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The Influence of Climate Risk on Interest Spread in the Banking Sector Performance in Kenya

Lucy Maru & Steve Anyona Makambi, PhD

Abstract

One of the most important steps towards a greener economy is assessing the path through which climate risks are internalized in to bank portfolios. Aligned with literature on market risks and credit risks emanating from climate risk exposure, this paper sought to assess the feedback effect between banking sector performance and climate risk and identify the transmission pathway of climate risk to banking sector performance. The paper employed conditional process analysis. Using meteorological data, data on weather disasters, bank level data and interest rate between 2011-2022, the study found that: - i) there exists a relationship between climate risk and bank performance to the extent that changes in interest rate spread are mediated by climate disasters having been moderated by temperature variation. ii) increase in non-performing loans leads to decrease in interest rate spread. Therefore, this paper persuades policy makers to adjust risks to include climate related risks and develop risk models that capture climate related risks in risk pricing. Additionally, the paper recommends that the regulator may develop an adaptable reporting framework to transition bank portfolios to a green and financially sustainable path.

Key words: Climate risk, Interest rate spread, non-performing loans, Carbon transition.

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1.0 Introduction

1.1 Background of the Study

Environmental degradation and climate risk are existential threats with the potential of causing unprecedented problems to the global economy. Studies have shown that about 90% of all nature disasters afflicting the world are related to severe weather and extreme climate change events (Gong et al., 2019). Given the rapid economic development and industrialization, production and consumption patterns have led to emissions of harmful greenhouse gases (GHGs). Cognizant to this fact, many governments and international organizations have endeavoured to introduce sustainable means of production that meets both socioeconomic needs of the populous and conservation of the environment (Allen et al., 2019; Bolton et al., 2020).

Therefore, climate risk is a burden that is of concern to the financial sector because extreme weather conditions have spatially leads to biodiversity loss, damage to infrastructure and loss of lives and livelihood. For example, the World-Wide Fund for Nature-Australia estimates that forest fires in Australia in 2019-2020 caused economic losses, particularly in the agricultural sector, worth \$4-5 billion or the equivalent of 6% to 8% of Australia's agricultural GDP (ABS, 2021). The level of economic loss often results in disruption of cash flows and damage to collateral and ultimately led to an increase in non-performing loan and financial instability.

Traditionally, commercial banks are largely profit-making organization that focus on maximization of shareholders wealth. Financial institutions deal with each project individually and independently by evaluating its return on investment. Given that banks operate in a competitive environment with information asymmetry, it is less likely that a profit-seeking financial institution would fail to extend a loan to a financially viable project due to externalities such as environmental concerns (Kaufman & Scott, 2003).

The Kenyan economy is highly vulnerable to climate-related disasters, such as droughts, famine and floods. According to International Climatic Initiative (2021)

Loss of income attributed to climate related disasters are approximately 2 to 3 percent of the economy's gross domestic product (GDP) annually. A report by National treasury and IKI (2020) shows that climate-related investment in Kenya is disproportionally targeting certain sectors and activities. In 2021, Central Bank recognizes the substantial threat of climate-related risk and issued a guidance under section 33(4) of the banking act. However, there is no clear policy, regulatory and legal framework.

Under the "common but differentiated responsibilities and respective capabilities" principle, there is need for financial systems to internalize climate related risk because the sector can both enhance or hamper cleaner environment. Essentially, the production sector makes emissions, which cause environmental pollution with significant harm to the society. While, the benefits of emission accrue to emitters, the damages are shared by all. Climate related risks cannot be exclusively addressed by the real sector, the financial sector has a key role to play because of its fundamental responsibility of pricing risks and allocating resources (Allen ***et al.,*** 2019; Bolton ***et al***., 2020).

Financial sector's fundamental role if capital allocation provides them with a significant leverage in transitioning the global economy to a greener, and more sustainable means of production. A systematic transition to a greener economy through financial sector would require financial system to integrate climate related risks in allocation of capital and risk assessment. This would play a significant role in supporting the much-needed investments in renewable energy, efficient production processes, and green technologies (Belianska ***et al***., 2022; Wambui, 2023).

1.2 Problem Statement

Climate related risks and unexpected extreme weather events are existential threats with the potential of causing unprecedented problems to the economy. Loss of income attributed to climatic disasters are approximately 2 to 3 percent of the economy's gross domestic product annually. Essentially, the production sector makes emissions, which cause environmental pollution with significant harm to the society. While, the benefits of emission accrue to emitters, the damages are shared by all. Given that banks operate in a competitive environment with incomplete information, it is less likely that a profit-seeking financial institution would fail to extend a loan to a financially viable project due to externalities such as environmental concerns. Under the common but differentiated responsibilities and respective capabilities, there is need for financial systems to internalize climate related risk because the sector can both enhance or hamper a cleaner environment. Therefore, the financial sector's response to these challenges is a crucial aspect of climate resilience and sustainability. The motivation of this study to evaluate the extent to which financial institutions internalize climate related risk in Kenya.

1.3 Research Questions

The main objective of the study is to evaluate the influence of climate risk on interest spread in the banking sector in Kenya. The study attempts to answer the following research questions:

1. To what extent does climatic risk exposure mediate the relationship between interest spread and commercial banks performance in Kenya?
2. To what extent does exposure to climatic risk moderate the relationship between interest rate spread and commercial banks performance in Kenya?

