A STUDY ON THE IMPACT OF CAPITAL ADEQUACY ON BANK RISK AND PERFORMANCE

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Abstract

This study investigates the impact of capital adequacy on bank performance and stability across various economic contexts, focusing on Tier 1 Leverage and Tier 1 Capital Ratios. Analysing panel data of 81 banks from 23 countries between 2005 and 2023 using the multivariate OLS estimation, the findings reveal that, contrary to expectations, large banks and those in developed nations benefit from higher capital levels but also face moral hazard issues and diminishing returns on profitability. This suggests that excessive capital can lead to riskier behaviour and reduced efficiency in these banks. In contrast, strong capital regulation is crucial for small banks and those in developing nations, where it significantly enhances resilience, profitability, and stability. The study concludes that a blanket approach to capital regulation is ineffective. Instead, the shreds of evidence advocate for tailored regulatory frameworks that account for the specific needs and characteristics of different banking environments, balancing financial stability with sustainable growth.

1. Introduction

Capital regulation in banks is a crucial aspect of financial oversight. It allows banks to engage in anticipatory action and ensures institutions maintain sufficient capital buffers to absorb losses (Andersen and Juelsrud, 2024) and protect depositors (Samad, 2011). Capital adequacy ratios are fundamental to these regulations. Serving as a mechanism to control the capital level of any financial institution to make them fundamentally strong, they are crucial to upholding the economic stability of a country (Athanasoglou, Brissimis and Delis, 2008), as banks are often considered the backbone of an economy due to their role as the financial intermediary (Santos,

2000). The development of capital regulation has been significantly influenced by the need to mitigate systemic risks posed by undercapitalised banks (Byres, 2012).

Abundant financial crises with significantly negative repercussions have highlighted this necessity over the previous decades - the Latin Debt crises of the 1980s, the Asian Financial Crisis of the late 1990s, and the Global Financial Crisis of the late 2000s – which led to numerous bank failures worldwide. Capital adequacy is essential for mitigating risks associated with excessive leverage, as observed in most of these crises (Byres, 2012). By mandating that banks hold a minimum level of capital relative to their assets, regulators aim to align the interests of bank managers with those of depositors and the broader society to maintain economic harmony (Bank of England, 2019; Central Bank of Ireland, 2024). However, the relationship between capital adequacy and bank behaviour is complex. While higher capital ratios generally enhance stability, they can also lead to unintended consequences, such as banks shifting towards riskier assets to maintain profitability (Furlong and Keeley, 1987).

The Basel Accords, established by the Basel Committee on Banking Supervision in 1988, have played a crucial role in setting global standards for capital adequacy while constantly evolving to address new threats, loopholes and disruptive developments in the financial realm. These accords reflect ongoing efforts to balance financial stability with economic growth (Byres, 2012). Santos (2000) notes that the Basel I Accord, introduced in 1988, was the first major international agreement to set risk-based capital requirements. It linked the amount of capital banks needed to hold with the riskiness of their assets. Santos (2000) further elaborates that Basel I was deemed too simplistic, and with more crises taking place despite the implementation of the regulatory accords, there was a need for more robust regulation encompassing sophisticated risk-weighing

methods and emphasised and encouraged internal risk management, leading to the development of Basel II. Byers (2012) expands on how the global financial crisis of 2008 exposed further weaknesses, prompting the introduction of Basel III, which implemented stricter capital requirements and additional capital buffers to enhance resilience against economic shocks. Currently, Basel III is still being implemented in numerous countries worldwide, with new countries regularly being bound by the accord, highlighting and recognising the indirect contributions and importance of these regulations to the economic well-being of their nations (Andersen and Juelsrud, 2024).

The research questions which this study will try to answer are listed below:

1) What is the impact of capital adequacy on bank risk and performance?
2) How does the impact of capital adequacy differ when tested under varying economic conditions, bank sizes and national development status?

Using multivariate OLS estimation of a panel dataset of 81 banks from 23 countries between 2005 and 2023 from the global sample, I find that a higher T1 Leverage generally improves efficiency and financial stability. However, it reduces returns on equity due to opportunity costs and earnings dilution. In some cases, increased capital leads to higher loan loss provisions. The results indicate that although a strong capital base is vital for stability, its impact on profitability and efficiency might decrease during crises because of heightened risk aversion and a focus on survival. Large banks and those in developed nations benefit more from higher capital levels, as they can exploit economies of scale and strong financial infrastructures. On the other hand, the stability of small banks depends heavily on having enough capital. Nevertheless, the findings indicate that larger banks and banks in developed nations suffer from diminishing benefits of higher Tier 1 Capital,

as excessive capital can constrain profitability and lead to moral hazard, especially in developed markets.

Previous studies have mainly examined how capital adequacy affects bank performance and risk, focusing on specific markets or periods. However, these studies often lacked a broad, global view, and earlier studies are distant from modern developments in capital regulations, which slightly lessens their impact in the contemporary economic context. Many of these studies have also used accounting-based capital ratios, which might be subject to accounting manipulation, instead of regulatory capital ratios. This study fills this gap by covering developed and developing nations from 2005 to 2023, using regulatory capital ratios and macroeconomic factors. This study offers multidimensional insights into how capital adequacy impacts banks under various global conditions and provides an in-depth analysis of how capital adequacy ratios, especially Tier 1 Leverage and Tier 1 Capital ratios, influence bank risk and performance across different contexts. By examining these differing effects, the study offers valuable insights into the effectiveness of current capital regulations. These insights are crucial for informing banking policy, suggesting that a blanket approach to capital regulation may be ineffective. Instead, the study advocates for tailored regulatory frameworks that consider the specific characteristics of banks and their economic environments, thereby promoting both financial stability and sustainable growth.

While this study provides valuable insights into the impact of capital adequacy on bank risk and performance, several limitations should be acknowledged. Firstly, the dataset can be expanded to include more countries to wholly capture the diversity of the global banking system. There is a divergence from the traditional banking that we know of to Islamic Banking and digital wallets in many nations globally, and these are gaining traction to change the definition of banking.

Expanding the dataset and conducting more segregated analyses to come to a general conclusion might improve the generalisability of the study. Similarly, the study assumes that capital regulation is uniformly applied across different nations. In reality, these are bound to vary and can, therefore, influence how banks respond to capital requirements, potentially affecting the conclusion of the study. Lastly, the banks are heavily influenced by corporate governance and management practices, which have not been accounted for in this study, which might misstate the actual effect of and on the variables in the study. Future research could address these limitations to make the understanding of the impact of capital adequacy on bank risk and performance more robust.

The remainder of the sections are structured as follows. Section 2 reviews the literature to develop a conceptual framework on capital adequacy's impact on bank profitability, performance, and risk. Section 3 outlines the data and methodology, including regression model specification. Section 4 presents the results and discusses their implications in the context of existing research. Section 5 concludes the study, summarising key findings and their implication and significance for banking regulation.

2. Literature review

The nature and impact of capital regulations are complex and multidimensional, often varying drastically depending on the firm-specific characteristics and broader economic conditions (Le, Nasir and Huynh, 2023). One key role of capital regulation is to mitigate risks associated with excessive leverage. Besanko and Kanatas (1996) emphasise that capital standards could reduce the risk of asset substitution, where banks might otherwise engage in riskier activities to enhance returns. They argue that by enforcing minimum capital requirements, regulators can align the

interests of bank managers with those of depositors, thereby reducing the likelihood of excessive risk-taking.

However, the effectiveness of capital regulation in controlling risk is not without its challenges. Koehn and Santomero (1980) note that while capital requirements minimise risk, they can sometimes lead to unintended consequences, such as banks shifting their portfolios towards riskier assets to maintain profitability. Although Mateev, Nasr and Sahyouni (2022) refute this reasoning in a later study, Koehn and Santomero (1980) and Altunbas *et al.* (2007) advocate that this behaviour is particularly problematic in competitive banking environments, where the pressure to generate returns can drive banks towards high-risk, high-reward investments, potentially undermining the stability that capital regulation seeks to ensure.

The strategic implications of capital regulation also extend to how banks allocate their resources. Kim and Santomero (1988) discuss that traditional capital regulations could influence banks to adjust their investment strategies by opting for safer, lower-yield assets or seeking new opportunities with higher returns but greater risks. This adjustment in strategy can have broader implications for the banking sector, affecting not only individual institutions but also the overall availability of credit in the economy. Gorton and Winton (2017) articulate that while bank regulation aimed at increasing capital may reduce the likelihood of bank failures, it can also lead to significant private costs, reduce liquidity in the economy, and potentially create incentives for the growth of less-regulated shadow banking, all of which could offset the intended benefits of such regulation.

Calem and Rob (1999) and Haq and Heaney (2012) put forward interesting arguments that provide new insights into the efficacy of capital regulations, suggesting that the relationship between capital and risk is U-shaped rather than linear and that there are limitations to which capital regulations can reduce the possibility of bank insolvency. The authors articulate that banks shift their investment strategy towards riskier but more profitable options when they feel confident that the chances of bankruptcy are minimal. Alternatively, they might choose to take on these risks, knowing that if things go wrong, the central banks or deposit insurance scheme will bail them out, giving rise to moral hazard problems.

