

**MODELLING THE EFFECTS OF RUSSIA-UKRAINE WAR ON THE COST OF  
DOMESTIC BORROWING USING THE VASICEK MODEL.**



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## DECLARATION AND APPROVAL

We hereby declare that this project is our original work and has not been presented by any other person for an award of academic certificate.

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## **DEDICATION**

We take this opportunity to dedicate this research project to the Almighty God for His grace, strength and life throughout the project period and to our parents for the support we have received throughout our lives especially during the project period.

## **ACKNOWLEDGMENTS**

We give the Almighty God the utmost gratitude for the gift of life and the good health throughout the project period. His love and inspiration Have always guided us in carrying out our duties and responsibilities.

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## **LIST OF ABBREVIATIONS AND ACRONYMS**

USSR	Union of Soviet Socialist Republics
TCDD	Tetrachlorodibenzodioxin
NATO	North Atlantic Treaty Organization
SWIFT	Society for Worldwide Interbank Telecommunications
FX	Foreign Exchange
CBK	Central Bank of Kenya
NSE	Nairobi Stock Exchange
KAM	Kenya Association of Manufacturers
OLS	Ordinary Least Squares Regression
KNBS	Kenya National Bureau of Statistics
MPC	Monetary Policy Committee
EU	European Union



## OPERATIONAL DEFINITION OF CONCEPTS

**Non-Proliferation Treaty** – A policy or a treaty aimed at preventing the spread or development of weapons of mass destruction, including nuclear, chemical, and biological weapons.

**Proxy** – A variable used as a substitute for an observable or added to measure variable.

**Separatists** – A person or group that advocates for separation of a particular region or group from a large political entity.

**Volatility** – A measure of the degree of variation of a financial instrument's price over time.

**Random market risk** – The risk associated with unpredictable changes in market conditions that affect the value of financial assets.

**Supply Chain** – The network of companies, organizations, and individuals involved in the production and delivery of product or service to customer.

**Economic sanction** – Measures taken by one country or groups of countries to restrict or cut off economic trade with another country or group of countries in order to influence their behavior.

**Least squares** – Statistical method used to find the best fit line or curve through a set of data points by minimizing the sum of squared residuals.

**Inflation** – The rate at which the general level of prices for goods or services in an economy is increasing over time.

**Cost of borrowing** – Refers to total cost that a borrower incurs when taking out a loan.

**Foreign Exchange** – Refers to the global market where currencies are bought and sold.

## ABSTRACT

The purpose of this study is to analyze the effect of Russia-Ukraine war on the cost of borrowing using the commercial banks' lending rate. A descriptive design was used where the monthly commercial bank lending rate data for the period from 1997 to 2022 was used to build the model. The monthly lending rate data for the period from 1997 to 2022 was obtained from the Central Bank of Kenya website.

Two mathematical models were used to model the dynamics of commercial banks' lending rate to the cost of borrowing. The Vasicek model which incorporates the logic of mean-reversion and applies it to interest rate dynamics. The model was calibrated using the simple ordinary least squares regression (OLS). The fitted model had a convergence parameter  $\alpha$ , which shows the speed at which the model reverts back to the mean and variance parameter which shows the volatility of the model. The model was then used to estimate future lending rates.

Results revealed that, in terms of impact of estimated parameters on volatility and lending rate forecast we can see that the more the stochastic factors impact the lending rate in the short run the more volatile the lending rate is affected in the long run, but also the smaller the convergence parameter  $\alpha$  is, the larger the variance would be. If the convergence speed is very low the lending rate can deviate for quite a long time unpredictably from the equilibrium level. These results show that small disruptions on financial systems like war can have significant effects on lending rates of commercial banks.

## **CHAPTER ONE**

### **1.0. INTRODUCTION**

#### **1.1. BACKGROUNG OF THE STUDY.**

Russian president Vladimir Putin has repeatedly made clear that he considers Ukraine's place to be under Russia's thumb. That was its position from the day of Russian Empire under Catherine the Great in the 18<sup>th</sup> Century through the nation's share history in the Soviet Union.

After the dissolution of the Soviet Union (USSR) in 1991, Ukraine and Russia maintained close ties. In 1994, Ukraine agreed to accede to the treaty on the Non-proliferation of nuclear weapon as a non-nuclear weapon state. Former Soviet nuclear weapons in Ukraine were removed and dismantled. In return, Russia, United Kingdom and the United States agreed to uphold the territorial integrity and political independence Ukraine through the Budapest Memorandum on security assurances.

