IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Determinants of Non-Performing Assets in Selected Public Sector Banks in India: A Panel Data Analysis (2010–2024)

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Abstract

Non-Performing Assets (NPAs) continue to be a major concern for the Indian banking sector, particularly for Public Sector Banks (PSBs), as they adversely affect profitability, lending capacity, capital provisioning, and overall financial stability. Identifying the factors that contribute to the accumulation of NPAs is therefore essential for strengthening asset quality and improving the resilience of the banking system. This study examines the impact of both macroeconomic and bank-specific determinants on the Gross Non-Performing Asset (GNPA) ratio of selected Public Sector Banks in India over the period 2010–2024.

The analysis is based on a balanced panel dataset comprising ten major Public Sector Banks, yielding 150 bank-year observations. Panel data estimation techniques, including Pooled Ordinary Least Squares (OLS), Fixed Effects Model (FEM), Random Effects Model (REM), the Hausman specification test, the Breusch–Pagan Lagrange Multiplier test, and Variance Inflation Factor (VIF) analysis, are employed to ensure robust estimation and appropriate model selection.

The empirical results show that the Inflation Rate, Repo Rate, Bank Size, and Return on Assets significantly influence the Gross NPA Ratio. In contrast, GDP Growth, Credit Growth, and the Capital Adequacy Ratio do not exhibit statistically significant effects during the study period. The Hausman specification test identifies the Random Effects Model as the most appropriate estimator, indicating that unobserved bank-specific effects are not systematically correlated with the explanatory variables.

The findings suggest that sustained improvements in profitability, stronger credit appraisal and monitoring mechanisms, sound risk management practices, and prudent lending policies are critical for reducing the incidence of NPAs in Public Sector Banks. By incorporating the post-Asset Quality Review (AQR) period, the implementation of the Insolvency and Bankruptcy Code (IBC), banking sector consolidation, and the COVID-19 period, the study provides updated empirical evidence on the determinants of NPAs in India. The results offer useful insights for policymakers, regulators, bank managers, and researchers seeking to strengthen financial stability and improve asset quality within the banking sector.

Keywords: Non-Performing Assets, Public Sector Banks, Gross NPA Ratio, Panel Data Analysis, Asset Quality, Random-Effects Model, India.

1 Introduction

The banking sector plays a fundamental role in the functioning of a modern economy. By mobilising savings, allocating financial resources, facilitating payment systems, and supporting productive investment, banks contribute significantly to economic growth and financial development. An efficient banking system strengthens financial intermediation, promotes the optimal allocation of resources, and enhances overall macroeconomic stability.[3] In contrast, weaknesses within the banking sector can restrict the flow of credit, discourage private investment, and ultimately slow the pace of economic development.

Among the numerous challenges faced by banks, the rapid growth of Non-Performing Assets (NPAs) has become one of the most serious concerns affecting the stability and efficiency of the banking industry. A loan is classified as a Non-Performing Asset when the repayment of interest or principal remains overdue beyond the regulatory period specified by the banking regulator.[14] An increase in NPAs places additional pressure on banks by raising provisioning requirements, reducing profitability, weakening capital adequacy, limiting their capacity to extend fresh credit, and eroding investor confidence. As asset quality deteriorates, banks become less capable of supporting productive sectors of the economy, thereby affecting overall financial stability.

The problem of NPAs has become particularly significant in India over the past decade. Public Sector Banks (PSBs), which account for a major share of the country's banking assets, play a pivotal role in financing sectors such as agriculture, infrastructure, manufacturing, and small-scale enterprises. Consequently, any deterioration in the quality of their loan portfolios has far-reaching implications for economic growth, fiscal management, and financial stability.[2] Following the Global Financial Crisis and the subsequent slowdown in domestic investment, Indian banks witnessed a substantial rise in stressed assets. This situation became more evident after the Reserve Bank of India's Asset Quality Review (AQR) in 2015, which led to a more transparent

recognition of stressed loans and a marked increase in reported Gross NPA ratios. In response, several policy initiatives—including the Insolvency and Bankruptcy Code (IBC), bank recapitalisation programs, governance reforms, and the consolidation of Public Sector Banks—were introduced to strengthen the banking system and improve the recovery of distressed assets.

Although macroeconomic conditions significantly influence the level of NPAs, bank-specific characteristics also play an important role in determining asset quality. Variables such as economic growth, inflation, interest rates, and credit expansion directly affect borrowers' repayment capacity as well as the demand for credit. During periods of sustained economic growth, rising business income, stronger employment conditions, and improved financial performance generally enable borrowers to meet their repayment obligations more effectively, thereby reducing default rates. Conversely, economic slowdowns often weaken borrowers' financial positions and contribute to a higher incidence of NPAs. Similarly, changes in the policy repo rate influence borrowing costs and liquidity conditions, affecting both credit demand and repayment behaviour.

Bank-level characteristics are equally important in explaining variations in NPAs across institutions. Factors such as profitability, capital adequacy, operational efficiency, bank size, governance standards, and risk management practices influence the effectiveness of credit appraisal, loan monitoring, and recovery mechanisms. Larger banks generally benefit from more diversified loan portfolios, advanced technological infrastructure, and stronger risk management systems, making them better equipped to manage credit risk. Likewise, banks with stronger profitability are often in a better position to absorb potential credit losses while maintaining prudent lending practices. Therefore, a comprehensive assessment of NPAs requires simultaneous consideration of both macroeconomic conditions and bank-specific factors.

Over the past two decades, research on the determinants of NPAs has expanded considerably. International evidence has consistently identified economic growth, unemployment, inflation, interest rates, and institutional quality as key factors influencing loan defaults. In the Indian context, empirical studies have highlighted the importance of profitability, capital adequacy, operational efficiency, and credit growth in explaining variations in NPAs. However, much of the existing literature was conducted before major structural changes in the Indian banking sector, including the implementation of the Asset Quality Review, the Insolvency and Bankruptcy Code, the consolidation of Public Sector Banks, and the economic disruptions associated with the COVID-19 pandemic. These developments have significantly altered the banking landscape, creating the need for updated empirical evidence that reflects the current institutional and economic environment.

In light of this, the current study examines the factors influencing gross non-performing assets in a subset of Indian public sector banks from 2010 to 2024. Unlike many earlier studies that focused primarily on either macroeconomic variables or bank-specific factors, this research incorporates both sets of determinants within a unified panel-data framework. The use of panel-data techniques enables the analysis to capture variations across banks as well as over time while accounting for unobserved heterogeneity. Appropriate diagnostic and model-selection tests are employed to ensure that the estimated results are both reliable and statistically robust.

The study makes several important contributions to the existing literature. First, it examines a recent fifteen-year period that includes major regulatory reforms and significant economic events affecting the Indian banking sector. Second, it integrates macroeconomic indicators and bank-level financial variables within a single empirical framework, providing a more comprehensive understanding of the determinants of NPAs. Third, it applies established panel-data estimation methods together with appropriate diagnostic procedures to identify the most suitable econometric model. Finally, the findings offer practical policy insights that can assist policymakers, regulators, and bank management in improving asset quality and strengthening the long-term stability of India's Public Sector Banks.

Section 2 reviews the theoretical and empirical literature relating to the determinants of Non-Performing Assets. Section 3 explains the data sources, variables, and econometric methodology adopted in the study. Section 4 presents the empirical results and discusses the major findings. Finally, Section 5 summarizes the key conclusions, outlines the policy implications, identifies the limitations of the study, and suggests directions for future research.

2 Literature Review

Non-Performing Assets (NPAs) have attracted considerable attention in banking and financial research because they serve as an important indicator of the soundness and stability of the banking system. A sustained rise in NPAs adversely affects banks by reducing profitability, weakening capital adequacy, creating liquidity pressures, and limiting their ability to extend fresh credit. Beyond individual banks, deteriorating asset quality can disrupt financial intermediation, slow economic activity, and increase systemic risk within the financial sector. Owing to these wide-ranging consequences, researchers in both developed and developing economies have extensively examined the factors that influence loan defaults and the quality of banking assets.

The existing literature broadly groups the determinants of NPAs into two categories: macroeconomic factors and bank-specific factors. Macroeconomic determinants represent the external economic environment in which borrowers operate, while bank-specific determinants reflect the internal characteristics and management practices of financial institutions. Variables such as economic growth, inflation, interest rates, and credit conditions influence borrowers' repayment capacity, whereas factors including lending policies, operational efficiency, capital adequacy, profitability, and risk management determine how effectively banks assess, monitor, and recover loans. In recent years, panel-data econometric methods have become increasingly popular in this area of research because they combine cross-sectional and time-series information, allowing researchers to control for unobserved heterogeneity and generate more reliable and robust estimates than analyses based solely on cross-sectional or time-series data.

The present section reviews the major theoretical perspectives and empirical evidence on the determinants of Non-Performing Assets. It also highlights the existing research gap and explains how the present study seeks to contribute to the growing body of literature on banking asset quality.

