Department of Economics and Finance

Working Paper No. 2424

Economics and Finance Working Paper Series

E Philip Davis and Samsher Singh

Bank Risk, Capital Adequacy and Banking Market Concentration – A Global Study

December 2024

http://www.brunel.ac.uk/economics

5th December 2024

BANK RISK, CAPITAL ADEQUACY AND BANKING MARKET CONCENTRATION – A GLOBAL STUDY

E Philip Davis and Samsher Singh[1]
Brunel University of London and NIESR
London

Abstract

We examine the dynamic relationship between banking sector capital adequacy, competition, and financial risk in an extensive global macro-financial dataset of 220 countries covering the years 1998 to 2021, using Generalised Method of Moments (GMM) and Logit models. Developing from the earlier work by Davis et al (2020), the study underlines not only the essential role of capital adequacy measured with and without risk adjustment in reducing financial risk, but also the key influence of competition as proxied by market structure in influencing financial stability. Macroeconomic factors such as GDP growth, inflation, and unemployment are also shown to have an important effect on bank risk. The findings offer crucial perspectives for policymakers and regulators, emphasising the need of strict capital regulation that considers regional and historical economic factors as well as banking market structure in order to enhance the resilience of the banking industry and reduce the risk of financial crises.

Keywords: Capital adequacy, leverage ratios, banking sector risk, banking market structure, competition.
JEL codes: E58, G28

[1] E Philip Davis, Brunel University, Uxbridge, Middlesex, UB8 3PH, UK, and Fellow, NIESR, 2 Dean Trench Street, Smith Square, London SW1P 3HE, emails philip.davis@brunel.ac.uk and e_philip_davis@msn.com, Samsher Singh, Brunel University email samshersingh0502@gmail.com . This paper was developed from Samsher's dissertation for the MSc degree in Banking and Finance in year 2023-24 for which Professor Davis was the supervisor. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Contents

List of Tables:-

1 . Introduction

Bank capital adequacy is widely seen as crucial for helping ensure resilience and a greater ability to absorb losses thus reducing risk. It may also offer incentives to reduce risk. Policy in respect of capital adequacy has undergone an evolution. Prior to 1988, regulators often assessed capital adequacy based on simple equity/asset ratios (leverage ratios), also with a focus on liquidity. However, in light of experience of financial crises, capital regulation evolved. According to the 1988 Basel accord, banks needed to maintain a capital ratio of 8% in regard to risk-weighted assets. The three-pillar structure of Basel II, while an advance on Basel I, was found to be inadequate during the financial crisis of 2007-2008. The Basel III framework emphasised the improvement of capital quality of the banks, adoption of explicit leverage ratios to complement risk adjusted measures, and inclusion of new liquidity regulations to improve bank resilience and stability within financial systems.

A wide range of studies have been undertaken on capital adequacy, risk taking and financial stability in the banking sector. Two different theories related to risk making choices and related incentives can be distinguished. The “skin in the game“ theory argues that banks accept lower level of risk when required to hold large amounts of capital, as their financial interest is directly related to it. The “regulatory hypothesis“ argues that banks with adequate capital are able to take more risks due to their capacity to absorb losses through their capital buffers.

Meanwhile, the importance of competition in the banking sector has been widely demonstrated by experience of crises and empirical research. The “competition-fragility” hypothesis argues that the presence of competition leads to a decline in franchise value and hence an incentive to increase the level of risk taking, possibly leading to instability within the financial system (Keeley 1990). On the other hand, according to the “competition-stability” hypothesis, competition can improve stability as lower lending rates in competitive banking markets increase borrowers’ scope for repayment (Boyd and De Nicolo 2005).

Most empirical studies of bank risk are, however, focused either on the capital risk or the competition-risk relations. They fail to address competition and capital alongside each other in respect of risk taking. Our research develops from a study that does integrate both, which was undertaken by Davis et al. (2020). They studied the relation of four banking-sector risk indices at a country level to competition as shown by the Lerner Index and capital of the banking sector at both a risk-adjusted and unadjusted level for 113 countries over the period up to 2015.

In common with that study, we utilise the worldwide Global Financial Development Database of the World Bank, which now includes 220 countries from 1998 to 2021, for a comprehensive worldwide analysis in this study. Also in line with the earlier work, we employ rigorous methodologies such as the Generalized Method of Moments (GMM) and Logit models to provide strong and reliable findings. These results have significant implications for policymakers and regulators concerned with financial stability.

In terms of advances on Davis et al (2020) and other earlier work on capital, competition and risk, first, this study examines more timely data up to 2021 and thus includes the period of the COVID pandemic as well as the Global Financial Crisis of 2008. Secondly, the study analyses determinants of banking sector liquidity as measured by liquid assets to deposits and short term funding, besides the four risk indicators in the earlier study, namely banking crises, the banking sector log Z-score, the NPL/loans ratio and the provisions/loans ratio. Thirdly the estimates all incorporate

additional factors such as the sectoral net interest margin, return on assets, and stock price volatility omitted from the earlier study. We also consistently use the macroeconomic variables GDP growth, inflation and unemployment when evaluating bank risk. Fourthly, we employ bank concentration as the competitive measure instead of the Lerner Index[2] to enhance comprehension of the impact of market structure on risk-taking and capital strategies.

The paper is structured as follows: Section 2 provides a comprehensive assessment of the literature on bank capital adequacy, risk, and competition. Section 3 outlines the methodology and data used for analysis. Section 4 outlines the main results of the study, while Section 5 provides a concise summary and analysis of these findings, with suggested policy implications and further research.

2. Literature review

Analysis of the relationship between bank capital adequacy and banking risk has been an important area of research for many years, with numerous studies examining this relationship using various capital indicators, datasets, and approaches. The following section examines the results of important research studies, including their techniques, the significance of their conclusions, and the implications for understanding the relationship between capital adequacy and banking risk, also including the relatively small number of studies that also include measures of banking competition.

2.1 Baseline research on capital and risk

Blum (1999) gave a baseline theoretical examination of the impact of capital requirements on bank risk-taking behaviour. This examined the decision-making process of a single bank under different capital regulation variables using a dynamic model and simulations. The study argued that whereas the existing literature saw increased capital requirements act as a financial buffer, therefore reducing the bank's incentive for turning to excessive risk-taking, under certain circumstances capital requirements can lead to increased risk taking. This is because such regulation reduces profits, so a bank has a smaller incentive to avoid default. In addition capital rules raise the value of equity to the bank. In order to raise the amount of equity tomorrow it may be optimal for a bank to increase risk today. This study offered significant insights into the role of capital adequacy in the banking industry. This paper establishes the foundation for understanding the role of capital in banking from a theoretical standpoint, specifically examining the incentives generated by various capital regulatory situations.

Demirgüç-Kunt et al (2013) conducted an empirical study to assess the impact of capital buffers on the equity returns of banks during the global financial crisis of 2007-2009. A large dataset covering banks from several countries was used in their analysis, and a fixed-effects regression model was used to identify the influence of the Tier 1 capital ratio on bank stability. The crisis underscored the crucial role of capital in mitigating financial shocks by demonstrating that banks with higher Tier 1 capital ratios had a much-reduced likelihood of failure as indicated by equity returns. These empirical findings support the idea that maintaining sufficient high quality capital is crucial for mitigating banking risk, especially during times of financial volatility.

[2] The Global Financial Development Database ceased to calculate the Lerner Index with effect from 2014 data

Berger and Bouwman (2013) performed an analysis of the performance of more than 10,000 banks in the United States between 1984 and 2009. In order to address the problem of endogeneity, which arises when capital levels simultaneously influence and result from bank performance, the study used an instrumental variable methodology. Capital was measured using both equity-to-assets ratios, which are a direct measure of the leverage ratio, and risk-weighted capital ratios. The findings suggested that banks with substantial capital levels demonstrated enhanced resilience during crises, as shown by increased survival rates and a continuing capacity to provide loans.

The field of work on capital and risk highlights two conceptual approaches to analysis that can be empirically tested, namely “skin in the game” and the “regulatory hypothesis”.

2.2 Skin in the game and the regulatory hypotheses

The idea of “skin in the game” argues that increased capital ratios allow an alignment of the interests of bank owners and management with those of depositors and other stakeholders, therefore mitigating the total risk undertaken by banks.

The skin in the game argument was supported by the study conducted by Lee and Hsieh (2013), who investigated the influence of capital levels on bank risk in Asian banking markets from 1994 to 2008. The study used a GMM dynamic panel regression in which risk was assessed inter alia by the standard deviation of return on assets (ROA) and return on equity (ROE), as direct measures of risk. Results demonstrated that greater capital levels were linked to reduced risk, especially in emerging Asian nations where banking institutions are more susceptible to shocks and regulation is weaker. These results indicate that large capital buffers serve the dual purpose of safeguarding banks against negative consequences and preventing excessive risk-taking, hence providing support for the skin in the game theory.

At a global level, Anginer, et al (2014) investigated the relationship between capital levels and systemic risk in 63 nations over the period of 1998 to 2010. A dynamic panel model was employed in this study to examine the impact of capital ratios on the probability of systemic banking crises. Systemic risk was evaluated using a co-dependence index that quantified the systemic risk contribution of banks. This metric is especially significant as it accurately represents the potential for spreading of adverse effects inside the banking sector. The findings indicated that increased levels of high quality (Tier 1) capital greatly decreased the likelihood of systemic crises, thus providing strong evidence that the adequacy of capital is crucial not only for the stability of individual banks but also for the stability of the financial system as a whole. But lower quality (Tier 2) capital was found to be destabilising.

The skin in the game hypothesis was further investigated by Keeley (1990) through an analysis of the interaction of capital buffers, market power, and deposit insurance in shaping bank risk-taking behaviour. Using data from banks in the United States throughout the 1980s, the research used a two-stage least squares (2SLS) regression model to account for endogeneity. The study's results suggested that in the presence of deposit insurance, increases in competition caused bank charter values to decline, which in turn caused banks to increase default risk through increases in asset risk and reductions in capital. Accordingly, strict regulation is needed to offset this.