In 1999, Russia was one of the signatories of the charter for European security which "reaffirmed the inherent right of each and every participating state to be free to choose or change its security arrangements, including treaties of alliance as they evolve.

The 2004 Ukrainian presidential election was controversial. During the election campaign, opposition candidate Victor Yushchenko was poisoned by TCDD dioxin, he later implicated Russian involvement.

At the 2008 Bucharest summit, Ukraine and Georgia sought to join the North Atlantic treaty Organization (NATO). The response among NATO members was divided; Western European countries opposed offering Membership Action Plan (MAP) in order to avoid antagonizing Russia, while US president George w. Bush push for their admission. NATO ultimately refused to offer Ukraine and Georgia MAPs. Putin received strong opposition to Georgia's and Ukraine's NATO membership bids. By January 2022, the possibility of Ukraine joining NATO remained remote.

The Russo-Ukrainian war has been ongoing between Russia (alongside Russia separatists in Ukraine) and Ukraine since February 2014. Following Ukraine's Revolution of dignity, Russia annexed Crimea from war in Donbas against Ukrainian government forces; fight for the first eight years of conflict also included naval incidents, cyber warfare and heightened political tension.

In February 2022, the conflict was a major escalation as Russia launched full scale invasion of Ukraine.

## **1.2. STATEMENT OF THE PROBLEM**

Economic shockwaves have been felt across all industries as penalties from the EU, the US, and many other countries ramp up on the Russian Federation. Energy prices are rising, stock prices are falling, supply chains are collapsing and inflation has reached record levels. These recent events have led to increased demand for haven assets, strengthening the US currency. The local currency neared a low of 114 and is expected to weaken further as the US prepares to hike interest rates. Kenya is looking at higher debt repayment and cost of living as the shilling remains vulnerable to the US Dollar, which is gaining from the Russia-Ukraine war. According to the latest statistics of the Kenyan shilling by Forecast Economics, accelerating inflation in the U.S. over the past few months and the Fed's increasingly hawkish tone have raised expectations of a sooner-than-anticipated rate hike.

The Russia-Ukraine war, in all its dimension, is producing alarming cascading effects to a world economy already battered by Covid-19 and climate change with particular dramatic impacts on developing economies like Kenya. The Kenyan economy is a commodity market implying it generates most of its revenue through commodity export. The sanctions against Russia directly impacts Kenya with disruption in trades of Kenya primary commodities. These disruptions have led to collapsing supplying chains and high energy prices which come with price implications therefore leading to high inflation. On October 2022, Kenya recorded an all-time high 12-month inflation of 9.59. To curb this high inflation the CBK increased the CBR rate which is the rate published by the Central Bank of Kenya under the provisions of the Central Bank of Kenya Act as the lowest rate at which the Central Bank lends money to Banks in Kenya and which has been adopted as the base rate under the provisions of the Banking (Amendment) Act, 2016. A hike in the CBR rate causes the Commercial Banks to increase the lending rate which raises the cost of borrowing money to curb the demand for goods and services.

Consequently, this study seeks to investigate if there is any significant effect of Russian-Ukraine war on the cost of domestic borrowing using the commercial banks' lending rate. To investigate the effect of Russian-Ukraine war on the cost of domestic borrowing using commercial banks' lending rate, we need a term-structure model with mean reverting behavior and constant volatility and can fit

historical data adequately, produce realistic dynamics and can be calibrated easily to current market lending rate data for which the appropriate model was the Vasicek model (1977).

### **1.3. OBJECTIVES OF THE STUDY**

Based on term-structure model (Vasicek model), the objective of this study is to establish the relationship between Russia-Ukraine war on the cost of domestic borrowing using commercial banks' lending rate.

### **1.4. Significance of the study**

The Central Bank's monetary policy decisions are made to maintain a low and stable inflation rate over time which is an indication of price stability. According to the Central Bank of Kenya the CBR is reviewed and announced by the MPC at least every two months. Movements in the CBR, both in direction and magnitude, signal the monetary policy stance. Whenever the Central Bank is injecting liquidity through Reverse Repo, the CBR rate is the lowest acceptable rate by law.

Likewise, whenever the Bank wishes to withdraw liquidity through a Vertical Repo, the CBR rate is the highest rate that the CBK will pay on any bid received.