In emerging markets, where financial systems are often less developed and more volatile, the need for robust capital regulation becomes even more crucial. Sufian and Kamarudin (2012) provided evidence from Bangladesh showing that higher capital ratios were associated with increased profitability. Their study suggests that capital adequacy is essential in less mature financial markets, where economic conditions can be more unpredictable, ensuring that banks can withstand shocks and continue operating effectively. Further, Lee and Hsieh (2013) find well-capitalised banks in Asian markets are generally more profitable and less prone to engage in risky behaviour. This highlights the role of capital regulation in stabilising influence in volatile markets, ensuring that banks maintain sufficient buffers to absorb losses while supporting economic growth through lending and investment. Danisman and Tarazi (2024) round up this argument of capital playing an essential role in survival and enhancing performance in countries with uncertain economic and political conditions.

Another critical area of focus is the influence of capital regulation on smaller banks. Berger and Bouwman (2013) find that higher capital levels significantly benefit smaller institutions,

particularly during economic downturns. Often more vulnerable to market fluctuations, these banks rely on solid capital buffers to survive challenging periods. Adequate capital allows small banks to maintain operations and continue serving their communities, even in adverse conditions. Their findings align with Altunbas *et al.* (2007), who conclude that capital is crucial in curbing banking risk in co-operative banks. These studies jointly highlight the importance of capital regulation in ensuring the resilience of these financial institutions, usually operating on a more grassroots level than larger banks and, therefore, have a direct impact on society.

Another significant aspect of capital regulation is its role in aligning banks' risk profiles with their capital levels. Jacques and Nigro (1997) study the effects of Basel I capital standards on U.S. banks and find that risk-based capital regulations successfully led to higher capital ratios and reduced portfolio risk. This alignment is crucial for maintaining the financial system's stability, as it ensures that banks with higher risk exposures hold sufficient capital to cover potential losses. Altunbas *et al.* (2007) provide a different perspective by examining the impact of increased capital requirements in European banks. Their research shows that heightened regulatory pressures could lead banks to take on more risk to compensate for the reduced returns associated with holding higher capital levels. This finding suggests that while capital regulation is intended to reduce risk, it may sometimes have the opposite effect, depending on how banks respond to the constraints imposed by these regulations.

The link between capital adequacy and bank performance has been widely explored, yet the findings vary significantly depending on the context, measurement metrics, and banking environments. While capital adequacy is often seen as a pillar of financial stability, its direct impact on bank performance remains a topic of considerable debate. Furlong and Keeley (1987)

were among the early researchers who explored the connection between capital and bank performance, particularly through the lens of the moral hazard hypothesis. They suggest that banks may be tempted to hold riskier assets when operating with higher leverage, possibly in an attempt to exponentially increase profitability.

When examining the impact of capital adequacy on profitability, the results are not uniform, especially when different profitability metrics are considered. Hutchison and Cox (2006) explore the relationship between capital structure and profitability in US banks from 1983 to 2002, finding a positive relationship when ROE proxied profitability but a negative one when ROA was used. This divergence suggests that while capital adequacy might enhance shareholder returns, as ROE indicates, it might also point to inefficiencies in asset utilisation through missed risky yet profitable opportunities, as shown by a negative effect on ROA. Al-Sharkas and Al-Sharkas (2022) find similarly mixed evidence, indicating that the impact of capital adequacy varies significantly depending on the profitability measure used. These differences raise questions about the reliability of ROA as a sole indicator of bank performance, a concern also voiced by Iskandar, Yahya, and Wahid (2019), who observed that ROE is more sensitive to changes in capital adequacy than ROA in their study of Malaysian banks. Olalere, Bin Omar, and Kamil (2017) also support this view, suggesting that ROE should be the preferred metric when assessing the impact of capital adequacy, as it better aligns with shareholder interests and overall bank performance.

Studies conducted in emerging markets often highlight a stronger positive relationship between capital adequacy and profitability. Sufian and Kamarudin (2012) examine the determinants of profitability in the Bangladeshi banking sector during the early 2000s, revealing a significant positive relationship between higher capital ratios and profitability. Their findings suggest that

capital adequacy is a critical buffer that enhances bank performance in developing economies where financial markets are less mature and more volatile. Similarly, Lee and Hsieh (2013) conduct a comprehensive study across 42 Asian countries from 1994 to 2008, finding that well-capitalised banks are generally more profitable and less likely to engage in risky behaviour. These findings are particularly relevant in developing economies, where banks often face higher market risks and economic instability, making capital adequacy a crucial factor in ensuring stability and profitability (Nguyen, 2020).

The significance of capital adequacy in emerging markets is further emphasised by Coccorese and Girardone (2021), who conduct a global study of banks from 125 countries from 2000 to 2018. They find that Tier 1 Capital significantly positively impacted profitability, particularly during crisis periods and in developing nations. Their findings suggest that during times of economic distress, well-capitalised banks are better positioned to absorb shocks and continue operations, thus safeguarding profitability. Alkhazali *et al.* (2024) extend this argument by concluding that banks with stronger pre-crisis capital performed better during the pandemic, particularly small banks in emerging economies, which experienced higher ROA post-crisis. Andersen and Juelsrud (2024) note that the marginal benefit is higher in banks where the starting capital adequacy is low, suggesting that banks in developing nations have the most to gain from increasing their capital adequacy. These pieces of evidence jointly highlight the critical role of capital adequacy in enhancing bank resilience and profitability, particularly in economically volatile environments where financial stability is often at risk.

Not all researchers, however, agree on the uniformly positive impact of capital adequacy on bank performance. Dietrich and Wanzenried (2011) offer a more subtle perspective, arguing that while

lower capital ratios might lead to higher returns due to increased leverage, well-capitalised banks benefit from lower bankruptcy risk and reduced cost of capital. They find that higher capital levels do not significantly affect profitability in the pre-crisis period but have a negative impact during crises. This suggests that the benefits of capital adequacy are more obvious during stable economic conditions, while during crises, the opportunity costs of holding large capital reserves might outweigh the benefits. Their findings imply that while capital adequacy is crucial for maintaining stability, its impact on profitability is context-dependent and may vary across different economic environments. Marcelin *et al.* (2022) support this view, noting that higher capital is often indirectly linked to the overall well-being of an economy, a view also emphasised by Danisman and Tarazi, (2024).

The relationship between capital adequacy and bank performance also appears to vary by size. Berger and Bouwman (2013) provide a detailed examination of how capital affects the performance of banks of different sizes across various periods. They find that capital significantly aids small banks' survival during regular and crisis periods, while medium and large banks benefit primarily during crises. Their finding is consistent with the work of Beltratti and Stulz (2009), who report that higher pre-crisis capital enhances the performance of banks during financial crises. Similarly, Ozkan, Balsari and Varan (2014) find that higher capital adequacy ratios provided Turkish banks with a protective buffer during the global financial crisis, supporting the view that capital adequacy is crucial for maintaining stability and performance during economic downturns.

In a broader context, Bitar, Pukthuanthong and Walker (2018) investigate whether higher capital ratios effectively reduce risk and improve profitability in a sample of OECD banks. They find that well-capitalised banks maintain higher loan loss reserves, which helps mitigate future loan losses

and improve management practices, thereby enhancing profitability. This perspective is reinforced by Ozili (2015) and Olalere, Bin Omar and Kamil (2017) who identify positive relationships between capital adequacy and profitability in Nigerian banks. Their findings suggest that robust capital buffers reduce risk and enhance overall bank performance, particularly in environments characterised by economic volatility and financial instability.

Bank capital has typically been viewed positively in academia—however, a strand of literature challenges this norm. Dowd (1996) argues that the higher cost of equity can erode profitability, an issue consistent with the pecking-order theory proposed by Donaldson (1961). Roulet (2018) supports this perspective, finding that stricter capital adequacy ratios, while necessary for stability, negatively impact bank lending and profitability in European banks following the global financial crisis. This effect is particularly pronounced during periods of economic uncertainty, where banks might hoard capital as a precautionary measure, thus reducing their lending activities and profitability. Chandrasegaran (2020) and Madugu, Ibrahim and Amoah (2020) further argue that maintaining higher capital ratios may lead to the immobilisation of capital, thereby reducing profitability. These findings suggest that while capital adequacy is important for maintaining financial stability, it can also carry opportunity costs that might negatively impact bank performance, especially in periods of economic uncertainty or in markets where capital costs are high.