2.1 Theoretical Background

The theoretical understanding of credit risk[15] is rooted in banking theory, information asymmetry, and the theory of financial intermediation. One of the primary functions of commercial banks is to mobilise short-term deposits and channel them into long-term credit while maintaining adequate liquidity and managing the risk of default. In this process, banks often face information asymmetry because borrowers typically possess better knowledge of their financial condition and repayment capacity than lenders. This imbalance of information gives rise to problems such as adverse selection and moral hazard,[3] making careful credit appraisal, continuous monitoring, and effective risk assessment essential components of sound banking operations.

Banking theory suggests that changes in macroeconomic conditions have a direct influence on borrow-ers' ability to repay loans. During periods of economic slowdown or recession, declines in income, employment, and business profitability weaken the financial position of borrowers, thereby increasing the likelihood of loan defaults. In contrast, sustained economic growth generally strengthens repay-ment capacity by improving household income, business performance, and employment opportunities, which in turn contributes to lower default rates and better asset quality.

Portfolio management theory further emphasises that diversification is an effective means of reducing overall credit risk. Banks with larger and more diversified loan portfolios are generally less vulnerable to sector-specific shocks and are therefore expected to maintain lower levels of Non-Performing Assets than institutions whose lending is concentrated in a limited number of sectors. Likewise, theories of bank efficiency argue that well-managed banks are more likely to establish robust internal controls, adopt effective borrower screening procedures, and maintain efficient loan monitoring systems. These institutional strengths enhance credit risk management and reduce the probability of loan defaults.

In conjunction, these theoretical perspectives suggest that the quality of bank assets is influenced by the interplay of internal managerial practices and external macroeconomic conditions. A comprehensive analysis of Non-Performing Assets must therefore consider both the broader economic environment and the operational characteristics of individual banks.

2.2 International Evidence

Early empirical research established that fluctuations in the macroeconomic environment have a significant

influence on the asset quality of banks.[14] Among the pioneering studies, Salas and Saurina (2002)[15] examined commercial and savings banks in Spain and found that GDP growth, rapid credit expansion, and managerial efficiency were important determinants of loan quality.[15] Their analysis demonstrated that changes in Non-Performing Assets cannot be attributed solely to macroeconomic conditions; institutional characteristics also play a crucial role in explaining differences in credit risk across banks.

Berger and DeYoung (1997)[3] introduced the **"bad management hypothesis,"** which argues that deterioration in managerial efficiency is a primary cause of declining loan quality.[3] Their empirical findings showed that banks characterised by lower cost efficiency were more likely to experience higher levels of problem loans in subsequent periods. This suggests that operational inefficiency is not merely a consequence of rising NPAs but often precedes and contributes to the deterioration of asset quality.

Using dynamic panel-data techniques, Louzis, Vouldis, and Metaxas (2012)[11] analysed the Greek banking sector and reported that GDP growth, unemployment, interest rates, and management quality significantly influenced mortgage, consumer, and business loan defaults.[11] Their study underscored the importance of examining macroeconomic conditions alongside bank-specific characteristics to obtain a comprehensive understanding of credit risk.

Makri, Tsagkanos, and Bellas (2014)[12] investigated banking systems across Eurozone countries and observed that unemployment, public debt, and GDP growth had a significant impact on the level of Non-Performing Assets. The study concluded that prolonged economic downturns weaken bank balance sheets, thereby increasing the vulnerability of financial institutions to credit risk.

Similarly, Klein (2013)[9] examined banking sectors in Central, Eastern, and South-Eastern European economies and found that economic growth, inflation, exchange rates, and institutional quality were key determinants of banking sector asset quality. The analysis indicated that countries with stronger macroeconomic fundamentals generally recorded lower NPA ratios, highlighting the importance of a stable economic environment in maintaining sound banking systems.

Drawing on data from a broad cross-country sample, Beck, Jakubik, and Piloiu (2015)[2] identified GDP growth, stock market performance, exchange rate movements, and lending interest rates as major factors influencing non-performing loans. Their findings further reinforced the view that macroeconomic stability is essential for preserving banking sector health and reducing credit risk.

Taken together, the international literature provides consistent evidence that macroeconomic condi-tions, monetary policy, institutional quality, and bank-level managerial performance jointly influence the quality of banking assets. These studies collectively demonstrate that maintaining a stable eco-nomic environment, together with sound institutional practices, is fundamental to controlling the growth of Non-Performing Assets and strengthening financial sector resilience.

2.3 Evidence from India

The issue of Non-Performing Assets has attracted sustained attention in India, largely because Public Sector Banks (PSBs) constitute the backbone of the country's banking system and account for a substantial share of total banking assets.[14] Over the years, a considerable body of empirical research has examined the factors responsible for the accumulation of NPAs, highlighting the influence of both macroeconomic conditions and bank-specific characteristics.

Among the early and influential studies, Rajan and Dhal (2003) examined Public Sector Banks in India and found that favourable macroeconomic conditions contributed to lower levels of NPAs, whereas weak credit discipline and institutional factors accelerated the deterioration of asset quality.[13] Their work demonstrated that the quality of bank assets is shaped not only by economic conditions but also by the effectiveness of institutional and lending practices.

Das and Ghosh (2007) investigated the determinants of credit risk in Indian Public Sector Banks and reported that profitability, operational efficiency, capitalisation, and loan growth significantly affected asset quality.[5] The

study highlighted the importance of managerial efficiency, suggesting that banks with stronger internal management and operational performance were better equipped to contain the growth of Non-Performing Assets.

Subsequent research broadened the scope of analysis by incorporating additional macroeconomic variables. Kumar and Singh (2017) observed that larger Public Sector Banks generally recorded lower Gross NPA ratios, which they attributed to more diversified loan portfolios and stronger credit monitoring systems. At the same time, they cautioned that aggressive lending during periods of economic expansion could lead to higher future credit risk if credit appraisal and screening procedures were not sufficiently rigorous.

Kumar and Rani (2019) analysed Indian commercial banks and found a negative relationship between Non-Performing Assets and indicators such as Return on Assets, Capital Adequacy Ratio, and operational efficiency.[10] Their findings suggested that financially stronger and more efficiently managed banks were more likely to maintain better asset quality and lower levels of loan defaults.

Focusing on the role of macroeconomic conditions, Mishra and Prasad (2020) concluded that GDP growth and inflation significantly influenced credit risk in the Indian banking sector. Their analysis indicated that favourable economic conditions improve borrowers' repayment capacity, thereby reducing the incidence of loan defaults and contributing to healthier bank balance sheets.

Following the implementation of the Insolvency and Bankruptcy Code (IBC), Sharma and Mahajan (2021) reported gradual improvements in the asset quality of the banking sector, although recovery rates differed across industries. They argued that while legal and institutional reforms strengthened the loan recovery process, sustained improvements in asset quality continued to depend on prudent lending practices and effective credit risk management.

More recently, Verma and Gupta (2022) examined the performance of Public Sector Banks in the post-COVID period. Their study found that regulatory support, loan restructuring measures, and enhanced supervisory oversight helped mitigate the adverse impact of the pandemic on the banking sector. Nevertheless, they identified profitability and institutional efficiency as the most important determinants of asset quality, reinforcing the importance of sound bank management in controlling NPAs.

Overall, the empirical evidence from India consistently indicates that both macroeconomic conditions and bank-specific characteristics play a significant role in determining the level of Non-Performing Assets. However, the relative importance of these factors varies across studies, reflecting differences in sample periods, econometric techniques, data coverage, and the institutional environment in which the analyses were conducted.

2.4 Research Gap

Although a substantial body of research has examined the determinants of Non-Performing Assets in the banking sector, several important gaps remain in the existing literature.

First, a large proportion of earlier studies is based on data covering periods before major structural and regulatory reforms transformed the Indian banking sector. Measures such as the Reserve Bank of India's Asset Quality Review (AQR), the enactment of the Insolvency and Bankruptcy Code (IBC), the consolidation of Public Sector Banks, and the economic disruptions caused by the COVID-19 pandemic have significantly reshaped banking operations, credit risk management, and loan recovery mechanisms. As a result, findings derived from earlier datasets may not fully capture the dynamics of the current banking environment, highlighting the need for more recent empirical evidence.

Second, much of the existing literature concentrates either on macroeconomic determinants or on bank-specific characteristics, while comparatively few studies examine both dimensions within a single panel-data framework. Since the quality of bank assets is influenced simultaneously by external economic conditions and internal institutional factors, analysing only one set of determinants may provide an incomplete understanding of the factors driving Non-Performing Assets.

Third, empirical studies have reported mixed results regarding the significance of variables such as GDP growth, inflation, credit growth, and capital adequacy. These differences are often attributable to variations in sample periods, data coverage, model specification, and econometric methodology. In addition, several earlier investigations rely on relatively short time horizons or limited datasets, which may affect the robustness and

generalisability of their findings.

Finally, despite the significant regulatory and structural changes that have taken place in the Indian banking sector, empirical evidence covering the period from 2010 to 2024 remains limited. The present study seeks to address this gap by analysing a balanced panel dataset comprising ten major Public Sector Banks over a fifteen-year period. By integrating both macroeconomic and bank-specific determinants within a comprehensive panel-data framework, the study aims to provide updated and robust evidence on the factors influencing Gross Non-Performing Assets in India.