However, to ensure flexibility and effectiveness of monetary policy operations in periods of volatility in the market, the CBK can raise the maximum acceptable interest rates on Term Auction Deposit to above the CBR. Movements in the CBR rate are transmitted to changes in short-term interest rates. Lower interest rates encourage economic activity and thus growth. When interest rates decline, the quantity of credit should increase.

This study is important in the following ways:

1. The Central Bank will be able to find out the level of impact of its monetary policy especially interest rates on the cost of borrowing.
2. Potential investors will be able to anticipate the impact of changes in interest rates on the cost of capital & capital returns.
3. Financial sectors like banks, insurance companies and brokerage firms will be able to curate new products based on short- & long-term interest rates.
4. The finding of the study will give the national government, domestic and foreign investors, financial market players an insight on the magnitude of impact of Russia-Ukraine war and its consequences to access to capital.

## **SCOPE OF THE STUDY**

The subject matter of this study is to establish whether the Russia-Ukraine war had a significant impact on the cost of domestic borrowing in Kenya. In order to realize this, the study will seek to determine the effect of war on financial markets especially the banking sector and how it affects access to capital through borrowing by use of a mathematical. Based on the findings of the study various measures that can be put in place to mitigate the impact of the war will be highlighted. During this research, commercial banks' lending rate will be used as proxy to develop and test a mathematical to explain the dynamics of lending and how they affect the cost of borrowing.

### **1.5. ASSUMPTION OF THE STUDY**

It was assumed that at the period of the study, that among other factors, the Russia-Ukraine conflict had a significant impact to the cost of borrowing. Moreover, the study was to be completed within the scheduled time without major external influences.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1. Introduction**

Several scholars have tried to analyze the impact of conflicts on financial systems across the world. Towards this end this chapter tries to look at some of the theories about interest, criticisms, plus the major findings and conclusions obtained. This chapter is organized into two sections; theoretical literature and empirical literature.

#### **2.2. REVIEW OF THEORIES**

##### **2.2.1. NEO-CLASSICAL THEORY OF INTEREST, LOANABLE FUNDS THEORY**

Loanable funds theory is a reformulation of the classical saving and investment theory of interest. It incorporates monetary factors with the non-investments. This loanable fund theory is associated with other Swedish economists and the British economist's improvement over old classical theory of interest.

According to this theory, the rate of interest is determined by the demand for and supply of loanable funds. Classical theory of interest considered only saving out of current income in the supply of saving while neo-classical economists considered not only saving but also bank credit, dishoarding and disinvestment. In classical theory, only saving was available for investment while in loanable funds theory of interest of neo-classical economists not only savings, but also hoarded wealth, bank loans, disinvestment wealth are another source of funds available for investment to the borrowers. Since loanable funds theory of interest considered both savings of classical theory of interest and bank loans, dishoarding, and disinvestment; it is often referred as real as well as monetary theory of interest. Thus, it is both real and monetary theory of interest. When rate of interest is zero, saving is not zero because in this theory saving is independent of rate of interest and it depends on income. Thus, saving is a steep curve as compared to dishoarding curve. Dishoarding curve is flat because it's interest elastic. As increase in interest rate brings out more hoarded funds and a decrease in interest rate brings out less of hoarded funds. Thus, dishoarding funds is directly related to interest rate. Investment is a declining function of interest rate. As interest rate increases, demand for investment decreases and vice-versa. Intersection of supply of loanable funds and demand for investment determines the rate of interest.

Loanable funds theory is a flow theory because it involves the linking of the interest rate with investment and hoarding of funds on the demand side with savings, dishoarding, and bank money on the supply side. These are all flow variables. As such, the theory hypothesizes that it is the ‘flow equilibrium’ (or the equilibrium between the two flows) of loanable funds, which determines the rate of interest.

According to Prof. Robertson, the loanable funds theory is a “commonsense explanation” of the determination of the rate of interest. But this theory is also not free from certain defects. The demand and supply schedules for loanable funds determine the equilibrium rate of interest which does not equate each component on the supply side with the corresponding component on the demand side. Thus, the equilibrium rate reflects unstable equilibrium. For stable equilibrium, it is essential that ex ante (planned) investment must equal ex-ante savings at the equilibrium rate. Prof. Hansen asserts that the loanable funds theory like the classical and the Keynesian theories of interest is indeterminate. The supply curve of loanable funds is composed of savings, dis-hoardings and bank money. But since savings vary with past income and the new money and activated balances with the current income, it follows that the total supply curve of loanable funds also varies with income. Thus, the loanable funds theory is indeterminate unless the income level is already known.