Le, Nasir and Huynh (2023) develop this view in their study of British and Australian banks, concluding that stricter capital ratios increase earnings before interest and tax but fail to improve overall profitability and efficiency. Their finding suggests that while capital adequacy might bolster earnings, it does not necessarily translate into improved efficiency or profitability,

particularly in developed banking systems where the marginal benefits of additional capital might be lower. Similarly, Begum, Rahman and Faruq (2024) find that capital adequacy negatively affects bank interest margins in Bangladeshi banks, potentially reducing profitability. They suggest that the stringency of capital regulations could deter bank performance, echoing concerns raised by Koehn and Santomero (1980), Besanko and Kanatas (1996) and Roulet (2018). These findings collectively indicate that while capital adequacy is a key component of banking regulation, its impact on bank performance is complex and context-dependent, requiring a careful balance between stability and profitability.

The relationship between capital adequacy and bank risk is another critical area of focus in the literature. Banking capital regulations enhance stability by ensuring banks maintain sufficient capital to absorb potential losses (Koehn and Santomero, 1980). However, the effectiveness of these regulations in reducing bank risk remains a matter of ongoing debate.

Furlong and Keeley (1987) suggest that banks with lower capital might be more inclined to take on higher asset risk, arguing that the moral hazard induced by increased leverage could lead to riskier behaviours. This perspective is supported by Dowd (1996), who argues that well-capitalised banks are generally safer and more attractive to depositors, enabling them to secure cheaper funds and reinvest at higher rates. This argument also suggests that higher capital levels can reduce overall bank risk by enhancing the bank's credibility and financial stability. However, this relationship becomes more complex in environments where banks are protected by mechanisms like the lender of last resort (LOLR) and deposit insurance schemes. Dowd (1996) articulates that while these schemes are designed to stabilise the banking sector, they can ironically encourage excessive risk-taking, as banks may feel less pressure to maintain adequate capital buffers. They

further note that in the United States, such safety nets have historically led to higher bank failure rates, highlighting the unintended consequences of these protective measures. Findings of Kaufman (1991) adds weight to this argument, pointing out that introducing the Federal Deposit Insurance Scheme in the US led to a significant reduction in capital ratios, reinforcing concerns about moral hazard.

Jacques and Nigro (1997) examine the impact of Basel 1 capital standards on U.S. banks, finding that risk-based capital regulations lead to higher capital ratios and reduced portfolio risk. Their findings further support the views of Ozkan, Balsari and Varan (2014), who stress the importance of aligning capital regulations with banks' risk profiles, suggesting that a more tailored approach to capital adequacy—one that considers the specific risk profiles of banks—might be more effective in reducing risk. This view is supplemented by Bitar, Pukthuanthong and Walker (2018), who highlight the role of capital ratios in reducing bank risk, particularly in smaller banks. Their findings suggest that well-capitalised banks are better equipped to manage risk, especially during periods of economic uncertainty.

Berger and Bouwman (2013) emphasise that higher capital significantly benefits small banks by increasing their chances of survival, especially during market downturns. This finding is particularly relevant in the context of emerging markets, where the count of smaller banks is high, and these often face greater risks and challenges from geopolitical conditions. Similarly, Lee and Hsieh (2013) find that in the Asian market, banks with higher capital are less likely to engage in risky behaviour, mitigating moral hazard concerns and suggesting that capital adequacy can effectively curb excessive risk-taking. Leung, Taylor and Evans (2015) observe a significantly negative relationship between Tier 1 Capital and various bank risks in U.S. bank holding companies, particularly during the global financial crisis. They conclude that Tier 1 Capital serves

as a strong shield against risks, emphasising the importance of regulatory capital requirements. Zarafat and Prabhune (2018) supplement this finding by concluding that higher capital levels reduce risk in Indian banks, highlighting the critical role of capital adequacy in emerging markets.

However, not all evidence supports the view that higher capital ratios reduce risk. Koehn and Santomero (1980) and Kim and Santomero (1988) argue that riskier banks might shift their portfolios towards higher-risk assets when required to increase their capital-asset ratios, thereby increasing overall risk. Besanko and Kanatas (1996) caution that while higher capital can reduce asset substitution risk, it might introduce agency problems by diluting insider ownership, potentially increasing bank risk. These arguments suggest that while capital adequacy is intended to reduce risk, it may have unintended consequences that could exacerbate risk under certain conditions. Altunbas *et al.* (2007) further dispute that higher capital reduces risk, showing a positive correlation between risk and capital in European commercial and savings banks. They argue that regulatory pressures and increased competition might drive banks to take on more risk to offset reduced returns, particularly in environments where the cost of capital is high. This view is further supported by Bitar, Pukthuanthong and Walker (2018), who find that while non-risk-based capital measures effectively minimise bank risk, risk-based capital adequacy measures have no significant impact. This finding contradicts the conclusions of Alkhazali *et al.* (2024), who advocate for Tier 1 Capital as a superior measure of capital adequacy, suggesting that different types of capital measures may have varying effects on bank risk.

3. Methodology

3.1. Data Collection

The study uses secondary data from 81 banks across 23 countries from 2005 to 2023. To create the dataset, the population is segregated into two parts to facilitate the secondary research of bank risk and performance by creating sub-samples of developed and developing nations, and 23 countries are chosen randomly to suit the sampling criteria. I then use the Bloomberg database to identify the banks to include in the sample. This ensures that there is enough data for our analysis and that the selected banks represent their population and national practices. Then, the data for this study was primarily sourced from the Orbis and LSEG Refinitiv databases, both renowned for their extensive and precise financial information on banks.

For the study, the banks have been consolidated at their highest levels and filtered out in other countries where they operate to avoid duplicity. Any missing data points were supplemented through manual collection from the respective banks' annual reports to ensure completeness (Hamadi *et al.*, 2016). This approach provided a comprehensive and accurate dataset essential for robust regression analysis. Macroeconomic data, namely yearly GDP growth rate and annual CPI data, has been sourced from the World Bank Financial Indicators database.Lastly, the sample observations range from 1,495 (T1 Leverage) to 1,539 (Macroeconomic indicators). The difference in the sample observation is due to missing data points which could not be obtained.

3.2. Description of variables

3.2.1. Dependent variables

The dependent variables in this study to assess bank performance are Return on Average Assets (ROAA), Return on Average Equity (ROAE), Net Interest Margin (NIM) and Efficiency Ratio (ER). ROAA is calculated as profit after tax divided by average assets, and ROAE is calculated as profit after tax divided by average equity (Adelopo, Vichou and Cheung, 2022). ROAA measures

a bank's efficiency in generating profits from its assets and is a critical indicator of managerial effectiveness and asset utilisation. In contrast, ROAE indicates the return on shareholders' equity, providing insights into profitability and financial performance by reflecting how effectively a bank uses equity capital to generate profits. NIM is defined as interest income minus interest expenses divided by total earning assets (Ozili, 2015; Chandrasegaran, 2020). This metric assesses how effectively a bank manages its interest-related income and costs, a critical measure of its profitability in its core lending operations. ER is calculated as total operating expenses divided by total interest and operating income and measures a bank's operational efficiency, with lower values indicating better cost management and higher efficiency in generating income (Moody's Investors Service, 2011).

Similarly, the dependent variables to assess bank risk are the solvency Z-Score and LLP Ratio (LLPR). Z-score, an accounting-based measure of insolvency risk, is measured as ROAA plus the ratio of equity to assets divided by the standard deviation of the ROAA (Li, Tripe and Malone, 2017) and serves as an indicator of bank stability and risk of insolvency, with higher values indicating greater financial soundness. Likewise, LLPR, representing the ratio of loan loss provisions divided by total assets, measures the provisioning level for potential loan losses, providing insights into a bank's risk management practices and readiness to absorb loan losses. Calculating LLPR as the loan loss provision ratio to total assets makes it comparable to banks of different sizes (Hamadi et al., 2016).

3.2.2. Independent variables

Based on previous literature by Al-Sharkas and Al-Sharkas (2022), various proxies are identified to measure the banks' capital adequacy. The first key variable of interest is the Tier 1 Leverage

Ratio (T1LEV), defined as the Tier 1 capital divided by total assets. This measure reflects the bank's core capital strength relative to its total size, serving as a crucial indicator of financial health and stability. Another key independent variable is the T1 Capital Ratio (TOCR), defined as Tier 1 capital divided by risk-weighted assets. This metric assesses a bank's capital adequacy, considering the riskiness of its asset base. Al-Sharkas and Al-Sharkas (2022) consider this important in measuring the bank's capacity to withstand financial shocks. Based on the literature, I expect the capital adequacy ratios to have a positive coefficient on profitability and risk metrics, while I expect a negative coefficient on the efficiency ratio. Nevertheless, given the different contexts on which the impact of capital adequacy will be tested, there is a severe likelihood that the coefficients might have a mixed effect based on the model.

