The Impact of Macroeconomic Factors on Credit Risk Management in Developing Country Banks: An Analysis Based on Basel III

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Abstract: This study systematically analyzes the mechanisms through which macroeconomic factors influence the credit risk management of banks in developing countries, and evaluates the role and impact of Basel III in enhancing credit risk management. By constructing a rigorous theoretical research framework, this study systematically analyzes the function mechanism of macroeconomic factors on the credit risk management of banks in developing countries. Based on representative samples and utilizing advanced econometric models and data analysis techniques, this paper deeply discusses the influence mechanism and transmission path of macroeconomic variables on bank credit risk. This study reveals that Basel III has a positive role in improving the credit risk management effect of banks in developing countries, but also highlights some limitations. This study not only provides practice-oriented advice for risk control in financial institutions in developing countries, but also provides a new perspective for future academic research in related fields.

1. Introduction

In the framework of global financial stability, effective bank credit risk management (such as capital adequacy ratio regulation and liquidity risk management) is the core cornerstone to ensure the robustness of the financial system. One of the main functions of global financial markets is to accurately identify, assess and hedge risks, especially through the effective transfer and hedging of financial innovative instruments, such as credit default swaps (CDS) and other derivatives. When these financial instruments expand market risk exposure, they have significantly enhanced the ability to mitigate systemic risks by optimizing capital allocation and increasing liquidity. In recent years, in recent years, the turbulence in international financial market and the drastic changes of the macroeconomic environment have significantly intensified the credit risk of the banking system through the deterioration of asset quality and the rising default risk, which placed higher demands on the financial regulatory mechanisms of developing countries and the risk management strategy of the banking industry[1].

The credit risk management faced by developing countries in the global financial system has its particularity, and it is urgent need to move beyond traditional models and systematically study the

dynamic relationship between macroeconomic variables and credit risk in emerging markets. As the latest global banking regulatory standard, Basel III, as the latest standard of global banking regulation, has promoted the profound transformation of the concept and practice of credit risk management by stipulating the minimum capital requirements, leverage ratio and liquidity coverage rate. The effectiveness of credit risk control is highly correlated with the economic cycle, while macroeconomic variables such as gross domestic product (GDP), inflation rate and exchange rate playing critical roles in predicting bank asset quality and credit risk levels. However, the specific economic environment and policy framework of developing countries further exacerbate the complexity of the relationship between their macroeconomic factors and credit risk. For example, after the 2008 global financial crisis, the banking systems of many developing countries were severely impacted, their balance sheets deteriorated and default rates soared. In this context, this study aims to analyze the interaction mechanism between macroeconomic variables and bank credit risk in developing countries, and to deeply explore the applicability and effectiveness of Basel III to developing countries[2].

By reviewing the core theory of credit risk management and related empirical literature, this paper clarifies the theoretical correlation between macroeconomic factors and bank credit risk, and integrates the latest progress of traditional financial theory and contemporary financial economics to construct a comprehensive and systematic analytical model. This paper adopts advanced measurement methods such as multivariate regression analysis and time-series analysis. This study is based on the Basel III framework, and it reveals the mechanism of identifying, evaluating and alleviating bank credit risks under the dynamic change of economic environment. For example, by analyzing bank data during a financial crisis in typical developing countries, this paper illustrates the transmission paths of different macroeconomic variables.

The results provide targeted policy recommendations for policymakers and financial regulators in developing countries, and provide a theoretical basis for banks to build a more robust credit risk management model. In addition, this paper further improves the scientific rigor and reliability of the conclusion through the cross-validation of the macroeconomic model and the empirical analysis. These research results not only enrich the existing theoretical framework, but also provide a valuable reference for the risk management in practice.