The loanable funds theory states that the supply of loanable funds can be increased by releasing cash balances of savings and decreased by absorbing cash balances into savings. This implies that the cash balances are fairly elastic. But this does not seem to be a correct view because the total cash balances available with the community are fixed and equal the total supply of money at any time. Whenever there are variations in the cash balances, they are in fact in the velocity of circulation of money rather than in the amount of cash balances with the community. The theory over-emphasizes the influence of the rate of interest on savings. It regards savings as interest elastic. Generally speaking, people save not to earn rate of interest but to satisfy precautionary motive. So, savings are interest inelastic.

### **2.2.2. THE SOCIAL CONTRACT THEORY AND INTEREST GROUP THEORY**

Social contract is a long-standing political theory or philosophy established by some of the founding fathers of modern political philosophers. Thomas Hobbes (famous for *Leviathan*) John Locke (known for two treaties of Government) and Jean Jacques Rousseau (Renowned for “the social contract”) (Mbah, 2021a).



Thomas Hobbes in his publication titled “Levithian” portrays the state of nature s a chaotic lawless society in which mankind constantly lives with the fear of death and as such gets asocial contract as a pathway to peace (presentation of lives and property). In attempt to preserve their lives and properties, citizens/subjects) voluntarily give away their rights and freedom units entirely to a sovereign power who in return must ensure their security (Mbah, 2021a; Ebenstein and Ebenstain 2000, p.412)

The state of nature in Locke’s view is a more peaceful environment without appropriate establish institutions that can enforce law and order in an event of dispute. Thus, social contract is needed to ensure established government institution (legislative) with the responsibility of enforcing law and order. According to Locke’s social contract, legislators are trustees who ought to serve in the interest of those who voted them into power (Ebenstein and Ebenstain 2000, p.430). meanwhile, Jean Jacques Rousseau’s state of nature is neither as optimistic as that of Locke nor as pessimistic as that of Hobbes. His state of nature is characterized by each person following their point that they realized that doing so is not effective, thus the need for social contract. Unlike Locke, Rousseau postulate that in social contract, the citizen does not surrender their will to a specific individual but rather to the community (social organization) who they expect to ensure their liberty, right and freedom (Mbah 2021a; Elahi 2014; Ebenstein and Ebenstain 2000, p.498).

Apart from looking at the Russia-Ukraine tension in the light of social contract theory, this persistence tension can be analyzed using the lenses of the interest group theory. According to Birk land (2016, P.158). an interest group is a “collection of people or organization that unite to advance their desired political outcomes in the government and society.” The power of interested group can not be undermined because individual voices become stronger when they get together into groups thus, they reason why interest groups are important in the policy process.

There groups can constitute economic interest groups, political groups as well as public interested group with the sole role of protecting the interest of their respective members (Mbah 2021b; Birkland, 2006, P.160-161). Despite the “divorce” between Ukraine and Russia, Ukraine progressive Euro-Atlantic amalgamation since the 2004 Orange Revolution has resulted in in cessation tension between both countries. The EU interest in a wide Europe policy has

tempered with the regions which Russia consider a “sphere of its national interest (Samokhralov 2007) in an attempt to examine the interest of each party in the wider Europe or post-soviet space, (Samokhralov2007) terms the Russia-EU-Ukraine triangle a sought of zero- subgame.

The consequence of each party fostering interest are the results of the Russia-Ukraine 2022 crisis. According to Pabrick and Kudos (2015, P.78-79) before Russia escalate the invasion of Ukraine, NATO sources indicate Russia has not only supported separatists in Ukraine, but also Russia special forces and troops have participated in the annexation of Crimea for the Russian Federation and fight in Eastern Ukraine.

The social contract is unwritten and is inherited at birth. It dictates that we will not break law or certain moral code and in exchange we reap the benefit of our society i.e., security, survival, education and other necessities needed to live.

Problems with the said contract theory include the following:

It gives Government to much power to make laws under the guide of protecting the public. Specifically, government may the cloak of social contract to invoke the fear of a state of nature to warrant laws that are intrusive. From the time we are born, we do not knowingly agree to a contract and therefore do not consent to the contract. An outflow of this thought is a movement called “sovereign citizens” or “free men of the land”. Law authorities identifies these movements as individual citizens who reject control and the government operates outside of its jurisdiction. Because of these beliefs they do not recognize federal, state or local laws, policies or regulations. If we do not accept the contract and with to abide by it, we may not fully understand what our part of the contract is or ought to be.