The study will use four independent control variables in addition to two independent variables of interest. Bank size (SIZE) is measured as the natural logarithm of total assets (Naili and Lahrichi, 2022). NPL is measured as the non-performing loans as a ratio of gross loans and advances and indicates the quality of the bank's loan portfolio and its exposure to credit risk (Hamadi *et al.*, 2016). Additionally, macroeconomic variables such as GDP Growth and Inflation Rate are included following Adelopo, Vichou and Cheung (2022). GDP Growth, represented by the annual growth rate of Gross Domestic Product (GDP), is a proxy for the overall economic environment in which banks operate, influencing banks' profitability and risk-taking behaviour. The inflation rate (INF), indicated by the annual growth rate in the Consumer Price Index (CPI), captures the macroeconomic conditions that impact banking operations, affecting interest rates, loan demand, and the actual value of financial assets.

The variables are summarised and listed in Table 1.

Table 1 Definition of variables

Variable	Definition	Source
Performance		
Return on Average Assets (ROAA)	Profit after tax / Average assets	Adelopo, Vichou, and Cheung (2022)
Return on Average Equity (ROAE)	Profit after tax / Average shareholder's fund	Adelopo, Vichou, and Cheung (2022)
Net Interest Margin (NIM)	(Interest income -Interest expense) / Total earning assets	Ozili (2015); Chandrasegaran (2020)
Bank Efficiency Ratio (ER)	Operating expense / Total operating income	Moody‚Äôs Investors Service (2011)
Risk		
Z-score	(ROA +Equity /Assets) / SD of ROA	Li, Tripe and Malone (2017)
Loan Loss Provision Ratio (LLPR)	Loan loss provision / Total assets	Hamadi et al. (2016)
Capital adequacy		
Tier 1 Capital Ratio (TOCAR)	Tier 1 capital / Risk-weighted assets	Al-Sharkas and Al-Sharkas (2022)
Total Capital Ratio (TCAR)	(Tier 1 capital + Tier 2 capital) / Risk-weighted assets	Al-Sharkas and Al-Sharkas (2022)
Tier-1 Leverage Ratio (T1LEV)	Tier 1 capital / Total assets	Al-Sharkas and Al-Sharkas (2022)
Controls		
Bank Size (SIZE)	ln (Total assets)	Naili and Lahrichi (2022)
Non-Performing Loan (NPL)	Non-performing loans / Gross loans and advances	Hamadi et al. (2016)
GDP Growth (GDP)	Annual change in of GDP rate	Adelopo, Vichou, and Cheung (2022)
Inflation Rate (INF)	Annual change of CPI	Adelopo, Vichou, and Cheung (2022)

3.3. Collinearity tests

TCAR was initially considered for inclusion. However, including *TCAR* would lead to multicollinearity issues with the *TOCAR,* and therefore, including both variables would inflate the standard errors of the regression coefficients, making it difficult to assess the actual effect of each variable on bank performance. By excluding *TCAR*, the study aims to ensure that the estimated coefficients for the *TOCAR* are unbiased and reflect its actual impact on the dependent variables. This decision was based on correlation and Variance Inflation Factor (VIF) tests. The correlation and VIF tables are summarised in Table 2 and Table 3, respectively.

Table 2 Correlation matrix for the variables

Variables	ROAA	ROAE	NIM	ER	Z-Score	LLPR	*T1LEV*	*TOCAR*	*TCAR*	*SIZE*	*NPL*	*GDP*	*INF*
ROAA	1												
ROAE	0.79	1											
NIM	0.80	0.54	1										
ER	-0.51	-0.54	-0.32	1									
Z-Score	0.02	0.15	-0.19	-0.35	1								
LLPR	0.31	0.05	0.51	-0.18	-0.21	1							
T1LEV	0.71	0.35	0.74	-0.42	-0.01	0.50	1						
TOCAR	0.44	0.14	0.39	-0.15	-0.04	0.21	0.59	1					
TCAR	0.40	0.13	0.36	-0.12	-0.05	0.22	0.52	0.95	1				
SIZE	-0.58	-0.41	-0.67	0.43	0.07	-0.44	-0.64	-0.30	-0.26	1			
NPL	0.10	-0.08	0.29	0.15	-0.31	0.65	0.17	0.07	0.10	-0.21	1		
GDP	0.24	0.25	0.23	-0.27	0.07	-0.03	0.25	0.00	-0.01	-0.35	-0.10	1	
INF	0.51	0.42	0.56	-0.22	-0.24	0.20	0.40	0.20	0.19	-0.49	0.15	0.30	1

Initially, TCAR was considered for inclusion but was ultimately dropped due to its high correlation (more than 0.80) with the TOCAR (Gujarati and Porter, 2009).

Table 3 VIF table for the independent variables

Variable	VIF	1/VIF
T1LEV	2.53	0.40
SIZE	2.04	0.49
TOCAR	1.64	0.61
INF	1.38	0.72
GDP	1.26	0.79
NPL	1.1	0.91
Mean	VIF	1.66

Values less than 10 means the variables are not showing signs of multicollinearity (Chandrasegaran, 2020).

3.4. Regression model

The study examines how the ROAA, ROAE, NIM and ER as performance measures, and solvency Z-score and LLPR as risk measures have been impacted by different proxies of capital adequacy determined by Basel regulation using other control variables listed in Table 1. Following Bitar, Pukthuanthong and Walker (2018) and Kumar, Thrikawala and Acharya (2022) who recognise the influence of past performance and the lead time for regulatory changes to affect current performance, I lag the independent variables by one year to capture this influence. The model can be established as below after the aforementioned adjustment:

$$Y_{it} = \beta_0 + \beta_1 T1LEV_{i,t-1} + \beta_2 TOCAR_{i,t-1} + \beta_3 SIZE_{i,t-1} + \beta_4 NPL_{i,t-1} + \beta_5 GDP_{i,t-1} + \beta_6 INF_{i,t-1} + \epsilon_{it}$$

where,

Y_{it} represents the dependent variables (ROAA, ROAE, NIM, ER, Z-SCORE and LLPR) for bank *i* at time *t (Models 1-6)*

β_1 and β_2 will be my coefficients of interest.

In addition to the above, the study will also test the impact of the crisis (Crisis model) in conjunction with capital adequacy to examine the extent of the effect on these performance and risk measures. Similarly, further analyses are done to explore how the size of the banks (Large vs Small Banks – LVSB model) and the development status of the country where they are based (Developed vs Developing Nations – DVDN model) amplifies the effect of capital adequacy. These are executed by creating an interactive interaction variable with my variables of interest for each case mentioned above, with dummy variables taking value one while representing crisis period, large banks and developed countries, and null otherwise. For separating the large and small banks in the LVSB model, a median of total assets was used, and banks with assets higher than the median value were assigned binary variable one. The discussed models are summarised below:

$$Dependent\ variables_{i,t} = Crisis\ x\ Independent\ variables_{i,t-1} + Independent\ variables_{i,t-1} + Control\ variables_{i,t-1} + \epsilon_{it} \quad (7)$$

$$Dependent\ variables_{i,t} = Size\ x\ Independent\ variables_{i,t-1} + Independent\ variables_{i,t-1} + Control\ variables_{i,t-1} + \epsilon_{it} \quad (8)$$

$$Dependent\ variables_{i,t} = Status\ x\ Independent\ variables_{i,t-1} + Control\ variables_{i,t-1} + Independent\ variables_{i,t-1} + \epsilon_{it} \quad (9)$$

3.5. Assumptions and heteroscedasticity check

Following the removal of TCAR, data was winsorised at 1 and 99 percentiles as winsorising data minimises the influence of outliers at extreme ends of data distribution (Alkhazali *et al.*, 2024). Normality tests were conducted on dataset pre and post-winsorization of data at 1% and 99%, followed by 5% and 95%. However, addressing normality was not feasible within the scope of this analysis. Despite this limitation, the results are robust, and the models have been tested for

heteroskedasticity, ensuring that standard errors are adjusted to provide valid inferences. Heteroskedasticity refers to the situation where the variance of the error terms is not constant across observations. Not addressing the presence of heteroskedasticity can lead to misleading inferences about the significance of the independent variables. Using heteroskedasticity-robust clustered standard errors ensures that the statistical significance of the regression coefficients is not overstated, providing a more accurate representation of the relationships between the independent and dependent variables (Danisman and Tarazi, 2024).

