Capital Adequacy Ratio and Systemic Risk: an Econometric Analysis of the Financial Risk Management of Chinese Commercial Banks

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Abstract: The capital adequacy ratio and systemic risk are two interlinked core concepts within the financial system, playing a crucial role in the risk management and stability of the banking sector. This study rigorously analyzes the impact of capital adequacy ratios on systemic risk among Chinese commercial banks employing advanced econometric methods. Considering the complexities of the global financial system, traditional capital adequacy frameworks have struggled to comprehensively address multifaceted risks present the in contemporary financial markets. Bv constructing multiple econometric models and integrating recent financial market dynamics, this paper demonstrates the inhibitory effect of the capital adequacy ratio on banks' systemic risk and explores the mediating role of capital buffer mechanisms in this relationship. The findings indicate that enhancing capital adequacy ratios not only significantly reduces the transmission of systemic risks among banks, but also bolsters their resilience and capacity to navigate uncertainties. The academic global contribution of this research lies in reevaluating the role of capital adequacy from a dynamic, global perspective and with providing regulators a robust framework to refine capital regulation, particularly in an era of accelerated financial innovation aimed at effectively mitigating systemic financial risks. These insights offer fresh and profound theoretical support for banking capital management practices and policymaking.

Keywords: Capital Adequacy Ratio; Systemic Risk; Chinese Commercial Banks; Financial Risk Management; Econometrics

1. Introduction

In the architecture of the global financial system,

commercial banks, acting as pivotal financial intermediaries, are essential in maintaining economic stability and fostering growth. Since the 2008 global financial crisis, enhancing the resilience of the banking sector has become a critical factor in safeguarding against systemic risks. The capital adequacy ratio, a critical metric for gauging the balance between a bank's capital reserves and its risk exposure, has emerged as an indispensable tool for evaluating both the financial robustness and the shock-absorption capacity of banks. Given its critical role in ensuring financial system stability, the management and regulatory oversight of the capital adequacy ratio have become paramount concerns for global financial regulators and the banking sector. Following a period of rapid growth and market liberalization, Chinese commercial banks have significantly enhanced their asset base and broadened their operational scope. However, the rapid evolution of financial markets and the advent of advanced financial technologies have heightened the exposure of China's banking sector to a spectrum of increasingly intricate risks, including market, credit, and operational risks. These challenges highlight the imperative of managing capital adequacy ratio both effectively and efficiently. Given this scenario, it is imperative to investigate the complex interplay between the capital adequacy ratio and systemic risk, as such an investigation can significantly enhance banks' risk management capabilities and strengthen overall financial stability.

This study endeavors to explore the relationship between capital adequacy ratio and systemic risk, underscoring its profound theoretical and practical implications. Theoretically, the capital adequacy ratio is a fundamental pillar of robust banking operations, crucial for elucidating how banks sustain stability across a spectrum of market conditions.

Furthermore, an exhaustive analysis of the interaction between capital adequacy ratio and

systemic risk can provide robust empirical evidence, guiding policymakers in enhancing the existing capital regulatory framework and fortifying against future financial crises.

As global economic interdependence deepens, systemic risks increasingly pose significant threats to the stability of the world's financial systems. In the face of escalating challenges within this interconnected financial landscape, Chinese commercial banks are increasingly pressured. This study examines how the capital adequacy ratio impacts these banks' ability to withstand systemic risks, thereby enhancing their strategies for risk management and improving their adaptability and resilience in a complex financial environment. Furthermore, this study investigates strategies for enhancing efficiency the operational and market competitiveness of banks through innovative capital management practices, which are anticipated to foster the sustainable growth of the banking sector.

This study not only advances the theoretical discourse on the capital adequacy ratio and systemic risk but also furnishes regulatory bodies with robust theoretical insights and pragmatic policy recommendations to craft more effective regulatory frameworks. This paper provides critical insights that guide the enhancement of regulatory frameworks, enabling commercial banks to refine their capital structures and bolster their risk management strategies. These improvements contribute significantly to the stability of China's financial system and promote sustainable economic growth.

2. Literature Review

2.1 The Concept of the Capital Adequacy Ratio and Its Importance

The Capital Adequacy Ratio (CAR) is an essential metric for evaluating a bank's capital structure and risk tolerance, playing a crucial role in maintaining their operational stability. Traditionally, the capital adequacy ratio is defined as the ratio of a bank's capital to its Risk-Weighted Assets (RWA), primarily serving to assess the bank's resilience against various risks, including credit, market, and operational risks. This ratio is particularly significant within the financial regulatory framework, as it plays a crucial role in maintaining the risk management practices and overall stability of the banking

III prescribes system.Although Basel а minimum capital adequacy ratio for global banks to bolster their resilience against systemic risks, research on capital adequacy should extend beyond the confines of this regulatory framework. Variations in financial market structures and economic conditions across regions necessitate tailored approaches to the capital adequacy ratio. Moreover, capital management strategies must consider diverse factors, including a bank's business model, risk appetite, and cost of capital. Current research demonstrates a positive correlation between enhancements in the capital adequacy ratio and a reduced likelihood of bank insolvency. However, overly stringent capital adequacy requirements may restrict banks' ability to extend credit and expand business operations, especially during economic downturns, consequently impairing profitability and hindering long-term growth. Therefore, determining the optimal balance between capital adequacy requirements and efficient capital management has become a pivotal issue in contemporary financial research. Recent studies have broadened the scope of capital adequacy ratio analysis, examining not only its impact on individual banks but also its role in enhancing the stability of the entire banking system. For instance, research has shown that a system-wide increase in the capital adequacy ratio significantly reduces systemic contagion risks, thereby bolstering the financial system's resilience. This indicates that policymakers can curb the spread of systemic moderately increasing risks bv capital requirements, while avoiding excessive burden on the routine operations of banks.^[1]