Whereas the skin in the game hypothesis emphasises the protective function of capital, the “regulatory hypothesis” suggests that banks considered to be more risky are generally subjected

to greater capital requirements, potentially resulting in a positive relationship between capital and risk. This theory was investigated inter alia by Rime (2001) through an analysis of Swiss banks from 1989 to 1995. To address the possible endogeneity between capital and risk, the study utilised a simultaneous equations model. Capital was measured by the capital-to-assets ratio, and risk by the ratio of non-performing loans (NPLs) to total loans. Tightening of risk adjusted capital requirements have no effect on risk but rises in the equity to assets ratio tend to accompany increases in risk. This discovery corroborates the regulatory hypothesis, indicating that the levels of capital are both a reaction to and a factor that determines the amount of bank risk.

A further empirical test of this hypothesis was conducted by Bitar et al (2018), studying 1,844 banks across 62 nations, including 36 OECD countries, from 1999 to 2013. In order to mitigate the fundamental endogeneity between capital and risk, the researchers applied a generalised method of moments (GMM) estimator, which is particularly suitable for handling panel data that could show endogeneity concerns. The findings were that risk-based capital ratios have no impact on bank risk while non-risk based capital ratios lead to an increase in bank reserves to protect against loan default, suggesting increased risk.

Altunbas et al. (2007) examined a sample of European banks between 1992 to 2000 to assess the relation of capital, risk and efficiency. They used a. system of equations and estimated them using the Seemingly Unrelated Regression (SUR) approach. Empirical evidence showed a positive relationship between risk, capital and liquidity, possibly indicating regulators' preference for capital as a means of restricting risk-taking activities.

2. 3 Leverage ratios, risk-adjusted capital ratios, and systemic risk

The comparative effectiveness of unadjusted bank leverage ratios and risk-adjusted capital ratios in predicting bank risk has been a key focus of a number of studies on banking regulation.

Anginer et al (2014) noted concerns that banks can meet capital requirements by either increasing capital or decreasing risk-weighted assets. As regulations provide discretion to banks in determining risk-weights, a key concern has been that individual banks may try to minimize capital requirements by underestimating the risks of assets on their balance sheets. And they did find that risk adjusted assets may not reflect actual risk, particularly for large banks, supporting complementing these with basic leverage ratios.

The accuracy of risk-adjusted capital indicators in reflecting actual risk exposure, particularly in the context of systemic banking crises, has been subject to examination by Barrell et al (2010) in a study of systemic banking crises in advanced countries covering the years 1970 to 2007. In this work, a logit regression model was employed to assess the level of systemic crisis risk while considering inter alia leverage ratios and risk-adjusted capital ratios as determinants. The study suggested that leverage ratios, because of their simplicity and transparency, were as reliable as predictor of an approaching financial crisis as risk-adjusted measures.

Cerutti et al. (2017) examined the impact of macroprudential rules and regulations, such as capital adequacy provisions, upon the mitigation of systemic risk in 43 countries from 2000 to 2014. They used a dynamic panel model to investigate the impact of capital regulation, on systemic risk. The success of risk-adjusted capital ratios in mitigating systemic risk was dependent upon bank supervision and the regulatory framework. This indicates that risk-adjusted procedures have the

potential to decrease risk, but they require rigorous monitoring and transparency in order to be successful.

Davis et al (2020) in the preceding work, found that leverage ratios were just as commonly significant in equations for risk at a macro level as risk adjusted capital, while insignificance of the latter in some cases underlined the possibility that risk based measures may be manipulated by bank managers.

2.4 Capital, competition and risk

Empirical evidence is conflicting on whether increased banking competition increases or decreases bank risk, while relatively few competition-risk studies include a role for bank capital.

For example, Beck et al (2013) gave empirical evidence with a global sample of individual banks. They found cross-country variation in the relationship between bank competition and risk measured by the Z-score, linked to market, regulatory and institutional features. On balance they found that competition increases risk, i.e.. "competition-fragility" particularly in regulatory environments that have liberal policies. Liu et al (2013) presented evidence of the relation of risk to competition in regional European banking markets. The results suggested that an inverted U-shaped relationship exists between regional bank competition and stability. Regional economic conditions are also found to play a significant role in determining the stability of European banks.

Meanwhile, support for "competition-stability" is offered by studies such as Anginer et al (2013) with a global sample of individual banks. They found a positive relationship between competition and systemic stability, consistent with the view that greater competition encourages banks to take on more diversified risks, making the banking system less fragile to shocks.

Among the relatively few studies that assess both capital and competition's effect on risk, Berger et al. (2009) undertook estimation for a sample of largely US banks over 1999-2005, using Z-score, non-performing loans (NPLs), and the leverage ratio as dependent variables. They found that competition increases overall bank risk and decreases capital adequacy, although the relation of the level of the Lerner index with capital adequacy was not significant. Schaeck and Cihák (2012) looked at the effect of competition on capital adequacy for banks from European countries over 1999-2005, and found higher competition gives rise to higher capital ratios. Although they found their result is robust to adjustment for risk-taking, the work did not assess risk per se as a dependent variable, focusing on the competition/capital link only. Tabak et al. (2012) found a U shaped relation of competition to risk - high and low competition benefit stability while average competition gives rise to instability. Larger banks tend to benefit more in terms of stability from competition. Capital benefits stability of all banks in less competitive markets but only large banks in markets with average and high competition.

Barrell and Karim (2020) in a study of banking crisis determinants in 19 countries, found that both banking market concentration and other competition indicators as well as house prices and capital ratios influence the incidence of crises. They argued that policymakers who wish to increase competition in banking markets should tighten supervision and raise capital standards.

The forerunner study by Davis et al (2020) noted that lack of integration of competition, capital and risk entails potential bias arising from omission of relevant control variables. They provided estimates for the relation between risk-weighted and unweighted capital adequacy, bank

competition as measured by the Lerner Index and four measures of aggregate bank risk for different country groups and time periods. Control variables captured aspects of banks' business models that contribute to financial stability, aggregated to the level of the banking sector, with macro data over 1999-2015 for up to 112 countries globally. Results largely supported "competition-fragility", i.e. a positive relation of competition to risk controlling for capital; both capital measures controlling for competition are significant predictors of risk, but signs vary across risk measures; the leverage ratio is just as widely relevant as the risk-adjusted capital ratio; and there are some differences in results between advanced countries and emerging market economies. Finally, they found competition drives capital ratios lower in a Panel VAR.

Owing to changes in regional regulatory frameworks, competitiveness and risk assessments, and study circumstances, these studies frequently yield different results. The relation of competition and bank risk may differ among countries or regions as a result of regulatory frameworks. Competition in well-capitalized banking systems can reduce risk and enhance efficiency, particularly when rules are more strict and banks hold large capital buffers. In less capitalized or inadequately regulated systems, competition can escalate risk-taking as banks attempt to maintain competitiveness, therefore destabilizing the banking system.

Indeed, evidence indicates that the level of competitiveness and the level of banking risk can be significantly affected by contextual variables such as the regulatory framework and the overall health of the banking system. A meta-analysis conducted by Zigraiova and Havranek (2016) revealed a limited correlation between competitiveness and stability. This implies that the quality of regulations may have a greater significance than competition in determining bank risk.

Furthermore, the selection of variables used to assess market competitiveness and risk in these studies might potentially influence the outcomes. Equally significant is the economic and banking environment assessed in the study. Empirical research has shown that the influence of competition on bank risk should be evaluated in conjunction with other important factors such as capital adequacy, as we do here. This illustrates the intricate and situation-dependent relation of competitiveness and bank risk.

3. Methodology

3.1 Foundational Studies

In this study, we use the methodological approach used by Davis et al. (2020) to examine the relationship between bank capital, risk, and competition using data from 1998 to 2021 from the World Bank's Global Financial Development Database (GFDD), for a full sample of 220 nations, but also separately for high-income countries, emerging market economies, pre-crisis, and post-crisis. In common with that study, we use a dynamic panel econometric model, specifically the Generalized Method of Moments (GMM), to handle potential endogeneity and the indirect relationships between leverage, risk, and competition, along with a logit panel econometric model to measure crises.

Anginer et al. (2014) investigated how bank capital affects systemic stability, particularly in highly leveraged banking systems. This study expands on their approach by including competition as a variable in a broader analysis of financial stability, using GMM and logit to analyse how competition interacts with leverage and capital adequacy across nations.

Altunbas et al. (2007) used stochastic frontier analysis and panel data regression to examine the links between capital, risk, and efficiency in European banks. This work expands on their methods by taking a dynamic approach, studying how the relationship of capital, risk and competition evolve over time using GMM, allowing for the investigation of optimal capital structures that balance stability and performance.

Finally, Beck et al. (2013) included country-time fixed effects in their cross-country research of bank competition and stability, taking into account regulatory differences between countries. Our current study takes a similar technique, incorporating competition as a control variable into the capital-risk equation with country level fixed effects to improve analysis accuracy across different regulatory situations and economic conditions.

3. 2 Innovations and Advances in Methodology

Our research makes an innovative contribution to the field of financial stability analysis by introducing numerous major improvements. First, we use the most recent Global Financial Development Database (GFDD) as of September 2022 to analyse data from 220 nations. This enables a complete and up-to-date examination of financial stability in both advanced and emerging countries, providing insights that extend beyond the scope of previous research. We are able to compare results for advanced and emerging market countries unlike most extant studies (an exception is Meng and Gonzalez 2017).

Second, we propose a new risk variable—the liquid assets to deposits and short-term financing ratio—that provides essential data about a banking sector's ability to meet short-term obligations and overall stability.