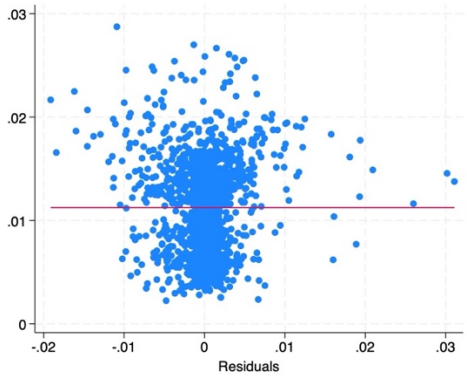

Figure 1: ROAA Residuals

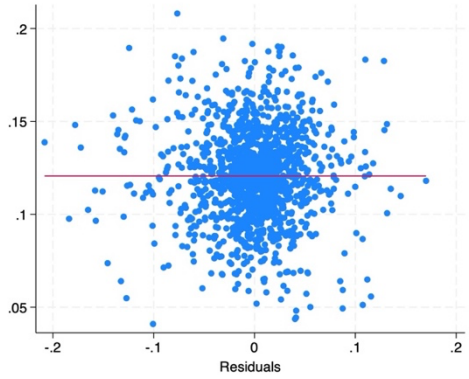

Figure 2: ROAE Residuals

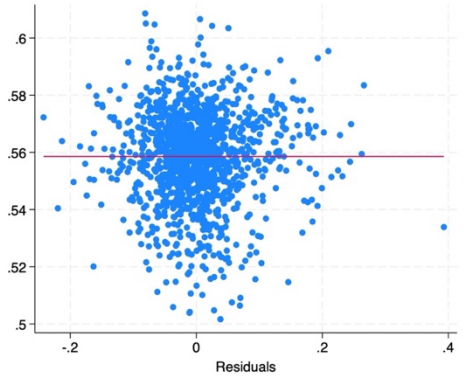

Figure 3: NIM Residuals

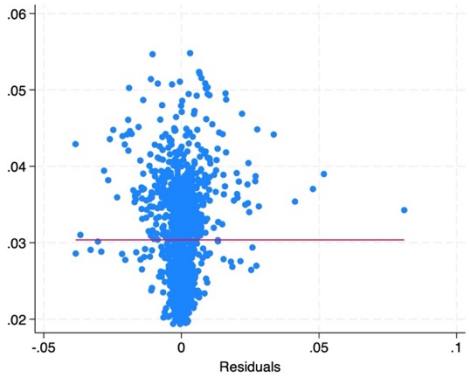

Figure 4: ER Residuals

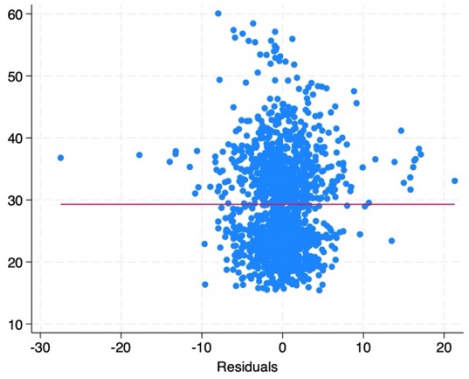

Figure 5: Z-score Residuals

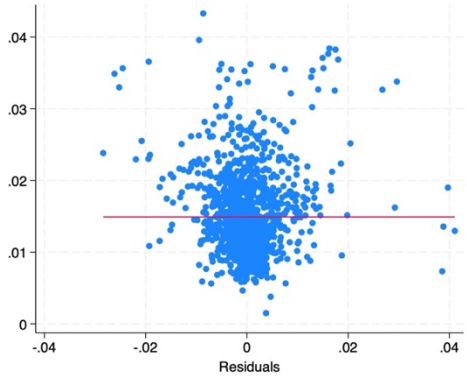

Figure 6: LLPR Residuals

Figures 1 to 6 represent scatter plot diagrams for the residuals of the variables in the Baseline model. Blue dots represent the linear prediction of the values, while the red lines represent the fitted values. The figures provide evidence of homoscedasticity i.e. constant error terms of residuals after line fitting the respective variables

3.6. Model estimation

The correct choice of model among fixed and random effects was estimated using a pooled regression model for the aforementioned regression models. Following the calculation of the estimates, the Hausman test was conducted (reported in Table 5), which indicated that the fixed effects (FE) model was more appropriate. For the baseline and LVSB model, I applied firm and year FE to control for unobserved characteristics at the bank level and time-specific factors influencing all the banks across the sample period. In the DVDN model, only the year FE was used as firm fixed effects were perfectly collinear. During the crisis period analysis, firm FE was employed to focus on firm-specific characteristics during economic shocks such as the global financial crisis, eurozone debt crisis and the COVID-19 pandemic. This approach ensures the results are not biased by omitted variables and accurately reflect the causal relationships between the variables of interest and bank risk and performance.

4. Results

4.1. Descriptive Statistics

Descriptive statistics provide a foundational understanding of the variables involved in the analysis, offering insights into their central tendencies and distributional properties before the explanatory variables are lagged for regression. The dataset includes a range of financial performance metrics and macroeconomic variables, all represented in ratios except for SIZE, expressed as the natural logarithm of total assets and Z-score, a numeric value indicating solvency risk. The summary statistics are presented in Table 4.

Table 4 Summary statistics for the main variables

Variable	N	Mean	SD	Skewness	Kurtosis	Median	Min	Max
ROAA	1,530	1.20%	1.00%	1.862	8.245	1.00%	-0.50%	5.50%
ROAE	1,530	12.40%	7.20%	-0.222	3.99	12.50%	-11.40%	30.80%
NIM	1,529	3.10%	2.20%	1.778	7.432	2.40%	0.60%	13.30%
ER	1,529	55.80%	12.50%	0.39	3.133	55.90%	30.10%	93.60%
Z-score	1,531	28.99	16.50	1.13	4.62	25.90	3.97	87.43
LLPR	1,515	1.50%	1.30%	1.937	7.558	1.10%	0.20%	7.40%
T1LEV	1,495	7.20%	3.50%	1.284	4.961	6.50%	2.00%	20.00%
TOCAR	1,500	13.90%	4.60%	1.479	6.722	13.20%	6.30%	32.70%
SIZE	1,534	12.13	1.85	-0.50	2.71	12.26	6.69	14.91
NPL	1,509	3.60%	3.40%	2.164	8.768	2.60%	0.30%	19.30%
GDP	1,539	2.90%	3.30%	-0.753	4.231	2.80%	-8.60%	9.00%
INF	1,539	4.10%	3.90%	1.75	6.576	3.00%	-0.90%	19.60%

Descriptive statistics show that, on average, banks exhibit an ROAA of approximately 1.20%, with a high of 5.5% and a low of -0.5%. The ROAE averages 12.40%, with a high of 30.80% and a low of 11.40%, with variations amounting to 1% and 7.2%, respectively. Similarly, for other performance-assessing variables, the average NIM is 3.07%, with a maximum value of 13.30% and a minimum value of 0.60%, while the efficiency ratio (ER) has an average value of 55.8% with an upper bound of 93.60% and a lower bound of 30.10%, with deviations from the mean of 2.2% and 12.5% respectively. Likewise, for the bank risk measurement variables, the Z-score has a mean value of 28.99, with a higher value reaching 87.43 and a lower value reaching 3.97 with a standard deviation of 16.50. Lastly, the banks demonstrate, on average, an LLPR of 1.5% with a maximum value of 7.4% and minimum value of 0.2%, amounting to a standard deviation of 1.3% from its mean value.

For the first primary variable of interest, the T1LEV averages 7.1% with a standard deviation of 3.4%, attaining a maximum value of 20.1% and a minimum value of 2.0%, generally higher than the requirement set by the BIS at 3% (Basel Committee on Banking Supervision, 2014). Similarly, The average TOCAR is significantly above the required value of 6% (Basel Committee on Banking Supervision, 2006), averaging at 13.7% with a standard deviation of 4.6%, a minimum value of 6.3% and a maximum value of 32.8%. This indicates that banks are adhering to capital buffer requirements, are in a solid position to absorb their losses, and can function even with the diminished disposal of capital in the economy. BIS also outlines that the leverage ratio serves as a safeguard against such financial instability by providing a straightforward, non-risk-based measure to complement the existing risk-based capital requirements because the banks, during the GFC (Global Financial Crisis), often amassed high leverage, although they held sufficient capital against RWAs.

4.2. Discussion

4.2.1. Baseline analysis

Table 5 Baseline Regression

	ROAA (1)	ROAE (2)	NIM (3)	ER (4)	Z-Score (5)	LLP Ratio (6)
T1 LEV	0.012	-0.599***	0.077***	-0.485***	106.089***	0.083***
	(0.013)	(0.115)	(0.025)	(0.178)	(10.641)	(0.017)
TOCAR	0.012	0.144*	0.003	0.075	-4.461	-0.024***
	(0.008)	(0.080)	(0.011)	(0.105)	(5.936)	(0.008)
Bank size	-0.003***	-0.015***	-0.003***	-0.004	-3.357***	0.001
	(0.001)	(0.005)	(0.001)	(0.009)	(0.622)	(0.001)

NPL Ratio	-0.034***	-0.433***	-0.019	0.212**	-11.817***	0.141***
	(0.006)	(0.066)	(0.012)	(0.091)	(4.243)	(0.014)
GDP	-0.008	0.09	-0.007	0.190*	-10.704**	-0.049***
	-0.008	(0.069)	(0.012)	(0.105)	(5.087)	(0.012)
Inflation	0.000	0.053	0.020	-0.231*	-22.200***	-0.014
	(0.013)	(0.089)	(0.022)	(0.127)	(7.422)	(0.014)
Constant	0.041***	0.343***	0.056***	0.624***	64.888***	-0.002
	(0.008)	(0.069)	(0.012)	(0.117)	(7.945)	(0.011)
N	1,396	1,396	1,396	1,395	1,396	1,391
F-stat	9.95	15.61	3.62	4.13	27.27	29.11
R-squared	0.82	0.66	0.90	0.75	0.95	0.83
Wald χ^2 statistic	91.89	49.56	118.31	62.75	40.51	80.37
Prob > Chi^2	0.00	0.00	0.00	0.00	0.00	0.00

Table 5 presents the results of the baseline model 1 to 6. The model uses OLS estimation with firm and time-fixed effects to control for unobserved heterogeneity between firms at different times. Standard errors are presented in parentheses. These standard errors are robust for heteroscedasticity and have been calculated using the robust function in STATA. Asterisks indicate significance at the 1 percent (*), 5 percent (**) and 10 percent (***) levels. Based on the Hausman test coefficients and probability denoted by the Chi^2 test, the fixed effects model is used in this study.