2.2 Definition of Systemic Risk and Its Influencing Factors

Systemic risk is one of the most destabilizing risks in the financial system. It refers to a cascade of effects triggered by a financial institution or market event, potentially leading to a systemic crisis. Systemic risk not only impacts individual institutions but can also trigger widespread financial instability through the intricate connections between financial entities. In recent years, the financial field has enhanced its understanding of systemic risks, evolving from initial studies on financial crises to the identification of hidden vulnerabilities within the banking system and the interdependence of financial institutions. Contemporary research consistently finds that systemic risk is strongly influenced by the size, complexity, and interconnectedness of financial institutions. Due to their significant market share and asset size, large institutions often assume the role of 'too big to fail' during crises. A single risk event occurring within any of these institutions can rapidly propagate through the financial network, impacting the entire system. Recent data indicate that the assets of China's top five commercial banks—namely, the Industrial and Commercial Bank of China, China Construction Bank, Agricultural Bank of China, Bank of China, and Bank of Communications—account for more than 50% of the total assets of China's banking sector, underscoring the potential for systemic risk during crises involving these large banks.^[2]

Additionally, financial innovations and the rapid derivatives markets expansion of have contributed to the accumulation of systemic risk. Owing to their complexity, derivatives markets can magnify risk exposures of financial institutions when markets fluctuate, initiating a chain reaction and escalating the potential for systemic risk propagation. To address these challenges, counter-cyclical capital buffers function as essential stabilizing tools, encouraging banks to accumulate capital during economic booms and provide liquidity during downturns. However, the expansion of the shadow banking system has augmented the opacity and complexity of the financial system, thereby undermining the efficacy of traditional regulatory frameworks.Consequently, enhancing regulatory effectiveness and bolstering the resilience of the banking system against systemic risks through innovative policies have become critical research priorities in the financial sector.

Recent research on systemic risk has shifted from focusing solely on the risk management strategies of individual financial institutions to a broader analysis of the vulnerabilities within the entire financial system. The emphasis is now on understanding the internal dynamics and transmission mechanisms of systemic risk, along with the principal factors influencing systemic risk and robust risk mitigation and management strategies. These areas are at the forefront of contemporary financial research. Future research should delve deeper into the interaction between capital adequacy ratios and systemic risk, especially focusing on curbing the propagation of systemic risk through dynamic capital adjustments, to ensure the long-term stability of the global financial system.

3. Research Technique

3.1 Theoretical Framework of Capital Adequacy Ratio and Systemic Risk

The capital adequacy ratio and systemic risk constitute the cornerstone of financial risk management in Chinese commercial banks. The capital adequacy ratio, as a pivotal indicator of a bank's ability to withstand risks, reflects the bank's capacity to buffer against losses from credit, market, and operational risks. Systemic risk refers to the risk events instigated by one or more financial entities that lead to widespread disruptions throughout the financial system or markets. The interaction between these two is reciprocal: an elevated capital adequacy ratio bolsters a bank's risk tolerance, thereby diminishing the likelihood of systemic risk occurrences; conversely, heightened systemic risk compels banks to fortify their capital base to withstand potential market turbulence.

To explore the dynamic relationship between the capital adequacy ratio and systemic risk, a range of sophisticated econometric models is utilized. This paper applies the dynamic panel data model, which captures the dynamic characteristics of the capital adequacy ratio and its effects on risk management. Furthermore, this study enhances the application of the credit scoring and Logistic regression models for a detailed analysis of quantitative credit risk and systemic risk transmission mechanisms. By integrating the Logistic regression model, it enables a more precise prediction of individual borrowers' default probabilities, which are then combined with macroeconomic variables to assess the impact of overall economic conditions on bank credit risk. The innovation of this approach lies in the fusion of micro-level credit risk assessment with macroeconomic factors, establishing a more integrated framework for managing systemic risk.

3.2 Data Sources and Processing Methods

This study employs a comprehensive array of data sources, including financial data from banks, macroeconomic indicators, and market data. The financial data of banks is mainly drawn from the annual reports and public financial statements of major Chinese commercial banks, spanning 2005 to 2023. This data will be employed to construct a comprehensive set of capital adequacy ratio indicators, including core Tier 1, Tier 1, Tier 2, and total capital adequacy ratios. Macroeconomic and market data are derived from the National Bureau of Statistics, the of China, among other People's Bank authoritative bodies, covering GDP, CPI, M2, interest rates, and unemployment rates. This data is crucial not only for analyzing the impact of the macroeconomic environment on banks' adequacy ratios for capital but also understanding the evolution of systemic risk across different economic cycles.

Regarding data processing, this study first cleans and pre-processes the data, including removing outliers and handling missing data. Outlier detection is performed using box plots, and mild outliers are addressed through interpolation methods. For statistical analysis, the panel data model is utilized, effectively controlling for heterogeneity across cross-sections and time series, thereby improving estimation accuracy. Moreover, to precisely quantify the relationship between capital adequacy ratio and systemic risk, this study implements multivariate regression analysis and the Generalized Method of Moments (GMM) technique. Multivariate regression reveals how multiple independent variables jointly affect dependent variables, while the GMM technique addresses potential endogeneity issues, ensuring consistent and efficient estimations.

Finally, this study constructs systemic risk measures employing advanced market risk analysis techniques, including Value at Risk (VaR) and Conditional Value at Risk (CoVaR). These indicators evaluate the maximum potential market losses at different confidence levels and the systemic risks that arise from the failure of a specific financial institution. Through these research methods and data processing techniques, this study aims to offer a comprehensive and in-depth understanding of the complex relationship between capital adequacy ratio and systemic risk, providing theoretical insights and practical policy recommendations for managing the risks faced by Chinese commercial banks.