Third, our study broadens the scope of analysis through the inclusion of a broader range of independent variables at a sectoral or country level, including the net interest margin, deposits/assets, loans/assets, the return on assets, stock market volatility and macroeconomic indicators such as GDP growth, unemployment and inflation. This approach allows for a more nuanced understanding of the factors that accompany capital adequacy in influencing risk in different economic contexts. We note that studies of banking crises, for example, typically use a much narrower range of independent variables.

Finally, our research provides wider perspectives on financial stability and significant insights for macroprudential analyses by focusing on macroeconomic data. This means our results are of particular relevance to regulators undertaking macroprudential surveillance, because such sectoral data gives a greater weight to large systemic institutions than the more commonly-used bank-by-bank data. This guarantees that our results are applicable to comprehending systemic threats and the banking sector's general health.

3.3 Dependent Variables

This study includes five risk variables at a country/sector level obtained from the Global Financial Development Database (GFDD) of the World Bank. Among these variables, four are derived from Davis et al. (2020): the log of the Bank Z-score (LN_ZSCORE), Bank Nonperforming Loans to Gross Loans (%) (NPLLOANS), Banking Crisis Dummy (CRISIS) extended manually to 2021, and Provisions/Gross Loans Ratio (PROVLOAN). In addition, we use the Liquid Assets to Deposits and Short-Term Funding (%) (LADSTF) measure to expand the scope of our study. These variables with

their links to the Global Financial Development Database are listed in Table A1 at the end of the paper. We now comment on the nature and relevance of each of these indicators.

The Banking Crisis Dummy (CRISIS) is a binary variable that indicates the occurrence of an ongoing crisis (1) or its absence (0). The data presented by Laeven and Valencia (2018) provides material to allow the investigation of the impact of leverage, capital adequacy, and competitiveness on the probability of a crisis using Logit regression statistical analysis. Many studies have assessed the macroeconomic and financial determinants of such banking crises, such as Barrell et al. (2010), Karim et al. (2013) and Barrell and Karim (2020).

The banking sector's liquidity ratio (LADSTF) on which we focus compares liquid assets with short-term funding and total deposits. A bank's ability to meet short-term obligations without selling assets is determined by liquidity. Studies such as Altunbas et al. (2007) highlight the importance of liquidity measures. This variable lets us evaluate the relation of solvency risk (capital adequacy measures) and liquidity risk (this liquidity measure).

The Z-Score (LN_ZSCORE) is a comprehensive quantitative assessment of a bank's risk, including profitability, capitalization, and earnings volatility. Greater Z-Scores are indicators of reduced risk and improved financial strength. In order to simplify regression analysis, we use a logarithmic transformation to the Z-Score to mitigate skewness, as suggested by Liu et al (2013).

The Non-Performing Loans to Gross Loans ratio (NPLLOANS) is a financial metric that indicates the credit risk of a bank by evaluating the quality of its assets. This measure is commonly employed to evaluate the influence of leverage and capital adequacy on asset quality, as demonstrated in the studies conducted by Berger et al. (2009).

The Provisions to Gross Loans ratio (PROVLOAN) assesses a bank's capacity to face any loan losses, providing valuable information on risk management strategies affected by leverage and capital sufficiency, as highlighted by Bitar et al. (2018).

Collectively, these indicators provide a thorough set of criteria for evaluating financial soundness.

3.4 Independent Variables

Independent variables of most interest for effects on bank risk at a sectoral level are the leverage ratio, regulatory capital adequacy and banking sector concentration.

The Leverage Ratio (LEVERAGE) defined as the ratio of a bank's equity to total assets, is a significant factor influencing financial risk. Davis et al (2020) explore this in their study, showing that lower leverage ratios can exacerbate bank risk-taking. They find that it amplifies the effects of market shocks and competition, suggesting that effective management of the leverage ratio is crucial for financial stability. Regulatory policies must therefore consider leverage ratios to balance competition with systemic risk.

The regulatory capital to risk-adjusted assets ratio (REGCAP) measures a bank's capital adequacy relative to its risk-weighted assets. Higher ratios indicate better financial stability, as banks have a larger buffer to absorb losses. Berger and Bouwman (2013) and Demirgüç-Kunt et al. (2013) demonstrate that higher capital ratios enhance stability, especially during financial crises. This study uses this ratio to evaluate how capital adequacy affects financial risk in varying leverage

and competitive contexts. We can compare the indicator properties of it against the leverage ratio in predicting risk.

Bank concentration (BANKCON), indicated by the market share of the top three banks in a country, is another critical variable. Beck et al (2006) found crises are less likely in economies with more concentrated banking systems, even after controlling for differences in commercial bank regulatory policies, national institutions affecting competition, macroeconomic conditions, and shocks to the economy. This study examines how concentration affects the relationship between leverage, capital adequacy, and financial risk, offering insights into how market structure influences stability.

To comprehensively assess the effects of leverage and capital adequacy on financial risk, the study includes several control variables, omission of which would risk omitted variables bias:

Deposit/Asset Ratio (DEPASS) and Loan/Asset Ratio (LOANASS)- These ratios provide insights into a banking sector's funding structure and asset risk.

Bank Noninterest Income to Total Income (NONINT) indicates income diversification, is vital for understanding how banks diversify, although studies differ as to the effect of such diversification on risk. Research by Davis et al (2024) highlights its role in stability.

Stock Price Volatility (STOCVOL) reflects market risk, with high volatility indicating potential instability that could affect banks' security portfolios.

Bank Return on Assets (ROA) measure profitability and is a key stability indicator.

Finally, macroeconomic variables such as GDP Growth (GDPG), Unemployment (UNEMPL), and Inflation (INFLA) are included to account for the broader economic context. Liu et al. (2013) show how these factors impact bank performance and stability.

3.5 Econometric Approach and Descriptive Statistics

The study employs both logit regression and generalized method of moments (GMM) panel models, techniques commonly used in economic research, to explore how leverage ratios, capital adequacy, competition, and financial risk are related in the banking sector.

The difference generalized method of moments (GMM) estimator is used in the study of banking risk variables using panel data, a methodology similar to that of Davis et al. (2020) as introduced by Arellano and Bond (1991). The decision is motivated by the effectiveness of GMM in addressing complexities that ordinary least squares (OLS) encounters, such as endogeneity between the dependent and independent variables, enabling us to prevent the biases that OLS can cause.

The Arellano-Bond Serial Correlation Tests are employed to assess the presence of serial correlation in dynamic panel data models, a crucial factor for ensuring the accuracy of Generalized Method of Moments (GMM) estimates. The analysis comprises two essential elements: the AR(1) test, which examines first-order autocorrelation, and the AR(2) test, which examines second-order autocorrelation. In our result of regression all baseline regression followed AR (1) with a p-value of less than 0.1 and AR(2) more than 0.1 which is considered acceptable. An evaluation of the validity of the instruments is conducted using the Sargan's J-

statistic and its corresponding p-value. A large p-value implies the validity of the instruments and the adequate specification of the model, whereas a small p-value may imply problems with the validity of the instruments or the specification of the model.

The analysis includes fixed effects to account for variations among countries that remain constant over time, such as regulatory conditions. In order to address discrepancies in the data, particularly heteroskedasticity, adjustments such as the White period instrument weighting matrix are implemented.[3]

The Logit model, which is particularly suitable for binary outcomes, is employed for the prediction of financial crises, in accordance with the methodology established by Barrell et al. (2010) and Karim et al. (2013).

According to the statistical analysis of tables 1 to 3, it is evident that the data exhibits substantial variability and certain extreme values, as indicated by the skewness and kurtosis measurements. These indicate that the dependent and independent variables, as well as macroeconomic indices, do not conform to a normal distribution. The high Jarque-Bera statistics provide additional evidence of substantial departures from normality among the variables. This observation indicates the presence of extreme values in the data and implies that the distribution of the data is intricate, which may necessitate modifications to conventional statistical models or the adoption of more resilient alternatives such as winsorisation, which we undertake in a robustness check (although we note such an approach is less common with macro data than individual bank/firm data).

The significant skewness and kurtosis indicate that the dataset encompasses a broad spectrum of economic and financial variables, therefore emphasizing the heterogeneity within the sample. The presence of this variability underscores the requirement of employing analytical techniques that are capable of efficiently managing non-normal data distributions. These observations are essential for ensuring the accuracy and dependability of the study results, particularly in studies where the assumption of normalcy is an important factor in the choice and interpretation of models..

Table 1: - Statistical measures for dependent variables

Statistical measures	CRISIS	LZ_SCORE	LADSTF	NPLLOANS	PROVLOAN
Mean	0.03	2.62	36.30	7.06	4.45
Median	0.00	2.71	32.39	4.27	2.89
Maximum	1.00	4.96	156.73	74.10	45.46
Minimum	0.00	-4.06	0.38	0.00	0.028
Std. Dev.	0.18	0.65	18.75	7.56	4.63
Skewness	5.14	-1.38	1.28	2.42	2.74
Kurtosis	27.44	10.99	5.71	11.64	15.95
Jarque-Bera	149843.76	9855.23	1875.37	10091.17	18339.73
Probability	0.00	0.00	0.00	0.00	0.00

[3] Note that in some of the subsamples the White correction led to a singular matrix and the difference GMM weights were used instead. These were the provisions/leverage and Z-score/regulatory capital for advanced countries and Z-score/regulatory capital for emerging markets.

Sum	174.00	8672.75	117899.87	17449.03	9902.16
Sum Sq. Dev.	168.08	1386.01	1141796.43	140972.21	47736
Observations	5116	3306	3248	2470	2225

Notes: CRISIS is a banking crisis dummy (1=banking crisis, 0=none), LADSTF is the banking sector liquid assets to deposits and short term funding ratio (%), log (Z score) is the log of the Z-score for the banking sector, NPLGROSSLOAN is the banking sector nonperforming loans to gross loans ratio (%), PROVLOAN is the banking sector ratio of provisions to gross loans (%).