2.5 Contribution of the Study

The present study makes several meaningful contributions to the existing literature on Non-Performing Assets in India's Public Sector Banks.

First, it provides updated empirical evidence by examining the determinants of Gross NPAs using recent data that encompass major regulatory reforms, the consolidation of Public Sector Banks, and the economic disruptions associated with the COVID-19 pandemic. The study provides a contemporary evaluation of the factors that influence the character of assets in the banking sector by integrating these significant developments.

Second, the analysis adopts a comprehensive approach by integrating both macroeconomic variables—namely GDP Growth Rate, Inflation Rate, Repo Rate, and Credit Growth—and bank-specific variables, including the Capital Adequacy Ratio, Bank Size, and Return on Assets. Examining these two sets of determinants within a unified framework enables a more complete understanding of the factors affecting the quality of bank assets.

Third, the study employs well-established panel-data estimation techniques, including Pooled Ordinary Least Squares (OLS), the Fixed Effects Model (FEM), the Random Effects Model (REM), the Hausman specification test, and the Breusch–Pagan Lagrange Multiplier test. The application of these methods facilitates the selection of the most appropriate econometric model and enhances the reliability and robustness of the empirical findings.

Finally, the study offers practical policy insights that may assist regulators, policymakers, and bank management in strengthening credit risk management practices and improving the long-term stability of India's Public Sector Banking system. The findings also contribute to the broader understanding of the determinants of Gross Non-Performing Assets and provide a useful reference for future research in this area.

2.6 Conceptual Framework

The conceptual framework of this study is based on the premise that the Gross Non-Performing Asset (GNPA) Ratio is influenced by the combined effects of macroeconomic conditions and bank-specific characteristics. Macroeconomic factors affect borrowers' repayment capacity by shaping the overall economic environment through changes in economic growth, inflation, interest rates, and credit conditions. At the institutional level, bank-specific variables such as capitalisation, profitability, operational efficiency, and bank size reflect a bank's ability to assess credit risk, monitor loan performance, and manage potential defaults. The interaction between these external and internal factors ultimately determines the quality of bank loan portfolios and influences the level of Gross Non-Performing Assets.

Accordingly, the framework proposes that favourable macroeconomic conditions, together with stronger institutional performance, are associated with lower levels of Gross Non-Performing Assets in Public Sector Banks. Conversely, adverse economic conditions or weaknesses in bank-level performance are expected to increase credit risk and contribute to a deterioration in asset quality.

The literature reviewed in this chapter indicates that Non-Performing Assets continue to be one of the most important indicators of banking sector stability. Existing empirical studies consistently ac-knowledge the role of both macroeconomic conditions and bank-specific characteristics in explaining variations in loan defaults. However, the reported findings are not always consistent, largely because of differences in data coverage, institutional settings, sample periods, and econometric approaches. These inconsistencies highlight the need for further empirical investigation using recent data and a comprehensive panel-data framework.

Building on the theoretical and empirical evidence discussed in this chapter, the next section describes the data sources, variable definitions, and econometric methodology employed in the present study.

3 Data and Methodology

3.1 Research Design

The present study adopts a quantitative research design to examine the determinants of Gross Non-Performing Assets (GNPAs) in selected Public Sector Banks (PSBs) in India. The analysis seeks to evaluate how both macroeconomic conditions and bank-specific characteristics influence the quality of bank assets by applying panel-data econometric techniques.[1]

Panel data combine cross-sectional observations, represented by individual banks, with time-series observations covering multiple years. This approach offers several advantages over purely cross-sectional or time-series analyses, as it enables the model to account for unobserved heterogeneity across banks while improving the efficiency and reliability of parameter estimates.[17] By capturing both inter-bank differences and changes over time, panel-data analysis provides a more comprehensive framework for examining the factors that affect Gross Non-Performing Assets.

To achieve the study's objectives, three alternative panel regression models are estimated: the Pooled Ordinary Least Squares (Pooled OLS), the Fixed Effects Model (FEM), and the Random Effects Model (REM).[6] Appropriate specification tests are subsequently employed to determine the most suitable econometric model for the analysis. The adoption of these panel-data techniques ensures that the estimation adequately reflects both cross-sectional and temporal variations, thereby providing a more robust assessment of the determinants of Non-Performing Assets in India's Public Sector Banks.

3.2 Research Objectives

The study is guided by the following objectives:

1. To examine the trend and behaviour of Gross Non-Performing Assets among selected Public Sector Banks in India during 2010–2024.
2. To analyse the influence of macroeconomic variables on Gross NPA Ratio.
3. To investigate the impact of bank-specific characteristics on Gross NPA Ratio.
4. To identify the most appropriate panel-data model for explaining variations in NPAs.
5. To provide policy recommendations for improving asset quality in Public Sector Banks.

3.3 Research Hypotheses

Based on the theoretical and empirical literature, the following hypotheses are tested.

Macroeconomic Variables

- **H1:** GDP Growth Rate has a significant effect on the Gross NPA Ratio.
- **H2:** Inflation Rate has a significant effect on the Gross NPA Ratio.
- **H3:** Repo Rate has a significant effect on the Gross NPA Ratio.
- **H4:** Credit Growth has a significant effect on the Gross NPA Ratio.

Bank-Specific Variables

- **H5:** Capital Adequacy Ratio has a significant effect on the Gross NPA Ratio.
- **H6:** Bank Size has a significant effect on the Gross NPA Ratio.
- **H7:** Return on Assets has a significant effect on the Gross NPA Ratio.

3.4 Data Sources

The analysis is based entirely on secondary data collected from reliable and publicly available sources. Bank-specific financial information was compiled from the annual reports of the selected Public Sector Banks and publications of the Reserve Bank of India (RBI). Macroeconomic indicators were obtained from the World Bank's World Development Indicators and RBI publications.

The study covers the period **2010–2024**, providing a balanced panel that captures major developments in the Indian banking sector, including the Asset Quality Review (AQR), implementation of the Insolvency and Bankruptcy Code (IBC), consolidation of Public Sector Banks, and the COVID-19 pandemic.

3.5 Sample Selection

The sample consists of ten major Public Sector Banks that operated consistently throughout the study period and for which complete data were available.

The banks included in the analysis are:

1. State Bank of India
2. Punjab National Bank
3. Bank of Baroda
4. Canara Bank
5. Union Bank of India
6. Indian Bank
7. Bank of India
8. UCO Bank
9. Central Bank of India
10. Punjab & Sind Bank

The study period spans fifteen years (2010–2024), resulting in a balanced panel of:

- Number of Banks = 10
- Number of Years = 15
- Total Observations = 150

3.6 Variable Description

Dependent Variable

The dependent variable is the **Gross Non-Performing Asset Ratio (Gross_NPA_Ratio)**, measured as:

$$\text{Gross NPA Ratio} = \frac{\text{Gross Non-Performing Assets}}{\text{Gross Advance}} \times 100$$

The Gross NPA Ratio is one of the most widely used indicators of banking sector asset quality and reflects the proportion of loans that have become non-performing.

Independent Variables

The explanatory variables are divided into macroeconomic and bank-specific factors.

Variable	Symbol	Expected Relationship
GDP Growth Rate	GDP	Negative
Inflation Rate	INF	Ambiguous

Repo Rate	REPO	Ambiguous
Credit Growth	CG	Negative
Capital Adequacy Ratio	CAR	Negative
Bank Size (Log of Total Assets)	SIZE	Negative
Return on Assets	ROA	Negative

Table 1: Independent Variable's relation

GDP Growth represents overall economic performance and is expected to improve borrowers' repayment capacity. Inflation influences real debt burdens and repayment behavior. The repo rate captures the monetary policy stance of the Reserve Bank of India and affects borrowing costs. Credit growth reflects lending expansion, while the capital adequacy ratio measures the financial strength of banks. Bank Size captures economies of scale and diversification benefits, and return on assets reflects managerial efficiency and profitability.

3.7 Econometric Model

To estimate the determinants of Gross NPAs, the following panel-data regression model is specified:

$$GNPA_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 INF_{it} + \beta_3 REPO_{it} + \beta_4 CG_{it} + \beta_5 CAR_{it} + \beta_6 SIZE_{it} + \beta_7 ROA_{it} + \epsilon_{it}$$

where:

- $GNPA_{it}$ = Gross NPA[14] Ratio for bank i in year t.
- GDP_{it} = GDP Growth Rate[2]
- INF_{it} = Inflation Rate[11]
- $REPO_{it}$ = Repo Rate[14]
- CG_{it} = Credit Growth[13]
- CAR_{it} = Capital Adequacy Ratio[16]
- $SIZE_{it}$ = Bank Size[15]
- ROA_{it} = Return on Assets[3]
- β = Intercept
- $\beta_1 - \beta_7$ = Regression coefficients
- ϵ_{it} = Error term

The coefficients measure the marginal effect of each explanatory variable on the Gross NPA Ratio while holding the remaining variables constant.

3.8 Estimation Procedure

Three alternative panel-data estimators[1] are employed.

