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Venturing into Risk Management: Examining Credit Risk and Performance in Pakistani Commercial Banks through Panel VAR Analysis from a Business Perspective

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ABSTRACT

In Pakistan's dynamic financial sector, effective credit risk management by commercial banks is critical to maintaining financial stability. In this study, we embarked on a unique and comprehensive journey, adopting the Panel Vector Autoregressive (PVAR) analysis, a novel methodology in this context. This approach allowed us to delve into the intricate relationship between credit risk management strategies and the aggregate business performance of commercial banks. The data used in this study spans from 2010Q1 to 2022Q4, investigating the comprehensive nexus of credit risk and macroeconomic indicators using a large dataset encompassing 18 strategically critical commercial banks of Pakistan. Our study uncovers several profound insights, documenting a remarkable increase in credit risk upon increases in the interest rate. The repercussions of the non-performing loans are observed nearly two years after the successive phases of a stern posture of monetary policy have been implemented. Our research findings carry significant weight for the banking industry. We discovered that the levels of credit risk could be reined in due to the protective shield offered by phases of sudden economic booms. This underscores the reinforcing effect of the improving economic conditions on defaults of loans, providing practical and actionable insights for credit risk management strategies.

INTRODUCTION

It is unsurprising that credit risk management has been described as fundamental to the success and stability of the banking systems worldwide. This seems particularly true in the complex money calculus of the developing world; however, it calls for understanding global academic research and pragmatic governance (Harb et al., 2022). One of the most critical activities in the banking industry is credit risk management (CRM). A bank takes risks to make a profit. As such, proper CRM also enables a bank to improve its overall performance and to survive in times of financial downturn. An effective CRM can minimize a bank's loan defaults and non-performing assets, which can significantly undermine the stability and soundness of a bank's loan portfolio. A well-structured CRM framework also gives the bank's management team the tools to underwrite loans soundly, allocate capital efficiently, and develop and maintain strong borrower relationships (Mennawi, 2020).

Credit risk, also referred to as default risk, is the probable risk a bank assumes when it makes a loan, line of credit, or any other form of financing to a borrower. Banks deploy a powerful credit risk management system to identify and manage pair risk through this. This means they work on their ability to detect, understand, and monitor credit risks to avoid facing default. Therefore, investing in robust credit risk management to increase the likelihood of default avoidance is crucial for banks to successfully and safely maintain their financial position (Rakhaev, 2020). It is well-supported by research, and many studies have unfolded on how effective credit risk management is a function of bank performance (Bhatt et al., 2023).

A literature review from a Pakistani vantage point identified several salient conclusions regarding credit risk management variables, key bank performance measures, and macro-level indicators from earlier research literature and the constructed frameworks of variables and their relationships, such as Zubair and Sajid (2014). They emphasized the continuing relevance of these interrelationships, particularly highlighting the strong negative relationship between one of the most critical bank performance measures of Gross NPL Ratio and key bank performance measures such as Return on Assets and Equity. The authors suggested that some of the specific phases of the management of credit risks, such as identification analysis and valuation, do not have a direct, substantial impact on financial robustness and strength as this is positioned with profit and loss strategies and interpretations, a perhaps striking exception to the general rule or direction in the literature revealed by Lafayette, Vaillant, and Vendrell-Herrero (2019).

With its peculiar economic evolution, regulatory landscape, and market exigencies, the Pakistani banking sector is an ideal context to scrutinize this paradigm. Our study seeks to reveal how credit risk management is related to the performance of commercial banks in Pakistan. The banking sector in Pakistan shares overlapping traits with other developing economies yet possesses its challenges and prospects. How its banks perform on the ground relative to micro and macroeconomic factors and navigate the ongoing progress between their regulatory environment and operating conditions provides an arena of splendid scholarly pertinence.

The panel Vector Autoregressive (VAR) methodology chosen for our reintegrating analysis is not accidental, given that VAR methodology enables a thorough analysis of multivariate time series data, as it captures the interdependent behavior among endogenous variables over time. Using our chosen methodology, we appraised performance dynamics within the sector, tapping both bank-specific metrics and acknowledging broader macroeconomic indicators. The set of variables chosen has been thoroughly selected based on existing literature and our research objectives to provide an extensive outlook of the sector characteristics. The chosen variables constitute a wide range of financial indicators, including profitability indices and liquidity indicators.

The motivation behind this academic endeavor is twofold: (a) to enhance the understanding regarding the symbiotic relationship between commercial banks' vitality and credit risk management under the canopy of an emerging economy and (b) to furnish scholars, practitioners, and policymakers with the valuable insights, which may allow them to synchronize the banking praxes with the tenets extracted from the pool of academicians' celebration.

Our study examined the performance of 18 major banks in Pakistan from 2010 to 2022 to determine their risk management strategies. We have collected data from official bank repositories, annual reports of banks, and regulatory bodies. In this tedious journey, we faced several challenges, including data consistency, heterogeneity in reporting standards, and evolving regulatory requirements. Bank profitability, capital adequacy, and macroeconomic factors were gauged. We found that interest rates significantly affect the riskiness of lending for banks, most likely due to the increased risk of loan defaults when lending becomes riskier as interest rates rise. Our results suggest that in addition to bank-specific variables such as profitability and solvency, credit risk is also significantly influenced by the monetary policy stance, economic activity, and inflation. While the reaction of credit risk to shocks to micro-level idiosyncratic variables is immediate, shocks to macro-level systemic variables manifest their impact after a lag. These findings have policy implications for the banks as well as regulators.

The structure of the paper is as follows. After this introduction, the next section is devoted to a literature review that sets the context and rationale for the research. Section 3 outlines our data methodology and discusses the techniques and datasets used. Section 4 presents the results and the discussion, which analyzes and interprets our findings on how various economic factors are related to credit risk in Pakistan's banking sector. Section 5 concludes our study, summarizes the main insights gained, and underscores their implications for policymakers and practitioners in the banking industry who seek to develop a comprehensive understanding of the dynamics of credit risk management in Pakistani commercial banks and formulate strategies for better and more sustainable management of financial stability.

