appendix C. Regression Equations

Public sector:

$$\text{ROA} = 1.42798 - 0.12509 \text{ GNPA}$$

Private sector:

$$\text{ROA} = 2.16932 - 0.21405 \text{ GNPA}$$

Pooled additive model:

$$\text{ROA} = 1.9610 - 0.1432 \text{ GNPA} - 0.4334 \text{ PUBLIC}$$

Interaction model:

$$\text{ROA} = 2.1693 - 0.2141 \text{ GNPA} - 0.7413 \text{ PUBLIC} + 0.0890(\text{GNPA} \times \text{PUBLIC})$$

Appendix D. Interpretation of Effect Sizes

Absolute Cohen's d	General Interpretation
Around 0.20	Small
Around 0.50	Moderate
Around 0.80	Large
Above 1.00	Very large in practical terms

The observed ROA effect size of 2.493 therefore indicates a substantial ownership-related profitability difference across the selected period.

Appendix E. Recommended Extended Bank-Level Model for Future Research

Future researchers with bank-level data may estimate:

$$\text{ROA}_{it} = \beta_0 + \beta_1 \text{GNPA}_{it} + \beta_2 \text{NNPA}_{it} + \beta_3 \text{CRAR}_{it} + \beta_4 \text{NIM}_{it} + \beta_5 \text{SIZE}_{it} + \beta_6 \text{COST}_{it} + \beta_7 \text{GROWTH}_{it} + \beta_8 \text{GDP}_t + \beta_9 \text{INF}_t + \mu_i + \lambda_t + \varepsilon_{it}$$

where:

GNPA = gross NPA ratio

NNPA = net NPA ratio

CRAR = capital adequacy ratio

NIM = net interest margin

SIZE = logarithm of total assets

COST = operating-cost indicator

GROWTH = loan growth

GDP = real economic growth

INF = inflation

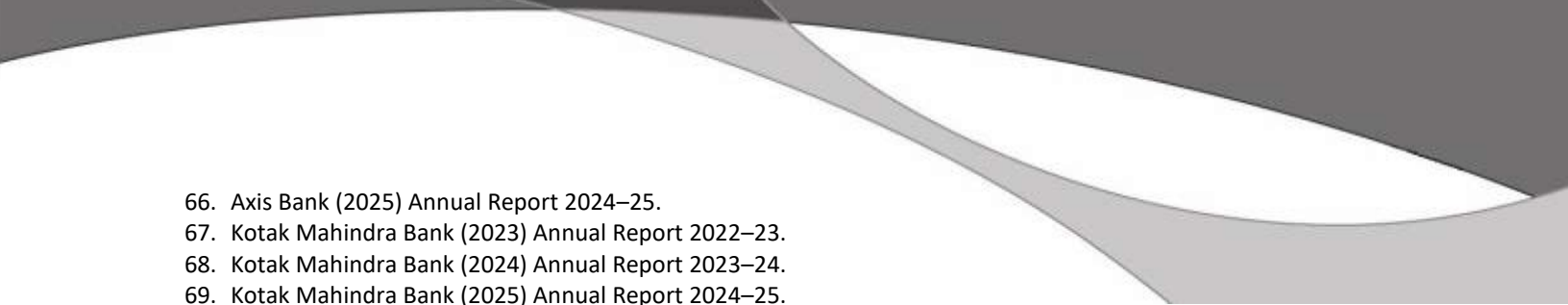
μ = bank fixed effect

λ = time effect

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