On the interest group theory, theoretically pluralism should work to protect the interest of many. When multiply interest strive to be heard by governmental actors, multiple interest is also heard. However, this can bring about problem of factionalism, where small groups of people with shared interests work to have their wishes represented in government despite majority interest. As Madison addressed in Federalist Paper No.10, while a multiple of interest may be represented, not all are heard or responded to equally and a narrow interest may hijack political attention at the expense of majority’s needs. This latter problem, known as economic bias is of the interest group theory.

### **2.2.3. Interest Rates (lending rate)**

An interest rate is the rate at which interest is paid by a borrower for the use of money that they borrow from a lender. Interest rates are normally expressed as a percentage of the principal for a period of one year. Interest rates targets are also a vital tool of monetary policy and are taken into account when dealing with variables like investment, inflation, and unemployment

Howells (2008) the rate of interest is a payment from borrowers to lenders which compensates the latter for parting with funds for a period of time and at some risk. The effect of interest rates is to influence behavior which stretches over a period of time- Lending for a period, forgoing the ability to consume for a period, investing in capital goods which yield a return over a period. The relevant concept of interest rates is, thus, strictly speaking, the expected rate. Nominal interest rates are the rates of interest that are actually paid, in money form.

Nominal interest rates consist of four elements:

$$i = r - \Pi + l + \sigma$$

Where  $r$ , is the real short-term rate of interest,  $\Pi$  is the inflation premium,  $l$  is the liquidity premium and  $\sigma$  is the premium for risk Real rate of interest is the returns that lenders require even if there is no risk and prices are constant. The determination of interest rates through demand and supply stresses the role of private decision makers or what might be called “market forces”. The ability of all central banks to exercise any influence over interest rates lies in their role as lenders of last resort.

## **2.3. REVIEW OF EMPIRICAL STUDIES**

### **2.3.1. THE ECONOMIC IMPACT OF RUSSIA-UKRAINE 2022 CRISIS.**

Countries worldwide including Kenya are barely recovering from the economic impact of the Covid-19 pandemic. The recent 2022 Russia attack on Ukraine could worsen the situation as a global economy may witness yet another rise in commodities prices and supply chain chokeholds. Russia is known as world largest exporter of wheat and in combination with Ukraine both countries impact a quarter of the sum of global export (Cohen and Ewing;2022)

### **2.3.2. Effects of economic sanctions on Russia to commodity market, imports and exports.**

In 2021, Kenya imported 85.7% of its wheat from the rest of the world i.e. both Russia and Ukraine in a ratio of about 60:40 between the two countries. In 2021 wheat importation stood at 2:1 million tons against 350 ton produced within the country. In terms of value, it was Ksh. 11.6 and Ksh. 8.6 billion from Russia and Ukraine respectively. The war disrupts the supply chain of these critical products that would come with price implications.

### **2.3.3. Foreign market and foreign exchange reserves**

The gradual decline of foreign exchange reserves in Kenya is fueling the black market and causing additional financial pain for manufacturers and importers.

Kenya's dollar stock has plunged by 15% to 8.17m as of 26 May from and 9.62m held in September 2021 with the marginal difference, the central tender is walking a tightrope trying to rein in runaway inflation with simultaneously tightening monetary policy.

Sourcing (FX). Importers are now forced to make prior currency arrangements to at least forge ahead with consistent supply, but there is still no guarantee. Rajul Maldel, C.E.O. and commercial director at Pwani Oil says nearly all the bank they use including NCBA, DTB, Equity, Citibank, Ecobank have placed dollar exchange limits between \$20,000 and \$50,000 depending on the availability. The oil makers, which is also battling raw material supply shortage after Indonesia banned palm oil exports, require between \$1m and \$1.5m to complete a single importation phase.

Parallel exchange rate; The Kenya Association of Manufacturers (KAM) reckons that the foreign exchange market is seemingly losing confidence and in extreme cases, supply have been cut or delayed as importers breach credit limits due to limited dollars.

Dollar scarcity; exporters are also the main source of dollars into financial system, but remain hesitant to realize FX into the market at the official exchange rate, anticipating further weakening of the shilling.

Inflation; Kenya's inflation rule has been a steady upward trajectory, hitting a two year of 7.1% by the end of May. This is just 0.4% shy of the upper bound of 7.5% inflation rates recommended by CBK. According to KNBS, the rise in inflation is

due to notable spike in price of food items. A liter of cooking oil for instance, has increased by 47% in the past year, currently retailing at Ksh.370(\$3.17) compared to Ksh.252 in May 2021. Within the same period, the price of 2kg of wheat flour has risen by 28% Maize has increased by 23% and the price of fuel has risen by 21%.