4. Empirical Analysis

4.1 Model Setting and Assumptions

This study aims to thoroughly investigate the

relationship between the capital adequacy ratio and systemic risk within the context of Chinese commercial banks. Considering the dynamic nature of systemic risk and its interaction with bank capital structures, we utilize a dynamic panel data model. This model excels in capturing the time-series characteristics of systemic risk and the intricate interdependencies between micro-level banking behaviors and macroeconomic factors, facilitated by incorporating lagged dependent variables as explanatory variables.

Moreover, this research significantly enhances the traditional analytical framework. It not only adheres to the capital adequacy standards recommended by the Basel Accords but also integrates macroeconomic elements and other crucial risk management indicators, thereby comprehensive establishing theoretical а framework. The innovation of this framework lies in its use of the lagged terms of the capital adequacy ratio, which effectively identifies and analyzes both the immediate and subsequent effects of changes in the capital adequacy ratio on systemic risk, thus providing a deeper understanding of the dynamic risk adjustment mechanisms.

Multidimensional Integration of Risk Management Indicators: Beyond the traditional capital adequacy index, this study incorporates specific bank risk indicators such as the loan loss provision ratio (LLP) and the non-performing loan ratio (NPL), along with macroeconomic variables like GDP growth rate and money market interest rates. These factors together establish a comprehensive framework for assessing systemic risk.

Methodological Innovation: The study employs the System Generalized Method of Moments (System GMM), which not only addresses potential endogeneity issues but also leverages the mixed characteristics of time-series and cross-sectional data to enhance the robustness of the estimations. Moreover, the model's applicability and the reliability of the estimated results are further validated through the Sargan test and the Arellano-Bond autocorrelation test.

Through these methodological and theoretical innovations, this study provides new insights and empirical evidence for understanding and managing the systemic risk of Chinese commercial banks in times of economic instability. These findings not only offer guidance to banking managers but also serve as a scientific basis for policymakers in developing relevant financial regulatory policies.

The model used in this study is as follows $SRISKi,t=\alpha+\beta ICARi,t-1+\beta 2SIZEi,t+\beta 3LIQi,t$ $+\beta 4GDPt+\beta 5NPLi,t+\varepsilon i,t$

Among them, SRISKi, t, represents systemic risk, quantified by the SRISK, measure developed by Brownlees and Engle (2012), which assesses the long-term marginal expected loss (LRMES) of bank i at time t and its impact on systemic crises financial pressures exceed when certain thresholds.^[3]*CARi*,t-1, denotes the capital adequacy ratio, specifically the core Tier 1 capital ratio, and accounts for its lagged effects to capture the dynamic influences of capital adequacy on systemic risk over time. SIZEi,t refers to the size of the bank, measured by total assets. While bank size can mitigate risk via economies of scale and diversification, it can also amplify systemic risk through "Too Big to Fail" mechanisms.^[4] LIQi,t measures liquidity, using the current ratio to assess the liquidity conditions; insufficient liquidity can escalate systemic risk. GDPt represents macroeconomic conditions, with GDP growth rate serving as the proxy. Fluctuations in the macroeconomy significantly influence systemic risk by impacting banks' operational environments. *NPLi*, *t* is the non-performing loan ratio, where a high ratio often signals deteriorating asset quality, potentially heightening bankruptcy risks and thereby increasing systemic risk. Ei,t is the random error term.

To ensure the robustness of the model and effectively address endogeneity, this study employs a dynamic panel data model and utilizes the System Generalized Method of Moments (System GMM). The principal advantage of System GMM lies in its capability to effectively mitigate endogeneity through the appropriate introduction of instrumental variables, thereby ensuring unbiased and consistent estimators. In this study, endogeneity primarily arises from potential bidirectional causal relationships among independent variables such as the capital adequacy ratio, bank size, liquidity, and systemic risk.^[5]

Within the System GMM framework, this study selects the lagged values of the independent instrumental variables as variables. This selection is informed by the following Temporal persistence: considerations: (1) Lagged independent variables can effectively capture historical relationships among the variables, thereby reducing endogeneity bias stemming from contemporaneous correlations. (2) Exclusion restriction: The lagged variables, serving as instrumental variables, must satisfy the exclusion restriction; that is, they should influence the dependent variables only through their effects on the current-period independent variables. This condition is vital in System GMM to ensure the effectiveness of the instruments.

Furthermore, to ascertain the appropriateness of the instrumental variables and the accuracy of the model specification, several statistical tests were conducted:

(1) Sargan Test: Employed to examine the overidentification of instruments and confirm their validity. (2) Arellano-Bond autocorrelation test: Executed to detect first and second-order autocorrelation in the error terms, thus verifying the suitability of the difference GMM estimator. These meticulous methodological procedures not only enhance the accuracy of the estimated results but also augment the capacity to elucidate the complex dynamic relationship between the capital adequacy ratio and systemic risk. The empirical findings shed new light on this relationship, providing significant theoretical and practical implications for risk management practices and regulatory policy development in the banking sector.

4.2 The Empirical Results and the Discussion

This study utilizes panel data from 25 major commercial banks in China spanning from 2008 to 2023 for empirical analysis. To ensure the robustness of the results, a dynamic panel data model was implemented, employing the System Generalized Method of Moments (System GMM) for regression analysis. The sample comprises three distinct types of banks—state-owned, joint-stock, and city commercial banks—fully representing the critical components of Chinese commercial banks sector. The details of the study's data and model include:

(1) Sample Selection and Data Sources: The sample encompasses key representatives of Chinese commercial banks sector, including six large state-owned banks, ten major joint-stock commercial banks, and nine prominent city commercial banks. This diverse sample design facilitates the exploration of differences in capital structure and risk management strategies among various types of banks, thereby broadening and deepening the study's scope. (2) Model Construction and Estimation Strategy: The dynamic panel data model addresses the potential influence of the capital adequacy ratio on systemic risk, alongside other control variables such as bank size, loan quality, and macroeconomic conditions. System GMM was selected due to its effectiveness in addressing potential endogeneity, ensuring the unbiasedness and consistency of the estimates by utilizing lagged variables as instruments.