2.0 Theoretical Literature

2.1` Theoretical Literature

Four theoretical arguments were used to underpin the study. The financial intermediation theory and expectancy theory were applied to assess the relationship between the conduct of financial institutions and climate risk. Additionally, theory of change and transmission channel of climate changes through financial system were evaluated.

2.1.1 Financial Intermediation Theory

This theory stipulates that commercial banks facilitate flow of funds from savers to borrowers in presence of information asymmetry and other related costs. The theory contends that even though reduction of transaction costs and information asymmetry has a fundamental role for financial institutions, they often deal with complex financial instruments and markets and therefore risk management is central to intermediation. In the context of climate risk, the theory therefore acknowledges that commercial banks can effectively manage and moderate the negative effects of climate change on their lending portfolios, investment decisions, and overall financial stability (Kaufman & Scot, 203; Huang, et al., 2019).

2.1.2 Environment Kuznet Hypothesis

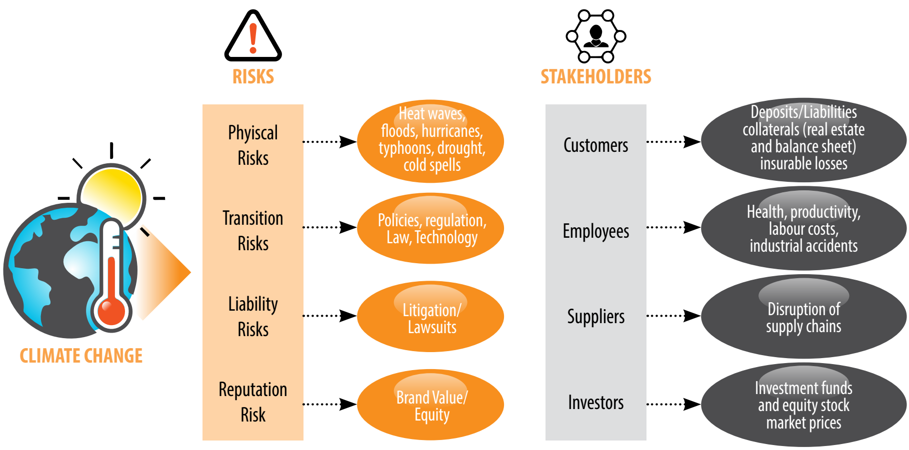
This theory was pioneered by a novel study conducted by Grossman and Krueger that was published in 1991. The hypothesis posits that economic growth and environmental degradation have an inverted U-shaped relationship. The EKC hypothesis contends that during the initial stages of economic growth, there is a positive relationship between growth and environmental degradation because increase in production and manufacturing activities lead to pollution. After attaining a certain stage of modernization, the society becomes aware of the potential harm of pollution and adopts more environmentally sustainable ways of production hence reversing the trend. The EKC argument therefore holds that high income economies are more likely to adopt green economy with the goal of achieving economic growth without the adverse impact on the environment. The theory acknowledges the fact that international collaboration among developing and developed countries is a vital factor that may foster transition towards a sustainable and green economy globally (Mikesh, 2020).

2.1.3 Transmission Channel of Climatic risk Through Financial System

To facilitate a low-carbon transition, there is need to understand transmission channels between climate risk and macro-financial risks. This requires quantitative assessment of feedback effect between climate change and the financial system (Allen *et al.,* 2019; Huang *et al*., 2019; Bolton *et al*., 2020; Lei *et al*., 2021; Belianska *et al*., 2022). Figure 1 shows transmission channels of climate related risk through the financial system.

The causal links from climate change to the financial system occur through climate related risks. Climate related risks can be categorized as follows: - i) physical risks, ii) transition risks, iii) liability risks and iv) reputational risks. Physical risk drivers related to climate change include extreme weather events such as heatwaves, floods, hurricanes impact the environment by causing loss of life, displacement destruction of infrastructure and property. Other long-term effects of climate change include adverse effects on the ecosystem such as increase in desertification, acute water shortage and soil degradation. These disasters lead to economic costs and financial losses (Gold et al., 2019).

Figure 1: Transmission of Climate related risks through the financial system



Source: Author

Transition risk refers to factors that either increase or reduce climate related risk. These factors include changes in demand for goods and services in the economy, technology and methods of production, changes in regulation and legislation and last but not least, changes in public policies. Transition risk have the potential to either exacerbate or mitigate climate change in the economy. Transition risks may also arise due to a change in climate policy and climate policy exposure. All factors remaining constant, climate shocks could lead to slow down, diversion of cash flows to health, erosion in value of collaterals, shrinking cash flows/revenues in the agricultural sector, tourism sector, manufacturing sector, transport sector among others (Gold et al., 2019).

Liability risks from banks could come from a failure to comply with set rules and regulations or being associated with certain disasters. A case in point is Pacific Gas and Electric (PG&E), California's largest electric utility company, whose filing for bankruptcy in 2018 resulted from multibillion-dollar liability claims from disastrous wildfires (Gold et al., 2019).

Lastly, reputation risk refers to the potential damage to financial institution's reputation arising from its approach, conduct and response to climate related risk. This encompasses the perceptions of the firm's commitment to low carbon transition and environmentally sustainable practices.

2.1.4 Theory of Change

The theory of change was proposed by Weiss in 1995. The theory explains how an intervention, or a program is supposed to work and the conditions required for success. Theory of change can help organize, conceptualize how change happens and therefore plan appropriate interventions. The theory is also emphasized by (Church and Rogers 2006) who note that the theory of change is useful in thinking through how a program is to work, who it will benefit, and the conditions required for success. By identifying the problem, determining required strategies, actions, conditions, resources and the required outcomes, the theory explains how specific interventions can lead to specific development change. As highlighted by (Wendt, K. 2021) in mapping sustainable development goals (SDGs), and target outcomes, theory of change can be used to provide target knowledge for a specific time. To incorporate the theory of change in transition to low carbon there will be need to incorporate innovations in technology, processes, and products, and determine target outcomes.