#### **2.3.4. Rates of investments and costs of borrowing in Kenya**

The conflict has also triggered a self-off of shares, pulling down market that has fully recovered from the economic damage caused by covid-19 pandemic.

A major risk event usually sees investors rushing back to bonds and safest assets in what could hurt the flow of foreign investors to the Nairobi Security Exchange (NSE) tracker: NSE given the foreigners count for 58% of trading at the bourse.

In Ukraine, which is under martial law, the central bank has suspended all currency trading and set a fixed exchange rate of approximately 29 hryvnia to the dollar. It also banned foreign currency withdrawal and most cross-border payment.

#### **2.3.5. Tourism and hospitality in Kenya.**

The current Russia-Ukraine crisis spell doom for Kenya by shutting down doors for Ukraine tourists to visit.

Already 1.2 million Ukrainians have crossed into bordering countries as refugees. But, scores of others are still trapped in Ukraine. Some chose to fight for their country leaving no much thought for a trip to Kenya.

This puts Kenya's tourism at a limbo as the Kenyan government projected Mombasa would host at least 5000 Ukrainian tourists by May 2022.

Mombasa county government has already signed tourism deal with 22 major cities in Ukraine as of November 2021. Direct chartered planes were launched from Kyiv Ukraine's capital to Moi International airport in Mombasa.

#### **2.3.6. Global and domestic supply chain.**

Disruption of supply chain will come from three sources;

- Difficulties affecting land-based routes; restrictions on air links; and the cancellation of sea freight routes from Ukraine.
- Food and transport account for 42.56% of the Kenya inflation basket.
- Value chain disrupted as a result of the ongoing war have led fuel, energy and fertilizers prices increased coupled with currency depreciation which are expected to continue increasing dollar denominated increase.

## **2.4. SUMMARY OF THE REVIEWED LITERATURE.**

Evidence from reviewed literature shows that although the consequences of crisis have had a total impact on Russia's economy, the world economy has begun to feel the impact of the crisis. Inflation which is already ravaging most global economy is steady rising due to the sharp increase in oil, natural gas and food prices just a few days into the crisis.

Experts expect negative impact on household consumption, increase uncertainties, unpredicted stock swings, supply chain disruption, bulging utility bills, decrease investments due to political risks and economic growth impediments. It is therefore vital for policymakers worldwide to seek alternative means of survival if the war persists for long.

## **CHAPTER THREE**

### **RESEARCH DESIGN AND METHODOLOGY**

#### **3.1. Introduction**

This chapter covers the methodology of study and includes the research design, model selection, model calibration, data sources, model components, data analysis procedure, tools used and conclusion.

The purpose of this chapter is to design the methodology of the research approach through mixed types of research techniques. The research approach also supports the researcher on how to come across the research results findings.

In this chapter, the general design of the research and the methods used for data collection are explained in detail. It includes three main parts. The first part gives a highlight about the dissertation design. The second part discusses about quantitative data collection, model selection, model calibration and analysis methods. The last part illustrates the general research frameworks. The purpose of this section is to indicate how the research was conducted throughout the study period, how the model was selected and fitted.

Research methodology is the path through which the researcher needs to conduct their research. It also shows the path through which the researcher formulates their problem and objective and present their result from the data obtained during the study period. This research methodology chapter also shows how the research outcome at the end will be obtained in line with meeting the objective of the study. This chapter hence discusses the mathematical models that were used during the research process. It includes the methodology of the study from the research strategy to the result dissemination.

#### **3.2. DATA SOURCES.**

##### **3.2.1. SECONDARY DATA**

The secondary data refers to data that was collected by someone other than the user. This data source gives insights of the research area of the current state - of-art methods. It also makes some sort of the research gap that needs to be filled by the researcher. This secondary data sources could be internal and external data sources of information that may cover a wide range of areas. Commercial banks' lending rate data from 1997 to 2022 was obtained from the Central Bank of Kenya website. Data cleaning was not required as the data directly suited our research design.

### 3.3. MODEL SELECTION (VASICEK MODEL)

Predicting how interest rates evolve can be difficult. Investors and analysts have many tools available to help them figure out how they will change over time in order to make well-informed decisions about how their investments and the economy

We used the Vasicek model in the case of modelling the movement and evolution of interest rates. It estimates where interest rates will move in a given period of time and can be used to help analysts and investors to figure out how the economy and investments will fare in the future.