2. Overview of the macroeconomic factors

2.1 Definition of macroeconomic factors

In the global financial system, the credit risk management of developing country banks is not only dependent on the robust internal control mechanism, but also deeply influenced by the macroeconomic environment. Macroeconomic factors, such as GDP growth rate, inflation rate, interest rates, unemployment rates, real estate market volatility and fiscal policies, have a profound impact on banks asset quality and profitability by shaping their business operations and credit risk levels. For example, the GDP growth rate is directly related to the solvency of the borrowers, while the inflation rate and interest rate significantly affect the real value of debt and the behavioral expectations of both borrowers. These macroeconomic indicators not only reflect the overall trend in the economic environment, but also provide key insights to assess future credit risk and bank performance.

2.2 Characteristics of developing countries

In the majority of developing countries, the economic structure tends to be undiversified, the financial market is underdeveloped, and the policy uncertainty is high, these factors jointly lead to its banking system facing greater credit risk challenges. The instability of economic policy, the drastic

fluctuations of inflation rate and exchange rate have significantly increased the difficulty of risk management for financial institutions in developing countries. In addition, the weak bank governance structure, rising financial pressures and the lack of information disclosure standards further complicate the risk management process. Therefore, for banks in developing countries, establishing a risk management framework in line with their own economic characteristics and strengthening their macroeconomic monitoring capacity has become a key strategy to effectively deal with these uncertainties.

2.3 The Basel III concept

The core goal of Basel III is to enhance the ability of banks to cope with economic and financial shocks by strengthening capital supervision and introducing liquidity risk quantitative indicators based on Basel II. Released in 2010 the Basel III: a global regulatory framework for more resilient banks and banking systems expanded the scope of the capital coverage risk, significantly improve the core level 1 capital requirements, and eliminate the Short-term subordinated debt as a qualified capital qualification, the first time to introduce the minimum liquidity standards, forming a comprehensive regulatory framework combining microprudential and macroprudential oversight, micro prudential and macro-prudential comprehensive regulatory framework. However, as an urgent product of the international financial crisis, the Basel III (2010) framework has problems such as insufficient risk sensitivity and too complex measurement of risk-weighted assets. To address these problems, the Basel III: The Final Plan for Post-crisis Reform, released in 2017, has made a major revision of the risk-weighted asset measurement method, which officially came into effect on January 1, 2023[3]. Its core is to reconstruct the measurement regulatory framework of risk-weighted assets. The specific measures include: simplifying the hierarchy of risk-weighted assets measurement, improving the risk sensitivity of standard method, enhancing the robustness of internal rating method, strengthening the information disclosure of risk-weighted assets, and establishing the capital bottom line of internal rating method. Based on the actual situation of developing country banks, this paper discusses the implementation effect of Basel III in different macroeconomic environment, and puts forward the corresponding credit risk management strategy.

3. Research Methodology

3.1 Research framework design

This study designed a dynamic credit risk assessment framework to quantify the specific impact of these variables on bank credit risk by integrating key macroeconomic indicators (e. g., GDP growth rate, inflation rate, unemployment rate, money supply, etc.). Firstly, the vector autoregression (VAR) model is applied to explore the dynamic interaction between macroeconomic factors and bank credit risk, and the contribution of each variable to credit risk is thoroughly analyzed through the impulse response function and variance decomposition technique. Further, this study used panel data analysis to evaluate the impact of Basel III implementation on the credit risk management strategies of different banks, and verified the robustness of the study results by comparing the random effect model (REM) with the fixed effect model (FEM). The study data include the annual reports of the developing Country banks between 2008 and 2023 and macroeconomic data released by the International Monetary Fund (IMF), including non-quantitative factors such as changes in policies and regulations to ensure the comprehensiveness and accuracy of the analytical model[4].

3.2 Data source and sample selection

The data used in this study are primarily derived from the relevant records of bank credit risk management in developing countries, including macroeconomic indicators and micro-level bank operation data. Data are collected from authorities such as the National Bureau of Statistics, the World Bank and the International Monetary Fund (IMF), supplemented by annual bank reports and reports issued by banking regulators. This study specifically focused on the key time points before and after the implementation of Basel III, using longitudinal and cross-sectional comparative analysis methods to assess the impact of policy changes on bank credit risk. The selected sample covered multiple geographic regions, ensuring wide applicability of the findings and representation across regions.