(3) Statistical Tests: To confirm the model's robustness, the Sargan test was conducted to evaluate the validity of the instrumental variables, and the Arellano-Bond test was performed to detect autocorrelation in the error terms. The outcomes of these tests validate the model's appropriateness for this study and the reliability of the estimated results. Through rigorous methodology and comprehensive data analysis, this study not only deepens the understanding of the relationship between the capital adequacy ratio and systemic risk in Chinese commercial banks but also provides empirical support for enhancing banking regulatory policies and risk management strategies.

4.2.1 Descriptive Statistical Analysis

During the descriptive statistical analysis, this study noted significant time-series volatility among the variables throughout the period examined. Particularly during the financial crisis, systemic risk (SRISK) escalated markedly, whereas the capital adequacy ratio (CAR) declined. These observations highlight the profound impact of the financial crisis on banks' capital structures and their capacity for risk absorption. Moreover, there was a notable negative correlation between the size of the bank (SIZE) and systemic risk (SRISK), indicating that larger banks tend to have more robust risk management frameworks.

(1) Systemic Risk (SRISK): Analysis showed that during the financial crisis, both the mean and variance of systemic risk significantly increased, reflecting drastic market fluctuations and their magnifying effect on the systemic risk faced by banks.

(2) Capital Adequacy Ratio (CAR): Conversely, the capital adequacy ratio trended downward during the crisis, likely due to declines in asset values and erosion of capital buffers.

(3) The size of the bank (SIZE): Larger banks demonstrated lower systemic risk levels, likely due to their enhanced capabilities in capital and liquidity management and their potential access to implicit or explicit government support during crises.

These descriptive statistical findings provide a foundation for further econometric model analysis, shedding light on the relationships between capital adequacy ratio, bank size, and systemic risk, and their dynamic changes different economic cycles. through This valuable empirical data contributes and understanding banking perspectives for behaviors and shaping relevant regulatory policies.

4.2.2 Regression Outcome Analysis of the Systematic GMM Estimation

The regression results obtained through System GMM estimation are as follows:

SRISKi,t = -0.235CARi,t-1 + 0.152SIZEi,t + 0.102 LIQi,t - 0.302GDPt + 0.285 NPLi,t

Among them, the analysis reveals a significant negative correlation between the capital adequacy ratio (CARi, t-1) and systemic risk, with a regression coefficient of -0.235, t-value of-4.12 and p-value of less than 0.01. This indicates that enhancing the capital adequacy ratio can effectively mitigate systemic risk, consistent with the buffer effect posited in financial theory. The size of the bank (SIZEi,t)exerts a positive influence on systemic risk, with a coefficient of 0.152, a t-value of 2.89, and a statistically significant *p*-value. This may be attributed to larger banks bearing more systemic risk under the "Too Big to Fail" doctrine. Liquidity (LIOi,t) has a positive effect on systemic risk, suggesting that banks are more susceptible to systemic shocks when liquidity is insufficient, with a coefficient of 0.102 and a *t*-value of 1.97, the result is nearing significance. Macroeconomic conditions (GDPt) negatively correlate with systemic risk, the regression coefficient for GDP growth rate is-0.302, with a *t*-value of-5.20, and a *p*-value significantly below 0.01, indicating that macroeconomic growth significantly buffers systemic risk. The non-performing loan ratio(*NPLi*,*t*) is positively and significantly correlated with systemic risk, with a coefficient of 0.285, a t-value of 4.89, and a *p*-value significantly below 0.01, indicating that an increase in non-performing loans exacerbates systemic risk.

To ensure the robustness of this study's findings, various methods were employed, including tests using alternative indicators and time window analyses. These robustness checks further substantiate the primary conclusion that there is a significant negative correlation between the capital adequacy ratio (CAR) and systemic risk. Alternative indicator tests: Initially, this study substituted systemic risk (SRISK) with other systemic risk indicators such as Market Expected Shortfall (MES) and Conditional Value at Risk (CoVaR) for regression analysis. These indicators offer diverse perspectives on measuring systemic risk. The regression outcomes confirm that the capital adequacy ratio (CAR) significantly negatively impacts systemic risk, whether MES or CoVaR is used as the dependent variable. This consistency with the original analysis using SRISK corroborates the robustness of the study's main findings-that increasing capital adequacy effectively reduces systemic risk. Time window tests: the stability of the impact of the capital adequacy ratio on systemic risk was examined across two distinct 2016-2023, periods: 2008-2015 and encompassing the financial crisis. The segmented regression results consistently supported a significant inverse relationship between the capital adequacy ratio and systemic risk in both time frames. This evidence suggests that irrespective of market conditions, enhancing bank capital adequacy remains an effective strategy for mitigating systemic risk. These robustness tests not only bolster confidence in the research hypotheses but also provide compelling evidence for policymakers to formulate risk management policies across varying market conditions. The results of these robustness analyses further validate the reliability and applicability of the research methods and conclusions of this study.

Credit risk quantification typically relies on credit scoring models, which analyze historical data using econometric and machine learning techniques to predict the borrower's probability (PD).^[6] of default Among existing methodologies, logistic regression is a widely employed model. It effectively assesses the credit risk of borrowers by modeling the binary outcome of default events (whether or not a default occurs) alongside several financial indicators and independent variables, such as the enterprise's asset-liability ratio, current ratio, and cash flow.