It outlines the movements of interest rates as a factor composed of market risk, time and equilibrium value. The rate tends to revert towards the mean of these factors over time. The model shows where interest rates will end up at the end of a given period of time by considering current market volatility, the long-run mean interest value and a given market risk factors. It is instantaneous interest using the following equation.

$$dr_t = \alpha(\mu - r_t)dt + \sigma dW_t$$

Where;

W = Random market risk (Represented by a wiener process)

t = Time period

$\alpha(\mu - r_t)$  = Expected change in the interest rate at time t (the drift factor)

$\alpha$  = speed of the reversion to the mean

$\mu$  = long-term level of the mean

$\sigma$  = volatility at time t

### 3.4. COMPONENTS OF THE VASICEK MODEL

The Vasicek interest rate model is a single-factor short-rate model that predicts where interest rates will end up at the end of a given period of time. It outlines an interest rates evaluation as a factor composed of market risk, time and equilibrium value.

$$dr_t = \alpha(\mu - r_t)dt + \sigma dW_t \quad (\text{eqn}^*)$$



In the case of eqn\*, the model specifies that the instantaneous interest rate follows the stochastic differential equation, where  $d$  refers to the derivative of the variable following it. In the absence of market stock (i.e., when  $dW_t=0$ ) the interest rate remains constant ( $r_t=\mu$ ). When  $r_t<\mu$ , the drift factor becomes positive, which indicates that the interest rate will increase towards equilibrium.

From eqn\*  $\mu$  represents the ‘mean’ level of the short rate. If the short rate grows the drift becomes negative, pulling the rate back to  $\mu$ . The speed of the ‘reversion’ is determined by  $\alpha$  ( $\alpha$  is the convergence speed of the interest rate back to the equilibrium level  $\mu$ ). If  $\alpha$  is high, the reversion will be very quick.

### 3.5. MODEL CALIBRATION

#### 3.5.1. ORDINARY LEAST SQUARES REGRESSION

Ordinary least squares regression (OLS) is a common technique for estimating coefficients of linear regression equations which describe the relationship between one or more independent variable. OLS is also a type of linear least squares method for choosing the unknown parameters in a linear regression model (with fixed level-one effects of a linear function of a set of explanatory variables) by the principle of least squares: minimizing the sum of the squares of the differences between the observed in the input dataset and the output of the (linear) function of the independent variable.

In the case of a model with explanatory variables, the OLS regression model writes

$$Y = \beta_0 + \sum_{j=1, \dots, p} \beta_j X_j + \varepsilon$$

To be able to calibrate the model efficiently to explain the dynamics of lending rate and minimize the standard error we had to express the continuous stochastic differential equation of the Vasicek model (eqn\*) into the discrete form according to the following (eqn\*\*).

$$\text{Discrete Form: } \Delta r_t = \alpha(b - r_{t-1}) \Delta t + \varepsilon_t(0, \sigma^2) \quad (\text{eqn**})$$

Where;

- $\Delta r_t$ -converts the derivative of interest to its first difference
- $\Delta t$ -represents the discrete changes of time (i.e., months)

- $\varepsilon_t$  is the error term and  $\sigma^2$  is the variance

OLS Form: 
$$r_t - r_{t-1} = \alpha b - \alpha r_{t-1} + \varepsilon_t (0, \sigma^2) \quad (\text{eqn***})$$

To estimate the model using simple OLS (eqn\*\*\*), we regressed the first difference of the lending rate onto the constant ( $\alpha b$ ) and the lagged lending rate ( $\alpha r_{t-1}$ ) and we will also have an error term absolute  $\varepsilon_t$  which in the Vasicek model is assumed to be identically and independently distributed(iid) with parameter  $\sigma^2$  that corresponds to the variance of the lending rate which is essential in estimating the volatility of lending rate in the short run and in the long run due to the mean reverting nature of the Vasicek model.

Before estimating the model, we used the OLS model to calculate the regression coefficients  $\beta$  and the standard error for the model. The Excel LINEST function was used to perform this task by regressing the delta values of lending rate to the lagged values to calculate the model parameter estimates and the statistical significance for the model. The model was then used to make projections of interest rate across various periods.

### **3.6. METHODS OF DATA ANALYSIS.**

Data analysis method follows the procedure listed under the following sections. The data analysis part answered the basic questions raised in the problem statement. The detailed analysis of the effect of Russia -Ukraine war on the cost of borrowing was analyzed, discussed, and compared.