Table 2: - Statistical measures for Independent variables

Statistical measures	**BANKCON**	**DEPASS**	**LEVERAGE**	**LOANASS**	**REGCAP**	**NIM**	**NONINT**	**ROA**	**STOCVOL**
Mean	70.14	1.05	10.02	0.79	17.01	4.50	38.45	1.29	20.14
Median	70.38	0.93	9.50	0.83	16.10	3.84	36.14	1.18	18.03
Maximum	100.00	9.59	30.60	1.00	48.60	23.32	95.42	38.30	163.66
Minimum	16.14	0.03	1.49	0.05	1.75	0.07	6.12	-55.17	1.97
Std. Dev.	19.72	0.59	3.96	0.16	5.40	2.84	13.84	2.05	11.97
Skewness	-0.19	4.01	0.98	-1.26	1.54	1.19	0.84	-6.18	3.85
Kurtosis	2.11	31.50	4.52	4.65	7.18	5.19	3.96	240.24	33.34
Jarque-Bera	128.96	149974.67	614.78	1564.37	2794.68	1388.48	501.16	7616496.68	78156.83
Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	233577.67	4307.16	23922.40	3279.95	42334.39	14347.40	124224.91	4175.26	38541.12
Sum Sq. Dev.	1294515.18	1406.38	37393.77	109.48	72463.99	25681.65	619096.72	13560.38	274247.56
Observations	3330	4105	2387	4151	2489	3186	3231	3239	1914

Notes: BANKCON is bank concentration, DEPASS is the sectoral deposit/asset ratio, LEVERAGE is the ratio of banking sector capital to total assets, LOANASS is the Loan/assets ratio, REGCAP is the risk-weighted measure of capital adequacy, NIM is the bank net interest margin, NONINT is the banking sector's noninterest income to total income, STOCVOL is national stock price volatility

Table 3: - Statistical measures for Macro variables

Statistical measures	**INFL**	**UNEMPL**	**GDPG**
Mean	6.51	8.23	3.39
Median	3.33	6.49	3.53
Maximum	557.20	37.32	153.49
Minimum	-16.86	0.10	-58.32
Std. Dev.	20.50	6.03	6.19
Skewness	15.81	1.34	3.33
Kurtosis	323.72	4.90	97.09
Jarque-Bera	18439502.16	1990.92	1806316.11
Probability	0.00	0.00	0.00
Sum	27719.79	36534.57	16495.31
Sum Sq. Dev.	1790836.13	161153.49	186720.54
Observations	4261	4440	4873

Notes: , UNEMPL is Unemployment, GDPG is national GDP growth and INFLA is CPI inflation.

Table 4 indicates that all variables exhibit stationarity based on the Im et al. (2003) test. This test permits the identification of unique unit root processes between nations, primarily at the 1% significance level. The exceptions are the Deposit/Asset ratio, Loan/Asset ratio, Unemployment rate, and Provisions/Gross loans ratio

Table 4: - Unit root tests for variables

Variable	Statistic	Prob.**
LEVERAGE	-2.55	0.01
BANKCON	-3.96	0.00
DEPASS	-0.54	0.30
GDPG	-39.76	0.00
INFLA	-27.94	0.00
LADSTF	-2.94	0.00
LOANASS	0.17	0.57
LZ_SCORE	-10.20	0.00
NIM	-11.27	0.00
NONINT	-6.76	0.00
NPLGROSSLOAN	-3.77	0.00
PROVLOAN	-0.89	0.19
REGCAP	-3.15	0.00
ROA	-18.84	0.00
STOCVOL	-7.44	0.00
UNEMPL	3.55	1.00

4. Results

4. 1 Baseline regression results for leverage and competition

This section outlines the findings of our empirical investigation, which specifically examines the relations between bank capital adequacy, market concentration and risk. The study was conducted using up to 220 banking sectors from around the world. Table 5 presents the baseline regressions that examine the leverage ratio as a key indicator of capital adequacy. A memo item is included to compare this ratio with regulatory capital run with the same specification. In order to account for possible endogeneity and accurately represent the changing characteristics of bank risk, we utilize the Generalized Method of Moments (GMM) regression approach. Due to the methodological need of including extra time lags (especially for the instrumental variables), we begin our analysis from the early 2000s but runs up to 2021. Incorporating the global financial crisis and COVID pandemic, our study enables us to evaluate the robustness of these relationships throughout periods of financial crisis.

In evaluating the estimates, note that risk rises when liquid assets to deposits and short-term funding and the log Z-score decrease. On the other hand, risk increases if nonperforming loans to gross loans or provisions/gross loans increase, or a banking crisis occurs.

Table 5: - Baseline regression results for banking sector risk, capital and competition (1998–2021)

Equation number and dependent variable	(1) CRISIS	(2) LADSTF	(3) LNZSCORE	(4) NPLLOANS	(5) PROVLOAN
Constant	-5.45*** (4.0)				
Dependent (−1)		0.604*** (64.2)	0.433*** (35.4)	0.670*** (366.1)	0.627*** (154.9)
Dependent (−2)		-0.00083 (0.1)	0.052*** (10.2)	0.01*** (9.7)	0.0935*** (59.6)
LEVERAGE(-1)	-0.25*** (3.5)	1.127*** (16.1)	0.043*** (17.1)	0.03*** (4.4)	0.489*** (125.2)
BANKCON(-1)	-0.019** (2.4)	0.130*** (11.9)	-0.001*** (7.8)	-0.069*** (48.8)	-0.0169*** (25.3)
DEPASS(-1)	-0.0313 (0.2)	14.303*** (9.3)	0.120*** (7.7)	-4.791*** (31.9)	0.13*** (7.9)
NONINT(-1)	0.0221 (0.2)-	-0.00029 (0.9)	0.001* (1.6)	-0.100*** (53.8)	-0.0992*** (94.5)
LOANASS(-1)	5.536*** (4.1)	0.972 (0.9)	-0.516*** (11.9)	-2.351*** (12.4)	2.369*** (15.1)
NIM (-1)	-0.142 (1.1)	0.815*** (9.0)	0.010*** (2.4)	-0.521*** (101.5)	-0.263*** (55.6)
STOCVOL(-1)	0.059*** (4.6)	0.131*** (16.9)	-0.001*** (3.5)	-0.024*** (36.3)	0.000868* (1.7)
UNEMPL(-1)	0.00708 (0.3)	-0.140*** (3.8)	0.018*** (14.8)	0.103*** (13.8)	-0.106*** (25.8)
ROA (-1)	-0.077* (1.6)	0.076*** (4.1)	-0.022*** (20.4)	-0.167*** (84.3)	-0.188*** (66.4)
GDPG (-1)	-0.18*** (3.3)	-0.082*** (4.5)	0.002*** (4.5)	-0.174*** (146.0)	-0.016*** (26.1)
INFLA (-1)	0.142*** (4.5)	0.081*** (3.7)	0.005*** (6.0)	0.138*** (55.8)	0.126*** (125.7)
Regression type	ML-Binary Logit	Panel GMM difference regression	Panel GMM difference regression	Panel GMM difference regression	Panel GMM difference regression
Effects		Cross-Section Fixed (First difference)	Cross-Section Fixed (First difference)	Cross-Section Fixed (First difference)	Cross-Section Fixed (First difference)
Sample (adjusted):	2001- 2021	2003 2021	2003-2021	2003 2020	2003 2021
Periods included:	20	19	19	18	18
Countries included:	214	200	200	200	190
Observation	1227	974	1018	917	801
S.E. of regression	0.226	9.621	0.218	2.978	1.982

Sum of squared residuals	61.914	88956.631	47.828	8017.135	3098.3
Sargan' s J (probability)		60.298(0.57)	64.389(0.428)	62.536(0.493)	62.53 (0.49)
AR (1) (probability)		0.000	0.002	0.08	0.09
AR (2) (probability)		0.190	0.142	0.94	0.90
Memo: REGCAP(-1) instead of leverage (−1)	-0.256*** (-5.44)	0.561*** (14.49)	0.020*** (3.43)	-0.049*** (-10.79)	0.25*** (86.2)

NOTES:CRISIS is a banking crisis dummy (1=banking crisis, 0=none), LADSTF is the banking sector liquid assets to deposits and short term funding ratio, log (Z score) is the log of the Z-score for the banking sector, NPLLOANS is the banking sector nonperforming loans to gross loans ratio, PROVLOAN is the banking sector ratio of provisions to gross loans. LEVERAGE is the ratio of banking sector capital to total assets, BANKCON is bank concentration, DEPASS is the sectoral deposit/asset ratio, NONINT is the banking sector's noninterest income to total income, LOANASS is the Loan/assets ratio, NIM is the bank net interest margin, STOCVOL is national stock price volatility, UNEMPL is Unemployment, ROA is the banking sector's return on assets GDPG is national GDP growth and INFLA is CPI inflation. T-values are shown in parentheses (Z-statistics for the logit model). Statistical significance is indicated by *** for 99%, ** for 95%, and * for 90%. Regressions (2-5) are estimated using difference-GMM, which includes lagged dependent variables and fixed effects for cross-sectional differences. The lagged instruments for these models are the second and third differences of the dependent variable and the second lag levels of the independent variables. A White period instrument weighting matrix, along with White period standard errors and covariance, is used. Regression (1) is estimated using a binary logit model.

4.1.1 Banking crises determinants

Table 5 reveals several important new perspectives on the elements that influence the likelihood of a crisis. The study reveals a negative relationship between crisis likelihood and the leverage ratio, indicating a thin capital cushion raises crisis risk as in Barrell et al (2010). Furthermore, low bank concentration leads to a higher crisis risk (as in Barrell and Karim 2020). In less concentrated financial markets with more competition, banks might follow riskier policies, therefore raising the likelihood of a crisis.

A high loan-to-asset ratio also coincides with a higher crisis probability, as banks with a large portion of their assets locked up in loans run more credit risk. High stock price volatility reflects growing market uncertainty and instability that may have a detrimental effect on banks, raising the chance of a crisis. Moreover, a low return on assets (ROA) boosts crisis risk. It implies that banks are less successful in producing income, which can contribute to enhanced financial vulnerability with less ability to accumulate capital, and crisis risk. We note that these banking sector variables are rarely used in crisis modelling.