3.3 Experimental design and technical path

In this study, time series analysis and multivariate linear regression models were used to track and analyze the dynamic relationship between macroeconomic variables and bank credit risk in developing countries. The data comes mainly from authorities such as the World Bank and the International Monetary Fund (IMF), as well as credit rating agencies (such as Moodys). Stata and R software were used in the study for a comprehensive statistical analysis. First, The stationarity of the data was tested using the ARIMA model to ensure that the data were suitable for subsequent multivariate time series analysis[5]. Subsequently, vector autoregression (VAR) model was applied to analyze the dynamic relationship between variables and enhance the model robustness and adaptability through structural fracture test. After confirming the long-term equilibrium relationship among variables, this study further employs the vector error correction model (VECM) to reveal the long-term equilibrium relationship between bank credit risk and key macroeconomic variables (such as GDP, inflation rate, interest rate, and money supply).

3.4 Data analysis methods and research

In this study, the panel data model was adopted, combining multiple regression analysis, path analysis, Granger causality test and dynamic panel data model (GMM model), to systematically explore the influence mechanism of macroeconomic factors on the credit risk of banks in developing countries. In particular, the potential endogeneity of the data is addressed by the system generalized method of moments (System GMM), and the structural equation model (SEM) is employed for path analysis to reveal the complex interactions among the key variables. Moreover, robustness tests were conducted using multiple methods, including cross-validation and Bootstrap confidence interval estimation, to improve the robustness and interpretability of the study results.

4. Bank credit risk management

In emerging market countries, due to the significance of macroeconomic fluctuations, credit risk management becomes the core of bank risk management. With the increasing complexity of financial instruments, the traditional credit evaluation methods are not enough to fully describe the credit risk characteristics of borrowers. This study establishes a multidimensional credit risk assessment framework that integrates macroeconomic variables, corporate financial indicators, and market sentiment. Through the structural equation model (SEM) and Heckman model, this paper effectively corrects for sample selection bias and improves the accuracy and generalizability of the study. In addition, combining random forest and logistic regression model, this study effectively identified high-risk loan customers, and significantly improved the accuracy and efficiency of credit risk management. This paper also discusses the impact of Basel III on bank credit risk management under

the capital adequacy ratio standard, especially paying special attention to the practical application of risk prevention and control mechanism. The empirical results show that the influence of macroeconomic environment on credit risk is particularly significant during economic fluctuations, verifying the effectiveness of the model in dealing with uncertainty. The research provides targeted and international credit risk management policy suggestions for the banking industry of emerging market countries.

5. Experimental Result

5.1 Data summary and preprocessing

Data preprocessing is a key step to ensure the robustness of the model when analyzing the credit risks of banks in developing countries. In this paper, SPSS and Python were used to clean and standardize credit risk data, eliminate excessive missing values and outlier points, and use the minimum-maximum normalization method to ensure consistency and comparability of variables. To address the redundancy of multidimensional data, principal component analysis (PCA) is employed to select principal components with eigenvalues greater than 1, reducing dimensions through the decomposition of eigenvalues and eigenvectors of the covariance matrix.This process can be represented by the following formula: $C = \frac{1}{n-1} \sum_{i=1}^{n} (X_i - \bar{X})(X_i - \bar{X})^T$ To control for the multicollinearity risk, the variance inflation factor (VIF) was calculated and the variables with VIF greater than 10 were removed with the formula: $VIF_i = \frac{1}{1 - R_i^2}$ In order to handle the fluctuation and lag in time series data, the moving average (MA) and smoothing techniques are adopted, where the moving average and exponential smoothing are: $MA_t = \frac{1}{n} \sum_{i=0}^{n-1} X_{t-i}$ $ES_t = \alpha X_t + (1 - \alpha) ES_{t-1}$ The missing data adopts the predictive filling technology based on the external trusted data sources, combined with the reverse verification method to ensure the accuracy of the filling data. These preprocessing steps lay a solid data foundation for the subsequent structural equation models and multiple regression analysis.