In the baseline model presented in Table 5, capital adequacy, measured by T1 Leverage (T1LEV) and T1 Ratio (TOCR), exhibits diverse impacts across the dependent variable. For T1LEV, ROAE exhibits a negative relation, which is consistent with Al-Sharkas and Al-Sharkas (2022). This suggests that higher T1 leverage correlates with lower returns on equity, possibly due to the opportunity cost of holding high capital, which leads to lower asset utilisation and the dilution of earnings for equity holders due to an increased equity base. For a 1% increase in the proportion of Tier 1 capital in the capital structure, ROAE decreases by 0.599%. Increased capital adequacy, however, improves efficiency - for every percentage point increase in T1LEV, efficiency increases by 0.485%. This is likely due to reduced costs associated with risk management, as banks with higher capital might invest more in risk monitoring technologies (Coccorese and Girardone, 2021), which will lower the cost of risk monitoring in subsequent years.

Similarly, the positive and significant coefficient for NIM implies that higher T1LEV enhances the bank's interest margins. For every 1% increase in core equity as a proportion of total assets, banks increase their earnings from net interest margin by 0.077%, potentially due to a perception of reduced risk by depositors, which helps lower the cost of funding the loans (Begum, Rahman and Faruq, 2024), while also being able to guarantee the provision of credit on demand to borrowers. The observed increase in profitability is consistent with the findings of Sufian and Kamarudin (2012), Louati, Gargouri Abida and Boujelbene (2015) and Ozili (2015).

Likewise, a statistically significant and positive coefficient for the Z-score suggests that greater capital adequacy enhances bank stability and reduces insolvency risk. This can be supported by greater capital adequacy acting like a safety net for banks, helping them withstand financial shocks more readily. Banks with more capital can absorb losses without raising any issues of going concern. This finding is consistent with Zarafat and Prabhune (2018) and Tran, Nguyen and Nguyen (2022) but contradicts the findings of Altunbas *et al.* (2007) Lastly, the positive relationship of LLPR to T1 Leverage suggests that higher equity in the capital leads to increased loan loss provisions (specifically, a 1% increase in T1LEV will increase LLPR by 0.083%, significant at 1%). It may imply that banks use LLP as a tool for income smoothing but Hamadi *et al.* (2016) find this trend is low post-Basel II era. Then again, they could be cautious about maintaining capital to meet the regulatory threshold adequately and avoid facing any negative repercussions which could impact their profitability.

However, both T1LEV and TOCR are found to have a weak positive association with ROAA, further substantiating the question regarding the suitability of ROAA as a measure of profitability (Iskandar, Yahya and Wahid, 2019). Surprisingly, the T1 ratio does not significantly impact the dependent variables, except ROAE and LLPR. Contradicting the relationship with T1LEV, TOCR

is observed to have a positive relationship with ROAE, which is consistent with Al-Sharkas and Al-Sharkas (2022), although at a lower magnitude than the former. The regression result shows that for every 1% addition of T1 Capital to fund risk-weighted assets, the return on equity increases by 0.144%, attributable to increased investor confidence backed by a solid capital base. A contrasting result compared to T1LEV is also observed for LLPR, where TOCR has a significantly negative coefficient at 1%, suggesting that increased capital adequacy via TOCAR results in lower provisioning, possibly as banks adopt a more prudent approach to lending as their capital is at risk and thus, reduce their expectation of future loan losses. Alternatively, it could be argued that they are following a more aggressive approach of not setting aside funds to cover future loan losses.

4.2.2. Crisis period

Table 6 Crisis model regression

	Model 7					
	ROAA	ROAE	NIM	ER	Z-Score	LLP Ratio
T1 LEV x Crisis	-0.017	-0.049	0.037**	-0.457***	32.756***	0.038**
	(0.011)	(0.106)	(0.018)	(0.168)	(8.071)	(0.015)
TOCAR x Crisis	-0.022***	-0.119	-0.039***	0.445***	-9.247	-0.031**
	(0.008)	(0.077)	(0.012)	(0.129)	(6.299)	(0.012)
T1 Leverage	0.011	-0.629***	0.070***	-0.329*	95.156***	0.073***
	(0.014)	(0.116)	(0.025)	(0.188)	(11.433)	(0.018)
T1 Ratio	0.026***	0.150**	0.002	-0.179	19.900***	-0.012
	(0.007)	(0.074)	(0.010)	(0.109)	(4.766)	(0.009)
Bank size	-0.002***	-0.027***	-0.003***	-0.009	-0.637	0.001**
	(0.000)	(0.004)	(0.001)	(0.006)	(0.457)	(0.001)
NPL Ratio	-0.034***	-0.456***	-0.017	0.256***	-18.459***	0.139***
	(0.006)	(0.066)	(0.012)	(0.093)	(4.595)	(0.014)
GDP	-0.007	0.025	0.006	0.124*	-17.380***	-0.028***
	(0.005)	(0.048)	(0.008)	(0.068)	(4.223)	(0.007)

Inflation	-0.012	0.127*	0.023	-0.356***	-5.228	0.002
	(0.010)	(0.071)	(0.016)	(0.097)	(5.880)	(0.009)
Crisis	0.002**	0.002	0.002	-0.022	-3.256***	0.002
	(0.001)	(0.011)	(0.002)	(0.017)	(0.795)	(0.002)
Constant	0.036***	0.490***	0.064***	0.716***	29.628***	-0.01
	(0.005)	(0.046)	(0.010)	(0.072)	(5.532)	(0.007)
N	1,396	1,396	1,396	1,395	1,396	1,391
F	16.13	22.8	5.98	6.36	42.42	21.82
R-squared	0.814	0.623	0.893	0.741	0.948	0.825

Table 6 presents the results of the crisis model (Model 7), where a dummy variable for crisis periods (GFC, Eurozone crisis for European banks, COVID-19 pandemic) taking value 1;0 otherwise, and interaction terms with capital adequacy ratios are added to the baseline model. The model uses OLS estimation with firm effects to control for unobserved heterogeneity between firms. Time-fixed effects were excluded as they were perfectly collinear with the dummy variable. Standard errors are presented in parentheses. These standard errors are robust for heteroscedasticity and have been calculated using the robust function in STATA. Asterisks indicate significance at the 1 percent (*), 5 percent (**) and 10 percent (***) levels.

A general observation of the crisis model (Model 7) presented in Table 6 shows that the relationship between capital adequacy ratios and risk and performance metrics is mainly similar to that of the baseline model. In the regression analysis, the impact of capital adequacy ratios reveals a mixed relationship with the financial metrics. TOCR now positively and significantly affects ROAA; however, the negative interaction of TOCR with the crisis dummy suggests that this benefit diminishes during downturns. Additionally, a decrease in NIM and efficiency, along with decreasing ROAA during the crisis, indicates an increased risk avoidance, as banks become more cautious and prioritise capital preservation over an aggressive lending strategy or pay lesser care to efficiency, leading to reduced profitability and tighter margins. For every 1% increase in the T1 Ratio, ROAA decreases by 0.022% during a crisis, which is significant at the 1% level. Similarly, LLP decreases by 0.031%, significant at the 10% level. This further demonstrates the difficulties banks encounter in maintaining a balance between stability and profitability during periods of

stress. The findings are contrary to the findings of Bitar, Pukthuanthong and Walker (2018), who argue that in crisis period, banks with high capitalisation have higher LLP, higher NIM and higher ER (efficiency ratio).

The higher costs associated with maintaining capital buffers during periods of distress can also strain resources, impacting profitability, as shown by a larger negative coefficient for T1LEV than the baseline model. However, the overall relationship between T1LEV x Crisis and the metrics is almost identical to the baseline model. The impact seems to have lessened compared to the baseline model during the crisis, implying that while a higher proportion of capital in the financial structure of the banks continues to play a crucial role, its effectiveness in supporting profitability and operational efficiency is diminished during crises, likely due to increased risk aversion and financial pressures, contrasting the findings of Berger and Bouwman (2013) and Coccorese and Girardone (2021).