In terms of macro variables, poor GDP growth is another important consideration, as economic downturns lower borrowers' capacity to pay back loans, thereby increasing default risks and strain on banks. Furthermore, a higher risk of a crisis is associated with excessive inflation, as it can erode actual revenues and complicate debt payment, thereby increasing financial instability.

Finally, when regulatory capital serves as a substitute for leverage, it also reduces the risk of a crisis.

4.1.2 Liquid assets to deposits and short term funding determinants

From table 5 we can analyse various factors influencing banking sector's liquidity levels. It reveals several key insights that are consistent with the existing literature. Higher liquidity levels relate with high leverage ratios, a sign of strong capital reserves, suggesting that well-capitalized banks also hold adequate liquidity. This observation contrasts with studies by Berger and Bouwman (2013), who found that banks with robust capital reserves can afford to maintain lower liquidity levels, particularly during stable periods.

Furthermore, the impact of bank concentration shows that sectors with fewer, larger banks tend to hold more liquidity. This suggests that increased competition leads to a focus on high risk assets and limits on holding of liquid reserves.

On the other hand, profitability, economic conditions, and equity market volatility also play significant roles in shaping banks' liquidity strategies. It has been found that banks with higher net interest margins are more liquid although they may focus the balance sheet on higher yielding loans. Conversely, high stock price volatility drives banks to maintain higher liquidity perhaps as a precaution against market instability, a trend supported by Demirgüç-Kunt et al. (2013).

Macroeconomic variables such as low unemployment and high inflation have contrasting effects; low unemployment correlates with reduced liquidity perhaps due to perceived economic stability, while high inflation prompts banks to hold more liquidity as a hedge against inflationary pressures.

4.1.3 Banking sector log Z score determinants

Table 5 shows that the Z-score, which serves as an indicator of overall solvency risk within the banking sector, has several important relationships with financial and economic indicators. A higher leverage ratio, indicating a stronger capital base relative to total assets, is associated with a higher Z-score, suggesting lower risk to the banking sector.

Lower bank concentration similarly correlates with a higher Z-score, indicating reduced risk, which aligns with the findings of Anginer et al (2014) on the positive effects of increased competition on systemic stability. Additionally, a higher deposit-to-asset ratio is linked to a higher Z-score, implying a lower risk profile, a relationship supported by Berger et al (2009), who emphasized the role of a stable deposit base in promoting financial stability.

Moreover, the analysis shows that a higher proportion of noninterest income, a higher net interest margin, and stronger GDP growth are all associated with higher Z-scores, indicating lower risk levels. Furthermore, lower loan-to-asset ratios and reduced stock price volatility are also linked to higher Z-scores, reflecting a decrease in risk.

Interestingly, higher levels of unemployment and inflation are associated with higher Z-scores as well, suggesting that these economic conditions may prompt countercyclical measures by banks that enhance banking sector resilience. Overall, these findings emphasize the importance of strong capital positions, diversified income streams, stable economic growth, and prudent risk management in maintaining a resilient banking sector.

4.1.4 Non-Performing Loans determinants

For non-performing loans, the leverage ratio has a positive sign consistent with the “regulatory hypothesis” that regulators ensure risky banks have high capitalisation. When replacing the leverage ratio with regulatory capital, the relationship remains statistically significant but with a negative coefficient. This suggests that an increase in regulatory capital is associated with a decrease in non-performing loans (NPLs) in line with the “skin in the game” hypothesis.

Unfavourable economic circumstances, such as low growth and increasing unemployment, put pressure on borrowers' ability to repay, resulting in a greater number of loans reaching non-performing status. Low stock price volatility, that may characterise depressed periods of economic activity, also link to higher NPL ratios.

Higher bank concentration is shown to entail lower NPL ratios. This finding aligns with the investigation conducted by Berger et al (2009), which found that reduced bank competition is linked to heightened risk, including elevated non-performing loans.

Additionally, a higher NPL/loans ratio is associated with a lower ratio of deposits to total assets, of bank noninterest income to total income, the ratio of loans to total assets, bank net interest margin and bank return on assets. This suggests that banks characterized by reduced liquidity, limited revenue growth, and inferior profitability are more vulnerable to poor loan performance.

4.1.5 Provisions loans ratio determinants

Regarding the ratio of provisions to loans, a greater ratio of bank capital to total assets results in a reduction in provisions, suggesting a lower expected level of risk. This result is contrary to that found by Bitar et al. (2018), who found that reserves increase with capital, suggesting greater risk.

An association exists between a low bank concentration and larger provisions, which supports the "competition-fragility" hypothesis that suggests increased competition can raise risk. Consistent with the findings of Anginer et al (2014), an increase in competition might diminish systemic stability and result in elevated risk, thereby necessitating the implementation of more supervisory measures.

Elevated provisions are observed when the ratio of noninterest income to total income is low, suggesting that reduced income diversification is associated with increased risk. Banks that heavily depend on conventional lending operations may encounter greater levels of risk due to adverse selection and moral hazard.

Regarding macroeconomic factors, elevated levels of unemployment and inflation result in more provisioning, therefore emphasizing the increased risk during economic recessions and periods of widespread inflation.

Finally, an increase in regulatory capital leads to a reduction in provisions, as is the case for the leverage ratio. This is another illustration of “skin in the game” as in Lee and Hsieh (2013).

Collectively, these results emphasize the crucial influence of financial indicators and macroeconomic conditions on provisioning , so strengthening the complex relationship between capital structure, competitiveness, and economic environment in banking.

4.2 Regression Results for Capital Adequacy, Competition, and Risk Across Various Measures and Periods

Regressions in Tables 6 to 10 correspond to the model specification in Table 5. We focus on the key indicators of capital adequacy and competitiveness, while noting that the regressions include all the control variables shown in Table 5. These tables expand the analysis to encompass a diverse range of subsamples. Specifically, the regressions encompass the nations with higher incomes versus emerging markets, and developing economies, which comprise both middle- and lower-income countries. They also include the period before the crisis until 2007 and the interval after the crisis starting in 2008. We also include the global results from Table 5 as a reference.

The tables aim to investigate possible variations in the correlations between capital adequacy and competitiveness with risk in different situations and throughout time by statistically evaluating these specific subgroups and time periods.

4.2.1 Subsample results for banking crises

The global result that there is an increased risk of crises in an excessively competitive environment is reproduced in a number of subsamples, especially advanced countries but also in the pre crisis period 1998-2007 and in one regression post crisis too. This suggests that over competition may have brought financial instability to these areas and periods. The result is consistent with those of Barrell and Karim (2020) who also found lesser concentration increases the incidence of crises in 19 countries. In contrast, our analysis suggests that in emerging markets bank concentration does not significantly predict banking crises. Non-bank factors such as regulatory environments or economic conditions may be more influential in the incidence of crises in these regions.

Additionally, capital adequacy is an important predictor of crisis prevention in some subsamples. Both the leverage ratio and the risk-adjusted capital ratio are highly significant determinants of crisis in advanced countries and in the post-2008 period data. Well-capitalized banking sectors are shown to be less vulnerable to crises. Banks with considerable capital are in a better position to absorb shocks, and are more capable of navigating through turbulent financial environments. These observations are consistent with the conclusions of earlier studies such as Barrell et al (2010) who found that the main determinants of banking crises in advanced countries were house prices, capital ratios and liquidity ratios.

The insignificance of capital in our global sample prior to 2007 and in emerging markets is however also noteworthy. The former may link to the lesser development of international capital agreements, while the latter may link to weaker overall supervision.

We suggest that the financial and economic climate can have a bearing on which factors are treated as critical for maintaining financial stability after the global credit crisis. Before 2007, competition was apparently a more important determinant of crises. Yet after 2008, capital adequacy became a key factor in reducing crisis risk. These results show that the dynamics of banking crises are complex and can depend heavily on economic framework in which they are located at a specific period, underscoring the importance for financial supervision of targeted regulations in each specific market's characteristics.

Table 6:- Subsample regression outcomes for crises – capital and concentration measures only

Sample	Variable	Equation with leverage ratio	Equation with regulatory capital/risk-adjusted assets
Full sample (1998–2021)	Bank concentration (−1)	-0.019** (2.4)	-0.012 (1.5)
Full sample (1998–2021)	Capital ratio (−1)	-0.248*** (3.5)	-0.256*** (5.4)
Higher-income (advanced) countries (1998–2021)	Bank concentration (−1)	-0.039*** (3.6)	-0.031*** (3.0)
Higher-income (advanced) countries (1998–2021)	Capital ratio (−1)	-0.245** (2.6)	-0.264*** (4.3)
Emerging market economies (1998–2021)	Bank concentration (−1)	0.022 (1.3)	0.019 (1.0)
Emerging market economies (1998–2021)	Capital ratio (−1)	0.007 (0.1)	-0.148 (1.5)
Pre-crisis (up to 2007)	Bank concentration (−1)	-0.090** (2.0)	-0.083** (2.1)
Pre-crisis (up to 2007)	Capital ratio (−1)	-0.123 (0.5)	0.213 (1.1)
Post-crisis (2008 onwards)	Bank concentration (−1)	-0.014 (1.5)	-0.004 (0.5)
Post-crisis (2008 onward	Capital ratio (−1)	-0.322*** (4.0)	-0.427*** (6.8)

Notes: all regressions also include the other control variables shown in Table 5.

4.2.2 Subsample results for banking sector liquid assets to deposits and short term funding

As shown in Table 7, bank concentration and liquidity are positively related in the global 1998–2021 sample as well as in advanced economies. These results show that greater concentrations boost liquidity buffers, especially when leverage ratios are included. Anginer et al (2014) suggest that less competitive, concentrated banking environments may promote financial stability by encouraging banks to hold more liquid assets.