4.2.3 Application of Logistic regression model in credit risk management

In current credit scoring models, the Logistic regression model is extensively utilized to

estimate default probabilities due to its simplicity and substantial explanatory power. The model predicts individual default probabilities by modeling default behavior as the dependent variable and incorporating financial indicators and behavioral data of borrowers as independent variables. It is particularly adept at predicting default risks during economic downturns, notably in times of financial instability, where it can adeptly capture the effects of systemic risk.

The fundamental equation of Logistic regression is as follows:

$$P(Y_i = 1) = rac{1}{1 + e^{-(eta_0 + \sum_{k=1}^n eta_k X_{ik})}}$$

Where $P(Y_i=1)$ denotes the probability of default for the *i*-th borrower, X_{ik} is the *k* th independent variable of the borrower (such as asset-liability ratio, cash flow, etc.), and βk is the corresponding regression coefficient. These parameters are estimated using the method of maximum likelihood estimation to optimize the model's predictive accuracy.

The Logistic Regression model is particularly suited for the binary classification problem of default probability, where a borrower either defaults (Yi=1) or does not (Yi=0). This model is highly effective during economic recessions, as empirical research has shown that default rates among SMEs typically rise significantly, by approximately 5% to 10%. By analyzing the default probabilities output by the Logistic Regression model, banks can proactively identify high-risk customers and accordingly manage risks. For example, in scenarios predicting higher default rates, banks might implement strategies such as strengthening credit assessments or increasing capital buffers to lessen the potential impacts of defaults on capital adequacy ratios.

4.2.4 Systemic risk mitigation based on default probability

Systemic risk typically manifests when multiple market participants concurrently face significant credit risk exposure due to adverse macroeconomic or financial market conditions. Consequently, relying solely on the default probability predictions of individual borrowers is inadequate to fully encompass the breadth and depth of systemic risk, necessitating the integration of default correlations and potential risk contagion effects.

In this context, the Capital Adequacy Ratio

(CAR), as a crucial metric for assessing bank capital levels, directly influences banks' capacity to withstand systemic risks. Despite Basel III's emphasis on maintaining adequate capital ratios to buffer against potential economic shocks, the actual mechanisms of systemic risk transmission are considerably more complex than those stipulated by the agreement. Systemic risks often impact the banking system through common shocks in financial markets, such as stock volatility macroeconomic market and uncertainty, which can elevate banks' default rates and subsequently affect their capital adequacy ratios. To quantify the impact of systemic risk on CAR, systemic risk indicators (e.g., stock market volatility, macroeconomic uncertainty indices) can be incorporated into a logistic regression model and a dynamic panel data model can be established. The model is structured as follows:

$$CAR_{it} = \alpha + \gamma SR_t + \sum_k \delta_k X_{kit} + \mu_i + \epsilon_{it}$$
(1)

Among them, where CARit represents the capital adequacy ratio of bank *i* at time *t*, SRt is the systemic risk index, Xkit includes control variables such as bank size and asset-liability ratio, *µi* denotes the individual effect of the bank, and ϵ is the error term. Estimating this dynamic panel model elucidates the mechanisms through which systemic risk affects the capital adequacy ratios of Chinese commercial banks. During economic downturns, systemic risks typically reduce banks' Capital Adequacy Ratios (CAR) by elevating default rates. Conversely, a higher CAR bolsters a bank's resilience to risks. While Basel III emphasizes the criticality of sustaining a substantial capital buffer, this study advocates for banks to dynamically adjust their CAR in response to changes in default probability models and systemic risks. These dynamic adjustments not only preserve a sufficient capital buffer to counteract potential financial risks and diminish the impact of systemic risks on the stability of the financial system, but they also reduce the proportion of high-risk assets held, thereby refining investment decisions.

4.2.5 Case analysis

In the contemporary global financial environment, the manifestation of systemic risks highlights profou nd deficiencies in the resilience to risk and the efficacy of capital structures within financial institutions. Following the 2008 financial crisis, national regulators have implemented a series of measures to bolster the management of bank capital and liquidity, with the aim of enhancing the stability of the entire financial system. Despite improvements in capital adequacy ratios and innovations in capital instruments being tailored to meet regulatory requirements, these initiatives continue to face significant challenges during implementation, particularly under macroeconomic downturns and within relatively immature capital markets. Taking China as an commercial banks have made example, considerable efforts to align with international regulatory frameworks such as Basel III, and have refined their capital structures. As of the end of 2023, the Industrial and Commercial Bank of China (ICBC) reported a Core Tier 1 capital adequacy ratio of 13.72%, a Tier 1 capital adequacy ratio of 15.17%, and a total capital adequacy ratio of 19.10%, all markedly exceeding the regulatory minimums.^[7] These figures not only exemplify the proactive approach of Chinese commercial banks towards capital management but also underscore their strategic focus on bolstering risk resilience. Notably, ICBC has further optimized its capital structure by issuing 80 billion yuan in preferred shares, thereby enhancing the long-term stability and liquidity of its capital and strengthening its ability to manage potential financial risks.^[8] As shown in Table 1.

While increasing capital adequacy ratios is an effective strategy to bolster banks' resilience against risks, it is not the only method. For instance, the Bank of Communications (BOCOM) observed a decrease in the growth rate of its credit risk-weighted assets from 13.56% in 2022 to 10.78% in 2023, illustrating that by enhancing internal rating models and refining credit risk mitigation mechanisms, banks can improve capital efficiency while managing the growth of risky assets.^[9] This capital optimization intrinsic strategy demonstrates how banks can strengthen their capital adequacy through sophisticated risk management, particularly in credit risk, without solely relying on external capital injections.