4.2.3. Large versus Small banks

Table 7 Large versus small banks regression

	Model 8					
	ROAA	ROAE	NIM	ER	Z-Score	LLPR
T1LEV x Large banks	0.127***	0.542*	0.05	-0.498	143.620***	-0.025
	(0.032)	(0.307)	(0.077)	(0.497)	(35.576)	(0.039)
TOCAR x Large banks	-0.043***	(0.17)	0.003	(0.22)	-16.058*	-0.040***
	(0.013)	(0.134)	(0.019)	(0.195)	(8.902)	(0.015)
T1LEV	-0.018	-0.699***	0.078***	-0.460**	80.963***	0.071***
	(0.015)	(0.134)	(0.029)	(0.198)	(10.586)	(0.019)
TOCAR	0.030***	0.205**	-0.001	0.160	2.660	-0.006
	(0.010)	(0.104)	(0.014)	(0.145)	(6.590)	(0.013)

SIZE	-0.002***	-0.015**	-0.003**	-0.017	-1.966***	0.000
	(0.001)	(0.006)	(0.001)	(0.010)	(0.516)	(0.001)
NPL	-0.036***	-0.440***	-0.019	0.214**	-13.366***	0.141***
	(0.006)	(0.067)	(0.012)	(0.091)	(4.102)	(0.014)
GDP	-0.007	0.099	-0.006	0.238**	-13.892***	-0.045***
	(0.008)	(0.069)	(0.012)	(0.103)	(5.101)	(0.012)
INF	0.000	0.054	0.020	-0.254**	-20.235***	-0.017
	(0.012)	(0.089)	(0.022)	(0.128)	(7.360)	(0.014)
Large banks	-0.006**	-0.016	-0.001	0.106***	-13.631***	0.006*
	(0.003)	(0.024)	(0.006)	(0.040)	(2.723)	(0.004)
Constant	0.038***	0.342***	0.055***	0.741***	53.100***	0.006
	(0.008)	(0.073)	(0.012)	(0.121)	(6.523)	(0.011)
N	1,396	1,396	1,396	1,395	1,396	1,391
F	7.71	10.70	3.44	4.64	22.07	22.90
R-squared	0.83	0.66	0.90	0.75	0.96	0.83

Table 7 presents the results of the large versus small bank (LVSB) model (Model 8), where a dummy variable taking value 1; 0 otherwise, and interaction terms with capital adequacy ratios are added to the baseline model. The model uses OLS estimation with firm and time-fixed effects to control for unobserved heterogeneity between firms at different times. Standard errors are presented in parentheses. These standard errors are robust for heteroscedasticity and have been calculated using the robust function in STATA. Asterisks indicate significance at the 1 percent (*), 5 percent (**) and 10 percent (***) levels.

The regression result LVSB model reveals an out-of-the-ordinary relationship between the capital adequacy variables and the risk and performance metrics. While the sign of the coefficients remains largely the same as in the previous model, the interaction terms display some contradicting results to the expectation.

The positive and significant impact of T1 Leverage x Large Banks on ROAA and ROAE, where a 1% increase in T1 Capital increases the metrics by 0.127% and 0.542%, respectively, suggests that larger banks efficiently use a greater T1 capital to total assets ratio to benefit from both asset and equity returns. It aligns with the theoretical understanding that, through economies of scale and diversification, large banks are better positioned to handle the risks of maintaining a sound capital base relative to their total assets, allowing them to leverage their capital strength towards superior financial performance. The significant positive impact on the Z-Score at the 1% level also showcases the enhanced stability of large banks brought on by a robust capital base funding their varying class of assets. The results support the findings of Abou-El-Sood (2016) but contradict the findings of Sufian and Kamarudin (2012) and Begum, Rahman and Faruq (2024).

On the other hand, the interaction term T1 Ratio x Large Banks has a negative and significant effect on ROAA and LLPR at a 1% level and Z-score at a 10% level, contrary to the typical expectation that a high T1 capital ratio translates to increased financial stability. This is contrary to Abou-El-Sood (2016), who finds that banks with higher risk of failure and the banks which allow for more loan losses tend to be smaller in size. My finding could be supplemented by the fact that a highly conservative capital base would constrain profitability due to accompanying opportunity costs and might give rise to moral hazard problems, propelling banks to pursue aggressive lending while minimising provision for losses to make up for the lost profits due to the enforcement of capital regulation to hold high capital buffer (Altunbas *et al.*, 2007; Madugu, Ibrahim and Amoah, 2020). Additionally, large banks are considered systemically important – "too big to fail" – and benefit from the LOLR provision, further bolstering the moral hazard hypothesis (Bitar, Pukthuanthong and Walker, 2018). Furthermore, It might also be argued that beyond a point, the high capital ratio stops being protective and produces diminishing returns for large banks

(Haq and Heaney, 2012), possibly because they can't use the capital efficiently like smaller banks due to reduced growth opportunities (Regehr and Sengupta, 2016).

4.2.4. Developed versus Developing Nation Banks

Table 8 Developed versus developing nation banks model

	Model 8					
	ROAA	ROAE	NIM	ER	Z-Score	LLPR
T1LEV x Developed Countries	0.095***	0.974***	0.091**	-1.513***	426.829***	(0.012)
	(0.019)	(0.172)	(0.039)	(0.329)	(42.848)	(0.024)
TOCAR x Developed Countries	-0.091***	-0.299**	-0.120***	0.033	-78.325***	-0.032*
	(0.015)	(0.116)	(0.030)	(0.224)	(25.792)	(0.017)
T1LEV	0.047***	-0.363***	0.189***	-0.731***	-106.779***	0.158***
	(0.016)	(0.122)	(0.037)	(0.221)	(25.495)	(0.021)
TOCAR	0.091***	0.381***	0.101***	0.328*	58.456***	(0.022)
	(0.015)	(0.108)	(0.029)	(0.183)	(17.414)	(0.017)
SIZE	0.000	0.001	-0.001***	0.022***	0.815**	-0.001***
	0.000	(0.002)	0.000	(0.004)	(0.394)	0.000
NPL	-0.028***	-0.455***	0.047***	0.863***	-142.043***	0.208***
	(0.007)	(0.064)	(0.013)	(0.090)	(12.207)	(0.012)
GDP	(0.013)	(0.047)	-0.048***	-0.321**	51.639***	-0.084***
	(0.010)	(0.078)	(0.018)	(0.141)	(18.030)	(0.013)
INF	0.048***	0.377***	0.126***	0.196	-157.820***	-0.048***
	(0.010)	(0.060)	(0.015)	(0.123)	(13.364)	(0.012)
Developed Countries	0.001	-0.085***	(0.001)	0.097***	-23.641***	0.003
	(0.002)	(0.016)	(0.004)	(0.028)	(3.483)	(0.002)
Constant	0.000	0.122***	0.019***	0.258***	35.272***	0.022***
	(0.003)	(0.028)	(0.006)	(0.050)	(5.565)	(0.004)

N	1,396	1,396	1,396	1,395	1,396	1,391
F	220.81	76.77	362.81	61.42	44.79	156.15
R-squared	0.62	0.39	0.71	0.33	0.24	0.63

Table 8 presents the results of the developed versus developing nation banks (DVDN) model (Model 8), where a dummy variable taking value 1; 0 otherwise, and interaction terms with capital adequacy ratios are added to the baseline model. The model uses OLS estimation with firm and time-fixed effects to control for unobserved heterogeneity between firms at different times. Standard errors are presented in parentheses. These standard errors are robust for heteroscedasticity and have been calculated using the robust function in STATA. Asterisks indicate significance at the 1 percent (*), 5 percent (**) and 10 percent (***) levels.

Table 8 reports the DVDN regression model. The regression coefficients indicate underlying differences between developed and developing nations' banks, which might have direct policy implications for the banks.

The interaction term T1 Leverage x Developed countries indicates a positive and significant impact on most performance metrics, suggesting that the benefit of holding a higher proportion of Tier 1 Capital in their capital structure is more pronounced for banks in developed countries. The results show that for a 1% increase in the proportion of core capital to their total assets, banks in developed countries improved their ROAA, ROAE and NIM by 0.095%,0.974% and 0.091%, respectively. Additionally, they can improve their efficiency by 1.513%, as indicated by a negative coefficient for ER and improve their financial stability heftily, as indicated by a significantly positive Z-score (426.829). This drastic performance improvement could be attributed to robust financial infrastructure, advanced risk management practices, and strong regulatory frameworks in developed countries (Laeven and Levine, 2009). These factors enable banks to optimise capital use, reducing costs and boosting returns without significantly increasing risk (Abbas *et al.*, 2024)

On the contrary, the T1 Ratio x Developed Countries interaction term has an unwarranted effect on the performance metrics. The results indicate that Tier 1 Capital significantly negatively affects

the profitability, efficiency, and financial stability of the banks in developed countries. Profitability decreases with an increase in Tier 1 Capital—ROAA decreases by 0.091%, ROAE decreases by 0.299%, and NIM decreases by 0.120% for each percentage increase in Tier 1 Capital. There is also a decrease in efficiency; however, this coefficient is insignificant. The findings are consistent with Le, Nasir and Huynh (2023). These results suggest that in developed countries, the marginal benefit of increasing Tier 1 capital is diminishing, and they will face negative returns if they hold more Tier 1 capital instead (Andersen and Juelsrud, 2024). This might be due to higher opportunity costs of keeping more capital without efficient mobilisation to generate returns (Madugu, Ibrahim and Amoah, 2020). This might also imply that the markets in developed countries are saturated, and low growth prospects hurt profitability. Likewise, the decrease in Z-score due to an increase in Tier 1 capital underlines the necessity to reiterate the moral hazard issue in developed countries, suggesting they highly rely on deposit insurance schemes that are more prevalent in developed nations than in developing nations (Suljić Nikolaj, Olgić Draženović and Buterin, 2022).

