The relationship between climate change, macroeconomic indicators and bank performance

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Abstract

This study is pursuing research on the influence of climate change and macroeconomic factors on bank performance is essential for risk management, long-term sustainability, regulatory compliance, reputation management, and strategic planning. It also aligns banks with global efforts to address climate change and its potential economic consequences. The study makes use of quantitative analysis using secondary data sourced from Iress, IMF database, SARB and the data was collected in quarterly format from 2000 to 2022. The study applied the multiple regression analysis, and the aim was to create a model that connects climate change to banks performance. Climate affect macroeconomic indicators which affect banks or climate change affect banks directly. The model uses climate change and macroeconomic variables as inputs, and the climate change variables were obtained from the two sources namely the climate watch online platform (greenhouse gas emission) and the World Bank climate knowledge portal (temperature and precipitation) emission) and the World Bank climate knowledge portal (temperature and precipitation). Macroeconomic inputs variables include inflation, changes in economic output and exchange rates. The data variables were gathered from Iress, IMF database and the SARB. The analysis of the data was done through statistical software called EViews. The findings revealed that both measures of climate change have a negative effect on bank performance thus profitability. The results also indicated that growth as measured by GDP and inflation are important factors determining the performance of the bank performance. The results obtained imply that policies aimed at mitigating the effects of climate change on the bank performance should be pursued.

Introduction

One of the most important issues of our day is climate change, which has a profound impact on ecosystems, economies, and societies all over the world. Comprehending its influence on the banking industry is essential for formulating efficacious approaches to alleviate hazards and leverage prospects. Significant obstacles are presented by climate change to companies in all sectors, including banking. It is critical to comprehend how the financial performance of banks is impacted by climate change as the world struggles with its effects. With an emphasis on South Africa, this study looks at how climate change affects bank performance to address this gap in the literature.

The banking industry is essential to the modern economy because it is the foundation upon which the whole financial system is built, moreover offers financial services that make it easier for people to save, invest, and lend money. Banks are financial intermediaries that take deposits from both private citizens and commercial clients to use the money for loans and other financial services. For the economy to allocate capital efficiently, this intermediation role is crucial (Beck, 2020).

Considering the significance of the banking industry to the economy, it is imperative to comprehend the ways in which external factors, like climate change can impact its stability and performance. For banks, climate change brings with its opportunities as well as risks. These risks include reputational, liability, and physical risks to bank assets (Bank of England, 2019). For banks to create strategies to effectively manage these risks and guarantee their long-term sustainability, they must have a thorough understanding of them.

It is crucial for regulators, legislators, investors, and banks themselves to comprehend how climate change affects bank performance. Authorities must guarantee that banks are suitably equipped to handle risks associated with climate change, and legislators must create policies and incentives that encourage sustainable practices in the banking industry. On the other hand, investors must determine how long-term banks will remain viable in a changing environment and allocate their capital appropriately. In addition, investors' and consumers' preferences are shifting in favour of ecologically friendly and sustainable practices due to climate change. Financial institutions that do not adjust to these shifting inclinations run the risk of losing investors and clients (KPMG, 2020).

Many industries are witnessing the effects of climate change, which can cause anything from physical harm to assets to supply chain disruptions and modifications in customer behaviour. For instance, the agricultural industry faces difficulties like shifting growing seasons, a lack of water, and an increase in the pressure from pests and diseases (Lesk et al., 2016). Because there are more extreme weather events, the insurance industry is seeing an increase in claims related to climate change (Linnerooth-Bayer et al., 2019). To reduce greenhouse gas emissions, the energy sector is transitioning to renewable energy sources (IEA, 2020).

Examining how climate change affects banks' financial performance is the goal of this study. The following are the specific goals to evaluate the impact of risks associated with climate change on banks' financial performance, investigating the tactics used by banks to reduce risks associated with climate change and take advantage of opportunities. Moreover, to determine how South African bank executives perceive and are aware of the risks associated with climate change and to offer suggestions to banks on how to improve their ability to withstand risks associated with climate change and take advantage of chances for sustainable growth.

Moreover, study intends to add to the expanding body of knowledge on climate change and its effects on the banking industry by illuminating these issues. The results of this study are expected to influence policy choices, direct bank strategic planning, and eventually aid in the development of a more robust and long-lasting financial system.

An urgent global issue, climate change has broad ramifications for companies in all sectors of the economy. Rising sea levels, more frequent and severe natural disasters, and altered precipitation patterns are some of the environmental changes brought about by the increase in global temperatures, which is mostly due to human activity like burning fossil fuels and deforestation (IPCC, 2014). Global businesses face enormous challenges because of these changes.

The growing possibility of supply chain disruptions is one of the main effects of climate change on businesses. Hurricanes, floods, and wildfires are examples of extreme weather events that can harm transportation networks, impair infrastructure, and cause shortages of raw materials, which can affect the processes involved in production and distribution (Hallegatte et al., 2016).

Additionally, the behaviour and preferences of consumers are being impacted by climate change. Concerns about the long-term effects of climate change and growing environmental awareness have led to an increase in the demand for sustainable goods and services (Accenture, 2020).

Businesses are realizing more and more that they must adapt to and lessen the effects of climate change in response to these difficulties. Numerous businesses are putting plans into place to lower their energy consumption, increase their resilience to risks associated with climate change, and decrease their greenhouse gas emissions (CDP, 2020).