LITERATURE REVIEW

This research aims to identify the relationship between credit risk management, bank performance, and macroeconomic variables. The second section of the literature review discusses the relationship and figures between Gross Non-Performing Loan Ratio (GNPLR), Return on Assets (ROA), Capital Adequacy Ratio (CAR), Inflation rate, GDP, and Interest rate. This literature review also contains the summarized findings of the above variables. Besides, the last part of the literature review critically analyzes the significant findings and suggests the implications for Pakistan's economy.

Adverse macroeconomic and bank-specific conditions lead to elevated credit risk in the banking industry. Recently, Alazis (2020) revealed that the Gross Non-Performing Loan Ratio (GNPLR) has a negative association with Return on Assets (ROA) and Capital Adequacy Ratio (CAR), which are the core performance indicators of the banks. Similarly, a recent study by Khurram and Siddiqui (2021) also found that inflation and GDP growth have a positive relationship with credit risk. However, the interest rate does not significantly affect credit risk.

Macroeconomic and bank-specific adversities magnify credit risk in the banking industry. Recently Alazis (2020) unveiled that Gross Non-Performing Loan Ratio (GNPLR) is negatively associated with Return on Assets (ROA) and Capital Adequacy Ratio (CAR), which are the core performance indicants of the banks. In addition, a recent study by Khurram and Siddiqui (2021) also found that inflation and GDP growth have a positive association with credit risk. However, interest rates do not significantly affect credit risk. The findings propose that effective credit risk management and stability of macroeconomic variables are pivotal to stimulating growth and stability in Pakistan's banking sector.

Banks' adoption of Islamic finance in credit risk management constitutes a nascent nexus for promoting entrepreneurship. In the absence of Islamic finance, start-ups struggle to obtain funds through conventional finance since the high cost of debt undermines their potential. In contrast, Islamic finance is a participative and equitable alternative to traditional finance by sharing objectives and risks with entrepreneurs. The absence of a supportive regulatory environment, however, encourages Islamic financial institutions to adopt a costly compliance approach, which has increased compliance costs for Islamic banks and thus pass on higher costs to their entrepreneurs, particularly amid high credit default rates resulting from non-performing loans (Arshed et al., 2023).

According to the research by Nuta et al. (2024) on the market performance of Romanian firms during the COVID-19 crisis, it is possible to draw a perspective on credit risk management in banks. The authors reveal significant differences in market performance by sector, with some sectors experiencing accelerated growth during the crisis. These differences imply that banks lending to firms in different sectors will have different levels of credit risk exposure. For example, communication services grew during the period, suggesting that banks lending to firms in this sector had lower credit risk than those in industries experiencing poor performance. Additionally, this study reveals the resilience and rapid recovery of the stock market, which quickly rebounded from the initial shock of the pandemic, suggesting that while short-term credit risks.

Gross Non-Performing Loans Ratio (GNPLR) and Bank Performance:

Gross Non-Performing Loan Ratio (GNPLR) is the most critical measure of a bank's asset quality, which allows an investor to assess the overall health of a bank's lending portfolio and the extent of risk associated with a bank's lending. A higher GNPLR indicates deteriorating asset quality and potential weakness in credit risk management, signaling the need for robust risk mitigation strategies

(Ponomarenko et al., 2017). Effective credit risk management can curtail the losses arising from non-performing loans. Banks can shield their finances by deploying stringent measures to soften their exposure to delinquent borrowers.

Research has confirmed an inverse correlation between the non-performing loan ratios (GNPLRs) and principal performance indicators of banks, such as return on assets and equity (Dhurup et al., 2022). They revealed the extent to which heightened GNPLRs affect a bank's profitability and financial soundness. Consequently, several scores fall well below credit risk management as banks identify, analyze, and evaluate credit risks. Placing the chances of default under given lending risks, ways of mitigating these risks, and providing resources minimizing these risks are allocated. This allows banks to write loans more confidently after identifying and evaluating potential credit risks and monitoring borrowers' worthiness. Thorough credit risk management is thus vital to minimize their GNPLRs and potential (Barjaktarović et al., 2022).

Effective credit risk management empowers banks to identify, assess, and proactively mitigate emerging risks, thereby enabling banks to build a strong loan portfolio and ensuring long-term sustainability and profitability for the lending institution (Spuchlakova & Misankova, 2017). Banks are well-advised to throttle back on loans that are not paying when due. The International Monetary Fund reports that banks with higher levels of non-performing loans are much less profitable than those with lower delinquent loans and are weaker during economic distress. Banks must act to manage and lessen the level of non-accruing loans to maximize the bank's bottom line over the long haul (Ando, 2019).

According to Safar et al. (2021), the Gross Non-Performing Loan Ratio (GNPLR) enables banks to assess the efficiency of their credit risk management. Closely monitoring GNPLR helps banks recognize their weaknesses and take timely actions to maintain their financial health and profitability.

Credit risk management plays a critical role in helping to keep a bank financially stable by reducing the impact of non-performing loans (Shrestha, 2017). A bank will be more likely to maintain its market of non-performing loans (Arora, 2021), Allowing a bank to keep a sustainable financial performance and adjust quickly not to become bankrupt and stay fully functional while doing this (Ibiz et al., 2021). This study concludes that the main feature of credit risk management's impact on banks' financial stability is to have a capital adequacy ratio and liquidity as they help investors measure the degree of risk involved in buying particular investments (Evbayiro & Osagie, 2023).

Banks struggle to address non-performing loans and defaulters employing conventional strategies. Indicators such as the Non-Performing Loan Ratio (NPLR) and the Capital Adequacy Ratio (CAR) are keenly examined by banks due to their significance on the soundness, profitability, and risk management by banks (Rehman et al., 2019). Key stakeholders are concerned about low non-performing loans, transparent risk management, and balanced interests (Gunningham, 2020), as the former indicates that borrowers are defaulting and increasingly placing financial risks. Minimizing

NPLR, like Expected Loss, lowers credit cycle exposure and maximizes banks' profits (Erdoğdu, 2017).