4.2.5. Impact of control variables

The analysis reveals that bank size generally exhibits negative coefficients across most models, with significant impacts on ROAA, ROAE and NIM at the 1% or 5% significance level except in the DVDN model, where it is only significant for NIM. Similarly, bank size also has a positive coefficient on ER. These results suggest that banks face diminishing returns on assets and equity as they grow, likely due to increased inefficiencies and higher operational costs. These are consistent with Sufian and Kamarudin (2012) and (Adelopo, Vichou and Cheung, 2022) but contrary to Trofimov, Md Aris and Kho Ying Ying (2018). This also highlights the challenges larger banks face in maintaining competitive interest margins, explaining their shift towards generating more income from non-interest operations. The Z-score is negatively affected by bank size at a 1% significance level in all models except DVDN, indicating that larger banks are more

vulnerable to financial instability unless they are based in a developed country. Conversely, negatively significant LLPR in the DVDN model suggests that larger banks in developed countries have more effective credit risk management, leading to lower loan loss provisions (Regehr and Sengupta, 2016).

The NPL ratio consistently negatively impacts ROAA, ROAE, and Z-score at a 1% level, while it positively impacts ER and LLPR at 1% and 5% levels across models. These findings indicate that poor-quality assets harm bank profitability in the long run and increase the overall risk profile, threatening the bank's financial stability, consistent with Leung, Taylor and Evans (2015) and Coccorese and Girardone (2021) Additionally, it suggests that banks with higher NPLs may engage in more intensive monitoring and provisioning for loan losses, reducing the bank's efficiency. Interestingly, in the DVDN model, NPL has a significantly positive impact on NIM, implying that banks in developed countries might increase interest spreads to compensate for higher risks associated with their existing portfolio, thereby boosting short-term profitability while potentially forgoing long-term financial stability (Altunbas *et al.*, 2007; Madugu, Ibrahim and Amoah, 2020).

GDP growth generally shows a muted effect on most performance variables. However, it has significantly negative coefficients for the Z-score and LLP ratio at the 1% and 5% levels across most models, except in the DVDN model, where GDP growth positively impacts the Z-score at 1%. This suggests that during periods of economic growth, banks in rapidly growing economies expand their loan portfolios with higher confidence, leading to lower loan loss provisions but increased risk-taking (Liang *et al.*, 2024) - except when they are in a developed nation. GDP growth appears to negatively impact NIM at the 1% level for banks in developed countries, implying that expansionary policies lead to lower net interest margins in these economies

compared to developing countries (Claessens, Coleman and Donnelly, 2018). While GDP positively affects ER at the 10% level in other models, indicating that higher GDP growth may lead to inefficiencies, in the DVDN model, GDP exhibits a significant negative coefficient at the 5% level for ER, suggesting that banks in developed nations may experience gains in efficiency during periods of economic growth, contrary to the findings of Nasim, Nasir and Downing (2024).

Inflation's effects on ROAA, ROAE, and NIM are generally insignificant, consistent with Adelopo, Vichou and Cheung (2022), except in the DVDN model, where it has significantly positive impacts, suggesting that banks in developed nations benefit from inflation through higher interest rates or adjusted pricing strategies, aligning with Sufian and Kamarudin (2012). Notably, inflation has a negative coefficient on ER at the 5% level during crisis periods, indicating that inflation may pressure banks to streamline operations and cut costs, resulting in better resource utilisation and operational efficiency, consistent with Sufian and Kamarudin (2012) but contrary to Nasim, Nasir and Downing (2024). Consistent negative coefficients for the Z-score at the 1% level, except during crises, further substantiate the notion that banks expand rapidly, possibly due to lucrative interest margins and take on more risk, reducing financial stability in high inflationary environments.

5. Conclusion

The study investigates the impact of capital adequacy on bank performance and stability across different economic contexts using T1 Leverage (Tier 1 Capital to Total Assets) and T1 Capital Ratio (Tier 1 Capital to Risk-Weighted Assets) as proxies for capital adequacy. Drawing from a sample of 81 banks across 23 countries from 2005 to 2023, the impact on risk and performance of the banks is analysed using multivariate OLS estimation based on their size, their country of domicile, and the economic conditions in which they operate.

Higher T1 Leverage generally reduces returns on equity due to opportunity costs and earnings dilution. However, it improves efficiency and financial stability, possibly due to the employment of enhanced risk monitoring technologies. However, increased capital can sometimes lead to higher loan loss provisions, possibly for income smoothing or regulatory compliance. The findings suggest that while a solid capital base is crucial for stability, its benefits on profitability and efficiency may diminish during crises due to increased risk aversion and focus on survival instead. Large banks and those in developed countries benefit more from higher capital levels, leveraging economies of scale and robust financial infrastructures, while capital adequacy is crucial for the stability of small banks. However, the findings indicate that larger banks and banks in developed nations suffer from diminishing benefits of higher Tier 1 Capital. Excessive capital can constrain profitability and lead to moral hazard, especially in developed markets.

The policy implications of these findings suggest that a blanket approach to capital regulation is ineffective in achieving the goal of capital regulation. Instead, regulatory frameworks should be tailored to the specific needs of different banking environments. In large banks and for banks in developed countries, where the marginal benefits of additional capital are lower, regulators might focus on optimising capital use to improve bank performance rather than merely increasing capital ratios. Conversely, robust capital regulation in small banks and banks in developing nations remains essential for enhancing resilience, profitability and stability. The study also highlights the potential for moral hazard, particularly in developed countries with prevalent deposit insurance schemes, suggesting a need for careful monitoring to ensure that safety nets do not inadvertently encourage excessive risk-taking. The findings advocate for a balanced approach to capital regulation that considers firm-specific characteristics and broader economic conditions to effectively balance financial stability and growth.

Appendix A

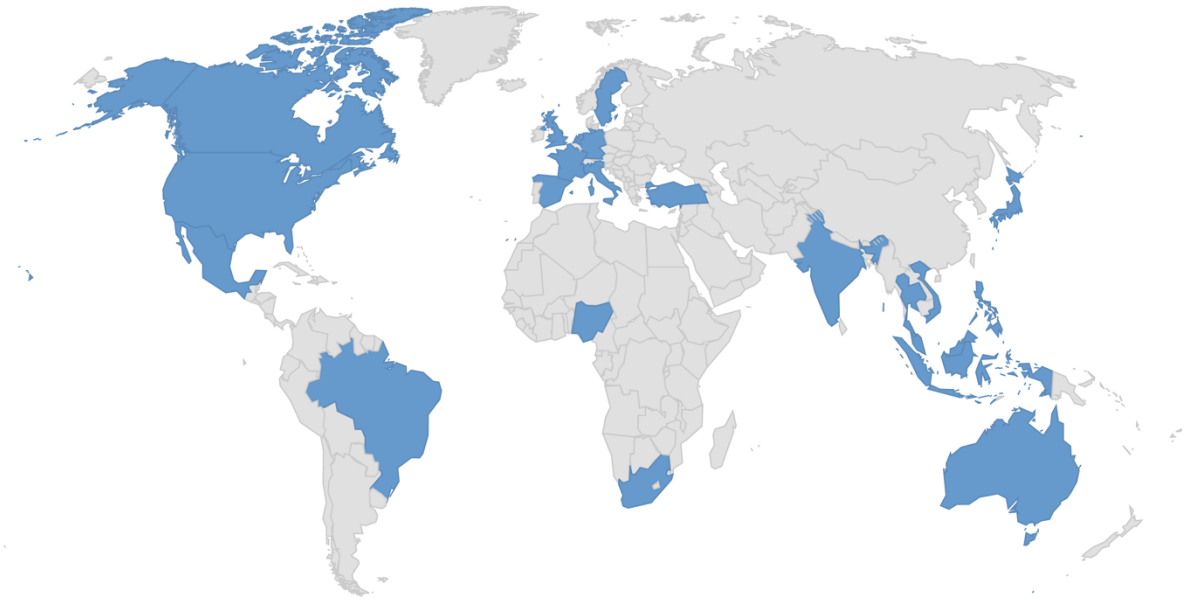

Figure 7: Map of the countries included in the sample

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