The banking industry faces both opportunities and risks because of climate change. Banks are vulnerable to a range of climate change-related risks, such as: (i) Physical Risks: According to the Bank of England (2019), climate change may cause more frequent and severe natural disasters like storms, floods, and wildfires. These events could harm bank property, cause operational disruptions, and lead to loan defaults. (ii) Transition Risks: Banks may be exposed to risks associated with regulatory, technological, and market shifts as governments and businesses shift to a low-carbon economy. These developments may have an impact on the value of the banks' loan portfolios and investments (Carney, 2015). (iii) Reputational Risks: According to KPMG (2019), banks that are thought to be causing climate change or neglecting to address its risks run the risk of losing their good name, which could result in a decline in business and investor confidence. Because of the threats to financial stability and the chances it creates for creativity and sustainable growth, climate change has a significant impact on the banking industry.

Moreover, despite of these risks that the banking sector face there are also opportunities that arise which includes (i) Green Finance: Banks have an opportunity to create new revenue streams and draw in environmentally conscious customers due to the growing demand for sustainable finance products like green bonds and loans (UNEP, 2018). (ii) Risk Management Services: Banks can assist businesses in evaluating and managing risks associated with climate change by offering risk management services, such as creating insurance plans for extreme weather occurrences (McKinsey, 2020). (iii) Innovation: In response to climate change, banks must be creative in creating new offerings that support sustainability, such as green investment funds and energy-efficient mortgages (Deloitte, 2021).

A company's performance in relation to environmental sustainability, social responsibility, and corporate governance is assessed using a set of criteria known as ESG factors. ESG considerations are becoming more and more significant in the banking industry as stakeholders' investors, clients, and regulators place a higher value on sustainability and moral business conduct. Environmental Factors: These factors centre on how a bank uses natural resources, how much carbon it emits, and what steps it takes to slow down climate change. By implementing sustainable practices, such as lowering energy consumption, assisting with renewable energy projects, and funding green initiatives, banks can integrate environmental considerations into their daily operations (UNEP FI, 2018).

Social Factors: A bank's treatment of its staff, clients, and the communities in which it operates all have an impact on society. Banks can tackle social factors through various means, such as advocating for diversity and inclusivity, endorsing community development initiatives, and providing responsible lending practices that assist marginalized communities (World Bank, 2019). Governance Factors: A bank's leadership structure, risk management procedures, and transparency are all examples of how it is managed and governed. Robust governance protocols have the potential to foster stakeholder trust in banks and reduce the likelihood of fraudulent activities, corruption, and unethical conduct (OECD, 2015).

Banking operations can be made more risk-averse, more reputable, and more appealing to socially conscious investors by incorporating ESG considerations. Furthermore, banks can support sustainable development and the accomplishment of international environmental and social goals by integrating ESG principles into their operations (UNEP FI, 2018). Because they direct banks' actions and decisions to support sustainability, moral behaviour, and long-term value creation, ESG factors are extremely important to the banking industry.

Several studies have explored the relationship between climate change and bank performance, focusing on the risks and opportunities that climate change presents to the banking sector. Climate Change Risks: Research has emphasized the range of risks that climate change presents to banks, including liability risks (such as lawsuits pertaining to climate change effects), transition risks (such as changes in regulations affecting investments in fossil fuels), and physical risks (such as damage to assets from extreme weather events) (UNEP FI, 2020). Financial Impacts: Studies have also looked at how climate change will affect banks financially. These studies have looked at the possibility of higher loan default rates because of climate-related disasters, as well as the chances that banks will be able to create new services and products in response to climate change (KPMG, 2021).

Research has also looked at the regulatory environment surrounding climate changRisk Management Practices: Research has shown how critical it is to incorporate risk related to clim ate change into banks' risk management procedures. This includes conducting stress tests to identify pote ntial risks and creating plans to reduce those risks (CERES, 2019). Research has also looked at the regulatory environment surrounding climate change and how it affects banks. Some of the issues that have been covered include the requirement that banks reveal the risks they face from climate change and the possibility of changes to the law that would encourage banks to invest in sustainable practices (Deloitte, 2020).