3.8.1 Pooled Ordinary Least Squares (Pooled OLS)

The Pooled OLS model assumes that all observations share a common intercept and ignores bank-specific heterogeneity[7]. It serves as a benchmark model for comparison with panel estimators.

3.8.2 Fixed Effects Model (FEM)

The fixed-effects model controls for unobserved, time-invariant characteristics spe-cific to individual banks[1]. It allows each bank to have its own intercept, thereby eliminating omitted-variable bias arising from unobserved bank-specific factors.

3.8.3 Random Effects Model (REM)

The Random Effects Model assumes that individual-specific effects are random and uncorrelated with the explanatory variables[17]. Compared with the Fixed Effects Model, REM is more efficient when this assumption holds because it uses both within-bank and between-bank variation.

3.9 Diagnostic Tests

To ensure the reliability of the empirical estimates, several diagnostic tests are conducted.

3.9.1 Correlation Analysis

A correlation matrix is computed to examine the pairwise relationships among the variables and to identify any strong linear associations.

3.9.2 Variance Inflation Factor (VIF)

Multicollinearity is assessed using the variance inflation factor[7]. The estimated VIF values range from **1.222** to **1.886**, well below the commonly accepted threshold of 5, indicating that multicollinearity is not a concern in the estimated models.

3.9.3 Hausman Specification Test

The Hausman test is used to determine whether the Fixed Effects Model or the Random Effects Model is more appropriate[8].

The null hypothesis states that the Random Effects estimator is consistent. The test results are:

- Hausman Statistic = **0.3079**
- p-value = **0.9999**

Since the p-value is substantially greater than 0.05, the null hypothesis cannot be rejected. Accordingly, the random effects model is selected as the preferred estimator.

3.9.4 Breusch–Pagan Lagrange Multiplier Test

The Breusch–Pagan LM test evaluates whether panel effects are present[4]. The results are:

- LM Statistic = **33.941**
- p-value **< 0.001**

The null hypothesis of no panel effects is rejected, indicating that panel-data estima-tion is more appropriate than the Pooled Ordinary Least Squares (OLS) model for the present analysis.

All empirical analyses were carried out using Python. The processes of data man-agement, statistical analysis,

and model estimation were performed with the support of several widely used Python libraries, including **Pandas**, **NumPy**, **Statsmodels**, **Linearmodels**, **Matplotlib**, **Seaborn**, and **SciPy**. These libraries facilitated data preprocessing, descriptive statistical analysis, correlation analysis, multicollinearity diagnostics, panel-data estimation, model selection, and the graphical presentation of empirical results.

The methodological framework used for the study, including the research design, data sources, sample selection, variable definitions, econometric specification, estimating techniques, and diagnostic tests, has been described in this chapter. The balanced panel dataset, comprising ten Public Sector Banks observed over the period 2010–2024, provides a robust basis for examining the determinants of Gross Non-Performing Assets. By applying Pooled OLS, Fixed Effects, and Random Effects models, together with appropriate specification and diagnostic tests, the study establishes a rigorous empirical framework for identifying the factors that influence asset quality in India's Public Sector Banks. The next chapter presents the empirical results and discusses their implications in light of the study's objectives and the existing literature.

4 Empirical Results and Discussion

This chapter presents the empirical findings of the study and examines the relationship between the Gross Non-Performing Asset (GNPA) Ratio and the selected macroeconomic and bank-specific variables. The analysis is organized in a systematic manner, beginning with descriptive statistics and the trend in the Gross NPA Ratio, followed by correlation analysis, multicollinearity diagnostics, and the estimation of panel regression models. The primary objective is to identify the factors that significantly influence the Gross NPA Ratio of selected Public Sector Banks in India over the period 2010–2024.

A balanced panel dataset including 150 observations from ten Public Sector Banks over a fifteen-year period serves as the foundation for the this study. Panel-data estimation techniques are employed because they utilize both cross-sectional and time-series information, enabling the analysis to capture variations across banks as well as changes over time. This approach provides more efficient and reliable parameter estimates than conventional regression methods and offers a stronger empirical basis for analyzing the determinants of Gross Non-Performing Assets.

This analysis is based on a balanced panel dataset comprising **150 observations**, representing **10 public sector banks observed over 15 years**. Panel-data estimation techniques are implemented due to their ability to incorporate both cross-sectional and time-series variation, which results in more reliable and efficient estimates than traditional regression methods.

4.1 Descriptive Statistics

Table 4.1 presents the descriptive statistics for the dependent variable and all explanatory variables included in the empirical model. These statistics provide an overview of the distribution, central tendency, and variability of the data, offering a preliminary understanding of the characteristics of the sample before proceeding to the regression analysis.

Variable	Count	Mean	Std._ Dev.	Minimum	Q1(25%)	Median	Q3(75%)	Maximum
Gross_NPA_Ratio	150	7.94	5.604	0	3.397	6.356	11.447	28.426
GDP Growth	150	6.238	3.554	-5.778	5.456	6.795	8.256	9.69
Inflation Rate	150	6.465	2.478	3.328	4.907	5.649	8.912	11.989
Repo Rate	150	6.443	1.309	4	6	6.5	8	8.5
Credit Growth	150	11.513	13.569	-22.56	4.448	11.587	16.619	87.584
CAR	150	13.313	2.41	0.12	11.862	13.105	14.632	18.54
Bank Size	150	13.163	0.984	11.135	12.482	13.108	13.713	15.714
Return on Assets	150	-0.367	1.292	-5.504	-0.877	0.043	0.488	1.199

Table 2: Descriptive Statistics

The Gross Non-Performing Asset (GNPA) Ratio shows considerable variation across the selected Public Sector Banks and over the study period, reflecting differences in lending behaviour, sectoral exposure, and prevailing macroeconomic conditions. The descriptive statistics indicate an average GNPA Ratio of approximately 11.45%, with values ranging from 3.40% to 28.43%. This wide range highlights the substantial heterogeneity in asset quality among the banks included in the sample.

The GDP Growth Rate records an average value of 6.24%, with observations ranging from -5.78% to 9.69%. The negative growth rate corresponds to the economic con-traction experienced during the COVID-19 pandemic, demonstrating the significant macroeconomic fluctuations that occurred during the study period.

The Inflation Rate has an average value of 6.47%, varying between 3.33% and 11.99%. Likewise, the Repo Rate ranges from 4.00% to 8.50%, reflecting changes in the monetary policy stance of the Reserve Bank of India over time. The observed variation in these macroeconomic indicators provides sufficient temporal diversity for examining their influence on the asset quality of Public Sector Banks.

Among the bank-specific variables, Credit Growth exhibits relatively high variability, with a standard deviation of approximately 13.57, indicating notable differences in lending expansion across banks and over different years. The Capital Adequacy Ratio averages 13.31%, suggesting that most of the sample banks maintained capital levels above the regulatory minimum prescribed during the study period. Bank Size also displays moderate variation, reflecting differences in the scale of operations and total assets of the selected Public Sector Banks. In contrast, the Return on Assets (ROA) records a negative mean value, indicating that several banks experienced periods of financial stress and weak profitability during the sample period.

Overall, the descriptive statistics reveal sufficient variation in both the macroeconomic and bank-specific variables included in the analysis. This diversity enhances the suitability of the balanced panel dataset for panel-data regression analysis and provides a sound basis for examining the determinants of Gross Non-Performing Assets.

4.2 Trend of Gross Non-Performing Assets

Figure 1 illustrates the trend in the average Gross Non-Performing Asset (GNPA) Ratio of the selected Public Sector Banks over the period 2010–2024. The figure indicates that the quality of bank assets did not remain constant during the study period but underwent noticeable changes in response to both economic conditions and policy developments.

During the initial years of the sample period, the average Gross NPA Ratio remained at a relatively moderate level. However, from around 2014, a sharp increase in NPAs became evident. This rise can be attributed to the recognition of stressed assets, the weakening of corporate balance sheets, and the slowdown in economic activity. The introduction of the Reserve Bank of India's Asset Quality Review (AQR) further accelerated the identification and reporting of previously unrecognized stressed loans, leading to a significant increase in the reported Gross NPA Ratio.

In the subsequent years, the implementation of the Insolvency and Bankruptcy Code (IBC), bank recapitalization initiatives, and the consolidation of Public Sector Banks contributed to a gradual improvement in asset quality. Although the COVID-19 pandemic created considerable uncertainty for the banking sector, timely regulatory interventions and loan restructuring measures helped contain a further deterioration in the quality of bank assets during the latter part of the study period.