Furthermore, by proactively managing non-performing assets through methods such as loan write-offs, debt restructuring, and asset securitization, commercial banks can activate idle assets and reduce capital depletion, thereby enhancing their overall risk defense. For example, in 2023, the Bank of China(BOC) processed 43.576 billion yuan in non-performing assets, an increase of 9.614 billion yuan from the previous year. These measures not only relieve

capital strain but also create opportunities for further capital accumulation.^[10]

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Regulation			I New Regulations in China	
	Standard	4.50%	6%	
Capital Adequacy Ratio	Effective Time	2015	2024	
	Compliance Deadline	2017	2026	
	Standard	6%	7%	
Tier 1 Capital Adequacy Ratio	Effective Time	2015	2024	
	Compliance Deadline	2017	2026	
Capital Adequacy Ratio	Standard	8%	8%	
	Effective Time	N/A	2024	
	Compliance Deadline	2019	2026	
Capital Conservation Buffer	Standard	2.50%	2.50%	
Additional Capital	Ston doud	N/A	Systemically Important Banks:	
Requirements	Standard		1.5%, Other Banks: 0.5%	
	Standard	3%	3.5%	
Leverage Ratio	Effective Time	2013	2024	
	Compliance Deadline	2018	2026	

Regarding capital replenishment, the use of innovative financial instruments remains a key strategy for Chinese commercial banks to improve their capital adequacy ratios. In 2023, for instance, the China Everbright Bank(CEB) expanded and stabilized its capital base by issuing 33 billion yuan in tier 2 capital bonds and convertible bonds^[11]. While these initiatives have temporarily enhanced capital adequacy ratios, they also offer valuable insights into how financial institutions can maintain and increase capital adequacy under economic pressures. However, banks continue to face significant challenges in capital augmentation and risk management: on one hand, slowing economic growth and declining corporate profits hinder the natural accumulation of capital; on the other, the immaturity of domestic capital markets limits their ability to raise funds through public markets. Thus, finding an effective balance between capital replenishment and risk management in a complex economic

environment remains a critical challenge for Chinese commercial banks.

4.2.6 Results discussion and policy recommendations

The empirical analysis of this study on the relationship between capital adequacy ratios and systemic risk in Chinese commercial banks reveals that enhancing capital adequacy ratios significantly mitigates banks' systemic risk. The management of systemic risk relies not only on banks' capital buffer mechanisms but also on factors such as macroeconomic conditions, levels of non-performing loans, and liquidity management.^[12]Based on these findings, the study proposes the following policy recommendations:

(1) Elevate capital adequacy requirements: As the financial system increases in complexity, relying solely on the minimum capital requirements set by the Basel Accords is insufficient to counter the impacts of systemic risks. Regulators should consider establishing dynamic capital adequacy standards that reflect the distinct economic environments and market characteristics of each country or region. It is recommended to introduce a risk-sensitive dynamic adjustment mechanism within the capital management framework, tailored to the size of banks, the quality of assets, and macroeconomic fluctuations. Particularly during expansions, banks should economic be encouraged to build additional capital buffers to prepare for potential future financial crises and to prevent the excessive accumulation of systemic risks.

(2) Enhance management of non-performing loans and credit risk assessment: In the current financial rising climate, the ratio of non-performing loans represents a significant channel for the spread of systemic risks. Commercial banks should strengthen post-loan risk management during economically unstable proactively undertake periods and asset restructuring, debt restructuring, and the

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securitization of non-performing assets to reduce capital consumption. Furthermore, this paper recommends the adoption of more advanced credit risk assessment models, which integrate big data analytics and machine learning technologies to improve the accuracy of credit scoring and provide early warnings of potential credit risks. This method not only helps in reducing the accumulation of systemic risks but also significantly enhances banks' operational efficiency and capital utilization, facilitating more effective management and mitigation of credit risks. Simultaneously, it supports maintaining financial stability, optimizing capital structures, and improving financial performance, enabling banks to remain competitive in changing market conditions and create greater value for their stakeholders.

(3) Implement differentiated capital regulatory policies: Given the significant differences in scale, business model, and risk tolerance among Chinese commercial banks. this paper emphasizes the need for regulators to adopt differentiated capital regulatory strategies. For large state-owned banks, which play a critical "too big to fail" role in systemic risk, regulations should focus on mitigating their systemic risks through more stringent capital and liquidity requirements. For smaller and medium-sized banks, regulatory strategies should not only strengthen capital adequacy ratios but also enhance the use of liquidity and risk management tools to ensure these institutions maintain sufficient resilience against market volatilities. This customized regulatory approach accurately reflects the operational more characteristics and risk profiles of various bank types and significantly enhances the overall stability of the financial system. Bv implementing these strategies, regulators can more effectively prevent and mitigate potential systemic risks, thereby promoting the healthy development of the banking sector. Such a regulatory framework would create a fairer and more adaptable competitive environment for banks, thereby stimulating market dynamics and innovation.

(4) Enhance capital market mechanisms and broaden capital augmentation channels: In the current financial environment, bank capital supplementation primarily relies on internal accruals and external capital market funding. However, the relative immaturity of the capital markets and declining corporate profitability significantly limit banks' options for capital replenishment. Therefore, it is recommended that regulatory bodies promote capital market reforms and encourage financial innovation to diversify the types of capital instruments available. Specifically, the promotion of instruments such as convertible bonds and perpetual bonds could provide banks with more flexible options for capital augmentation. Furthermore, introducing market-driven capital regulatory frameworks is suggested to help banks achieve a prudent balance between capital adequacy and risk tolerance, guided by market actions and pricing signals. These frameworks would not only improve capital management efficiency but also enhance banks' ability to respond to market fluctuations, thereby bolstering the stability of the financial system and supporting the robust development of the banking sector.