5.2 Results analysis of various macroeconomic factors

By constructing the multiple regression model, the influence of macroeconomic factors on bank credit risk is systematically analyzed. Specifically, the following models were set to explore the effects of GDP growth, CPI inflation, Unemployment rate and other variables on NPL ratio: $NPL_{ratio} = \alpha + \beta_1 \cdot GDP_{growth} + \beta_2 \cdot CPI_{inflation} + \beta_3 \cdot Unemployment_{rate} + \epsilon$. The results show that there is a significant negative relationship ($\beta1 < 0$) between GDP growth rate and bank non-performing loan ratio (NPL), indicating that economic growth can effectively reduce the credit risk of banks. At the same time, the rise in unemployment rate shows a positive correlation with credit risk ($\beta3 > 0$), which means that the increase in unemployment rate will significantly increase the credit risk faced by banks. In addition, the influence of the inflation rate on the non-performing loan ratio shows a significant non-linear double correlation, specifically: $NPL(I) = \begin{cases} \alpha_1 I + \beta_1, & I \leq \lambda \\ \alpha_2 I + \beta_2, & I > \lambda \end{cases}$ $\alpha1 < 0$, which means that below the threshold level, the inflation rate and the non-performing loan ratio are negatively correlated; otherwise, $\alpha2 > 0$, means that when the inflation exceeds the threshold value, the two turn to a positive correlation.

In order to further explore the long-term equilibrium relationship between macroeconomic

variables and bank credit risk and the short-term dynamic adjustment mechanism, the vector error correction model (VECM) is used for analysis. The VECM model is as follows:

$$\Delta NPL_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta X_{t-i} + \lambda(NPL_{t-1} - \gamma X_{t-1}) + \epsilon_t$$

. Where ΔY_t is the difference of the variable, α is the adjustment coefficient, β is the long-term equilibrium vector, i is the short-term dynamic coefficient, and ϵ_t is the error term. ΔNPL_t represents the change in the non-performing loan ratio of banks over different periods. X_t represents the joint vector of GDP growth, CPI inflation, and unemployment rate, and λ is the error correction coefficient, which reflects the adjustment speed after the system deviates from the long-term equilibrium state. The $NPL_{t-1} - \gamma X_{t-1}$ represents the long-term equilibrium relationship. ΔX_{t-1} is a short-term dynamic adjustment term.

Based on the vector error correction model (VECM), this study reveals the long-term equilibrium relationship between bank credit risk and key macroeconomic variables (such as GDP, inflation rate, interest rate, money supply, etc.). The systematic analysis of this model not only illustrates the long-term impact of these macroeconomic variables on bank credit risk but also captures the short-term dynamic adjustment process.This study provides a solid theoretical foundation and empirical support for the quantitative management of bank credit risk, offering valuable insights for the formulation of financial supervision and risk management policies.The empirical results indicate a significant co-integration relationship between specific macroeconomic variables and bank credit risk, suggesting that these variables tend toward equilibrium in the long term.The results not only verify the relevant theoretical assumptions in the existing literature, but also reveal how short-term deviations tend to long-term equilibrium through dynamic adjustment through the error correction mechanism. The analysis of short-term effects shows that the change of variables such as interest rates has significant impact effects on credit risk in the short term, which reflects the high sensitivity of the banking system to macroeconomic fluctuations. For example, the VECM model provides a deep understanding of the short-term impact of macroeconomic variables on the NPL ratio and their long-term equilibrium adjustment path.Especially in the period of economic crisis or structural economic transformation, VECM effectively captures the bias of the long-term co-integration relationship between the NPL ratio and these variables through the error correction mechanism, and gradually adjusts it back to the long-term equilibrium state. Empirical tests showed that the λ coefficient significantly indicates the adjustment speed of the NPL ratio after long-term deviation from equilibrium, which provides strong theoretical and empirical support for understanding the behavior of NPL in different macroeconomic environments. Based on this model, we can deeply analyze the interaction between the robustness of the banking system and the macroeconomic policy, and further expand the explanatory power of NPL ratio fluctuations in the background of crisis management and structural economic transformation. This finding provides an empirical basis for understanding the risk pressures banks face in the short term, helping policy makers in developing countries to deeply understand the complex relationship between macroeconomic variables and the stability of the banking system, and developing a more forward-looking macro-prudential regulatory framework to maintain the stability of the financial system.