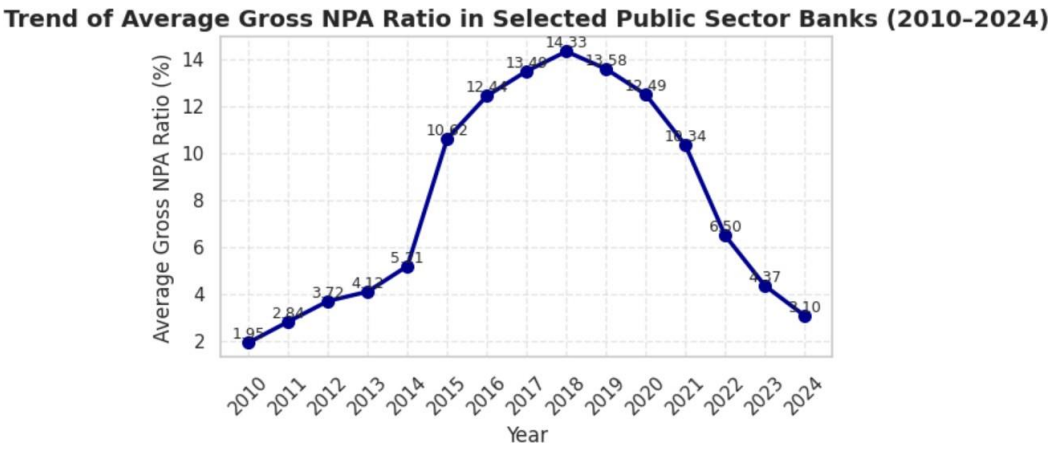

Figure 1: Trend of NPAs

Overall, the trend depicted in Figure 1 suggests that the movement in the Gross NPA Ratio was influenced by the combined effects of changing macroeconomic conditions and institutional reforms. The observed pattern underscores the importance of both economic stability and effective regulatory measures in improving asset quality and strengthening the resilience of India's Public Sector Banks.

4.3 Correlation Analysis

The pairwise correlation matrix was computed to examine the linear relationships among the variables included in the study. This preliminary analysis provides an initial understanding of the direction and strength of the associations between the dependent and explanatory variables before estimating the panel regression models.

The results indicate that the **Gross Non-Performing Asset (GNPA) Ratio** is negatively correlated with most of the explanatory variables, particularly **Return on Assets (ROA), Inflation Rate, Repo Rate,** and **Bank Size**. Among these, the strongest negative association is observed between the GNPA Ratio and ROA, suggesting that banks with higher profitability generally tend to report lower levels of Non-Performing Assets. This finding supports the view that profitable and efficiently managed banks are better positioned to maintain effective credit appraisal, loan monitoring, and recovery mechanisms.

A negative relationship is also observed between **Bank Size** and the GNPA Ratio. This suggests that larger Public Sector Banks, owing to their diversified loan portfolios, stronger institutional capacity, and more advanced risk management practices, are generally better equipped to manage credit risk. Similarly, the negative correlations of the **Inflation Rate** and **Repo Rate** with the dependent variable indicate that changes in the macroeconomic environment and monetary policy are associated with variations in banking sector asset quality during the study period.

Although several explanatory variables exhibit meaningful correlations with the Gross NPA Ratio, the magnitude of the pairwise correlation coefficients is not sufficiently high to indicate the presence of serious multicollinearity. This prelimi-

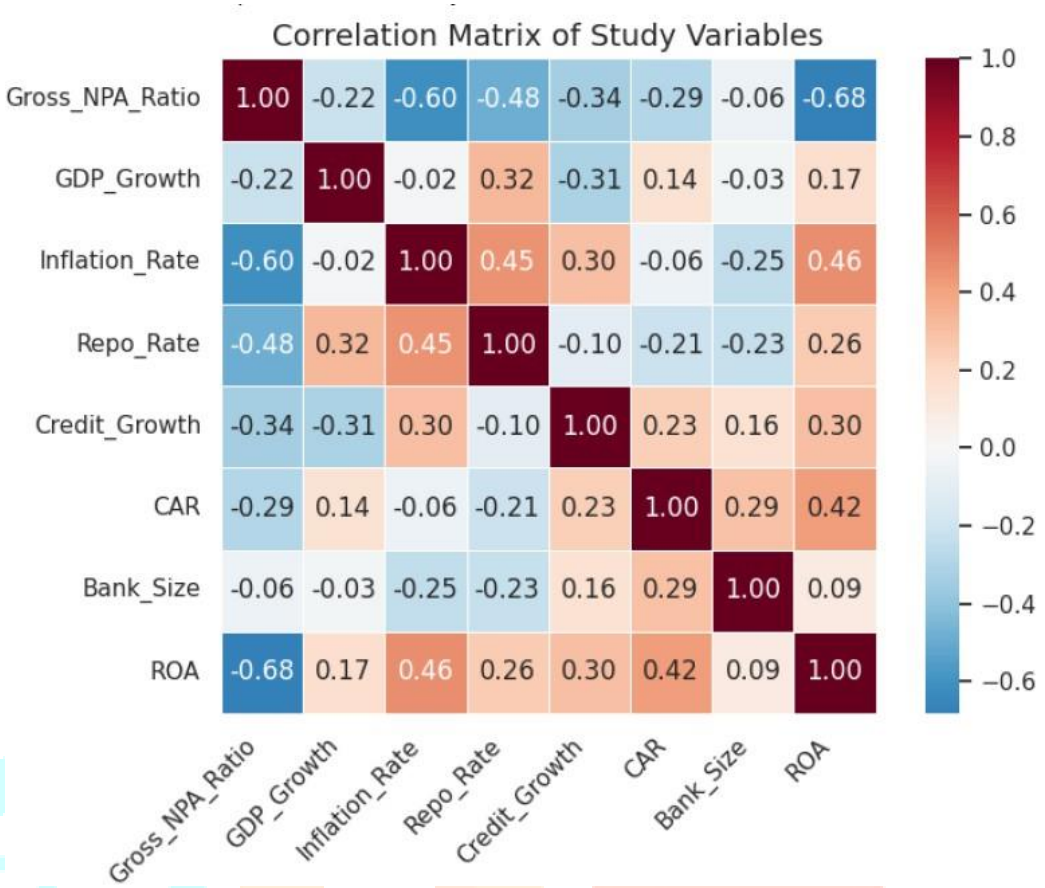

Figure 2: Correlation Heatmap

nary assessment is further confirmed through the **Variance Inflation Factor (VIF)** analysis presented in the following subsection.

4.4 Multicollinearity Diagnostics

Before estimating the panel regression models, the possibility of multicollinearity among the explanatory variables was assessed using the **Variance Inflation Factor (VIF)**. This diagnostic test helps determine whether a high degree of linear association exists among the independent variables, which could affect the reliability of the estimated regression coefficients.

The estimated VIF values range from **1.22** to **1.89**, which are well below the conventional threshold value of **5**. These results indicate that none of the explanatory variables exhibits a level of multicollinearity that would raise concerns regarding the stability of the regression estimates.

The relatively low VIF values suggest that each explanatory variable contributes unique information to the empirical model and that the regression coefficients are unlikely to be influenced by strong linear relationships among the regressors. Consequently, the estimated effects of the explanatory variables can be interpreted with greater confidence.

Based on these diagnostic results, all explanatory variables were retained for the subsequent panel-data regression analysis.

4.5 Pooled Ordinary Least Squares Results

The **Pooled Ordinary Least Squares (OLS)** model is initially estimated to provide a benchmark against which the Fixed Effects and Random Effects models can be compared. Although this approach offers useful preliminary insights into the relationship between the explanatory variables and the Gross Non-Performing Asset (GNPA) Ratio, it does not account for unobserved bank-specific characteristics that may influence asset quality.

The estimated regression model is statistically significant overall, as indicated by the **F-statistic ($F = 49.21$, $p < 0.001$)**. This result suggests that the explanatory variables, when considered jointly, explain a substantial proportion of the variation in the Gross NPA Ratio across the selected Public Sector Banks.

Among the macroeconomic variables, both the **Inflation Rate ($\beta = -0.6970$, $p < 0.001$)** and the **Repo Rate ($\beta = -1.2914$, $p < 0.001$)** exhibit statistically significant negative coefficients. These findings indicate that changes in the macroeconomic environment and monetary policy are significantly associated with variations in banking sector asset quality during the study period.

With respect to the bank-specific variables, **Bank Size ($\beta = -0.6387$, $p = 0.0259$)** and **Return on Assets ($\beta = -1.4024$, $p < 0.001$)** are found to have statistically significant negative effects on the Gross NPA Ratio. The negative coefficient of **Bank Size** suggests that larger Public Sector Banks generally maintain lower levels of Gross NPAs, possibly because of greater portfolio diversification, stronger institutional capacity, and more effective risk management practices. Likewise, the negative relationship between **Return on Assets** and the Gross NPA Ratio indicates that more profitable banks tend to experience fewer loan defaults, reflecting stronger financial performance and more effective credit management.

In contrast, **GDP Growth**, **Credit Growth**, and the **Capital Adequacy Ratio** do not exhibit statistically significant effects in the Pooled OLS specification. Within the sample period, these variables do not appear to have a measurable influence on the Gross NPA Ratio under this estimation approach.

Although the Pooled OLS model provides useful baseline evidence, it assumes that all sample banks are homogeneous and therefore ignores unobserved bank-specific heterogeneity. To account for these unobservable characteristics and obtain more reliable estimates, the analysis proceeds with the estimation of the **Fixed Effects** and **Random Effects** models.