Meanwhile, the significant association between capital ratios and liquidity in the global sample and advanced countries suggests that well-capitalized banks have superior liquidity, protecting them from financial instability. This result is consistent with strict supervision of both capital and liquidity. The whole sample's high positive relationship between capital adequacy and liquidity supports Berger, et al (2009)'s regulatory premise that tight capital requirements are important for financial resilience.

This contrasts with the result for emerging market countries where the effect of the regulatory capital ratio is to reduce the liquidity ratio. In light of Calomiris and Herring (2013), a negative association between capital ratios and liquidity, especially risk-adjusted capital, may imply a trade-off between capital buffers and liquidity, showing a distinct risk management approach in these locations and a need for vigilance by supervisors.

Comparing results before and after the global financial crisis demonstrate how banking behaviour changed. Pre crisis there is no link of capital to liquidity, and for regulatory capital regressions the more concentrated sectors have less liquidity, After the crisis, bank concentration and capital adequacy both are significant positive determinants of liquidity, as in the global sample. Stronger capital and liquidity requirements in the post-crisis regulatory environment have strengthened this relationship, enhancing financial stability. These findings confirm Cerutti et al (2017), who found macroprudential interventions effective after the crisis.

Overall, the results support the "skin in the game" approach in developed economies but suggest a more complex interplay of factors in emerging and developing markets.

Table 7 Subsample regression outcomes for liquidity – capital and concentration measures only

Sample	Variable	Equation with leverage ratio	Equation with regulatory capital/risk-adjusted assets
Full sample (1998–2021)	Bank concentration (−1)	0.130*** (11.89)	0.050*** (7.3)
Full sample (1998–2021)	Capital ratio (−1)	1.127*** (16.1)	0.561*** (14.5)
Higher-income (advanced) countries (1998–2021)	Bank concentration (−1)	0.084 (1.6)	0.085*** (3.0)
Higher-income (advanced) countries (1998–2021)	Capital ratio (−1)	0.99*** (13.3)	0.754*** (8.5)
Emerging market economies (1998–2021)	Bank concentration (−1)	-0.018 (0.6)	-0.031 (0.7)
Emerging market economies (1998–2021)	Capital ratio (−1)	-0.424 (1.5)	-0.685*** (3.5)
Pre-crisis (up to 2007)	Bank concentration (−1)	-0.152 (0.5)	-0.47488* (2.0)
Pre-crisis (up to 2007)	Capital ratio (−1)	-1.278 (0.5)	1.500 (1.4)
Post-crisis (2008 onwards)	Bank concentration (−1)	0.080*** (5.3)	0.101*** (8.2)
Post-crisis (2008 onwards)	Capital ratio (−1)	0.678*** (10.3)	0.929*** (18.7)

Notes: all regressions also include the other control variables shown in Table 5.

4.2.3 Subsample results for banking sector nonperforming loans to gross loans

Table 8 shows a complex relation of non performing loans to bank concentration and capital adequacy. As in the global sample, bank concentration in emerging markets and in the post 2008 period is negatively related to NPLs, consistent with the "competition-fragility" concept. This suggests that credit quality is better in contexts with fewer banks or more concentration, which may be due to lower competitive pressure that could otherwise lead to riskier lending. On the other hand, the regression for advanced countries with the leverage ratio shows the opposite

sign, with more concentrated banking sectors having higher NPLs. This may relate to the relative rigour of supervision across advanced countries, where a concentrated banking sector may give rise to incentives to take risks as banks see themselves as “too big to fail”.

Meanwhile, higher capital ratios (both leverage ratios and regulatory capital ratios) are consistent with higher NPLs in both advanced countries and emerging markets, supporting the "regulatory hypothesis" that capital adequacy measurements may reflect underlying risk owing to supervisory and market pressure. Capital ratios and NPLs are also positively correlated post-crisis (2008 forward), whereas before the crisis the relation was zero (leverage ratio) or negative (regulatory capital).

This move may highlight tighter capital regulation after the financial crisis, potentially due to regulatory capital measurements catching up with credit risk as revealed during the crisis, bearing in mind NPLs are a lagging indicator of risk. Other studies, such as Davis et al. (2020) found that while higher leverage ratios are intended to improve stability, they may relate to increases in NPLs, especially in volatile economic conditions.

These findings suggest that effects of capital regulation and bank competition on risk are complex, and while increased capital promotes stability, its effects on credit risk and NPLs is context-dependent.

Table 8- Subsample regression outcomes for NPL/loans ratio – capital and concentration measures only

Sample	Variable	Equation with leverage ratio	Equation with regulatory capital/risk-adjusted assets
Full sample (1998–2021)	Bank concentration (−1)	-0.069*** (48.8)	-0.023*** (26.2)
Full sample (1998–2021)	Capital ratio (−1)	0.032*** (4.4)	-26.158*** (9.1)
Higher-income (advanced) countries (1998–2021)	Bank concentration (−1)	0.013*** (6.1)	-0.0009 (0.3)
Higher-income (advanced) countries (1998–2021)	Capital ratio (−1)	0.159*** (13.1)	0.070*** (4.2)
Emerging market economies (1998–2021)	Bank concentration (−1)	-0.067*** (15.7)	-0.052*** (10.4)
Emerging market economies (1998–2021)	Capital ratio (−1)	0.421*** (9.1)	0.320*** (6.1)
Pre-crisis (up to 2007)	Bank concentration (−1)	-0.050 (1.6)	-0.022 (0.8)
Pre-crisis (up to 2007)	Capital ratio (−1)	-0.343 (1.6)	-0.816*** (7.3)

Post-crisis (2008 onwards)	Bank concentration (−1)	-0.075*** (83.2)	-0.052*** (65.4)
Post-crisis (2008 onwards)	Capital ratio (−1)	0.676*** (118.7)	0.383*** (60.1)

Notes: all regressions also include the other control variables shown in Table 5.

4.2.4 Subsample results for banking sector Z-score

Table 9 shows that bank concentration has a significant negative relationship with the Z-score in the global sample, in advanced countries and post 2008 but not consistently across the regressions with the different capital measures. Where it is significant, it indicates that higher concentration, or less competition, is associated with greater risk, bearing in mind that the Z-score is negatively related to risk. This supports findings by Anginer et al (2013) who emphasized the role of competition and financial soundness in systemic stability (the "competition-stability" paradigm). Conversely, in emerging markets, bank concentration does not significantly affect risk.

As in the global sample, the capital ratio is positively related to the Z-score in all subsamples except leverage pre crisis. This implies that higher capital ratios reduce solvency risk, acting as a protective buffer. Overall, robust capital levels are essential for reducing bank risk across different economic contexts. Note, however, that this is to be expected since capital adequacy enters the calculation of the Z-score along with the return on assets and the volatility of the return on assets.

Table 9 - Subsample regression outcomes for banking sector log Z score – capital and concentration measures only

Sample	Variable	Equation with leverage ratio	Equation with regulatory capital/risk-adjusted assets
Full sample (1998–2021)	Bank concentration (−1)	-0.001*** (7.8)	-0.001 (0.8)
Full sample (1998–2021)	Capital ratio (−1)	0.043*** (17.1)	0.020*** (3.4)
Higher-income (advanced) countries (1998–2021)	Bank concentration (−1)	-0.00388*** (2.9)	-0.004* (1.9)
Higher-income (advanced) countries (1998–2021)	Capital ratio (−1)	0.0663*** (14.3)	0.011* (1.8)
Emerging market economies (1998–2021)	Bank concentration (−1)	0.00047 (0.6)	0.0006 (0.7)
Emerging market economies (1998–2021)	Capital ratio (−1)	0.0284*** (2.7)	0.016*** (3.1)
Pre-crisis (up to 2007)	Bank concentration (−1)	0.0003 (0.1)	-0.00226 (0.7)

Pre-crisis (up to 2007)	Capital ratio (−1)	0.049 (1.2)	0.0468** (2.1)
Post-crisis (2008 onwards)	Bank concentration (−1)	-0.0008*** (2.7)	-0.00104*** (2.9)
Post-crisis (2008 onwards)	Capital ratio (−1)	0.030*** (16.9)	0.0113*** (12.5)

Notes: all regressions also include the other control variables shown in Table 5.

4.2.5 Subsample results for banking sector provisions/gross loans ratio

Table 10 examines the impact of bank concentration and capital adequacy on different samples and time periods for the provisions/loans ratio at the banking sector level. The findings suggest increased bank concentration, which is commonly linked to decreased competition, is generally related with lower provisioning. Besides the global sample this is the case for advanced countries, (regulatory capital regression), in the emerging markets and in the post crisis period (leverage ratio regression). This finding substantiates the notion that banking sectors with lower levels of competitiveness generally assume lower levels of risk and hence do not require high levels of provisioning.

The capital ratio, whether assessed by leverage or regulatory capital, consistently establishes a positive correlation between higher ratios and greater provisions, consistent with strict supervision. Post-crisis, this tendency is particularly robust, also indicating a more prudent stance by banks in the aftermath of the financial crisis. We note the contrast with the pre-crisis period when there was a negative correlation between capital ratios and provisions across both capital measures. This indicates a distinct risk-taking pattern prior to the financial crisis.

Table 10 - Subsample regression outcomes for banking sector provisions/loans – capital and concentration measures only

Sample	Variable	Equation with leverage ratio	Equation with regulatory capital/risk-adjusted assets
Full sample (1998–2021)	Bank concentration (−1)	-0.0169*** (25.7)	-0.00528*** (5.4)
Full sample (1998–2021)	Capital ratio (−1)	0.489*** (125.2)	0.25*** (86.2)
Higher-income (advanced) countries (1998–2021)	Bank concentration (−1)	-0.00744 (1.2)	-0.00727*** (6.8)
Higher-income (advanced) countries (1998–2021)	Capital ratio (−1)	-0.0151 (0.4)	0.0179*** (2.9)
Emerging market economies (1998–2021)	Bank concentration (−1)	-0.0313** (2.6)	-0.0176** (2.2)
Emerging market economies (1998–2021)	Capital ratio (−1)	0.578*** (12.8)	0.387*** (13.4)

Pre-crisis (up to 2007)	Bank concentration (−1)	0.0059 (0.5)	0.0042 (0.2)
Pre-crisis (up to 2007)	Capital ratio (−1)	-0.303*** (5.7)	-0.0715* (2.0)
Post-crisis (2008 onwards)	Bank concentration (−1)	-0.0247*** (108.7)	-0.00026 (-0.6)
Post-crisis (2008 onwards)	Capital ratio (−1)	0.631*** (194.5)	0.421*** (168.7)

Notes: all regressions also include the other control variables shown in Table 5.