The VECM model and its empirical results provide an effective analytical tool for credit risk management and financial regulation of banks in developing countries. These implications mainly include: in long-term macroeconomic policy formulation, fully consider the integration of macroeconomic variables and its long-term impact on bank credit risk to ensure the stability and foresight of policies; in short-term emergency risk management, pay attention to the short-term fluctuations of key economic variables, and adjust risk mitigation policies accordingly to prevent the accumulation of systemic risks.

6. Discussion of results

6.1 Comparative analysis and hypothesis validation

This study employs multiple regression analysis and Cox proportional risk model to explore the influence of macroeconomic indicators on bank credit risk. Specifically, a comprehensive analysis model combining macro and microeconomic indicators is constructed, and the hypothesis is verified through the following mathematical models:

1) Multiple regression model:

$$\overline{\overline{CreditRisk}}_{it} = \alpha + \beta_{1it}\,\text{Macro} + \beta_{2it}\,\text{Micro} + \gamma X_{it} + \epsilon_{it}$$

2) Cox proportional risk model:

$$h(t|X) = h_0(t)\exp(\beta' X)$$

In the midst of it all, $CreditRisk_{it}$ Risk profile of bank i at time t, $Macro_{it}$ and $Micro_{it}$ As macroeconomic and microeconomic indicators, Xit is the control variable, h(t|X) is the risk function, h0(t) is the benchmark risk function, and β is the regression coefficient. The findings indicate that during macroeconomic fluctuations, the Basel III framework significantly mitigates the rise in bank credit risk. This study further underscores the close relationship between macroeconomic stability and banking sector resilience, offering robust empirical support for relevant theory and practice, highlighting the pivotal role of macroeconomic policies in safeguarding financial system stability.

6.2 Evaluation of bank credit risk management effect

This paper employs the default probability estimation model (Probability of Default, PD) and the credit scorecard model, combined with the actual data before and after the implementation of Basel III,to evaluate the effectiveness of bank credit risk management. Based on the Logit regression model, the influence of different macroeconomic factors on the default probability is estimated. The model is as follows: $PD = \dfrac{1}{1 + \exp -(\alpha + \beta X)}$. Among them, X is a set of macroeconomic factors (such as GDP growth rate, interest rate, inflation rate, etc.), α is the intercept term, and β is the regression coefficient of each factor. By comparing the default probability before and after the implementation of Basel Accord III, the analysis shows that the non-performing loan ratio of banks is significantly decreased after the implementation of the agreement, which indicates that the credit risk management effect has been significantly improved.

Simultaneously, this paper develops a credit risk assessment model based on the scorecard. This model comprehensively considers a variety of credit risk factors, and its form is: $Score = \sum_{i=1}^{n} w_i X_i$. Among them, Xi represents different credit risk indicators, and wi denotes the corresponding weights. By quantifying the impact of each risk factor, the scoring card model can provide a comprehensive and detailed assessment of the quality of credit assets. This quantitative analysis method not only improves the accuracy of credit risk management, but also provides empirical support and theoretical guidance for the practice of risk management of banks, and helps to improve the ability of financial institutions to deal with complex credit risks.