2.2 Empirical Literature

Ghasemi & Rostami (2015) conducted a study assessing factors that affect interest rate spread in the Iranian banking industry. The study identified capital adequacy, Return on assets and Non-performing Loan ratio as the main bank-related factors and inflation and exchange rate as control variables. It was established that economic variables namely inflation and exchange rate had a positive significant effect on interest rate spread. Capital adequacy and non-performing loans were also identified as significant determinants of interest rate spread. This study was insightful in identifying bank related and economic factors that determine interest rate spread.

Noth (2017) examined the effect of weather-related disasters on the financial stability of banks in the United States. The study used panel data which consisted of a sample 5,709 commercial banks across from the year 1994 to 2012. The study used credit quality, bank stability and profitability as the main dependent variables. Key measures of climate risk included rainfall and disaster damage. Disaster damage was estimated as the product of the ratio of climate damage in a particular county over loss of personal income and ratio of local banking activities in a county over total banking activity. Using fixed effect model, study provides empirical evidence that weather-related natural disasters significantly weaken the commercial banks stability and negatively affects business activities in affected regions. This study was insightful as it proposes useful ways of measuring climate risk.

Anjon (2021) explored the factors affecting the interest rate spread of commercial banks of Bangladesh. The study utilized time series data from 2011 to 2019. The study identified the difference between lending and deposit rate as the main dependent variable that measures banks' interest rate spread. Additionally, independent variables consisted of bank-specific factors such as credit risk, bank size, capital adequacy; industry-specific factor such as regulations and market share, and macroeconomic factors which included GDP and Inflation. The findings demonstrated that both bank specific and macroeconomic variables had a significant influence on the spread. This study was insightful in identifying bank related and economic factors that determine interest rate spread.

Wambui (2021) analysed the climate risk exposure of Kenyan banks given the greenhouse gas (GHG) emissions in Kenya. The study utilized a measure of a bank's climate risk exposure through its sectoral loan portfolio. The study findings show that commercial banks are significantly exposed to climatic risk through their loan portfolio. Additionally, the exposure is not only related to the size of the bank but is also linked to the exposure associated with different sectors of the economy. This study was useful to the extent that it related climate risk exposure across different sectors to bank performance in Kenya.

(Mueller & Sfrappini, 2022) investigated banks' lending behaviour and their response to climate related regulatory risks using Paris Agreement as the benchmark. The study conducted a detailed literature review using worldwide loan-level information using quarterly data from 2010 and 2019. The study established that the reaction to the Paris Agreement depended on exposure and location of the banks. This study was limited to the extent that it did not evaluate causal relationship between regulation and bank credit. This notwithstanding, the study was relevant to the extent that it evaluated commercial bank's reaction to a specific regulation.

Li and WU (2023) evaluated the impact of climate risk on supply of Credit in China. The study utilised panel data which consisted of a sample of 403 commercial banks and annual time series from the year 2008 to 2018. The study utilized a fixed effect model for analysis. It was established that climate risk had a significant negative impact on the bank loan supply. The study further established that the effect of climate risk was mitigated by government intervention. This study was insightful to the extent that it evaluated and modelled the link between climate risk and performance of the banking sector.

3.0 Methodology

3.1 Introduction

This section presented the methodology used to evaluate the study objective. Theoretical literature has shown that climate related risk is internalized in the banking systems through its effect on the counterparties. The novel of this study is to attempt to evaluate the underlying effect of transmission of climatic disasters and the risk to the financial sector using mediated-moderation analysis.

3.2 Model Specification

Conditional processes analysis is the analytical integration of mediation and moderation analysis. It is applied when evaluating how or by what process certain phenomena are transmitted and its effect on the dependent variable. A mediator is defined as a variable M that is causally located between the independent variable and the dependent variable. Y. For the purpose of this analysis climatic risk is

$$\hat{Y}_t = \alpha' + \beta' X_t + \omega W_t \qquad (1)$$

Equation (1) captures the total effect of the independent variable (X) on Y. The coefficient β' therefore measures the marginal change in Y given a unit change in X. For the purpose of this study, the independent variable (X) exerts its influence on Y through different pathways which include climatic conditions. The study introduces the mediator (M) in two successive equations such that: -

$$\hat{Y}_t = \alpha + \beta X_t + \theta M_t + \omega W_t \qquad (2)$$

$$\hat{M}_t = \tau + \rho X_t + \varphi W_t + \delta X_t W_t \qquad (3)$$

The total effect of the independent variables X and M are captured by **equation 1** through **3** and measured through the estimated values of parameters β', β and θ. **Equation 2** and **3** specified the mediation process which is affected by the independent variable (X) and the moderator (W). Evaluation of the transmission process required the decomposition of the direct and indirect effect of the X, M and

W on Y. Substitution of equation 2 into equation 1 illustrate the pathways or transmission channels which Hayes refers to as the mediated moderated process.