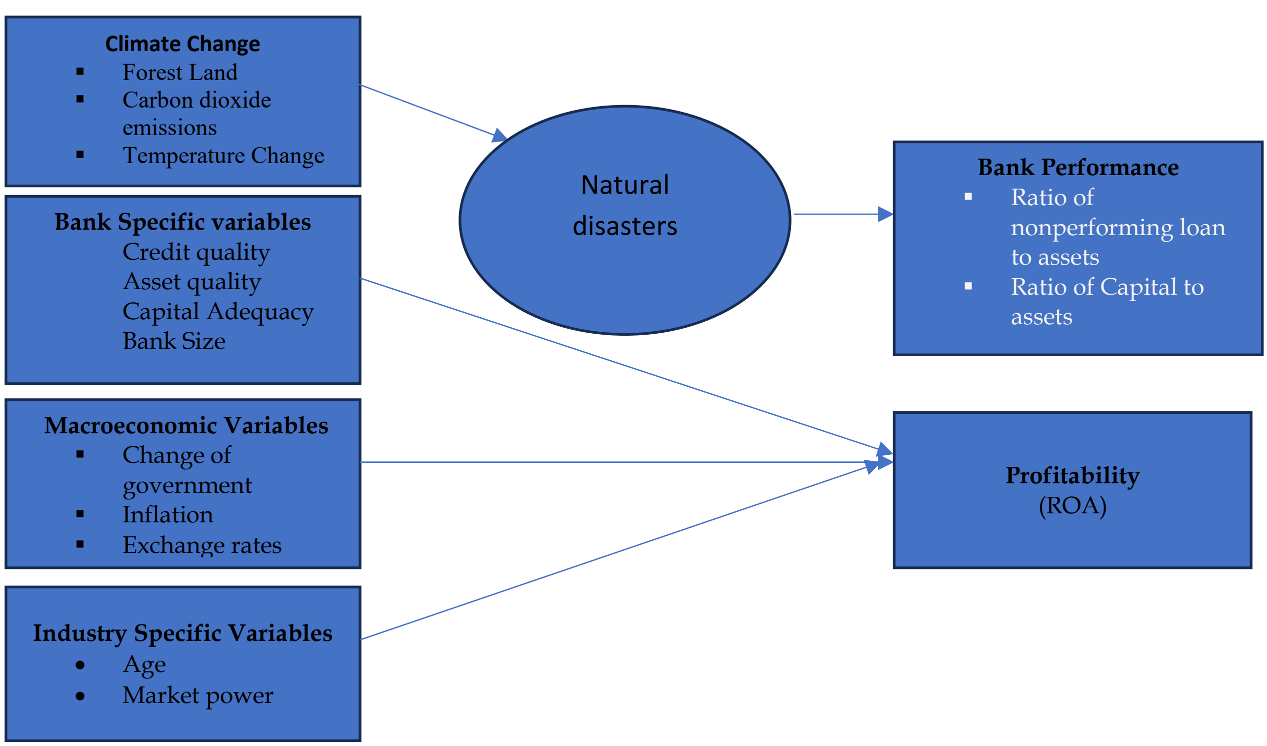
These studies shed important light on the opportunities and difficulties that the banking industry faces because of climate change, emphasizing the necessity for banks to create strong plans to manage risks associated with the issue and take advantage of new opportunities. Although prior research has offered insightful information regarding the connection between climate change and bank performance, this study aims to fill in a few gaps that are key. The previous studies had restricted attention to developing nations, much of the research on bank performance and climate change that has been done so far has concentrated on developed nations. Further studies are required in developing nations because they may be more vulnerable to the effects of climate change and may present difficulties for banks (Fankhauser et al., 2019). This study will focus on developing countries specifically South Africa with a mission to address this gap in the existing body of knowledge.

While some research has looked at how regulators and investor's view climate change and bank performance, little is known about how other stakeholders, like customers and bank executives, feel about it. By investigating bank executives' knowledge and perception of climate change risks in South Africa, this study seeks to close this gap (Bank of England, 2019). Taking care of these gaps in the literature will help us comprehend climate change's effects on bank performance more thoroughly, especially when it comes to developing nations like South Africa. The study will seek to examine the impact of climate change on banks performance in South Africa. Tersely, the study intends to examine the financial implications of climate change-related risks on the profitability, stability, and resilience of banks in South Africa

There are various reasons why the study on how climate change affects South African bank performance is important. By concentrating on an area that has not gotten much attention in earlier studies, it fills a significant void in the body of literature. This is significant because, due to its reliance on natural resources and agriculture, as well as its vulnerability to extreme weather events, South Africa, like many other developing nations, is especially vulnerable to the effects of climate change. The study has applications for South Africa's banking industry. Banks looking to improve their resilience and sustainability practices can benefit greatly from the study's examination of the approaches and procedures taken by banks to manage risks associated with climate change and seize opportunities for sustainable growth. This can assist South African banks in better positioning themselves for long-term success in a changing environment and preparing for the challenges presented by climate change.

Moreover, the research can provide valuable insights to South African policymakers and regulators regarding the unique obstacles and prospects that banks encounter concerning climate change. This can assist regulators in formulating laws and guidelines that support environmentally friendly banking practices and foster an atmosphere that makes it easier for banks to prosper in the face of climate change.

All things considered, the research on how climate change affects South African banks' performance is noteworthy because it can advance both academic understanding and real-world banking solutions. It may offer insightful information that banks and legislators need to successfully navigate the difficulties presented by climate change and move toward a more sustainable future.



Literature Review

The interconnectedness of climate change, macroeconomic dynamics, and bank performance has garnered increasing scholarly attention in recent years. The rising frequency and severity of climate-induced events, coupled with regulatory and societal pressures for sustainable finance, have made it imperative to understand the channels through which environmental risks affect banking operations and financial stability. This literature review synthesizes contemporary findings and theoretical advancements from various regions and methodological perspectives to delineate the contours of this relationship.

Climate Change and Bank Performance

Climate change presents both physical and transitional risks to financial institutions. Physical risks refer to direct damages caused by extreme weather events such as floods, droughts, and hurricanes, whereas transitional risks encompass the economic shifts stemming from the transition to a low-carbon economy (e.g., regulatory changes, technological shifts, and market sentiment).

Boungou (2023) provides empirical evidence that climate change-related risks negatively impact bank stock returns, suggesting that market participants factor in environmental vulnerabilities when valuing banking stocks. Similarly, Brik (2024) examines the effect of climate risk on financial stability in China, revealing a significant relationship between climate-induced shocks and non-performing loans (NPLs). These findings emphasize that banks exposed to regions or industries sensitive to climate volatility are more likely to experience credit risk deterioration.