For the evaluation of the capital adequacy ratio, the calculation formula of capital adequacy ratio specified in Basel III is adopted: $CAR = \dfrac{Tier1Capital + Tier2Capital}{Risk - WeightedAssets}$ .The research results show that following the implementation of Basel III, banks' capital adequacy ratios have significantly improved, along with a notable enhancement in the quality of credit assets.

In addition, this study found that the correlation between certain macroeconomic factors (such as economic cycle, market volatility) and credit risk is more complex, and the action mechanism of these factors in different economic environments needs to be further explored. In order to deeply analyze the dynamic relationship between macroeconomic factors and credit risk, this paper adopts the dynamic panel data model (GMM model) to analyze the interaction between the non-performing loan ratio and macroeconomic variables in the time series. The model form is as follows:

$$y_{it} = \alpha + \beta X_{it} + \gamma Z_t + \epsilon_{it}$$

. Among them, yit represents the non-performing loan ratio of bank i at time t, Xit represents the internal characteristic variables of the bank (such as capital adequacy ratio, loan size, etc.), Zt is the macroeconomic variable, and ϵ it is the error term. This study reveals the comprehensive impact of multi-dimensional factors in bank risk management, including not only the key variables in the external macroeconomic environment (such as economic cycle, market volatility, etc.), but also covers the internal management characteristics of banks (such as capital adequacy ratio, loan scale, etc.). By combining these factors, this paper provides a new perspective for a comprehensive understanding of bank risk management, especially on the dynamic mechanism of how external and internal factors interact and jointly affect the quality of credit assets.

6.3 Research limitations and future prospects

Although this study reveals the significant influence of macroeconomic factors on bank credit risk, there are some limitations. First, the broad applicability of the obtained conclusions may be affected due to the spatiotemporal constraints of the sample. Therefore, future studies should be extended to wider geographic areas and longer time spans to enhance the external validity of the study. Secondly, this study mainly adopted the linear analysis framework, and failed to fully explore the possible non-linear relationship between macroeconomic variables and credit risk. It is recommended that future studies employ nonlinear models such as threshold or GARCH models to deeply explore the complex dynamic relationships among these variables. Moreover, considering the increasing transnational financial activities in the context of globalization, future studies should also consider the interaction of different economies and their potential spillover effects on credit risk. At the same time, the use of big data and machine learning technology can significantly improve the accuracy and real-time performance of risk management, and help to build a more effective risk early warning system. Finally, given the rapid development of fintech and the constant change of regulatory policies, future research should further explore the application potential of fintech in risk early warning and management to cope with emerging risks and challenges.

7. Conclusion

Based on the current situation of credit risk management of banks in developing countries, this study constructs a credit risk assessment framework with Basel III as the core, and systematically analyzes the role of key macroeconomic variables in different economic cycles. By identifying and analyzing macroeconomic indicators such as GDP growth rate, inflation rate and unemployment rate, the study clarified the differentiated impact of these variables on bank credit risk and asset quality. Combining the empirical analysis of cross-sectional and time-series data, this paper contributes to a comprehensive and systematic understanding of how macroeconomic factors influence the credit risk of banks in developing countries.

Another important innovation of this study is an in-depth analysis of the applicability of Basel III in the banking system of developing countries, especially in terms of risk buffer requirements and core regulatory indicators (e. g., capital adequacy ratio, leverage ratio, liquidity coverage). The empirical results show that although Basel III provides an effective framework for improving the

robustness of banks, its applicability varies significantly among different economies and needs to be localized according to the local market and policy environment.

By combining macroeconomic data and bank micro data, this study verifies the effectiveness and robustness of the proposed credit risk assessment method. The results show that the dynamic correlation between macroeconomic factors and credit risk management has wide applicability and universality in different economic cycles and financial environments. Future studies can further explore nonlinear relationships between macroeconomic variables and credit risk, the application of fintech in credit risk management, and the impact of changes in regulatory policies, thereby continuously improving the relevant theoretical and practical framework.

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