$$\hat{Y}_t = \alpha + \beta X_t + \theta(\tau + \rho X_t + \varphi W_t + \delta X_t W_t) \tag{5}$$

$$\hat{Y}_t = \alpha + \beta X_t + \theta\tau + \rho\theta X_t + \varphi\theta W_t + \delta X_t W_t + \omega W_t \tag{6}$$

$$\hat{Y}_t = (\alpha + \theta\tau) + (\beta + \rho\theta + \delta W_t) X_t + (\omega + \varphi\theta) W_t \tag{7}$$

$$\hat{Y}_t = a' + b' X_t + c' W_t \tag{8}$$

Where, $a' = (\alpha + \theta\tau)$, $b' = (\beta + \rho\theta + \delta W_t)$ and $c' = (\omega + \varphi\theta)$. The channels through which meditated moderated process is evaluated focuses on the interaction between variables M, X and Y after controlling for the moderation effect of W. Hayes used the term mediation effect of M conditional on moderation effect of W. The first transmission channel relevant to this study is explained by **equations 2** through **7**. From **equation 2**, the coefficient estimates the difference in the mediated variable (M) that is caused by changes in the independent variable (X). From **equation 1**, the coefficient captures the difference in dependent variable (Y) that results from changes in the mediator (M) holding X constant. Therefore, the product of in **equation 7** captures the difference in Y attributable to changes in X that operates through the joint effect of X on M conditional on the moderator W.

The second channel of interest is the decomposition of the total effect of X on Y as is captured by β in **equation 1** into direct effect and indirect effect conditional on moderation process W. The conditional direct effect of X on Y is measured by b', in **Equation 8**. It estimates the marginal change in Y given a small change in X after controlling for the influence of the mediated process (M) conditional on moderation effect of W. This means that the conditional indirect effect of X that is observed through its interaction, the mediation process is captured by the difference between the coefficient of X in **equation one** and **8** that is $(b'-\beta)$.

Therefore, the study applied a reparametrized version of Hayes process analysis which is robust for heteroskedasticity and binary outcomes. Ordinary least squares were used for estimation. Bootstrap confidence intervals were used to estimate the mediation analysis. Bootstrap method was deemed appropriate because it computes standard errors that are robust for heteroskedasticity. Two models are estimated and presented for analysis. The first model presented the results for mediation variable. These results evaluate whether there exists a channel from independent variable (X) to the mediator (M). For the same of analysis, natural log of non-performing loans was used as the main independent variable while capital adequacy was used as a control variable that affects both the mediator (M) and dependent variable (Y).

4.0 Empirical Findings

4.1 Introduction

This section represented the findings of the study. The study utilized conditional process analysis to evaluate the transmission process by isolating the moderating and mediating effects of climate risk related variables on the relationship between interest rate spread and banks performance in Kenya. The section was presented thematically based on each objective

4.2 Descriptive Statistics

This section presented the summary descriptive statistics, stationarity test analysis and correlation analysis. Descriptive statistics included the average, standard deviation from the mean minimum and maximum observations. Table 4.1 shows a summary of descriptive statistics.

Table 4.1: Descriptive Statistics

Variable	Obs.	Mean	Standard Deviation	Mini-mum	Maxi-mum
Maximum temperature	143	28.44	1.469	25.25	33.02
Interest rate Spread	143	7.914	2.628	4.9	13.05
Non-Performing Loans	143	233.734	148.56	53.07	514.4
Capital Adequacy	143	1.18	0.0104	1.154	1.261

Source: Author's Computation

Descriptive analysis shows that the monthly average of maximum temperature in Nairobi during the study period was 28.44 degrees Celsius and ranged from 25.25 to 33.02degrees Celsius. The mean of Interest rate spread was 7.9 percent but had a relatively wide dispersion as depicted by the standard deviation of 2.62 percent. Additionally, non-performing loans had a mean of KES 233.73 billion with a standard deviation of KES 148.56 billion during the study period. Therefore, descriptive statistics show that interest rate spread and non-performing loans had a wide dispersion indicating that the Kenyan banking sector has faced diverse degree of financial instability between February 2011 to December 2022.

4.3 Stationarity Analysis

Stationarity test was conducted using Augmented Dickey Fuller test and Phillip Perron tests. Critical values applied at 5 percent significance level were considered for the purpose of this analysis. The null hypothesis for both tests held that the series is not Stationary. The null hypothesis was rejected if the coefficient is less than the critical value. Augmented Dickey Fuller (ADF) test and Phillip Perron tests were used as complementary analysis in order to provide robust checks of the stationarity condition.

Table 4.3: Stationarity Analysis

	Dickey Fuller Test		Phillip-Perrons Test		Decision
	Level	First Difference	Level	First Difference	
Interest Rate Spread	-1.413	-12.839***	-1.311	-12.91***	I(1)
Maximum Temperature	-5.699***		-5.749***		I(0)
Natural log of NPL	-0.780	11.671***	-0.739	-12.02***	I(1)
Capital adequacy ratio	-7.301***		-7.566***		I(0)

Source: Author's Computation

Table 4.3 shows that maximum temperature and capital adequacy ratio were stationary at level which implies that the variables were integrated of order zero *I(0)*. Interest rate spread and non-performing loans were stationary at first difference or integrated of order one *I(1)*. Preliminary analysis showed that the dependent variable (interest rate spread and non-performing loans independent variables were not stationary *I (1)*. However, the linear combination of these variables was cointegrated which implied that the model could yield consistent results despite presence of stationarity.

4.4 Regression Analysis

This study sought to investigate whether variation in temperature moderates the effect on climatic disaster. The dependent variable (Y) is the interest rate spread, independent variable (X) is the natural log of non-performing loans, mediating variable (M) is climatic disaster and moderating variable (W) is maximum temperature. The regression models were estimated using monthly data from February 2011 to December 2022. **Table 4.4** presented the regression results.