4.3. Robustness check

We noted above that there are clearly some extreme observations in the main series, linked to national economic crisis periods for the most part. The question arises whether this is likely to bias our results and hence whether winsorisation would be useful. This takes observations beyond a certain point in the distribution such as 1% and 99% and sets them to a common level. A counter argument is that such observations are part of the distribution and to exclude them is to not use potential information. Whereas with firm or bank data it is usually assumed that outliers are best winsorised away, this is as we note less common for macroeconomic data as used here.

In any case, to test whether there are major problems arising from outliers, we reran the global samples in Table 5 with winsorised variables (other that crises). As we show in Appendix Table A2, there are clearly changes to the exact values taken by coefficients but there are few sign changes and only a few variables are no longer significant. This is particularly the case for our key variables of interest, namely the leverage ratio, risk adjusted capital and bank concentration. The main exception is the coefficient on the leverage ratio in the equation for non performing loans, which is no longer significant (although regulatory capital remains significant).

Other changes with winsorisation are that GDP growth is no longer significant for crises, as is the case also for unemployment in liquid assets and noninterest and inflation in the Z-score. The second lagged dependent for liquid assets is now significant, as is the loan/asset ratio. There are two sign changes of significant variables, which are the loan/asset ratio for non performing loans and unemployment for the provisions equation.

The diagnostics are all still satisfactory with one exception, an AR(1) for nonperforming loans which is just over 0.1.

On balance, we suggest that the robustness check underpins the main results of the paper.

5. Conclusions

Our empirical analysis provides an overview of how banking stability and risk are affected by bank capital adequacy, banking market structure, bank performance and economic conditions. Our work has covered a wider sample than earlier work as well as including a wider range of control variables and risk indicators than is typically the case. A number of important conclusions derive from the findings:

Persistence of Bank Risk: The analysis illustrates that bank risk is a persistent phenomenon whereby the liquid assets ratio, the log Z score, the NPL/loans ratio and the provisions/loans ratio have strong positive significant lagged dependent variables, indicating past risk has a strong influence on current vulnerability. Exposure continues today with bank stability. This approach emphasises the importance of risk management and long lasting vulnerability of weakened banking systems.

Leverage vs. Regulatory Capital: While the leverage ratio and regulatory capital both play significant roles in determining bank risk, they have different impact effects for some risk indicators. Higher leverage ratios go hand in hand with increased non-performing loans and provisions, consistent with the “regulatory hypothesis” that capital rises with risk, although the signs for crises, liquidity and the Z-score are consistent with the “skin in the game” whereby higher capital leads to lower risk. It is worth noting that the Z score is a broader indicator of bank risk than NPLs or provisions which typically link to the banking book only.

Meanwhile, whereas the signs and significance of regulatory capital are generally the same as for the leverage ratio, higher regulatory capital is associated with lower non-performing loans suggesting that it enhances risk management. This reflects a finding from our analysis, as well as one that has been confirmed many times over elsewhere: that having abundant regulatory capital helps bankers have incentives to better monitor their exposure to risk and keep out of trouble.

We do not find any evidence in the subsamples that regulatory capital is inferior to leverage ratios in predicting risk, although signs do differ as noted for NPLs in the global sample. Indeed, there are more cases with a significant coefficient for regulatory capital than is the case for the leverage ratio, perhaps underlining the growing rigour of supervision under Basel III, which is mainly focused on regulatory capital.

Impact of Economic Conditions: in all the risk equations, banking sector performance is highly dependent on national economic circumstances. Low economic growth, high unemployment and high inflation are, for example, strongly associated with higher non-performing loans and provisions, indicating the vital importance of macroeconomic stability in maintaining a sound loan portfolio. Lower growth also leads to higher bank risk as shown by the Z-score and the risk of a banking crisis. On the other hand, the result for liquidity suggests that banks economise on liquidity during periods of high growth which may leave them vulnerable when a recession occurs. These results underline the need for macroprudential surveillance whereby regulators focus on the wider economy and the banking sector and not just individual institutions.

Bank Concentration and Competition: We found that lower bank concentration is associated with higher non-performing loans, lower liquidity and greater provision for loans as well as greater risk of financial crises. This may suggest that as competition becomes more intense banks will tend toward riskier lending practices; it also supports the "competition-fragility” hypothesis - that competition exacerbates risk. On the other hand lower concentration is related directly to a higher Z-score showing lower risk; thus, competition in some circumstances might even enhance stability.

Liquidity Management: Strongly capitalized banks maintain higher liquid assets, suggesting prudence and tighter regulation in both fields. Higher stock price volatility and inflation also prompt more liquidity, suggesting a conservative position during bouts of market instability and

inflationary pressures. Banks may economise on liquidity in boom periods and need to increase it during recessions.

Crisis Likelihood: Many factors significantly explain the probability of a crisis in commercial banking. These include low leverage ratios or regulatory capital, low bank concentration, high loan-to-asset ratios and high stock price volatility. These are elements that indicate weaker capital buffers under intense competition and markets under pressure. Moreover high inflation and low GDP growth themselves contribute to crisis risk, showing the interrelated nature of economic conditions and banking stability as such.

Differences in results across subsamples: While we find a great deal of commonality between the global results that we focus on above and those divided across country-development and time periods, there remain a number of differences. These may relate to aspects such as differences in financial structure and supervision across advanced and developing countries as well as the greater and more rigorous supervision of banks in the period since the subprime crisis.

Our work is, we contend, of particular relevance to policymakers undertaking macroprudential surveillance, because such sectoral data gives a greater weight to large systemic institutions than the more commonly-used bank-by-bank data. It can provide a helpful complement to bank-by-bank data and analysis in this respect. Drawing from the comments above, we suggest that both the leverage ratio and risk based capital measures are useful indicators of risk at a macro level. They need to be viewed alongside the important role of banking market structure in influencing sectoral risk. We have also highlighted the relevance of a range of banking sector indicators that are rarely considered in macroprudential surveillance. These include measures based on banking sector income such as the interest margin, return on assets and noninterest income/total income ratios as well as measures based on banking sector balance sheets including the aggregate loan/asset and deposit/asset ratios.

Further research could Incorporate interest rates (monetary policy) and macroprudential policy tools as control variables. The World Bank Regulation data indicators could be added as extra controls. House prices could also be relevant, but they tend to be only available for advanced countries. An additional risk variable could be the growth of bank lending at a sector level, which typically leads to adverse selection and banking difficulties when it is excessive. Although it is less commonly used with macro data that individual bank data, experimentation with winsorisation could check whether there are outliers that significantly affect the results. And since our sample covers the COVID period we could investigate further any differences in relationships to risk over that specific period.

There could be a study focused on the top five global economies—such as the United States, China, Japan, Germany, and India—can indeed yield valuable insights into the interplay between monetary policy, economic stability, and global financial risk. The influence of these economies is vast, and changes in their interest rates can have significant repercussions across the global economy, particularly affecting international banks and financial markets.

6. References

Albulescu, C.T. (2015). Banks' profitability and financial soundness indicators: A macro-level investigation in emerging countries. Procedia Economics and Finance, 23, pp. 203-209.

Altunbas, Y., Carbo, S., Gardener, E.P., and Molyneux, P. (2007). Examining the relationships between capital, risk, and efficiency in European banking. European Financial Management, 13(1), pp. 49-70.

Anginer, D., Demirgüç-Kunt, A., and Zhu, M. (2013). How does bank competition affect systemic stability?. Journal of Financial Intermediation,

Anginer, D., Demirgüç-Kunt, A., (2014), "Bank capital and systemic stability", Policy Research Working Paper No. 6948. The World Bank, Washington

Arellano, M., and Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. The Review of Economic Studies, 58(2), pp. 277-297.

Barrell, R., Davis, E.P., Karim, D., and Liadze, I. (2010). Bank regulation, property prices and early warning systems for banking crises in OECD countries. Journal of Banking & Finance, 34(9), pp. 2255-2264.

Barrell, R., and Karim, D. (2020) Banking Concentration and Financial Crises, National Institute Economic Review No. 254 (November 2020), R28-R40

Beck, T., Demirguc-Kunt, A. and Levine, R. (2006) Bank concentration, competition, and crises: first results.Journal of Banking and Finance 30: 1581–1603

Beck, T., De Jonghe, O., and Schepens, G. (2013). Bank competition and stability: Cross-country heterogeneity. Journal of Financial Intermediation, 22(2), pp. 218-244.

Berger, A.N., and Bouwman, C.H. (2013). How does capital affect bank performance during financial crises?. Journal of Financial Economics, 109(1), pp. 146-176.

Berger, A.N., Klapper, L.F., and Turk-Ariss, R. (2009). Bank competition and financial stability. Journal of Financial Services Research, 35(2), pp. 99-118.

Berger, A.N., Klapper, L.F., and Turk-Ariss, R. (2017). Bank competition and financial stability. In Handbook of competition in banking and finance (pp. 185-204). Edward Elgar Publishing.

Bitar, M., Pukthuanthong, K., and Walker, T. (2018). The effect of capital ratios on the risk, efficiency, and profitability of banks: Evidence from OECD countries. Journal of International Financial Markets, Institutions and Money, 53, pp. 227-262.

Blum, J. (1999). Do capital adequacy requirements reduce risks in banking?. Journal of Banking & Finance, 23(5), pp. 755-771.