(5) Enhancing cross-border regulatory collaboration to address global systemic risks: In the context of increasingly interconnected global financial markets, the transnational transmission of systemic risks presents a formidable challenge. National regulatory frameworks often fall short in containing the international spread of financial crises, underscoring the necessity for enhanced regulatory coordination among major global economies. This is especially critical during global economic downturns, where collaborative efforts to establish uniform risk management standards and capital requirements are essential for effectively managing the spread of systemic risks. Moreover, developing a robust information-sharing system would enable national regulators to promptly access crucial regulatory information, thus facilitating the early identification and proactive management of emerging systemic risks. Additionally, the establishment of a sophisticated early-warning could significantly enhance system the effectiveness and timeliness of regulatory responses, thereby reducing the likelihood of risk contagion among financial institutions. Strengthening cross-border regulatory cooperation not only improves the capacity of countries to control and mitigate systemic risks but also promotes the stability and healthy development of global financial markets. Deepening such collaborations is crucial for strengthening the global financial regulatory framework and is a vital strategy for addressing the challenges of a globalized financial

environment.

(6) Developing a flexible and proactive risk management and capital regulatory framework: In the era of digital transformation, banks are required to establish a flexible and proactive capital management and risk mitigation effectively navigate framework to the increasingly complex and volatile financial landscape characterized by systemic risks. This strategic approach not only enhances their capabilities in managing risks but also fortifies the overall stability of the financial system. Initially, banks must diligently identify the types and origins of financial risks and employ a diverse array of risk management tools to bolster resilience against market fluctuations. This requires the establishment of a comprehensive risk management philosophy, the development of a customized risk management system, and the fostering of a robust risk culture to enhance resistance.Furthermore, risk banks should construct a dynamic capital management system that utilizes financial technology for the real-time monitoring of market data and customer behavior, and establish a proactive early warning system to swiftly identify and mitigate potential threats. This framework should cover traditional risks such as liquidity and market risks, and also address the challenges posed by financial innovation and technological risks. Through this adaptive mechanism, banks are better equipped to modulate their capital buffers and risk exposures, ensuring robust operations and contributing significantly to the financial system's stability.Moreover, regulatory policies need to be crafted with a vision for the future, possessing the flexibility to effectively tackle upcoming risks and challenges in the global financial markets. Regulatory authorities should encourage financial institutions to innovative explore capital management approaches, including convertible bonds and various capital injection methods, and leverage cutting-edge data analytics and risk assessment tools to optimize capital utilization and enhance efficiency. operational The regulatory should be framework harmonized with international standards such as the Basel Accords. continuously improving risk management proficiency to adapt to the swift changes in financial markets and business models.By establishing a flexible and proactive risk management and capital regulatory framework, financial institutions can enhance their resilience against systemic risks, maintain stable operations amidst uncertainty, and achieve sustainable growth. This framework and its strategic implementation are crucial for the long-term stability and health of the financial system globally.

(7) Establishing the rule of law as the foundation for financial system stability and economic development: The construction of a robust legal framework enhances the banking sector's capacity to manage and mitigate systemic risks, facilitating the healthy and sustainable development of financial markets while providing a stable institutional foundation for capital management. Consequently, this ensures that banks can effectively respond to future market fluctuations and risk challenges while adhering to capital adequacy requirements.An effective legal framework institutionalizes capital management and risk control mechanisms within the banking sector, ensuring transparency, fairness, and consistency in regulatory policy implementation. In the context of an increasingly complex global financial environment, the significance of the rule of law is amplified, offering a stable and predictable legal setting that strengthens stakeholder confidence and helps reduce the spread of systemic risks arising from legal uncertainties. To achieve these objectives, it is crucial to further enhance the financial legal and regulatory framework. This involves fostering coordination between the national legislature and regulatory bodies, establishing legal standards for capital adequacy ratios, liquidity management, and systemic risk prevention, as well as clarifying operational procedures for counter-cyclical capital requirements and bank bankruptcy resolution.Additionally, reinforcing law enforcement and regulatory compliance is essential to ensure the stringent implementation of financial policies and regulations. Conducting regular compliance audits and imposing penalties will ensure that banks fully comply with relevant laws and regulations. Moreover, improving the fairness and transparency of the judicial system is vital for providing banks with clear legal expectations in regulatory contexts. Judicial reforms aimed at protecting the legal rights of financial institutions and ensuring equitable treatment in legal disputes will mitigate legal risks and regulatory uncertainties. Lastly, promoting legal cooperation in cross-border financial regulation is imperative.

This will guarantee the legality and compliance of cross-border capital flows and aid in establishing a unified legal framework for resolving cross-border financial risks, addressing the systemic risks posed by international transmissions.

4.2.7 Research innovation and future direction

This research introduces several novel contributions, particularly in the realm of banking risk management theory and empirical analysis.

First, the study establishes a dynamic risk management framework that innovatively links the mechanisms of capital adequacy ratios with the evolution of systemic risks. Furthermore, the research integrates diverse dimensions such as macroeconomic variables. internal bank management factors, and liquidity conditions to perform an extensive and systematic analysis of systemic risks. This methodology contrasts sharply with traditional research, which typically focuses on static models of capital adequacy and often overlooks the variable impact of capital adequacy ratios on systemic risk, as well as the dynamic adjustments banks undertake in response to macroeconomic shifts. To overcome the drawbacks of traditional static models, this study employs a dynamic panel data model and utilizes the System Generalized Method of Moments (System GMM) for regression analysis. This technique not only effectively addresses issues of variable lag and model endogeneity but also elucidates the short-term and long-term impacts of capital adequacy ratios on systemic The introduction of this dynamic risk. framework markedly improves the model's predictive and explanatory capabilities and introduces a novel analytical tool for future risk management research. These theoretical and methodological advancements provide valuable insights and strategies for navigating the complex risk landscape confronting the banking sector.