Table 4.4: **Analysis of the Moderating & Mediating effect of Climatic Variables on Spread**

	Model I Total Effect		Model II Direct Effect		Model IIII Indirect Effect	
	Coeff	p-value	Coeff	P-Value	Coeff	P-Value
Climate Disaster			-0.542**	(0.014)		
Natural log of NPL	-3.137***	(0.000)	-3.304**	(0.000)	0.174***	(0.000)
Max temperature	0.0615	(0.339)	0.329	(0.608)	0.029	(0.812)
Capital Adequacy	-11.157	(0.207)	-17.868**	(0.05)	4.979***	(0.000)
Intercept term	37.70***	(0.000)	45.08***	(0.000)	-7.246***	(0.000)
Index of Moderated Mediated			0.035*	(0.089)		
Natural log of non-performing loans: Low			0.118**	(0.05)		
Natural log of non-performing loans: Medium			0.169**	(0.016)		
Natural log of non-performing loans: High			0.219**	(0.0014)		
Adjusted R Square		0.82		0.83		
n		143		143		

p-values in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Author Computation

Table 4.4 presented three models the first model was estimated based on **Equation 1** which includes the generic independents without the climatic disaster. This model aims at capturing the total effect of independent variable (Natural log of non-performing loans) on the dependent variable (Interest rate spread). Model II estimated based on **Equation 8** which includes the generic independents with the climatic disaster as the mediating variable. This model aims at capturing the direct effect of independent variable (Natural log of non-performing loans) on the dependent variable (Interest rate spread) conditional on presence of the controlling variable and the moderator. Model III was estimated as the difference between model I and II, the standard errors were estimated using bootstrap method for robustness.

The results in **Table 4.4** shows that both the coefficients of climate disaster and non-performing loans were negative and significant at 5 percent. These results suggest that holding other factors constant, the spread decreases by approximately 0.54

percent during climatic disaster. Additionally, increase in NPL by one basis point causes a decrease in the spread by approximately 3 percent. Further analysis shows that the index of mediated moderation was significant indicating that the relationship between NPL and interest rate spread is mediated by climatic disaster conditional on variation of temperature. The first objective sought to find out the extent to which climatic risk mediates the relationship between interest rate spread and non-performing loan. Firstly, the index of moderated mediated term (0.035) was significant at 10 percent. In addition, the coefficient of climatic risk of -0.542 (see model II) is significant at 5 percent. This implies that changes in interest rate spread are mediated by climatic disaster having been moderated by temperature variation.

The second objective analyses the extent to which exposure to climatic risk moderate the relationship between interest rate spread and commercial banks performance in Kenya. Analysis of Model III shows that the conditional indirect effect of NPL when mediated for climate related disaster is an increase in spread by approximately 1.74 percent. This implies that having moderated for temperature variations, positive changes in NPL during climatic disasters leads to an increase in spread by approximately 1.7 percent holding other factors constant. Furthermore, both coefficients of non-performing loans in Model 1 (-3.137) and Model II (-3.304) are negative and significant at 5 percent. The coefficient is positive and significant in Model III (0.174). These finding suggests increase in NPL by a small margin has a larger impact on Interest rate spread during periods with climatic disaster compared to periods without climatic disaster. The coefficients of Capital adequacy (CA) are insignificant in model I but becomes negative and significant in Model II (-17.868) after providing for climatic risk. The coefficient is positive and significant in Model III (4.979).

These findings imply that increase in CA leads to decrease in interest rate spread. There is evidence to suggests that increase in Capital adequacy by a small margin has a larger impact on Interest rate spread during periods with climatic disaster compared to periods without climatic disaster. In addition, having moderated for temperature variations, positive changes in capital adequacy during climatic disasters leads to an increase in spread by approximately 5 percent holding other factors constant (Huang et al., 2019; Allen et al., 2020; Bhattacharyay, 2021; Wambui, 2023).

The results therefore confirm that climate risk can reduce the value of collateral and asset quality of financial institutions. Extreme weather conditions destroy fixed assets and investment such as factories, equipment and real estate. This may consequently lead to erosion of capital, thus reducing borrowers' solvency and ultimately increasing their credit risks. Therefore, in order to avoid losses, commercial banks will tend to increase interest rate spread to provide for increase in credit risk (Huang et al., 2019; Allen et al., 2020; Bhattacharyya, 2021; Wambui, 2023).

The results also show that capital adequacy is negatively related to interest rate spread. Capital adequacy ratio is an important indicator of capital management and commercial banks resilience to both credit and market risk. To this end capital adequacy plays a critical role in safeguarding financial stability. This explains why diminishing level of capital adequacy ratio may affect the sensitivity of bank loans portfolio to climate risk (Battiston et al., 2020; Li & Wu, 2023).

This study's uniqueness is based on the fact that it attempts to evaluate the transmission channels of climatic risk in the banking sector. While robust estimation techniques were applied, the study results are illustrative rather than conclusive because of the limitations encountered during data collection and analysis. Therefore, the following caution should be observed when using the results for inferential purposes. First, given data unavailability, the study used a binary measure of climatic disaster. This measure maybe inadequate and/or biased to the extent that it does not capture the intensity of the disaster. Second, the study used gross non-performing loans as a measure of financial sector performance. Even though changes of NPL reflect the banks overall financial health, it may be an inadequate measure of performance. Future studies may employ suitable variables that capture profitability measures such as return on asset. Thirdly, future studies should consider robust analysis by conducting different mechanisms and transmission. Lastly, the mediation moderation analysis should be evaluated across tier 1, II and tier III banks and/or by using sectoral data on private credit and non-performing loans.