Aguilar-Gomez et al. (2024) contribute by highlighting the relationship between thermal stress and firms' loan defaults in Mexico, where extreme temperatures increase default probabilities. These micro-level insights corroborate the notion that environmental conditions materially influence borrower creditworthiness and, by extension, bank asset quality.

Governance and Strategic Adaptation in Climate-Affected Banking

Corporate governance and strategic adaptation mechanisms play pivotal roles in mediating the adverse impacts of climate change on banks. Adu et al. (2024) argue that sound corporate governance can enhance a bank's climate resilience and financial performance, particularly when aligned with climate change initiatives. Their findings reveal that governance structures supporting sustainability efforts bolster investor confidence and operational robustness.

Afzal et al. (2024) analyze the effect of green technology adaptation and human capital in the European banking sector. The study shows that banks that invest in green technologies and upskill their workforce demonstrate superior financial outcomes and reduced climate exposure. This aligns with findings from Secinaro et al. (2020), who note that climate change mitigation policies, while initially costly, eventually enhance the corporate financial performance of European firms, highlighting a long-term value proposition in sustainability.

Climate Reputation and Loan Financing

Bank reputation in the context of climate responsiveness has emerged as a novel determinant of financial outcomes. Hrazdil et al. (2024) explore how a bank’s climate reputation influences loan contracting, noting that borrowers perceive environmentally responsible banks as more credible and trustworthy, thereby reducing moral hazard and improving contract terms. In a complementary study, Choi, Gam, and Shin (2023) find that environmental reputation positively correlates with bank liquidity, particularly during periods of climate transition uncertainty.

The concept of climate reputation is further explored by Huang et al. (2022), who investigate how firms’ climate risk management practices affect their bank loan financing. The study shows that proactive risk management leads to more favorable lending terms, implying a feedback loop wherein climate preparedness improves financial access, which in turn supports sustainability investments.

Climate Risks and Bank Profitability

Lee and Alam (2024) examine the impact of climate risks on bank profitability through the liquidity creation channel in G7 countries. Their empirical analysis demonstrates that increased climate risk negatively affects banks' liquidity creation, thereby reducing profitability. This suggests that climate-related uncertainties strain banks' intermediation functions and impede their earnings capacity.

De Marco et al. (2023) offer further evidence of climate-induced profitability shifts through their analysis of El Niño’s impact on U.S. banks. Their study finds that climate shocks adversely affect bank loan portfolios, provisioning behavior, and overall profitability, indicating that macro-level climate events translate into micro-level financial strain.

Regional Insights and Asymmetric Impacts

The regional context significantly moderates the relationship between climate change and bank performance. Amo-Bediako et al. (2024) investigate the asymmetric effects of climate change on banking system stability in selected Sub-Saharan economies. They find that climate events disproportionately affect banking systems in low-income countries due to weaker adaptive capacities, limited insurance coverage, and underdeveloped financial infrastructure.

Moyo and Wingard (2015) provide one of the earlier assessments of climate change impacts on South African companies, showing that environmental shocks lead to lower profitability and market valuation, indirectly affecting banks through corporate loan exposures. These findings reinforce the need for region-specific policy responses and risk mitigation strategies.

Nie, Regelink, and Wang (2023) extend the conversation by analyzing banking sector risk in the aftermath of environmental disasters. Their study concludes that climate-related disasters increase credit risk, operational disruptions, and capital adequacy concerns, especially in emerging markets.

The Role of Macroeconomic Variables

While the direct relationship between climate change and bank performance is critical, macroeconomic variables act as both mediators and moderators in this dynamic. Climate events influence macroeconomic indicators such as inflation, GDP growth, and unemployment, which in turn affect banking performance.

For instance, during climate-induced economic slowdowns, loan demand declines, defaults increase, and interest margins shrink. This creates a negative feedback loop between macroeconomic stress and banking stability. Studies like those by Im, Pesaran, and Shin (2003) offer econometric tools to analyze such panel-level dynamics, enabling researchers to disentangle heterogeneous effects across countries and time periods.

Bandyopadhyay and Kashyap (2023) apply such methodologies in their analysis of Indian firms, revealing that climate risk increases banks’ credit exposure through deteriorating firm fundamentals, thus emphasizing the role of sector-specific vulnerabilities.

Integrative Framework and Future Directions

The extant literature provides robust evidence that climate change influences bank performance through multiple interconnected channels, including credit risk, liquidity constraints, profitability erosion, and reputational shifts. It also underscores the importance of macroeconomic conditions and institutional readiness in shaping the extent and direction of these impacts.

Despite the growing body of research, gaps remain. First, most empirical studies are region-specific, limiting generalizability. Second, climate risk modeling in banking remains in its infancy, necessitating the development of integrated assessment models that capture non-linear interactions between environmental, financial, and economic systems. Third, the role of regulatory frameworks, such as green taxonomies and climate stress testing, requires deeper exploration.

In conclusion, the relationship between climate change, macroeconomics, and bank performance is multifaceted and evolving. Future research should aim to build comprehensive, multi-country datasets, incorporate advanced econometric techniques, and consider the behavioral dimensions of climate finance. Only then can stakeholders—from policymakers to practitioners—craft resilient financial systems capable of withstanding the environmental upheavals of the 21st century.