GNPLR is consistently associated with various bank performance measures. A study on Pakistani banks found a solid and significant negative association of GNPLR with both Return on Assets (ROA) and Return on Equity (ROE). It implies that the profitability and overall performance of the bank decreases with increasing GNPLR due to higher provisions for loan losses. Consequently, effective credit risk management is indispensable for the long-term survival of the banking sector (Noor & Siddiqui, 2019).

An unchecked GNPLR can drain a bank's capital reserves, which affects lending ability: as these loans dwarf income generation, it disenchants investors–all of which is antithetical to profitability. Banks must remain ever more vigilant in risk management and stay ahead of these loans to pursue a financially robust position that sustains profitability (Shahin et al., 2022). Finally, the relationship between GNPLR and the bank's performance is instructive on two main counts. Firstly, it is a helpful guide to effective risk management and overall banking sector soundness. On this score, an assessment of this association will aid in identifying areas of weakness and choosing how to address the profitability effects of non-performing loans. Secondly, regulators and policymakers must implement measures to enhance financial soundness and protect stakeholder interests (Matemane & Wentzel, 2019).

In conclusion, robust banking systems rely on effective risk management, of which GNPLR is a crucial leading indicator. Empirical evidence demonstrates that elevated GNPLR is associated with more extended periods of economic slowdown. However, banks with lower GNPLR report higher returns and are less disrupted from their financial intermediation role. These are the very reasons why these indicators matter to policy and regulation concerned with banking sector resilience and overall economic health (Ibrahim, 2018).

Return on Assets (ROA) as a Measure of Bank Performance:

Return on assets (ROA) is a crucial metric reflecting a bank's profitability, i.e., its ability to generate earnings from its assets. Data analyzed from Pakistan show a clear trend: banks that utilize credit risk management strategies more effectively tend to have higher ROA values (Khan, 2014). ROA is more than a metric; it is a story. A high ROA suggests that a bank is successfully earning on its assets. For stakeholders reviewing a bank's financial performance, ROA provides significant intelligence on the financial health of a bank and its proficiency in managing credit risks (Farah, 2020).

Achieving a high ROA is not enough. Banks must also remain dominant. Banks with dismal ROA cannot grow complacent. They must enhance their asset quality, shrink non-performing loans, and become more operationally nimble (Sharma, 2019).

Diversification, too, is essential. New business ventures can raise profitability and revenue streams (Alzoubi et al., 2022). For the banks of Pakistan, then, the lesson stands. Their future revolves around innovation. The intelligent adoption of data analytics, regular credit risk model updates, and strict adherence to industry best practices can change their future (Mushtaq et al., 2015). Furthermore, insight into the value added from the ROA and ROI matrices and a thorough review of historical trends could likely be invaluable. At the same time, robust internal controls alongside an ongoing and rigorous audit regimen could help them raise the quality of their risk management practices and ensure those (Purnomo et al., 2022).

Capital Adequacy Ratio (CAR) and Bank Stability:

Against this backdrop, the banking metrics adjudicators prefer the Capital Adequacy Ratio (CAR) to measure the bank's resilience against future adversities. In this regard, the Pakistan State Bank points out that the banks would have remained unfazed by unscheduled insomnia had they met the correct ratio (Rahman et al., 2018). The capital adequacy ratio is significantly related to bank stability in Pakistan's banking sector as a solid capital base temporizes the risks (Rahman et al., 2018).

Critics argue that a high CAR does not guarantee risk readiness, as demonstrated by Lehman's crisis (Connerty, 2010). This underscores the need for a comprehensive risk assessment beyond CAR (Spina, 2013). To safeguard the global financial system, the analysis must extend beyond CAR to include liquidity ratios, leverage ratios, and stress testing (Kibritcioglu, 2002). Qualitative aspects such as governance and risk culture enhance the evaluation process, creating a comprehensive risk management blueprint (Tongurai & Vithessonthi, 2020).

Macroeconomic Factors: Inflation, GDP, and Interest Rates:

Different macroeconomic factors significantly impact the credit risk landscape and the financial well-being of institutions (V. De Leon, 2020; GRISSE, 2021). For instance, high inflation reduces the value of loans, causing the risk of default to increase; GDP growth generally improves credit quality and reduces default rates. Fluctuations in interest rates impact borrowing costs and the likelihood of default (Caruso & Coroneo, 2023).

The State Bank of Pakistan's policies, such as adjustments in interest rates, influence collateralized loaning and loan repaying ability (Platte, 2022). Securitization, if used prudently, could maximize wealth, but default risks are to be minimized (Kashyap, 2016). In Pakistan, GDP growth fortifies banking operations while inflation weakens them. The interest rate changes either encourage or discourage borrowing; thus, the lending policies are based on this factor. Knowing these dynamics of banks and borrowers helps the banks adjust to the changes in economic conditions and, therefore, remain protected from defaults (Zubair & Sajid, 2014).

RESEARCH METHODOLOGY

In this study, we scrutinize the nuanced undertaking of credit risk management and performance of commercial banks in a developing country, i.e., Pakistan, in the presence of macroeconomic factors. The methodological architecture of the study is based on panel Vector Autoregressive (VAR) techniques. This approach provides a sagacious analytical framework for multivariate time series data. This allows for simultaneous examination of the endogenous relationship among variables over time when we have multiple banks for a critical dependent variable. The model specification is expressed as:

$$\boldsymbol{Y_{it} = A_0 + A_1 Y_{it-1} + \cdots + A_p Y_{it-p} + \varepsilon_{it}}$$

Within this model, $\boldsymbol{Y_{it}}$ represents a vector of endogenous variables, amalgamating bank-centric indicators and macroeconomic metrics. The indices $\boldsymbol{i}$ and $\boldsymbol{t}$ demarcate individual banking entities and specific time intervals.