5.0 Conclusion

The results therefore show the following. First, there exists a relationship between climate related risk and bank performance to the extent that changes in interest rate spread are mediated by climate related disaster having been moderated by temperature variation. These results imply that there exists a feedback effect between changes in climate and performance of commercial banks in Kenya. Secondly, after controlling for temperature variation, there is evidence to suggests that increase in non-performing loans and capital adequacy ratio during periods of climate related disaster leads to higher spread compared to periods without climatic disaster. These results confirm that financial instability is exacerbated by extreme weather conditions.

The study findings therefore show that financial institutions have a responsibility to their stakeholder to protect them from a disruptive carbon transition path. This may be achieved through supporting the sustainability path of their stakeholders by introducing a risk model that scores customers on environmental issues. This may play a significant role in introducing adaptable green banking products and sustainability linked products to include investment facilities, loan products, climate bonds among others. Additionally, the regulator may consider coming up with a well-structured policy framework to guide financial sector in transitioning banks portfolios and facilitating climate resilience.

The following policy recommendations were drawn from the study findings. First, there exists a feedback effect between climate related risk and banking sector performance. Therefore, commercial banks should internalize climate risk by evaluating the impact of physical risk and transition risk. This can be achieved by introducing a risk model that scores customers on environmental issues thus generating adaptable green banking products and sustainability linked products to include investment accounts, loan accounts, climate bonds among others.

Second, the results show that climate related risk may trigger financial instability in the financial sector and the economy at large. To this end, the study recommends that Central Bank of Kenya, the regulator, may consider coming up with a well-structured policy framework to guide financial sector in transitioning banks portfolios and facilitate climate resilience and sustainability.

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Appendices

Figure 2: Analysis of the Moderating effect of temperature variation on Climatic Disaster

Dependent Variable: Climatic Disaster	Model I: Mediation Model	
	Coefficients	P-Value
Natural log of non-performing loans (i)	-1.291	(0.105)
Maximum temperature (ii)	-0.28	(0.103)
Interative term: (i*ii)	-0.063^{**}	(0.05)
Capital Adequacy	9.69^{***}	(0.005)
Constant Term	-5.451	(0.273)
Adjusted R Square	0.30	
N	143	

p-values in parentheses $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Source: Author Computation

Figure 3: Interest Rate Spread

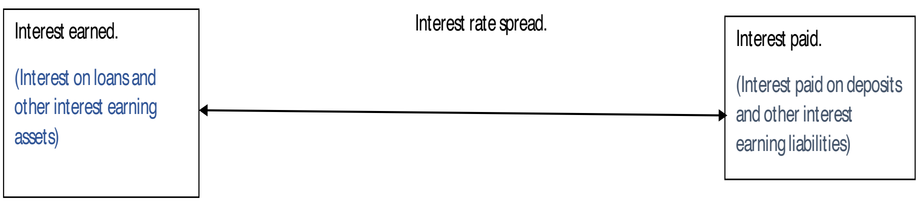


Figure 4: Maximum Temperature data for 5 stations

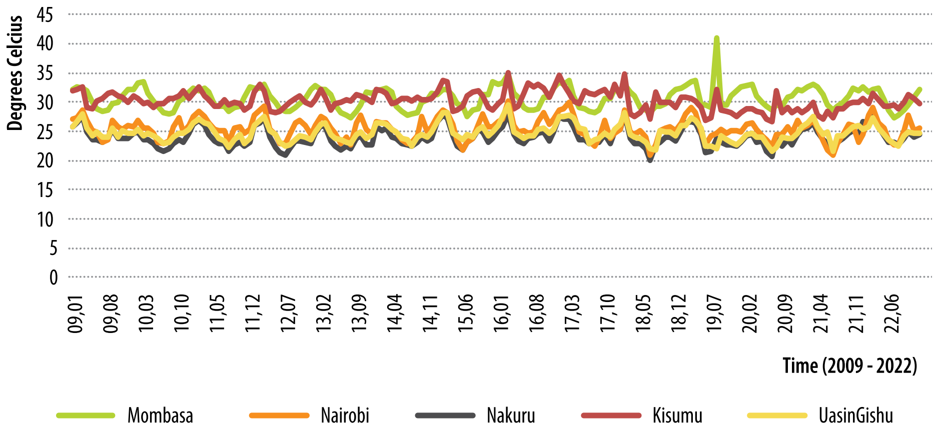


Figure 4 above shows temperature data on 5 stations. Maximum recorded temperatures from January 2009 to December 2022. High temperatures are recorded in Mombasa and Kisumu.