Boyd, J.H., and De Nicolo, G. (2005), "The theory of bank risk taking and competition revisited", Journal of Finance, 60 (3), 1329–1343.

Calomiris, C.W., and Herring, R.J. (2013). How to design a contingent convertible debt requirement that helps solve our too-big-to-fail problem. Journal of Applied Corporate Finance, 25(2), pp. 39-62.

Cerutti, E., Claessens, S., and Laeven, L. (2017). The use and effectiveness of macroprudential policies: New evidence. Journal of Financial Stability, 28, pp. 203-224.

Davis, E.P., Karim, D., and Noel, D. (2020). The bank capital-competition-risk nexus–A global perspective. Journal of International Financial Markets, Institutions and Money, 65, p. 101169.

Davis, E.P., Karim, D. and Noel, D. (2024), "Noninterest income, macroprudential policy and bank performance"", Brunel Economics and Finance Working Paper No. 24-15 and NIESR Discussion Paper No. 561

Demirguc-Kunt, A., Detragiache, E., and Merrouche, O. (2013). Bank capital: Lessons from the financial crisis. Journal of Money, Credit and Banking, 45(6), pp. 1147-1164.

Keeley, M.C. (1990). Deposit insurance, risk, and market power in banking. The American Economic Review, pp. 1183-1200.

Karim, D., Liadze, I., Barrell, R., and Davis, E.P. (2013). Off-balance sheet exposures and banking crises in OECD countries. Journal of Financial Stability, 9(4), pp. 673-681.

Laeven, M.L., and Valencia, M.F. (2018). Systemic banking crises revisited. International Monetary Fund.

Lee, C.C., and Hsieh, M.F. (2013). The impact of bank capital on profitability and risk in Asian banking. Journal of International Money and Finance, 32, pp. 251-281.

Liu, H., Molyneux, P., and Wilson, J.O. (2013). Competition and stability in European banking: A regional analysis. The Manchester School, 81(2), pp. 176-201.

Meng, C., and Gonzalez, R.L. (2017). Credit booms in developing countries: Are they different from those in advanced and emerging market countries?. Open Economies Review, 28, pp. 547-579.

Rime, B. (2001). Capital requirements and bank behavior: Empirical evidence for Switzerland. Journal of Banking & Finance, 25(4), pp. 789-805.

Schaeck, K. and Čihák, M. (2012), "Banking competition and capital ratios", European Financial Management, 18, 836-866

.Tabak, B.M., Fazio, D.M., and Cajueiro, D.O. (2012). The relationship between banking market competition and risk-taking: Do size and capitalization matter?. Journal of Banking & Finance, 36(12), pp. 3366-3381.

Zigraiova, D., and Havranek, T. (2016). Bank competition and financial stability: Much ado about nothing?. Journal of Economic Surveys, 30(5), pp. 944-981.

ANK, W. (n.d.). Global Financial Development Report 2019/2020: Bank Regulation and Supervision a Decade after the Global Financial Crisis. Retrieved from WORLD BANK GROUP: https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database

7. Appendix

TABLE A1 Data codes from the World Bank for the variables used.

Variable type	Variable name	Acronym	Data code	Source
Dependent	Bank Z-score	Z-SCORE	GFDD.SI.01	Global Financial Development Database
Dependent	Bank nonperforming loans to gross loans (%)	NPLLOANS	GFDD.SI.02	Global Financial Development Database
Dependent	Liquid assets to deposits and short term funding (%)	LADSTF	GFDD.SI.06	World Development Indicators Database
Dependent	Banking crisis dummy (1=banking crisis, 0=none,2=afeter 2018	CRISIS	GFDD.OI.19	Global Financial Development Database
Dependent	Provisions/gross loans ratio	PROVLOAN	GFDD.SI.07 *GFDD.SI.02	World Development Indicators Database
Independent (basic equations)	Bank net interest margin (%)	NIM	GFDD.EI.01	Global Financial Development Database
Independent (basic equations)	Bank noninterest income to total income (%)	NONINT	GFDD.EI.03	Global Financial Development Database
Independent (basic equations)	Bank return on assets (%, after tax)	ROA	GFDD.EI.05	Global Financial Development Database
Independent (basic equations)	Bank capital to total assets (%)	LEVERAGE	GFDD.SI.03	Global Financial Development Database
Independent (basic equations)	Bank credit to bank deposits (%)	CREDIT DEPOIST	GFDD.SI.04	Global Financial Development Database
Independent (basic equations)	Bank regulatory capital to risk-weighted assets (%)	REGCAP	GFDD.SI.05	World Development Indicators Database
Independent (basic equations)	Stock price volatility	STOCVOL	GFDD.SM.01	Global Financial Development Database
Independent (basic equations)	Bank concentration (%)	BANKCON	GFDD.OI.01	Global Financial Development Database
Independent (basic equations)	Deposit/asset ratio	DEPASS	GFDD.OI.02 /GFDD.DI.02	World Development Indicators Database
Independent (basic equations)	Loan/asset ratio	LOANASS	GFDD.DI.01 /GFDD.DI.02	World Development Indicators Database
Independent (robustness equations)	GDP growth (annual %)	GDPG	NY.GDP.MKTP.KD.ZG	World Development Indicators Database

Independent (robustness equations)	Unemployment, total (% of total labor force) (modeled ILO estimate)	UNEMPL	SL.UEM.TOTL.ZS	World Development Indicators Database
Independent (robustness equations)	Inflation, consumer prices (annual %)	INFLA	FP.CPI.TOTL.ZG	World Development Indicators Database
construct	Private credit by deposit money banks to GDP (%)	loangdp	GFDD.DI.01	Global Financial Development Database
construct	Deposit money banks' assets to GDP (%)	DI02DEPOSITGDP	GFDD.DI.02	Global Financial Development Database
construct	Provisions to nonperforming loans (%)	pronpl	GFDD.SI.07	World Development Indicators Database
construct	Bank deposits to GDP (%)	Oi02depositgdp	GFDD.OI.02	Global Financial Development Database

Note:- Notes: The ratio of provisions/gross loans is constructed as provisions to non-performing loans times non-performing loans to gross loans. The deposit/assets ratio is constructed as the ratio of deposit money bank deposits/GDP to deposit money banks' assets/ GDP. The loan/assets ratio is constructed as the ratio of private credit by deposit money banks/GDP to deposit money banks' assets/GDP.

Table A2: - Winsorised baseline regression results for banking sector risk, capital and competition (1998–2021)

Equation number and dependent variable	(1) CRISIS	(2) LADSTF	(3) LNZSCORE	(4) NPLLOANS	(5) PROVLOAN
Constant					
Dependent (−1)		0.544*** (47.3)	0.518*** (33.3)	0.653*** (192.4)	0.572*** (166.1)
Dependent (−2)		-0.0452*** (3.6)	0.0324*** (3.2)	0.0192*** (10.7)	0.0882*** (49.4)
LEVERAGE(-1)	-0.236*** (3.2)	0.8*** (15.0)	0.0347*** (10.5)	-0.00096 (0.1)	0.327*** (101.3)
BANKCON(-1)	-0.0179** (2.2)	0.192*** (18.6)	-0.00118*** (7.3)	-0.0502*** (52.1)	-0.00232*** (5.3)
DEPASS(-1)	-0.00885 (0.1)	15.0*** (17.9)	0.151*** (7.7)	-4.757*** (32.9)	0.141** (2.3)
NONINT(-1)	0.00588 (0.6)	0.0196 (1.5)	-0.00014 (0.3)	-0.0755*** (36.9)	-0.064*** (87.5)
LOANASS(-1)	5.836** (4.2)	-4.493*** (3.3)	-0.474*** (8.3)	0.7*** (4.4)	5.075*** (39.3)
NIM (-1)	0.0398 (0.3)	0.272*** (2.6)	0.0224*** (3.9)	-0.281*** (65.7)	-0.13*** (27.4)
STOCVOL(-1)	0.0591*** (4.2)	0.0392*** (6.0)	-0.00083*** (3.9)	-0.0389*** (40.9)	0.000652 (1.1)
UNEMPL(-1)	-0.016 (0.6)	-0.0633 (1.3)	0.0155*** (10.9)	0.0784*** (12.5)	0.134*** (30.1)
ROA (-1)	-0.751*** (4.8)	0.898*** (11.5)	-0.0796*** (15.7)	-0.357*** (30.1)	-0.305*** (49.1)
GDPG (-1)	-0.053 (1.4)	-0.12*** (8.5)	0.00511*** (11.4)	-0.207*** (170.8)	-0.0745*** (94.8)
INFLA (-1)	0.122*** (3.8)	0.143*** (4.2)	-0.000024 (0.1)	0.112*** (32.7)	0.1*** (86.3)
Regression type	ML-Binary Logit	Panel GMM difference regression	Panel GMM difference regression	Panel GMM difference regression	Panel GMM difference regression
Effects		Cross-Section Fixed (First difference)	Cross-Section Fixed (First difference)	Cross-Section Fixed (First difference)	Cross-Section Fixed (First difference)
Sample (adjusted):	2001- 2021	2003 2021	2003-2021	2003 2020	2003 2021
Periods included:	20	19	19	18	18
Countries included:	214	200	200	200	190
Observation	1227	974	1018	917	801
S.E. of regression	0.221	8.45	0.217	2.626	1.433

Sum of squared residuals	59.8	68604	47.1	6238	1617.9
Sargan' s J (probability)		58.6 (0.63)	63.4 (0.49)	69.4 (0.27)	69.1 (0.28)
AR (1) (probability)		0.0003	0.0008	0.11	0.03
AR (2) (probability)		0.81	0.28	0.22	0.17
Memo: REGCAP(-1) instead of leverage (−1)	-0.258*** (5.0)	0.505*** (15.3)	0.0183*** (10.2)	-0.0401*** (10.0)	0.192*** (55.6)

Notes: See Table 5