To bolster our analysis, based on the foundational empirical model, we derived the following model:

$$\boldsymbol{Y_{it} = A(L)Y_{it} + \varepsilon_{it},}$$

Where,

$$\boldsymbol{Y_{it} = [Bank\ Specific\ Variables,\ Macrofinancial\ Variables]}$$

$$\boldsymbol{Y_{it} = [GNPLR_{it}, ROA_{it},\ CAR_{it},\ y_{it},\ \pi_{it},\ r_{it},\ Dummies_{it}],}$$

Where macroeconomic variables$y_{it}, and\ rit,$ respectively, are the real growth, Consumer Price inflation, and 3-month Treasury bill rate. Our empirical focus is pivoted around a meticulously curated set of variables, informed by pertinent literature and with direct bearing on the study's objectives. These variables spanned bank profitability metrics, liquidity indicators, capital adequacy, etc. A cohort of 18 strategically significant commercial banks in Pakistan was selected for examination, with choices informed by market footprint, their emblematic nature within the broader banking milieu, and the reliability of the data they proffered.

In consonance with the open source philosophy, the data frame set for our exploration spans a quarterly time series between 2010Q1 and 2022Q4. The financial statements, the principal manuscript for this inquisition, were methodically distilled from eminently authentic repositories, including official bank domains, annual discourses, and pertinent regulatory sanctums. Despite employing insider techniques, the process was not without its tribulations. Discontinuities, for instance, necessitated contingencies, such as direct outreach to banks. Also, as with legacy, the reporting standards varied, mandating hours of normalization— a chore augmented by the mutable accounting standards and regulatory mandates. Robust validation infrastructure, however, was instituted so as not once to forsake exactness or reproducibility. The objective of this latest illumination is a holistic view of the inchoate theme, as viewed through the refined lens of our VAR framework, aimed to juxtapose the credit risk

management imperative versus the macroeconomic health of Pakistan's commercial banks. Based on this model, we anticipate significant scholarly and practical contributions from our research.

RESULT AND DISCUSSION

Data Analysis and Interpretation

To investigate the presence of unit roots within the panels, we conducted the Im-Pesaran-Shin (IPS) test for all the variables. The IPS test employs autoregressive parameters and fixed-N critical values for panel-specific. The hypotheses for IPS tests are:

H_0: All panels have unit roots

H_a: Some panels have stationarity

The results of the IPS tests for the variables are as follows:

Variable	Statistic	p-value	Critical Values (1%, 5%, 10%)	Result
GNPLR	$Z_{\bar{t}bar}$: 1.6326	0.9487	-1.980, -1.840, -1.780	Likely non-stationary
ROA	$Z_{\bar{t}bar}$: -6.0647	6.611e-10	-1.980, -1.840, -1.780	Likely stationary
CAR	: -1.0317	0.1511	-	Marginally non-stationary
RGDPG	$Z_{\bar{t}bar}$: -6.7620	6.803e-12	-1.980, -1.840, -1.780	Likely stationary
INFL	$Z_{\bar{t}bar}$: 10.8341	1	-1.980, -1.840, -1.780	Likely non-stationary
TB3	$Z_{\bar{t}bar}$: 4.4093	0.99999482	-1.980, -1.840, -1.780	Likely non-stationary

These results give a sense of the time series characteristics in the variables and will be used as a basis for the subsequent modeling and analysis. The lags used in these tests were selected automatically based on the lowest AIC. Time series properties of the time series are of no concern as we are using this data merely to establish that the variations are significantly different.

Non-stationary Variables: Transforming for Stationarity

Variable stationarity is necessary for econometric studies to draw reliable statistical inferences and modeling outcomes. A variable is defined as non-stationary if it displays trends. Also, non-stationary variables are called unit root variables. The existence of unit roots or trends can result in the creation of spurious relationships, and it can complicate analysis. To expunge trends and make the variables stationary for further analysis, the Im-Pesaran-Shin test was used to confirm the presence of non-stationary variables (inflation, interest rate, CAR, GNPLR) and differentiate these into stationary series by differencing. A subsequent first differencing resolves the presence of unit roots. Implementing the sequence ensures that the dataset is ready for a vehement test and affords accurate statistical inferences in the later stages.

Cointegration Analysis: Insights from the Kao (1999) Test

Cointegration analysis is an instrumental tool in econometric studies, serving as a lens to discern long-term associations between variables. Such an analysis probes whether a set of variables exhibit synchronous movement over extended periods (long run), potentially reflecting shared intrinsic relationships. Within the framework of this study, the Kao test was employed to evaluate the Cointegration stance of our panel variables.

Applying the Kao test, the competing hypotheses set the stage: the null hypothesis (Ho) contending the absence of cointegration, and the alternative hypothesis (Ha) proposing cointegration across all panels. This evaluative exercise spanned a panel dataset composed of 18 panels, boasting an average period count of 48.778.

The essence of the panel variables' cointegration profile is encapsulated in the outcomes of the Kao test, summarized in **Table I**.

Table I: Kao Test Findings on Cointegration

Kao Test for Cointegration				
Ho: No cointegration		Number of panels	=	18
Ha: All panels are cointegrated.		Avg. number of periods	=	48.778
Cointegrating vector:	Same			
Panel means:	Included	Kernel:	Barlett	
Time trend:	Not included	Lags:	2.28 (Newey-West)	
AR parameter:	Same	Augmented lags:	1	

	Statistic	**p-value**
Modified Dickey-Fuller t	-0.3169	0.3757
Dicky-Fuller t	0.2171	0.4140
Augmented Dicky-Fuller t	3.3545	0.0004
Unadjusted modified Dicky-Fuller t	-1.7795	0.0376
Unadjusted Dicky-Fuller t	-0.7186	0.2362

Insights gained from the test statistics and associated p-values provide valuable information on the relationship dynamics among panel variables. The Modified Dickey-Fuller and Dickey-Fuller t statistics indicate a weak indication of cointegration. In contrast, the Augmented Dickey-Fuller t statistic presents strong evidence supported by a low p-value.