Figure 5: Minimum Temperature data for 5 stations

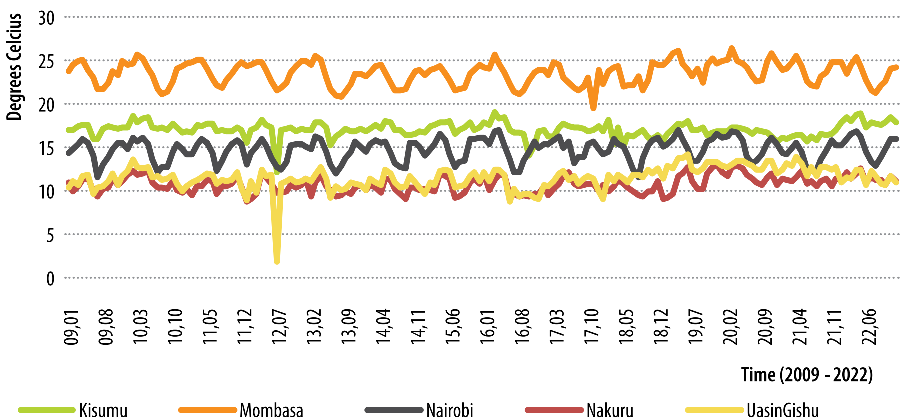
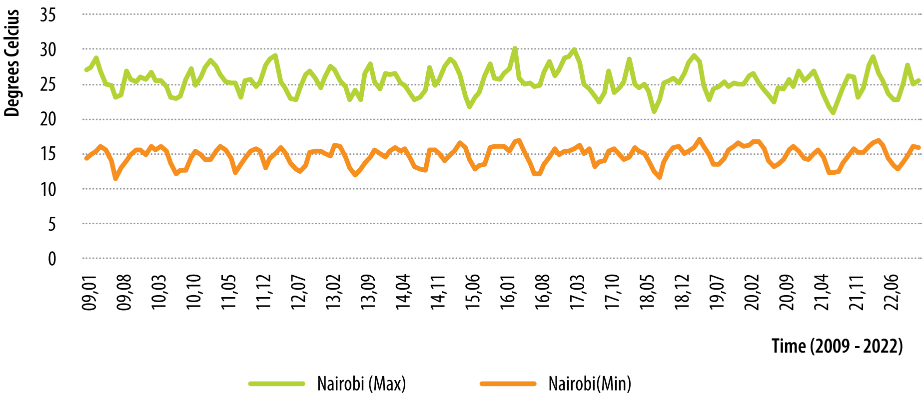


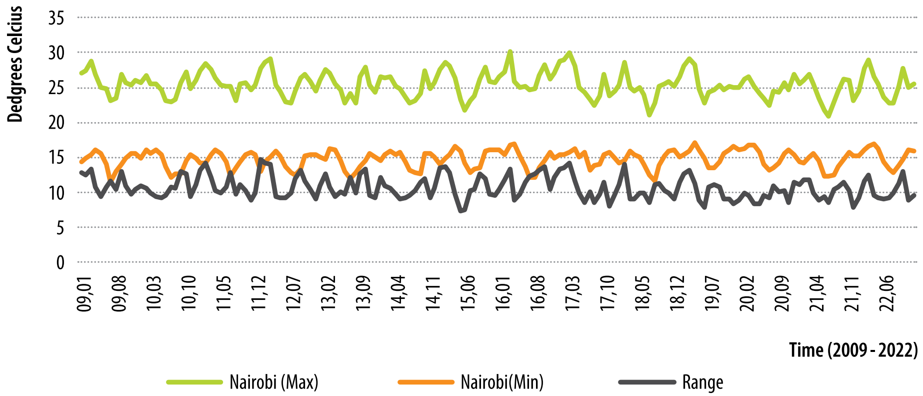
Figure 5 above shows minimum temperature data on five stations. Low temperatures are recorded in Uasin Gishu and Nakuru.

Figure 6: Maximum and Minimum Temperature data for Nairobi



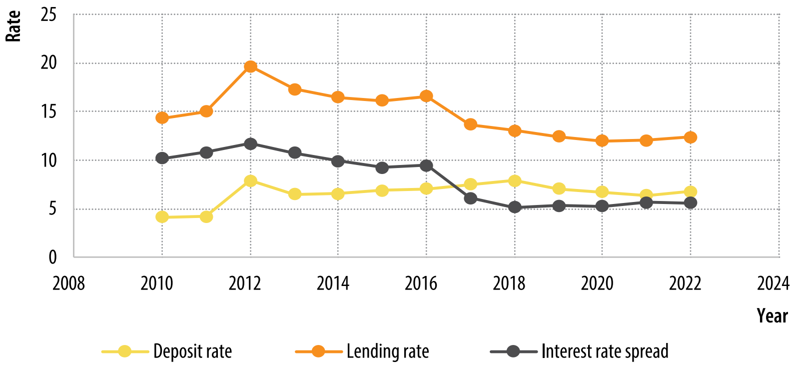
From **figure 6** above, whereas there's noted increase in daytime high temperatures (maximum temperatures), minimum temperatures (night time low) have also been rising. This could lead to extreme weather events, severity of natural disasters and proliferation of invasive and alien species (Finch et al 2021)

Figure 7: Nairobi – Maximum, Minimum, and Range



From **figure 7** above, the gap between the maximum and minimum temperatures follow a similar trend. When maximum temperatures drop the minimum temperatures also drop. When maximum temperatures rise, minimum temperatures also rise. Temperature fluctuation could lead to heat waves and cold waves which in turn affect productivity, could result in industrial and transport accidents among other adverse weather events.

Figure 8: Interest Rate Spread and NPL Ratio



From **figure 8** above deposit rates have been relatively stable while loan rates have been reducing. The reduction in loan rates has followed certain industry policies and adjustments. A case in point is year 2016 when the interest cap was introduced. Interest rate spread also follows a similar trend as the loan rates and has been reducing from year 2010.