Methodology

This study employs a quantitative research design to investigate the impact of macroeconomic and climate-related variables on financial performance indicators in the banking sector. The primary objective is to understand how variables such as GDP, repo rate, inflation, and proxies for climate change (e.g., temperature and precipitation) influence key profitability metrics: Return on Assets (ROA), Return on Equity (ROE), and Net Interest Margin (NIM).

Data Collection and Variables

Secondary time-series data were extracted for all variables under consideration. The dependent variables are:

- Return on Assets (ROA)
- Return on Equity (ROE)
- Net Interest Margin (NIM)

The independent variables encompass both economic and environmental indicators, including:

- Balance of Trade
- Consumer Price Index (Inflation Rate)
- Gross Domestic Product (GDP)
- GDP Growth Rate
- Precipitation Sum Average (PSA)
- Temperature at 2 meters (T2M)
- Real Effective Exchange Rate (REER)
- Repo Rate
- Unemployment Rate

Climate change variables such as PSA and T2M serve as proxies for environmental shocks, while traditional economic indicators help contextualize the macroeconomic environment.

Statistical Analysis and Assumptions

EViews software was used for the econometric modelling. Preliminary diagnostic tests were conducted to ensure the validity of the regression models. The Augmented Dickey-Fuller (ADF) test was applied to assess the stationarity of variables. The results showed that variables such as ROA, ROE, GDP, Repo Rate, CPI, PSA, T2M, and NIM were stationary at level I(0). The unemployment Rate, REER, and Balance of Trade were stationary at first difference I(1). This informed the transformation of some variables via differencing to ensure model consistency.

Multicollinearity was assessed and ruled out based on the Variance Inflation Factor (VIF) and correlation diagnostics. The results showed no perfect multicollinearity among the independent variables, affirming the robustness of coefficient estimates.

The Jarque-Bera test indicated that residuals were not normally distributed. However, since OLS regression does not require normally distributed residuals for unbiased estimators (only for efficiency), the models remain valid for inference.

Model Specification

Each dependent variable was modelled as a linear function of the economic and environmental predictors:

For example, the general form of the regression equation is:

$$Y = \beta 0 + \beta 1(DBalanceofTrade) + \beta 2(CPI) + \beta 3(GDP) + \beta 4(GDPGrowthRate) + \beta 5(PSA) + \beta 6(DREER) + \beta 7(RepoRate) + \beta 8(T2M) + \beta 9(DUnemploymentRate) + \varepsilon$$

Where Y is substituted by ROA, ROE, or NIM respectively in each model.

Each model was assessed for overall statistical significance using the F-statistic, and individual predictors were evaluated using t-statistics and p-values at the 5% significance level.

Data Analysis and Findings

Model 1: Return on Equity (ROE)

The regression model for ROE demonstrated strong statistical significance with an F-statistic of 7.097 and a p-value of 0.000000, indicating a reliable model for interpreting the influence of macroeconomic and climate variables on ROE.

Dependent Variable: ROE
Method: Panel Least Squares
Date: 09/02/24 Time: 11:34
Sample (adjusted): 2003Q2 2022Q4
Periods included: 79
Cross-sections included: 5
Total panel (balanced) observations: 395

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DBALANCEOFTRADE	2.57E-11	3.67E-11	0.702376	0.4829
CPI	0.112016	0.187376	0.597813	0.5503
GDP	0.660612	0.246414	2.680896	0.0077
GDPGROWTHRATE	-0.116826	0.187021	-0.624667	0.5326
PSA	-0.014040	0.013901	-1.010004	0.3131
DREER	-0.071446	0.046379	-1.540462	0.1243
REPORATE	0.698637	0.177840	3.928466	0.0001
T2M	-0.016291	0.055407	-0.294031	0.7689
DUNEMPLOYMENTRATE	0.148662	0.306248	0.485432	0.6276
C	-51.95399	23.70148	-2.192015	0.0290

R-squared	0.142300	Mean dependent var	18.69274
Adjusted R-squared	0.122250	S.D. dependent var	6.195281
S.E. of regression	5.804254	Akaike info criterion	6.380050
Sum squared resid	12970.40	Schwarz criterion	6.480781
Log likelihood	-1250.060	Hannan-Quinn criter.	6.419960
F-statistic	7.097225	Durbin-Watson stat	0.129693
Prob(F-statistic)	0.000000		

Gross Domestic Product (GDP) had a coefficient = 0.6606; p-value = 0.0077. A one-unit increase in GDP is associated with a 0.6606 increase in ROE. This finding aligns with conventional economic theory, suggesting that expanding economic output enhances corporate profitability.

Repo Rate had a coefficient = 0.6986; p-value = 0.0001. Higher repo rates significantly increase ROE, possibly due to improved returns on interest-bearing assets within banks' portfolios. Variables like GDP growth rate, precipitation, and temperature showed minimal influence on ROE, with p-values exceeding 0.05. These may affect financial performance indirectly or under specific conditions, suggesting non-linear or lagged effects.

Model 2: Net Interest Margin (NIM)

The NIM model was also statistically significant with an F-statistic of 4.19 and a p-value of 0.000035. This confirms that the included macroeconomic variables collectively explain variations in net interest margins.