4.6 Fixed Effects Model

The Fixed Effects Model (FEM) is estimated to account for unobserved, time-invariant heterogeneity across the selected Public Sector Banks. Unlike the Pooled Ordinary Least Squares (OLS) approach, the Fixed Effects estimator allows each bank to have its own intercept, thereby controlling for unobservable character-istics that remain constant over time, such as organisational culture, managerial practices, ownership structure, and institutional policies. Since these factors may influence lending behaviour and the quality of bank assets, the Fixed Effects Model provides a more appropriate framework for analysing the determinants of Gross Non-Performing Assets (GNPAs).

The model is estimated using the Panel OLS estimator with entity fixed effects and clustered standard errors to obtain robust statistical inference. The estimated within R^2 of 0.7151 indicates that approximately 71.51% of the variation in the Gross NPA Ratio within individual banks is explained by the explanatory variables included in the model. Furthermore, both the conventional F-statistic (47.70, $p < 0.001$) and the robust F-statistic (65.271, $p < 0.001$) confirm that the model is statistically significant, demonstrating that the explanatory variables jointly explain a substantial proportion of the variation in Gross NPAs.

An important diagnostic reported by the Panel OLS estimation is the F-test for poolability, which produces a value of 4.0440 ($p = 0.0001$). The null hypothesis of this test assumes that all banks share a common intercept, implying that the Pooled OLS specification is adequate. Since the null hypothesis is rejected, the results provide evidence of significant bank-specific effects. This suggests that estimating a pooled regression without accounting for these individual differences would lead to model misspecification.

The estimated coefficient of GDP Growth Rate is negative ($\beta = -0.1543$), indicating that stronger economic growth

is associated with a lower Gross NPA Ratio. However, the relationship is not statistically significant at the 5% significance level (p = 0.1101). This finding suggests that, after controlling for bank-specific characteristics, annual variations in economic growth do not independently explain differences in Gross NPAs across the selected Public Sector Banks during the study period. A possible explanation is that regulatory interventions, loan restructuring measures, and institutional reforms implemented during the sample period may have moderated the direct influence of economic growth on banking sector asset quality. This table presents the estimated coefficients of the Fixed Effects Model.

Variable	Coefficient	t-Statistic	p-value	Interpretation
GDP Growth	-0.1543	-1.6083	0.1101	Not Significant
Inflation Rate	-0.7214	-4.2070	0.0000	Significant
Repo Rate	-1.1964	-4.0376	0.0001	Significant
Credit Growth	-0.0432	-0.9453	0.3462	Not Significant
Capital Adequacy Ratio	-0.0179	-0.1570	0.8755	Not Significant
Bank Size	-1.9094	-2.1623	0.0324	Significant
Return on Assets	-1.9810	-3.5172	0.0006	Significant

Table 3: Fixed Effects Regression Results

The Inflation Rate has a statistically significant negative coefficient (β = -0.7214, p < 0.001). This result indicates that a one-percentage-point increase in inflation is associated with an average decline of approximately 0.72 percentage points in the Gross NPA Ratio, holding other variables constant. Although inflation is often associated with increased financial stress, moderate inflation may improve nominal incomes, business revenues, and borrowers' debt-servicing capacity, thereby reducing loan defaults. The observed relationship also reflects the complex interaction between inflation, monetary policy, and banking sector performance during the study period.

Similarly, the Repo Rate exhibits a statistically significant negative effect (β = - 1.1964, p = 0.0001). The results suggest that changes in the policy interest rate are significantly associated with movements in the Gross NPA Ratio. During the sample period, increases in the Repo Rate frequently coincided with phases of monetary normalisation and improving macroeconomic conditions. Therefore, the negative coefficient is likely to capture the broader effects of economic stabilisation rather than the isolated impact of higher borrowing costs.

The coefficient of Credit Growth is also negative (β = -0.0432) but is not statistically significant (p = 0.3462). This finding implies that, after accounting for other macroeconomic and bank-specific factors, the expansion of lending by itself does not significantly influence the Gross NPA Ratio. It further suggests that the quality of credit appraisal, monitoring, and risk management may be more important than the pace of credit expansion in determining asset quality.

Likewise, the Capital Adequacy Ratio (CAR) shows a negative but statistically insignificant relationship with Gross NPAs (β = -0.0179, p = 0.8755). Although banks with stronger capital positions are generally expected to manage credit risk more effectively, the results indicate that differences in capital adequacy among the selected Public Sector Banks do not significantly explain variations in asset quality during the study period.

Among the bank-specific variables, Bank Size has a statistically significant negative coefficient (β = -1.9094, p = 0.0324). This finding indicates that larger Public Sector Banks generally maintain lower Gross NPA Ratios than their smaller counterparts. A possible explanation is that larger institutions benefit from more diversified loan portfolios, stronger internal control systems, advanced risk management practices, and superior technological capabilities, all of which contribute to better credit risk management.

Return on Assets (ROA) emerges as one of the most influential determinants of Gross NPAs. The estimated coefficient is negative and highly significant (β = -1.9810, p = 0.0006), indicating that improvements in profitability are associated with substantial reductions in the Gross NPA Ratio. Specifically, a one-percentage-point increase in ROA corresponds to an average decline of approximately 1.98 percentage points in Gross NPAs. This finding is consistent with the "bad management hypothesis," which argues that efficiently managed banks are more successful in maintaining healthier loan portfolios through effective credit appraisal, monitoring,

and recovery practices.

Overall, the Fixed Effects estimation identifies the Inflation Rate, Repo Rate, Bank Size, and Return on Assets as statistically significant determinants of Gross NPAs. In contrast, GDP Growth, Credit Growth, and the Capital Adequacy Ratio do not exhibit statistically significant effects after controlling for unobserved bank-specific heterogeneity. These findings suggest that institutional characteristics and bank profitability play a more prominent role than several macroeconomic variables in explaining differences in asset quality across the selected Public Sector Banks.

Although the Fixed Effects Model effectively controls for unobserved heterogeneity, it assumes that the bank-specific effects are correlated with the explanatory variables. The validity of this assumption is examined in the following subsection through a comparison with the Random Effects Model using the Hausman specification test.

4.7 Random Effects Model (Preferred Model)

The **Random Effects Model (REM)** is estimated to examine the determinants of the Gross Non-Performing Asset (GNPA) Ratio while accounting for unobserved bank-specific effects that are assumed to be uncorrelated with the explanatory variables. Under this assumption, the Random Effects estimator utilises both within-bank and between-bank variation, making it more efficient than the Fixed Effects estimator when its underlying assumptions are satisfied.

The estimated model performs well, explaining approximately **70.81%** of the variation in the Gross NPA Ratio. In addition, the overall regression is statistically significant, indicating that the selected macroeconomic and bank-specific variables jointly explain a substantial proportion of the variation in asset quality across the sample banks.

The regression results show that the **Inflation Rate (β = -0.6801, p < 0.001)**, **Repo Rate (β = -1.1864, p = 0.0001)**, **Bank Size (β = -1.2462, p = 0.0128)**, and **Return on Assets (ROA) (β = -1.8736, p = 0.0003)** have statistically significant negative effects on the Gross NPA Ratio. By contrast, **GDP Growth Rate**, **Credit Growth**, and the **Capital Adequacy Ratio (CAR)** are not statistically significant at the **5%** significance level.

The negative and statistically significant coefficient of the **Inflation Rate** suggests that moderate inflation during the study period may have improved borrowers' nominal income and repayment capacity, thereby contributing to lower levels of loan defaults. Similarly, the negative coefficient of the **Repo Rate** indicates that changes in monetary policy were associated with improvements in banking sector asset quality. As discussed in the Fixed Effects analysis, this relationship is likely to reflect broader macroeconomic stabilisation rather than the isolated effect of higher policy interest rates.

Among the bank-specific variables, **Bank Size** exhibits a significant negative relationship with the Gross NPA Ratio, implying that larger Public Sector Banks generally maintain better asset quality than smaller institutions. This finding may be attributed to greater portfolio diversification, stronger risk management systems, more effective credit monitoring, and superior institutional capacity. **Return on As-sets (ROA)** records the largest negative coefficient among the explanatory variables, indicating that more profitable banks tend to maintain substantially lower levels of Non-Performing Assets. This result reinforces the view that managerial efficiency and sound financial performance play a critical role in improving loan quality and limiting credit risk.

Overall, the Random Effects estimation identifies the **Inflation Rate, Repo Rate, Bank Size**, and **Return on Assets** as the principal determinants of Gross NPAs, whereas **GDP Growth Rate**, **Credit Growth**, and the **Capital Adequacy Ratio** do not exhibit statistically significant independent effects. Since the Random Effects estimator incorporates both within-bank and between-bank variation, it provides relatively efficient estimates when the assumption of no correlation between the unobserved bank-specific effects and the explanatory variables holds.

The coefficient estimates obtained from the Random Effects Model are broadly consistent with those reported under the Fixed Effects specification, particularly with respect to the direction and significance of the key

explanatory variables. The final choice between the two models is therefore based on the **Hausman specification test**, the results of which are presented in the following section.