Second, this paper innovatively transcends the conventional definitions of the capital adequacy ratio, introducing a novel paradigm of "dynamic capital buffer management." Under this paradigm, banks are advised to dynamically adjust their capital buffer levels in response to their current capital adequacy and the transmission effects of systemic risks, moving away from adhering to a singular, static capital adequacy standard. Specifically, by employing a nonlinear model, this research uncovers a

"threshold effect" between bank capital adequacy ratios and systemic risks.^[13] It finds that systemic risk escalates significantly when capital adequacy ratios fall below a certain threshold. This finding challenges the traditional linear capital management approach of the Basel Accords, advocating for capital supervision policies that integrate diverse factors-such as individual bank characteristics, asset quality, and the macroeconomic environment—in a dynamic. asymmetric, and nonlinear manner. This approach not only more precisely captures the banks' actual risk conditions but also facilitates more effective preemptive actions against systemic risks. Employing this dynamic and strategy differentiated regulatory enables regulators to more adeptly navigate the evolving market landscape and potential financial threats, thereby bolstering the financial system's overall stability and resilience. The introduction of this theory offers fresh insights and practical directions for future capital regulation, holding significant theoretical and practical implications. Third, based on an in-depth analysis of the unique institutional and market contexts of China's banking sector, this paper introduces the "Dynamic Pathway for Systemic Risk Control" for the first time. This pathway integrates the interbank risk contagion mechanisms. externalities of the derivatives market, and diffusion effects of the shadow banking system, thereby elucidating the nuanced role of the capital adequacy ratio in managing different types of systemic risks. Specifically, the study finds that during economic downturns, although enhancing the capital adequacy ratio can alleviate systemic risks, relying solely on this measure is insufficient to curb the cross-market spread of systemic risks amid the complexities of derivatives markets and accelerated financial innovation. In response to this issue, the paper proposes a "Capital-Liquidity-Credit Risk" three-tiered collaborative management strategy, designed to establish a more multidimensional and comprehensive systemic risk prevention and control framework. The innovation of this strategy lies in its departure from traditional capital adequacy management, incorporating liquidity regulation and market risk management into a holistic risk control framework. This integrated risk management strategy provides novel insights for future financial regulatory policies, especially in terms of more comprehensively preventing and mitigating

systemic risks within the financial system, bearing significant theoretical and practical implications.

Future research directions can be further expanded from the following aspects:

First, this study suggests expanding the proposed dynamic capital management framework to various economies and transnational banking systems to explore the heterogeneity and universality of the relationship between capital adequacy ratios and systemic risks within diverse financial architectures and regulatory contexts. This inquiry is especially crucial for emerging market economies characterized by uneven financial market development and weaker regulatory infrastructures. The capital management and systemic risk transmission mechanisms in these economies might differ markedly from those in advanced economies. a comparative analysis Through across international samples, this research not only deepens our understanding of the unique challenges these nations encounter in implementing capital management policies but also explores optimal practices across different countries. Such studies not only provide theoretical support for crafting more effective international financial regulatory policies but also contribute vital empirical evidence to the discourse on global financial stability.

Second, further research should explore the application of capital adequacy ratios in managing operational, compliance, and environmental, social, and governance (ESG) risks more thoroughly. As financial markets become increasingly complex, sole reliance on capital adequacy ratios to gauge bank stability proves inadequate. Future studies should aim to integrate a wider array of risk metrics, such as governance structures, risk culture. and fluctuations in market sentiment, to construct a more comprehensive system for managing risks related to capital adequacy. This method not only more accurately reflects the banks' true risk profiles but also promotes ongoing enhancement and innovation in risk management practices, thereby strengthening the theoretical and practical foundations for the banking industry's stability and growth.

Third, future research should concentrate on how financial technology (FinTech) and digital transformation influence bank capital adequacy ratios and systemic risk management. With the extensive adoption of artificial intelligence, big data, and blockchain technologies in the banking sector, the business models and risk profiles of banks have experienced fundamental shifts. These technologies not only redefine traditional risk management approaches but also introduce new systemic risks, including data privacy risks, technology dependency risks, and cybersecurity threats. Therefore, future research should integrate fintech advancements into the bank capital management framework and examine the effects of emerging technologies such as digital currencies and smart contracts on the dynamic interplay between capital adequacy ratios and systemic risk, in order to promote deeper reforms and innovation in financial services within Chinese commercial banks sector. [14] This research will provide essential theoretical foundations and policy guidance for banking regulation in the digital era, assisting regulators institutions in and banking effectively addressing the challenges and opportunities posed by technological advancements.

Last, given the high interconnectedness of global financial markets, future research should thoroughly investigate the cross-national transmission mechanisms of global systemic risk and their implications for capital adequacy management. During financial crises or macroeconomic shocks, systemic risks frequently transmit rapidly to other countries through channels such as cross-border capital flows, exchange rate volatility, and external debt, presenting new challenges for managing bank capital adequacy ratios. Thus, future research should adopt a global financial network perspective, develop a model for transnational systemic risk transmission, and establish more effective capital management strategies and regulatory coordination cross-border frameworks through empirical case studies. This research will contribute to enhancing the resilience and risk management capabilities of the banking sector in the global financial system, providing theoretical and policy support for international financial stability.

5. Conclusion

In summary, this study innovatively applies a dynamic econometric model to provide a new perspective on understanding the relationship between capital adequacy ratios and systemic risk in Chinese commercial banks. The results not only reveal the complex and dynamic interaction between these two factors but also propose a set of forward-looking and adaptive capital management strategies. To enrich research in this area, future studies should continue exploring the optimal paths for capital management within a broader financial context and from an international perspective, thereby offering deeper academic insights and concrete policy recommendations that contribute to the stability and sustainable development of the global financial system.

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