Dependent Variable: NIM
Method: Panel Least Squares
Date: 09/02/24 Time: 11:38
Sample (adjusted): 2003Q2 2022Q4
Periods included: 79
Cross-sections included: 5
Total panel (balanced) observations: 395

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DBALANCEOFTRADE	-1.10E-10	1.67E-10	-0.658666	0.5105
CPI	-3.236945	0.852646	-3.796354	0.0002
GDP	-0.124516	1.121297	-0.111047	0.9116
GDPGROWTHRATE	0.788025	0.851031	0.925966	0.3550
PSA	0.039686	0.063254	0.627412	0.5308
DREER	-0.035237	0.211047	-0.166963	0.8675
REPORATE	3.845253	0.809250	4.751625	0.0000
T2M	-0.156650	0.252128	-0.621313	0.5348
DUNEMPLOYMENTRATE	-1.206342	1.393566	-0.865651	0.3872
C	16.26101	107.8524	0.150771	0.8802

R-squared	0.089219	Mean dependent var	11.35233
Adjusted R-squared	0.067928	S.D. dependent var	27.35748
S.E. of regression	26.41197	Akaike info criterion	9.410502
Sum squared resid	268573.0	Schwarz criterion	9.511234
Log likelihood	-1848.574	Hannan-Quinn criter.	9.450413
F-statistic	4.190447	Durbin-Watson stat	0.029087
Prob(F-statistic)	0.000035		

Repo Rate had a coefficient = 3.8452; p-value = 0.0000. A substantial positive effect implies that as the central bank increases the repo rate, banks benefit from higher interest spreads between loans and deposits. Consumer Price Index (CPI) had a Coefficient = -3.237. This large negative impact, though statistically significant, may reflect inflation-driven erosion of real returns. GDP unexpectedly negative coefficient (-0.1245), though its p-value suggests marginal significance. This might suggest that growth alone doesn't translate into wider interest spreads, possibly due to competitive lending or regulatory pressures.

Model 3: Return on Assets (ROA)

The ROA model, while statistically significant, had a lower explanatory power relative to ROE and NIM. Repo Rate had a coefficient = 0.2158; p-value = 0.0049. Suggests a positive and statistically significant relationship between repo rates and asset returns. Higher interest environments improve income from interest-generating assets. Variables like CPI, GDP, and PSA had relatively weak effects on ROA, indicating that profitability per asset may be less sensitive to environmental and general macroeconomic fluctuations than broader equity returns or interest margins.

Dependent Variable: ROA
Method: Panel Least Squares
Date: 09/02/24 Time: 11:41
Sample (adjusted): 2003Q2 2022Q4
Periods included: 79
Cross-sections included: 5
Total panel (balanced) observations: 395

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DBALANCEOFTRADE	8.08E-13	1.57E-11	0.051353	0.9591
CPI	-0.068391	0.080400	-0.850635	0.3955
GDP	0.037988	0.105732	0.359289	0.7196
GDPGROWTHRATE	0.017401	0.080248	0.216844	0.8284
PSA	-0.002932	0.005965	-0.491567	0.6233
DREER	-0.008133	0.019901	-0.408686	0.6830
REPORATE	0.215815	0.076308	2.828219	0.0049
T2M	-0.001969	0.023774	-0.082816	0.9340
DUNEMPLOYMENTRATE	-0.011543	0.131406	-0.087844	0.9300
C	-2.447470	10.16989	-0.240659	0.8099

R-squared	0.030486	Mean dependent var	2.361677
Adjusted R-squared	0.007822	S.D. dependent var	2.500301
S.E. of regression	2.490503	Akaike info criterion	4.687837
Sum squared resid	2388.002	Schwarz criterion	4.788568
Log likelihood	-915.8477	Hannan-Quinn criter.	4.727747
F-statistic	1.345149	Durbin-Watson stat	0.024484
Prob(F-statistic)	0.211751		

Across all models, the Repo Rate consistently emerged as the most influential and statistically significant predictor, underscoring its central role in shaping financial performance. Conversely, climate variables (PSA, T2M) showed limited immediate effects, perhaps due to their indirect and long-term nature. GDP exhibited divergent effects: strongly positive for ROE, negative for NIM, and marginal for ROA. This suggests that while economic growth enhances shareholder returns, it may not uniformly boost margins or asset profitability.

Conclusion and Recommendations

This research concludes that macroeconomic variables, particularly the Repo Rate and GDP, significantly influence the financial performance of banks. Among all predictors, the Repo Rate emerged as the most consistent and influential, enhancing ROA, ROE, and NIM.

- **Monetary Policy**: Central banks' policy rates are pivotal in banking profitability.
- **Strategic Financial Planning**: Banks should hedge against interest rate volatility and align portfolios accordingly.
- **Climate Awareness**: Though not immediately impactful, climate variables must be integrated into long-term risk assessments.

The linear nature of the model and the exclusion of non-linear or lagged effects may limit interpretations. Future studies should consider panel data, machine learning techniques, or non-linear models to capture complex interactions.

In conclusion, this study reinforces the critical role of macroeconomic policy and economic growth in determining banking sector health, with emerging attention to climate risks.