In contrast, the Unadjusted Modified Dickey-Fuller t statistics provide more cautious support for cointegration. The Kao test results also offer conflicting evidence on the cointegration question, suggesting that further research and nuanced interpretation of these results is required. One direction of such future research might involve a probe of the underlying long-term connections and their implications for constructing econometric models and predicting financial markets.

Dissecting Dynamics of Stationary Variables

Because the interactions of economic variables are essential for policy and research, this paper uses a framework to study such interactions. Our framework combines the Generalized Method of Moments (GMM) estimation with Panel Vector Autoregression (PVAR). We employ 18 panels from 860 observations that are quarterly for each panel (i.e., 18*860= 15480 observations). Our implementation allows an extensive examination of variable dynamics and, as evident in the GMM criterion, results in a practically precisely identified model. A model is precisely identified by three moments per equation; an under-identified model has fewer moments than equations. Our robust GMM weight matrix is based on the homoskedasticity and serial correlation of the errors. The lags of the endogenous variables serve as instruments to address endogeneity.

These analyses contribute to the panel data analytics literature. Moreover, they underscore the need to understand economic coordination. Our methodology depends on GMM weight matrix robustness and the use of instrumental variables. Appendix I reports detailed results such as estimated coefficients, their standard errors, the t-statistics, the value of the GMM criterion, and the lags of the endogenous variables.

Model Stability

It is essential to ensure the meaningfulness and accuracy of the results yielded by a panel VAR model. Assessing the stability of the model has led us to verify all of its eigenvalues falling within the unit circle, confirming its stability with the Eigenvalue stability criterion. Eigenvalues are scaling factors used in a vector transformation. Stability is guaranteed when its values are less than or equal to one. Our investigation revealed that all eigenvalues have moduli less than one. This signified their stability. The maximum eigenvalue, while closely approaching one, remains within the bounds of stability. The fact that all eigenvalues remain within the unit circle confirmed the model's stability. It is a self-correcting system, immune to wild trends. Its ability to be ratified reassures us of its reliability.

Table II: Eigenvalue Stability Condition

Eigenvalue		Modulus
Real	Imaginary	
0.998	0	0.998
0.666	0.418	0.786
0.666	-0.418	0.786
-0.372	-0.682	0.777
-0.372	0.682	0.777
0.716	0	0.716
-0.278	0.13	0.307
-0.278	-0.13	0.307
0.281	0	0.281
-0.259	0	0.259
0.138	-0.037	0.142
0.138	0.037	0.142

Relationship between Variables: Granger Causality Tests

We turn to results from our benchmark panel VAR model. First, we present the results from the Granger-causality test in **Table III**.

Table III: Granger Causality Test

	Equation					
	GNPLR	ROA	CAR	RGDP	INFL	TB3
Excluded						
GNPLR		**0.098**	0.318	**0.047**	**0.044**	0.978
ROA	0.246		0.144	0.415	0.468	0.975
CAR	**0.099**	**0.033**		0.881	0.663	0.269
RGDP	0.297	0.367	0.734		**0.000**	**0.037**
INFL	0.416	0.354	0.870	**0.002**		**0.000**
TB3	**0.006**	0.496	**0.086**	0.299	**0.000**	
ALL	**0.003**	**0.005**	**0.045**	**0.000**	**0.000**	**0.000**

Notes: (i) **H0**: *Excluded* variable Does No Granger Cause *Equation* Variable. (ii) p-values are reported. (iii) Bold entries show rejection at a 10 percent confidence level.

Examining the Relationship of Credit Risk with Other Variables:

The study focused on the relationships between credit risk and various economic determinants. Specifically, variables such as credit risk (GNPLR), profitability (ROA), capital adequacy ratio (CAR), real growth rate (y), inflation (π), and interest rates (r) were investigated. **Table 3** shows that for credit risk, all variables are jointly significant. Capital adequacy and interest rates individually Cause credit risk in the banking sector. This implies that changes in a bank's solvency and the prevalent price of money in the market can meaningfully predict the credit riskiness of the banks.

Investigating Profitability's Interactions with Other Variables:

The banks' profitability is significantly predictable by the credit risk and solvency of the banks. However, the macroeconomic variables are not significant. Nonetheless, all variables jointly significantly predict profitability. A rising level of credit risk puts a drag on profitability by increasing the provisioning expenses of the banks, affects the solvency, and leads to lower profits.

Relationship between Capital Adequacy Ratio and Other Variables:

Capital adequacy is only significantly predicted by the level of economic interest rates. While individually insignificant, all macro and bank-specific variables are jointly significant.

Relationship between Real Growth Rate and Other Variables:

It is interesting to note that real economic growth is Granger-caused by the credit risk and the inflation levels. It is well known that inflation causes uncertainty in the economy and affects aggregate demand by causing households and firms to postpone consumption and investment decisions. At the same time, a rising credit risk in the banks would restrain banks from making loans to households and firms, thus hampering the overall investment levels in the economy.

Relationship between Inflation and Other Variables:

The changes in price levels are affected by the changes in economic activity, the interest rates as well as the credit risk of banks. The channels seem to be economically consistent and as per expectations. Theoretically, the price levels rise or fall when the economy operates above or below its potential. Further, a rising cost of investments (interest rates) would hamper productivity and inflation. Furthermore, when banks brake on lending activity due to a rise in credit riskiness, the investment and economic activity affect the price levels.

Relationship between Interest Rates and Other Variables:

The interest rates, as expected, are driven by macroeconomic factors, viz., real growth and inflation levels. The relationship can be explained via essential interaction within the IS-LM framework and the well-known Fisher effect.