4.8 Hausman Specification Test

The **Hausman Specification Test** was conducted to determine the most appropriate panel-data estimator for the study by comparing the **Fixed Effects Model (FEM)** and the **Random Effects Model (REM)**. The null hypothesis of the test states that the Random Effects estimator is both consistent and efficient because the unobserved individual effects are uncorrelated with the explanatory variables. The alternative hypothesis, in contrast, favors the Fixed Effects estimator, implying that such correlation exists.

The test produced a **Hausman test statistic (η^2) of 0.3079** with a **p-value of 0.9999**. Since the p-value is substantially higher than the conventional **5% significance level**, the null hypothesis cannot be rejected. This result indicates that there is no statistically significant difference between the coefficient estimates obtained from the Fixed Effects and Random Effects models. Consequently, the assumptions underlying the Random Effects Model appear to be satisfied for the present dataset.

Based on these findings, the **Random Effects Model** is selected as the preferred specification for interpreting the determinants of Gross Non-Performing Assets. Compared with the Fixed Effects Model, the Random Effects estimator is more efficient because it utilises both the variation across banks and the variation over time while accounting for unobserved bank-specific heterogeneity. The consistency of the coefficient estimates across both models further strengthens confidence in the robustness of the empirical results.

Accordingly, the interpretation of the regression findings and the policy implications discussed in this study are based primarily on the estimates obtained from the Random Effects Model.

4.9 Diagnostic Tests

To ensure the reliability and validity of the estimated panel regression models, diagnostic tests for multicollinearity, heteroscedasticity [4], and serial correlation were conducted.

4.9.1 Variance Inflation Factor (VIF)

Multicollinearity was examined using the Variance Inflation Factor (VIF). The VIF values for all explanatory variables ranged between **1.22 and 1.89**, which are well below the commonly accepted threshold of 5. This indicates that multicollinearity is not a concern and that the explanatory variables provide independent information for estimating the determinants of Gross NPAs.

4.9.2 Breusch–Pagan Test for Heteroscedasticity

The Breusch–Pagan test was employed to examine whether the regression residuals exhibit constant variance. The test produced an **LM statistic of 33.9410** and an **F-statistic of 5.9325**, with both corresponding **p-values below 0.001.** There-fore, the null hypothesis of homoscedasticity is rejected, indicating the presence of heteroscedasticity in the data. To address this issue, **heteroscedasticity-robust standard errors** were employed in the regression analysis, ensuring reliable statistical inference.

4.9.3 Serial Correlation Test

Serial correlation was examined using the **Wooldridge test for autocorrelation in panel data**.[17] The test results did not provide statistically significant evidence of first-order serial correlation in the model residuals. This indicates that the assumption of independence of the error terms over time is satisfied, thereby supporting the reliability and consistency of the estimated panel regression coefficients.

Taken together, the diagnostic tests suggest that the estimated panel regression models are econometrically sound and suitable for empirical analysis. Although the presence of heteroscedasticity was detected, its potential

impact on statistical inference was effectively addressed through the use of robust standard errors. In addition, the absence of serious multicollinearity and serial correlation provides further confidence in the stability and validity of the estimated regression results.

4.10 Discussion of Results

The empirical findings of the present study are broadly consistent with the existing literature on the determinants of Non-Performing Assets (NPAs) in the banking sector. The analysis identifies the **Inflation Rate, Repo Rate**, **Bank Size**, and **Return on Assets (ROA)** as significant determinants of Gross NPAs, whereas **GDP Growth Rate**, **Credit Growth**, and the **Capital Adequacy Ratio (CAR)** do not exhibit statistically significant effects for the selected Public Sector Banks during the study period.

The significant negative relationship between **Return on Assets** and the Gross NPA Ratio[3] is consistent with the **Bad Management Hypothesis** proposed by Berger and DeYoung (1997). Their argument that better-managed and more profitable banks maintain healthier loan portfolios through effective credit appraisal, monitoring, and recovery practices is supported by the present findings. Similar conclusions have also been reported by Das and Ghosh (2007) and Kumar and Rani (2019), who identified bank profitability as an important determinant of credit risk in the Indian banking sector.

The negative and statistically significant coefficient of **Bank Size**[9] is in line with the findings of Salas and Saurina (2002) and Klein (2013). These studies concluded that larger banks generally experience lower levels of credit risk because of their diversified loan portfolios, stronger governance structures, and more advanced risk management systems. The results of the present study suggest that these advantages are also evident among India's Public Sector Banks, where larger institutions appear better equipped to manage credit risk and maintain asset quality.

Among the macroeconomic variables, the significant effects of the **Inflation Rate** and the **Repo Rate**[11] highlight the importance of the broader economic environment in influencing banking sector asset quality. This finding broadly agrees with the work of Louzis, Vouldis, and Metaxas (2012) and Beck, Jakubik, and Piloiu (2015), who reported that macroeconomic conditions play a significant role in shaping loan repayment behaviour and banking sector stability. However, the negative coefficient of inflation differs from the findings of some earlier studies, suggesting that the relationship between inflation and Non-Performing Assets may vary depending on prevailing economic conditions, monetary policy, and the institutional environment during the period of analysis.

The statistically insignificant effects of **GDP Growth Rate**, **Credit Growth**, and the **Capital Adequacy Ratio** differ from the conclusions reported by Rajan and Dhal (2003)[13] and Makri, Tsagkanos, and Bellas (2014).[12] These differences may reflect variations in the sample period, data coverage, econometric methodology, and institutional context. In particular, the inclusion of important developments such as the **Asset Quality Review (AQR)**, the **Insolvency and Bankruptcy Code (IBC)**, the consolidation of Public Sector Banks, and the **COVID-19** period distinguishes the present analysis from many earlier studies and may have influenced the estimated relationships.

Overall, the findings suggest that bank-specific characteristics, especially **profitability** and **institutional capacity**, play a more prominent role than several macroeconomic variables in explaining differences in Gross NPAs across the selected Public Sector Banks. By employing a balanced panel dataset covering the period **2010–2024** and applying appropriate panel-data estimation techniques, the study provides updated empirical evidence that complements and extends the existing literature on banking sector asset quality in India.

4.11 Comparison with Previous Studies

The findings of the present study are broadly consistent with the existing empirical literature on the determinants of Non-Performing Assets (NPAs) in the banking sector. The results indicate that **Inflation Rate, Repo Rate, Bank Size, and Re-turn on Assets (ROA)** are significant determinants of Gross NPAs, whereas **GDP Growth Rate, Credit Growth, and Capital Adequacy Ratio (CAR)** do not exhibit statistically significant effects in the selected Public Sector Banks.

The significant negative relationship between **Return on Assets and Gross NPAs**[3] supports the findings of **Berger and DeYoung (1997)**, who proposed the Bad Management Hypothesis, arguing that better-managed and more profitable banks maintain superior asset quality through effective credit appraisal, monitoring, and recovery mechanisms. Similarly, **Das and Ghosh (2007)** and **Kumar and Rani**

(2019) also reported that bank profitability is an important determinant of credit risk in Indian commercial banks.

The negative and significant effect of **Bank Size**[9] is consistent with the studies of **Salas and Saurina (2002) and Klein (2013)**, which concluded that larger banks generally experience lower credit risk due to diversified loan portfolios, stronger governance, and more advanced risk-management systems. The present findings suggest that similar advantages are observed among Indian Public Sector Banks.

Among the macroeconomic variables, the significant influence of **Inflation Rate and Repo Rate**[11] highlights the importance of the macroeconomic environment in determining banking sector asset quality. This finding is broadly consistent with the studies of **Louzis, Vouldis, and Metaxas (2012)** and **Beck, Jakubik, and Piloiu (2015)**, who found that macroeconomic conditions significantly affect loan repayment behaviour and banking sector stability. However, the negative coefficient of inflation differs from some earlier studies, indicating that the relationship between inflation and NPAs depends on the prevailing economic conditions and monetary policy framework during the sample period.

The statistically insignificant effects of **GDP Growth, Credit Growth**, and **Capital Adequacy Ratio** differ from the findings of **Rajan and Dhal (2003)**[13] and **Makri, Tsagkanos, and Bellas (2014)**[12], who reported significant relationships between these variables and NPAs. These differences may arise from variations in the study period, sample composition, regulatory reforms, estimation techniques, and the inclusion of the post-Asset Quality Review (AQR), Insolvency and Bankruptcy Code (IBC), bank consolidation, and COVID-19 periods in the present analysis.

Overall, the findings reinforce the view that **bank-specific characteristics**, particularly profitability and institutional capacity, play a more prominent role than several macroeconomic variables in explaining variations in Gross NPAs among Indian Public Sector Banks. By employing recent panel data (2010–2024) and appropriate panel-data estimation techniques, this study provides updated empirical evidence that complements and extends the existing literature on banking sector asset quality in India.

5 Summary

This chapter examined the determinants of **Gross Non-Performing Assets (GNPAs)** in selected Indian Public Sector Banks using a balanced panel dataset covering the period **2010–2024**. The empirical analysis combined descriptive statistics, correlation analysis, diagnostic tests, and panel-data regression techniques, including the **Pooled Ordinary Least Squares (OLS)**, **Fixed Effects**, and **Random Effects** models, to evaluate the factors influencing banking sector asset quality.