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Appendix

Preliminary Tests and Model Assumptions

1. **Stationarity of Variables**

1.1 ROA (Return on Assets)

Panel unit root test: Summary
Series: ROA
Date: 08/23/24 Time: 12:56
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
User-specified lags: 2
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.85353	0.0319	5	385
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-3.04204	0.0012	5	385
ADF - Fisher Chi-square	25.6970	0.0042	5	385
PP - Fisher Chi-square	15.9464	0.1012	5	395

Return on Assets is stationary at level I(0)

1.2 ROE (Return on Equity)

Panel unit root test: Summary
Series: ROE
Date: 08/23/24 Time: 13:23
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
User-specified lags: 2
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.67312	0.0472	5	385
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-2.46450	0.0069	5	385
ADF - Fisher Chi-square	21.4391	0.0182	5	385
PP - Fisher Chi-square	16.2870	0.0917	5	395

Return on Equity is stationary at level I(0)

1.3 T2M (Temperature at 2 meters)

Panel unit root test: Summary
Series: T2M
Date: 08/23/24 Time: 13:28
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
User-specified lags: 2
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-13.1127	0.0000	5	385
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-31.3424	0.0000	5	385
ADF - Fisher Chi-square	92.1034	0.0000	5	385
PP - Fisher Chi-square	92.1034	0.0000	5	395

Temperature at 2 meters is stationary at level I(0)

1.4 Unemployment Rate

Panel unit root test: Summary
Series: D(UNEMPLOYMENTRATE)
Date: 08/23/24 Time: 13:55
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
User-specified lags: 2
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-9.52442	0.0000	5	380
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-11.5313	0.0000	5	380
ADF - Fisher Chi-square	129.665	0.0000	5	380
PP - Fisher Chi-square	92.1034	0.0000	5	390

Unemployment rate is stationary at first difference I(1)

1.5 Repo Rate

Panel unit root test: Summary
Series: REPORATE
Date: 08/23/24 Time: 13:57
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
User-specified lags: 2
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.32232	0.3736	5	385
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-2.28713	0.0111	5	385
ADF - Fisher Chi-square	19.2134	0.0376	5	385
PP - Fisher Chi-square	40.2777	0.0000	5	395

The Repo rate is stationary at level I(0)

1.6 REER

Panel unit root test: Summary
Series: D(REER)
Date: 08/23/24 Time: 14:05
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
User-specified lags: 2
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-7.98154	0.0000	5	380
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-10.1912	0.0000	5	380
ADF - Fisher Chi-square	111.863	0.0000	5	380
PP - Fisher Chi-square	161.051	0.0000	5	390

The REER is stationary at first difference I(1)

1.7 Precipitation Sum Average (PSA)

Panel unit root test: Summary
Series: PSA
Date: 08/23/24 Time: 14:06
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
User-specified lags: 2
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.19231	0.0142	5	385
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-5.96335	0.0000	5	385
ADF - Fisher Chi-square	55.2951	0.0000	5	385
PP - Fisher Chi-square	151.031	0.0000	5	395

PSA is stationary at level I(0)

1.8 Net Interest Margin (NIM)

Panel unit root test: Summary
Series: NIM
Date: 08/23/24 Time: 14:16
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
User-specified lags: 2
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-3.02261	0.0013	5	385
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-4.06243	0.0000	5	385
ADF - Fisher Chi-square	37.1891	0.0001	5	385
PP - Fisher Chi-square	27.5280	0.0021	5	395

Net Interest Margin is stationary at level I(0)

1.9 Inflation Rate

Panel unit root test: Summary
Series: INFLATIONRATE
Date: 08/23/24 Time: 14:19
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
User-specified lags: 2
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.66730	0.2523	5	385
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-5.16673	0.0000	5	385
ADF - Fisher Chi-square	46.1217	0.0000	5	385
PP - Fisher Chi-square	48.0687	0.0000	5	395

Inflation rate is stationary at level I(0)

1.10 GDP Growth Rate

Panel unit root test: Summary
Series: GDPGROWTHRATE
Date: 08/23/24 Time: 14:31
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
User-specified lags: 2
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-7.34497	0.0000	5	385
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-12.5684	0.0000	5	385
ADF - Fisher Chi-square	142.318	0.0000	5	385
PP - Fisher Chi-square	92.1034	0.0000	5	395

GDP growth rate is stationary at level I(0)

1.11 GDP

Panel unit root test: Summary
Series: GDP
Date: 08/23/24 Time: 14:35
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
User-specified lags: 2
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-3.82458	0.0001	5	385
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-4.81010	0.0000	5	385
ADF - Fisher Chi-square	42.2350	0.0000	5	385
PP - Fisher Chi-square	67.0055	0.0000	5	395

GDP is stationary at level I(0)

1.12 Balance of Trade

Panel unit root test: Summary
Series: D(BALANCEOFTRADE)
Date: 08/23/24 Time: 14:39
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
User-specified lags: 2
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.99463	0.0014	5	380
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-12.1640	0.0000	5	380
ADF - Fisher Chi-square	137.357	0.0000	5	380
PP - Fisher Chi-square	92.1034	0.0000	5	390

Balance of trade is stationary at first difference I(1)