Figure 9 Banking Sector NPLs ROA Interest Rate Spread

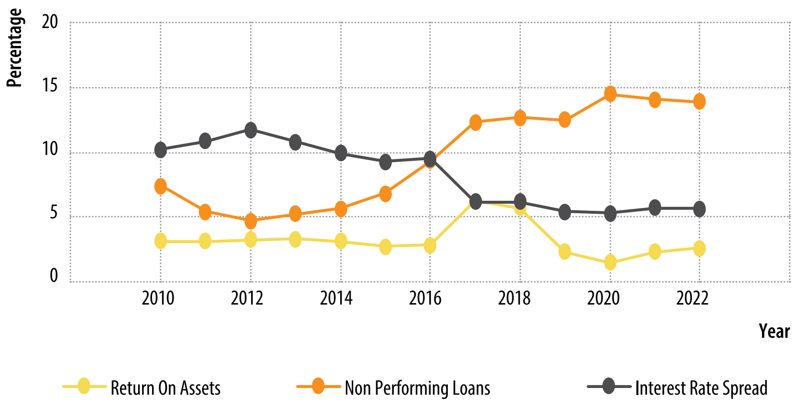
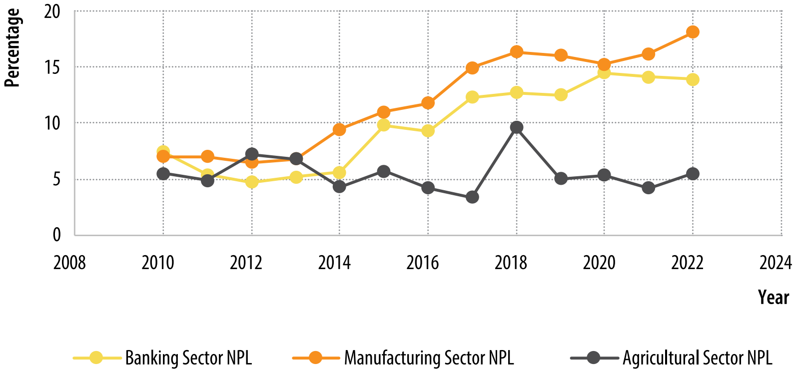


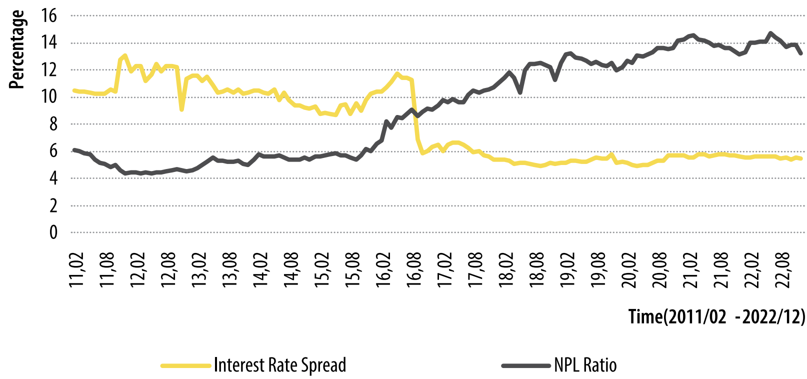
Figure 9 above is a graphical presentation of ROA, NPL and Spread rate. When NPLs are high, ROA is low and when NPLs are Low ROA is high.

Figure 10 **NPLs in Banking, Manufacturing and Agricultural sector.**



From **Figure 10** above, NPLs in the manufacturing sector have from year 2013 remained above the gross NPLs. NPLs in the agricultural sector have been below gross NPLs.

Figure 11 **Spread Rate and NPL Ratio**

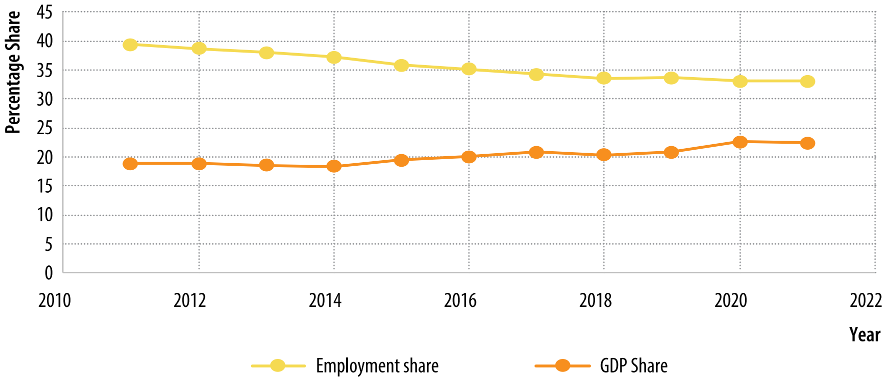


This graph depicts the interest rate spread and NPLs between February 2011 to December 2022. When NPL ratio is high, the interest spread appears to be constantly low during the study period.

The agricultural sector in Kenya has continued to play a fundamental role in Kenya's economy. In the year 2021 the agricultural sector contributed 22.4% of the Kenyan GDP and was a main source of employment in the country.

Out of the rural economy, the Agricultural sector employs 60%. Though the share of loans in the agricultural sector and manufacturing sector is moderate, the contribution of the sectors to GDP and employment is high.

Figure 11 GDP and Employment Share (Agricultural sector)



From the **figure 12** above, the agricultural sector has consistently had a large share of contribution to gross domestic product and employment in Kenya. According to CBK report 2022, the largest number of loan accounts were personal & household, trade and agriculture. Notably, agriculture also contributes the highest GDP in Kenya.

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