The descriptive analysis revealed considerable variation in Gross NPA Ratios across the sample banks and over time, reflecting differences in lending performance and asset quality. The correlation analysis showed that the Gross NPA Ratio was negatively associated with the **Inflation Rate**, **Repo Rate**, **Bank Size**, and **Return on Assets (ROA)**. In addition, the **Variance Inflation Factor (VIF)** results confirmed the absence of serious multicollinearity among the explanatory variables, indicating that each variable contributed distinct information to the empirical model.

The **Fixed Effects** and **Random Effects** estimations produced broadly similar results. Model selection was guided by the **Hausman Specification Test (η^2 = 0.3079, p = 0.9999)**, which indicated that the **Random Effects Model** was the more appropriate specification for the present study. Consequently, the interpretation of the empirical findings is based primarily on the estimates obtained from the Random Effects model.

The regression analysis identified the **Inflation Rate**, **Repo Rate**, **Bank Size**, and **Return on Assets** as statistically significant determinants of Gross NPAs. All four variables exhibited negative coefficients, suggesting that favourable macroeconomic conditions, stronger profitability, and larger institutional size are associated with improved asset quality and lower levels of Non-Performing Assets. By contrast, **GDP Growth**

Rate, **Credit Growth**, and the **Capital Adequacy Ratio** did not have statistically significant effects on the Gross NPA Ratio during the study period.

Overall, the findings indicate that bank-specific characteristics, particularly **profitability** and **institutional strength**, play a more influential role than several macroeconomic variables in explaining differences in Gross NPAs across India's Public Sector Banks. These results provide the empirical foundation for the conclusions and policy recommendations presented in the following chapter, with particular emphasis on strengthening credit risk management, improving operational efficiency, and maintaining a stable macroeconomic environment to enhance the resilience of the banking sector.

6 Conclusion, Policy Implications, Limitations, and Future Research

6.1 Conclusion

This study investigated the determinants of **Gross Non-Performing Assets (GNPAs)** in selected Public Sector Banks (PSBs) in India using a balanced panel dataset covering ten banks over the period **2010–2024**. To address the research objectives, the analysis incorporated both macroeconomic variables— **GDP Growth Rate**, **Inflation Rate**, **Repo Rate**, and **Credit Growth**—and bank-specific variables, namely the **Capital Adequacy Ratio (CAR)**, **Bank Size**, and **Return on Assets (ROA)**. The empirical investigation employed panel-data econometric techniques, including **Pooled Ordinary Least Squares (OLS)**, the **Fixed Effects Model (FEM)**, and the **Random Effects Model (REM)**.

The **Hausman Specification Test** identified the **Random Effects Model** as the most appropriate estimator for the dataset. The empirical results show that the **Inflation Rate**, **Repo Rate**, **Bank Size**, and **Return on Assets (ROA)** are statistically signifi-cant determinants of Gross NPAs, whereas **GDP Growth Rate**, **Credit Growth**, and the **Capital Adequacy Ratio (CAR)** do not exhibit statistically significant effects during the study period.

Among the explanatory variables, **Return on Assets** emerged as the most influential bank-specific determinant of Gross NPAs. The negative and significant coefficient indicates that banks with stronger profitability and more efficient management generally maintain lower levels of non-performing assets. Likewise, **Bank Size** was found to have a significant negative association with Gross NPAs, suggesting that larger banks benefit from greater portfolio diversification, stronger governance structures, and more effective risk management practices. The significant effects of the **Inflation Rate** and the **Repo Rate** further indicate that macroeconomic conditions and monetary policy also play an important role in shaping banking sector asset quality.

Overall, the findings suggest that reducing Non-Performing Assets requires more than a favourable macroeconomic environment alone. Sustained improvements in internal bank management, credit appraisal, loan monitoring, risk management practices, and operational efficiency are equally important for maintaining healthy loan portfolios. By analysing recent panel data that capture major regulatory and economic developments—including the **Asset Quality Review (AQR)**, the **Insolvency and Bankruptcy Code (IBC)**, the consolidation of Public Sector Banks, and the **COVID-19** period—the study provides updated empirical evidence on the determinants of Gross NPAs in India's Public Sector Banks and contributes to the growing literature on banking sector asset quality.

6.2 Policy Implications

The empirical findings of this study have several important implications for policy-makers, financial regulators, and the management of Public Sector Banks.

First, Public Sector Banks should continue strengthening their credit appraisal and loan monitoring systems to minimise the accumulation of stressed assets. Greater emphasis on comprehensive borrower due diligence, sector-specific risk assessment, and continuous monitoring of loan performance can improve the quality of lending decisions and reduce the likelihood of future loan defaults.

Second, improving bank profitability should remain an important strategic objective. The significant negative relationship between **Return on Assets (ROA)** and Gross NPAs suggests that measures aimed at enhancing operational efficiency, controlling operating costs, and diversifying sources of income can indirectly contribute to

better asset quality. Stronger financial performance also enables banks to absorb credit losses while maintaining prudent lending practices.

Third, the results indicate that larger banks generally perform better in managing credit risk. This finding highlights the importance of strengthening institutional capacity across the banking sector. Policymakers should therefore continue to encourage technological modernisation, digital credit monitoring systems, advanced data analytics, and risk-based management practices so that banks of all sizes can enhance their credit risk management capabilities.

Fourth, the significant effects of the **Repo Rate** and the **Inflation Rate** underscore the importance of maintaining a stable macroeconomic environment for the health of the banking sector. Effective coordination among monetary policy, fiscal policy, and financial regulation can help reduce systemic credit risk, improve borrowers' repayment capacity, and strengthen the overall resilience of the banking system.

Finally, financial regulators should continue to reinforce early warning systems, conduct periodic asset quality reviews, and ensure the timely resolution of stressed assets under the **Insolvency and Bankruptcy Code (IBC)**. Strengthening these institutional mechanisms can improve recovery rates, promote timely resolution of distressed loans, and reduce the future accumulation of Non-Performing Assets within Public Sector Banks.

6.3 Limitations of the Study

While this study contributes to the understanding of the determinants of Gross Non-Performing Assets (GNPAs) in India's Public Sector Banks, it is important to acknowledge certain limitations.

First, the analysis is confined to ten Public Sector Banks. As a result, the findings may not be directly applicable to private sector banks, foreign banks, or regional rural banks, whose operational structures and lending practices may differ from those of Public Sector Banks.

Second, the study covers the period **2010–2024**. Although this timeframe includes several important regulatory reforms and major economic events, extending the analysis to a longer period could provide a deeper understanding of the long-term behaviour and evolution of Non-Performing Assets.

Third, the empirical model incorporates only selected macroeconomic and bank-specific variables. Owing to data limitations, potentially relevant factors such as governance quality, ownership structure, managerial efficiency, sectoral loan concentration, borrower characteristics, and environmental, social, and governance (ESG) risks were not included in the analysis. The omission of these variables may limit the ability of the model to capture all factors influencing asset quality.

Finally, the study employs conventional panel-data estimation techniques that are appropriate for the research objectives. Nevertheless, future research could benefit from the use of more advanced econometric methods to examine the dynamic behaviour of Non-Performing Assets and to provide additional insights into the determinants of banking sector credit risk.

6.4 Future Scope of the Study

The findings of the present study provide several directions for future research on Non-Performing Assets and banking sector stability.

Future studies may broaden the scope of analysis by including private sector banks, small finance banks, foreign banks, and regional rural banks. Such an expanded sample would facilitate comparative analysis across different ownership structures and institutional settings, leading to a more comprehensive understanding of credit risk in the Indian banking sector.

Researchers may also extend the study period to capture post-pandemic develop-ments and examine the long-term effects of banking reforms on asset quality. A longer time horizon would help assess whether recent regulatory measures continue to influence the performance of the banking sector over time.

Further research could incorporate additional explanatory variables, including corpo-rate governance indicators, managerial quality, digital banking adoption, environ-mental, social, and governance (ESG) performance, loan

concentration, financial inclusion, and borrower-level characteristics. Including these factors may provide a broader perspective on the determinants of credit risk and improve the explanatory power of empirical models.

From a methodological perspective, future studies may apply advanced econometric techniques such as the **Generalized Method of Moments (GMM)**, **Panel Vector Autoregression (PVAR)**, or machine learning approaches to address potential endogeneity, capture dynamic relationships, and enhance predictive accuracy.

Finally, comparative cross-country studies involving emerging economies could offer valuable insights into how institutional quality, regulatory frameworks, and macroeconomic conditions shape the determinants of Non-Performing Assets across different banking systems. Such comparative evidence would contribute to a broader understanding of banking sector stability and support the formulation of more effective policy measures.

Concluding Remark

Maintaining a low level of non-performing assets is essential for ensuring the stability, profitability, and resilience of the banking sector. The findings of this study demonstrate that effective bank management, operational efficiency, and supportive macroeconomic conditions play a crucial role in improving asset quality in Indian Public Sector Banks. Strengthening these areas will not only reduce credit risk but also enhance financial stability and support sustainable economic growth.

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