Impulse Response Analysis of Panel VAR Model: Dynamic Interactions among Variables

Having established the relationship among various variables via the Granger Causality results, we delve into the results derived from the impulse response analysis conducted on our benchmark panel VAR model. Impulse response functions (IRFs) enable a nuanced understanding of the dynamic interplay and implications of variations in one variable on others within the model. This investigation is central to deciphering the transmission mechanisms and interconnectedness inherent in the panel VAR structure. The focal variables for this analysis are the credit risk (GNPLR) about shocks in the macro-variables like interest rate (TB3), real output growth (RGDPG), and inflation changes (DINFL), as well as bank-specific determinants, such as profitability (ROA) and alterations in solvency (DCAR).

Response of Credit Risk to Monetary Policy Shock:

Utilizing the IRFs for the changes in interest rate (r_{it}), we gauge the implications of fluctuations in this variable on the credit risk (GNPLR). A graphical representation in **Figure 1** elucidates the dynamics over 15 quarters. Notably, an upswing in interest rates amplifies credit risk. To elaborate, a contractionary monetary policy pushes the cost of borrowing up for new and existing loans, increasing the propensity of loan impairments, specifically non-performing loans. This escalation unfolds progressively, peaking at approximately eight quarters, in line with the conventional wisdom that the repercussions of a tight monetary policy manifest after a delay.

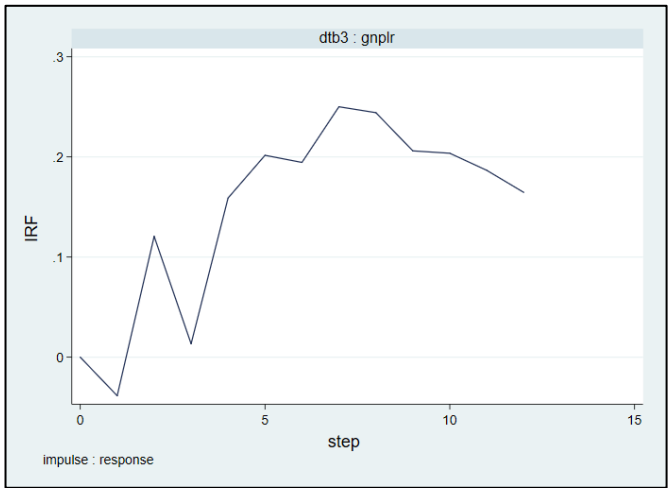

Figure 1: Response of Credit Risk to a Monetary Policy Shock

Response of Credit Risk to Economic Growth:

A careful analysis of the graph in **Figure 2** reveals the complex relationship between output growth and loan impairments. An increase in economic activity has an inverse effect on the non-performance of loans. This inverse relationship is based on the idea that a thriving economy leads to higher income levels, making it easier for borrowers to service and repay loans, thus reducing non-performing loans. Another perspective suggests that the decrease in the non-performing loan ratio (GNPLR) is due to a consistent level of non-performing loans and an increased lending velocity, which could mitigate the contagion levels in loans.

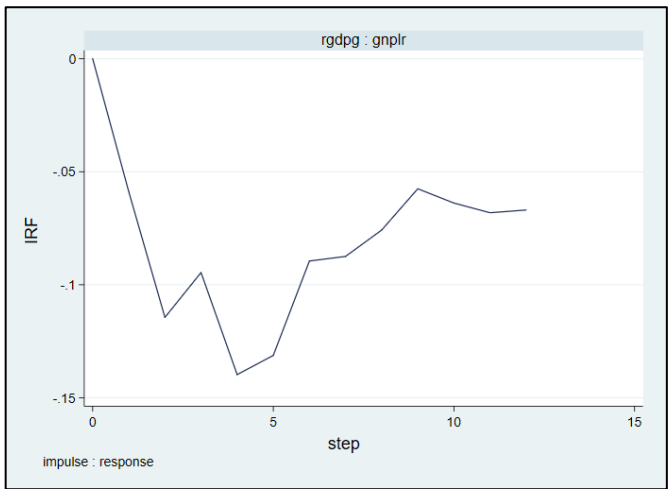

Figure 2: Response of Credit Risk to a Shock in Economic Activity

Response of Credit Risk to Inflation:

Our analysis further examines the relationship between credit risk (GNPLR) and inflationary pressures. **Figure 3** shows that changes in inflation have an impact on credit risk. An increase in inflation generally leads to higher credit risk. This finding highlights the potential adverse effect of inflation on borrowers' ability to repay, resulting in a rise in non-performing loans and an overall increase in credit risk. The increase in credit risk due to inflation can be attributed to various factors. Inflation primarily reduces economic agents' purchasing power, limiting their ability to service loans. Additionally, inflation introduces economic uncertainty, making cash flow planning more complex for borrowers. This increased uncertainty potentially raises credit risk. It is important to note that the effects of inflation on credit risk may not be immediate but rather unfold gradually, as depicted in the graph. However, these impacts diminish after the completion of the seven quarters.

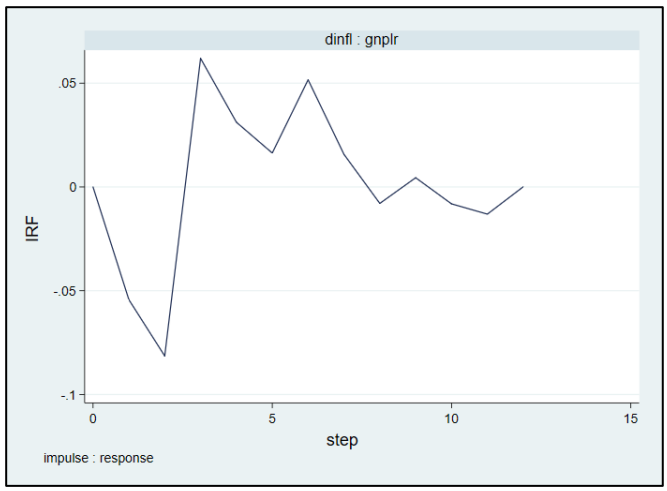

Figure 3: Response of Credit Risk to a Shock in Inflation

Response of Credit Risk to Profitability:

Verifying the impact of credit risk on profitability, or vice versa, is also essential. As revealed in **Figure 4**, an increase in profitability leads to a significant decrease in bank credit risk. In contrast, a reduction in bank profitability increases credit risk. Diminishing bank profitability can signal trouble for banks in generating revenue to cover costs and potential loan losses. Causes of a reduction in bank profitability may include higher credit impairment provisions, increased loan defaults, and challenging economic conditions. Hence, worsening credit risk looms, reflecting prospective degradation of loan quality and increased likelihood of non-performing loans. Importantly, this relationship is bi-directional; as declining profitability potentially leads to credit risk, elevated credit risk can decrease bank profitability.