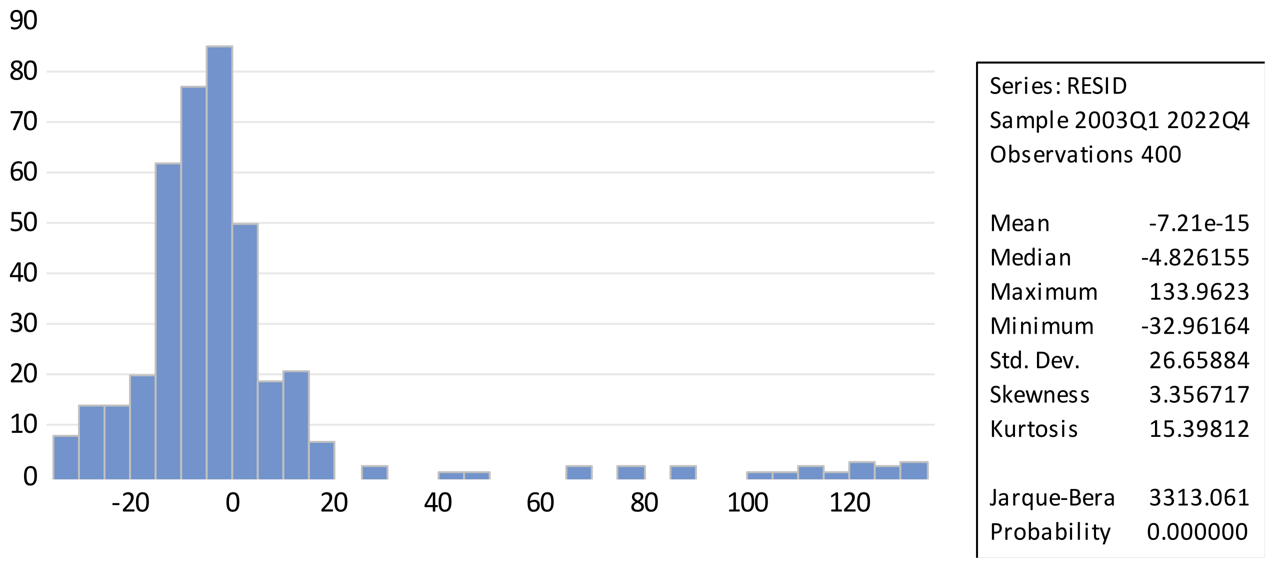
2. No Perfect Multicollinearity

	ROE	T2M	UNEMPLOY...	ROA	REPORATE	REER	PSA	NIM	INFLATION...	GDPGROW...	GDP	BALANCEO...
ROE	1	-0.0135284...	-0.2908182...	0.32767044...	0.31452267...	0.02250141...	-0.0783382...	-0.0641043...	0.23662931...	0.01368875...	0.27661862...	-0.2979492...
T2M	-0.0135284...	1	0.00081489...	-0.0090403...	-0.0020164...	-0.0676344...	0.39246997...	-0.0173277...	-0.0055572...	0.08937182...	0.09966866...	0.04548135...
UNEM...	-0.2908182...	0.00081489...	1	-0.1256588...	-0.4340361...	-0.2404449...	0.15108322...	-0.1085848...	-0.1397606...	0.12223174...	-0.2239951...	0.65969524...
ROA	0.32767044...	-0.0090403...	-0.1256588...	1	0.16761058...	0.07180155...	-0.0314632...	0.81344909...	0.04759867...	0.01950936...	0.08135919...	-0.1279869...
REPO...	0.31452267...	-0.0020164...	-0.4340361...	0.16761058...	1	0.12011293...	-0.0588545...	0.18758340...	0.49637640...	0.03015330...	0.42910031...	-0.5424912...
REER	0.02250141...	-0.0676344...	-0.2404449...	0.07180155...	0.12011293...	1	0.07267224...	0.18213265...	-0.3427739...	0.17096569...	0.10606632...	-0.1986674...
PSA	-0.0783382...	0.39246997...	0.15108322...	-0.0314632...	-0.0588545...	0.07267224...	1	0.03221501...	-0.0531706...	0.12849329...	0.01866850...	0.06651653...
NIM	-0.0641043...	-0.0173277...	-0.1085848...	0.81344909...	0.18758340...	0.18213265...	0.03221501...	1	-0.0976156...	0.04875728...	0.02891776...	-0.1375235...
INFLAT...	0.23662931...	-0.0055572...	-0.1397606...	0.04759867...	0.49637640...	-0.3427739...	-0.0531706...	-0.0976156...	1	-0.0239827...	0.45917804...	-0.2250239...
GDPG...	0.01368875...	0.08937182...	0.12223174...	0.01950936...	0.03015330...	0.17096569...	0.12849329...	0.04875728...	-0.0239827...	1	0.38707721...	-0.1052611...
GDP	0.27661862...	0.09966866...	-0.2239951...	0.08135919...	0.42910031...	0.10606632...	0.01866850...	0.02891776...	0.45917804...	0.38707721...	1	-0.5821023...
BALAN...	-0.2979492...	0.04548135...	0.65969524...	-0.1279869...	-0.5424912...	-0.1986674...	0.06651653...	-0.1375235...	-0.2250239...	-0.1052611...	-0.5821023...	1

After running a multicollinearity test, we figured out that among the explanatory variables we do not have variables that suffer from multicollinearity meaning the chances of having instability in the coefficient estimates is reduced.

3.

4. Normality of Errors



The Jarque Bera P value is less than 5% meaning we reject the null hypothesis meaning the residuals are not normally distributed. The normality of residuals is not strictly necessary for sufficient estimates to be unbiased.