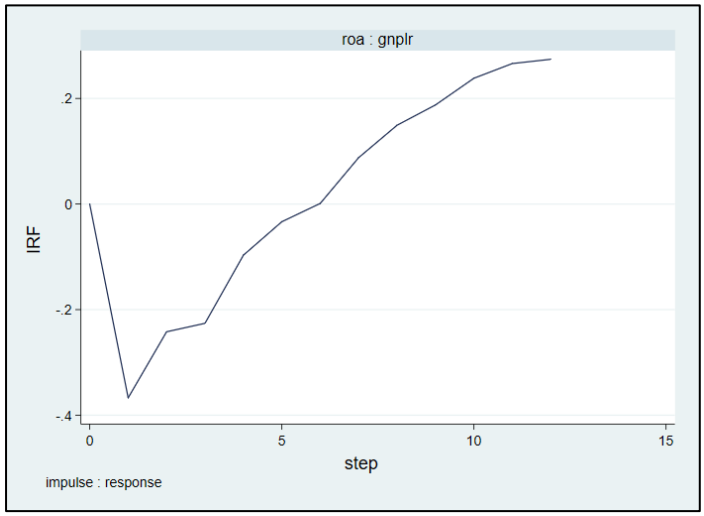

Figure 4: Response of Credit Risk to a Shock in Profitability

Response of Credit Risk to Capital Adequacy Ratio (CAR):

Figure 5 offers a more detailed correlation analysis of credit risk (GNPLR) and the Capital Adequacy Ratio (CAR). The figure shows that an increase in the CAR resulted in a decline in credit risk. The CAR measures a bank's capital strength and ability to absorb losses. A decline in the CAR signifies that a bank has weaker capital reserves, rendering its loan portfolio more risky. This decline in the CAR, associated with an increase in credit risk, signifies a heightened probability of loan defaults and impairments. This observation validates the widely accepted argument that a robust capital position fortifies a bank to endure shocks.

Conversely, a bank with lower capital levels is more exposed to loan defaults and a deterioration in credit quality. Moreover, the Granger causality results confirm that the relationship between credit risk and CAR is unidirectional: a fall in CAR raises credit risk, whereas an increase in credit risk will strain bank capital metrics, leading to higher loan impairment provisions and potential capital depletion.

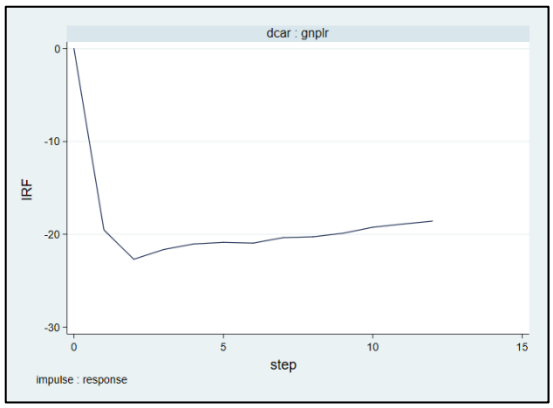

Figure 5: Response of Credit Risk to a Shock in Capital Adequacy

CONCLUSION AND POLICY IMPLEMENTATION

Robust credit risk management strategies are vital to the resilience and performance of the banking sector, and this is especially the case in emerging economies like Pakistan. This paper provides a comprehensive evolutionary examination of the intricate relationships between credit risk management and the operational dynamics of commercial banks in the context of Pakistan's dynamically evolving financial landscape. We deploy panel Vector Autoregressive (VAR) methodology to explore the complex relationships among many variables represented in multivariate time series data, and we thus focus on the endogenous relationships between bank-specific indicators and the broader macroeconomic determinants.

Our analytical approach, substantiated by the empirical model, incorporated macro financial and micro (bank-specific) variables, making our approach comprehensive. The diversity and number of our variables (looking at profitability, liquidity, etc.) demonstrate the depth of our study and the fact that we have also aligned our study to the current discourse. We have carefully examined a select group of 18 central commercial banks so that our findings truly reflect Pakistan's banking sector, capturing its nuances, challenges, and potential.

This research culminates a comprehensive picture that underscores the cardinal significance of credit risk management in the health and resilience of banks and the interconnectedness of micro-level banking operations with broader macroeconomic undulations, especially in a dynamic economic environment such as Pakistan.

Our results indicate that credit risk is influenced not only by bank-specific variables, including profitability and solvency, but also significantly by monetary policy, economic activity, and inflation. However, while the effect of shocks from micro-level idiosyncratic variables on credit risk is instantaneous, macro-level systemic variables are observed with a lag, as the extant literature suggests.

This study translates these insights to create value, transcending an academic exercise. It guides policymakers, financial practitioners, and banking leaders to inform their credit risk strategies amid economic ebb and flow. It suggests a roadmap for future academic work, combining rigorous research with practical relevance to indicate that there is more than a token to the argument that scholarly work can influence - and improve - real-world financial landscapes.

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Appendix: I

Panel Vector Autoregressive Model Results

	Coef.	Std.Err.	Z	P>z	[95%Conf.	Interval]
gnplr						
gnplr						
L1.	0.734	0.133	5.54	0	0.474	0.994
L2.	0.259	0.09	2.88	0.004	0.083	0.434
roa						
L1.	-0.367	0.325	-1.13	0.259	-1.005	0.271
L2.	0.246	0.237	1.04	0.299	-0.218	0.71
dcar						
L1.	-19.524	12.286	-1.59	0.112	-43.603	4.556
L2.	-12.938	6.017	-2.15	0.032	-24.731	-1.146
rgdpg						
L1.	-0.059	0.047	-1.25	0.213	-0.152	0.034
L2.	-0.072	0.053	-1.36	0.175	-0.176	0.032
dinfl						
L1.	-0.054	0.095	-0.57	0.566	-0.24	0.131
L2.	-0.097	0.082	-1.19	0.235	-0.257	0.063
dtb3						
L1.	-0.039	0.122	-0.32	0.751	-0.277	0.2
L2.	0.23	0.074	3.09	0.002	0.084	0.376
roa						
gnplr						
L1.	-0.024	0.025	-0.95	0.344	-0.072	0.025
L2.	0.027	0.013	2.08	0.038	0.002	0.052
roa						
L1.	0.857	0.168	5.1	0	0.528	1.187
L2.	-0.021	0.095	-0.23	0.821	-0.207	0.164
dcar						
L1.	3.275	2.553	1.28	0.2	-1.729	8.28
L2.	4.015	1.719	2.34	0.019	0.646	7.384
rgdpg						

L1.	0.002	0.014	0.13	0.897	-0.026	0.029
L2.	0.018	0.013	1.4	0.161	-0.007	0.043
dinfl						
L1.	0.002	0.02	0.12	0.907	-0.038	0.043
L2.	0.023	0.021	1.1	0.269	-0.018	0.063
dtb3						
L1.	-0.006	0.028	-0.22	0.828	-0.061	0.049
L2.	-0.024	0.021	-1.11	0.268	-0.066	0.018
dcar						
gnplr						
L1.	0.001	0.001	0.78	0.433	-0.001	0.003
L2.	0	0.001	0.52	0.604	-0.001	0.002
roa						
L1.	-0.01	0.005	-1.87	0.062	-0.02	0
L2.	-0.002	0.003	-0.65	0.518	-0.009	0.004
dcar						
L1.	-0.332	0.12	-2.76	0.006	-0.567	-0.096
L2.	-0.049	0.083	-0.59	0.555	-0.212	0.114
rgdpg						
L1.	-0.001	0.001	-0.73	0.463	-0.002	0.001
L2.	0	0.001	-0.03	0.973	-0.002	0.002
dinfl						
L1.	-0.001	0.001	-0.39	0.695	-0.003	0.002
L2.	0	0.001	-0.06	0.952	-0.002	0.002
dtb3						
L1.	-0.001	0.002	-0.6	0.549	-0.005	0.002
L2.	0.002	0.001	1.87	0.062	0	0.004
rgdpg						
gnplr						
L1.	-0.396	0.211	-1.87	0.061	-0.81	0.018
L2.	-0.034	0.132	-0.26	0.797	-0.293	0.225
roa						
L1.	0.897	0.68	1.32	0.187	-0.437	2.231
L2.	0.078	0.473	0.16	0.87	-0.85	1.005

dcar						
L1.	5.743	12.946	0.44	0.657	-19.63	31.116
L2.	0.391	12.658	0.03	0.975	-24.419	25.2
rgdpg						
L1.	0.55	0.107	5.16	0	0.341	0.758
L2.	-0.416	0.129	-3.24	0.001	-0.668	-0.165
dinfl						
L1.	-0.72	0.205	-3.5	0	-1.122	-0.317
L2.	-0.486	0.168	-2.89	0.004	-0.816	-0.156
dtb3						
L1.	0.387	0.264	1.47	0.142	-0.13	0.905
L2.	0.109	0.166	0.66	0.512	-0.216	0.434
dinfl						
gnplr						
L1.	-0.256	0.152	-1.68	0.093	-0.555	0.043
L2.	-0.075	0.095	-0.79	0.427	-0.261	0.111
roa						
L1.	0.658	0.544	1.21	0.227	-0.409	1.725
L2.	0.074	0.388	0.19	0.848	-0.686	0.834
dcar						
L1.	9.598	10.793	0.89	0.374	-11.555	30.752
L2.	6.004	9.963	0.6	0.547	-13.524	25.531
rgdpg						
L1.	-0.499	0.077	-6.45	0	-0.651	-0.347
L2.	0.146	0.105	1.38	0.166	-0.061	0.352
dinfl						
L1.	-0.17	0.163	-1.04	0.297	-0.49	0.15
L2.	-0.503	0.131	-3.83	0	-0.76	-0.245
dtb3						
L1.	1.219	0.193	6.33	0	0.842	1.597
L2.	0.291	0.128	2.28	0.023	0.04	0.542
dtb3						
gnplr						

L1.	-0.008	0.039	-0.2	0.842	-0.084	0.068
L2.	-0.001	0.012	-0.11	0.909	-0.024	0.022
roa						
L1.	0.021	0.168	0.12	0.903	-0.309	0.35
L2.	-0.015	0.093	-0.16	0.873	-0.196	0.167
dcar						
L1.	-4.427	2.792	-1.59	0.113	-9.899	1.045
L2.	-1.563	2.148	-0.73	0.467	-5.773	2.647
rgdpg						
L1.	0.082	0.046	1.76	0.078	-0.009	0.172
L2.	0.064	0.036	1.75	0.079	-0.007	0.135
dinfl						
L1.	0.155	0.048	3.27	0.001	0.062	0.248
L2.	-0.059	0.057	-1.05	0.295	-0.171	0.052
dtb3						
L1.	0.402	0.077	5.19	0	0.25	0.554
L2.	0.064	0.047	1.34	0.179	-0.029	0.157