#### **3.6.1. QUANTITATIVE DATA ANALYSIS.**

Quantitative data was generated from secondary data obtained from the Central Bank of Kenya website. In order to build and calibrate the data obtained easily, the data was imported into Excel to generate lagged lending rate values and delta values which helped in model calibration and estimation of parameters. Statistical significance and regression estimates were calculate using EXCEL.

### **3.7. CONCLUSION**

The research methodology and design indicated overall process of the flow of the research for the given study. The data sources and data collection methods were used. The overall research strategies and framework are indicated in the research process from problem formulation to problem validation including all the parameters. It has laid some foundation and how research methodology is devised

and framed for researchers. This means, it helps researchers to consider it as one of the samples and models for the research data collection and process from the beginning of the problem statement to the research finding. Especially, this research flow helps new researchers to the research environment and methodology in particular.

## **CHAPTER FOUR**

### **DATA ANALYSIS, RESULTS AND DISCUSSION**

#### **4.1 Introduction**

This chapter represents the results and findings of the study based on the research objectives. The results are presented in form of summary tables and graphs. Regression and correlation analysis are used to analyze the data to answer research objectives. For the purposes of the study, test of hypothesis was carried to test the hypothesis that the Russia-Ukraine war had significant effects on the Commercial Banks lending rate. Hypothesis testing is a form of statistical inference that uses data from a sample to draw conclusions about a population parameter or probability distribution. First, a tentative assumption is made about a parameter or distribution. This assumption is called the Null Hypothesis ( $H_0$ ).

Chi-Squared Test of hypothesis was used with a significance level threshold of 0.05. Chi-Squared test is for testing the relationship between two categorical variables. The underlying principle is that if two categorical variables are independent, then one categorical variable should have similar composition when the other categorical variable change.

#### **4.2. Descriptive Analysis**

Secondary data was sourced and used for the purpose of addressing the main research objectives of this project. The monthly Commercial Bank Lending Rate was sourced from the CBK for the years 1991 to 2022. The study had only one variable (lending rate) and descriptive measures were computed and are summarized in the table 4.21 below.

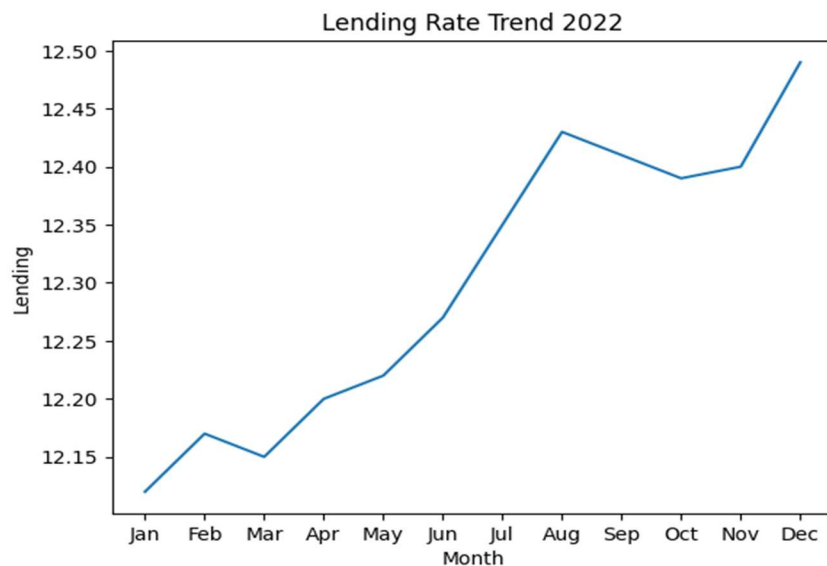
Table 4.21 Summary of descriptive statistics for study variables.

## Statistics

	Deposit	Savings	Lending	Overdraft
<b>count</b>	376.000000	376.000000	376.000000	376.000000
<b>mean</b>	8.099202	5.121569	17.976862	17.930984
<b>std</b>	4.417903	4.454682	5.718373	6.061925
<b>min</b>	1.960000	0.960000	11.750000	10.720000
<b>25%</b>	4.840000	1.580000	13.532500	13.455000
<b>50%</b>	6.650000	3.470000	16.310000	15.915000
<b>75%</b>	9.525000	6.912500	20.232500	20.387500
<b>max</b>	23.430000	18.620000	32.280000	33.500000

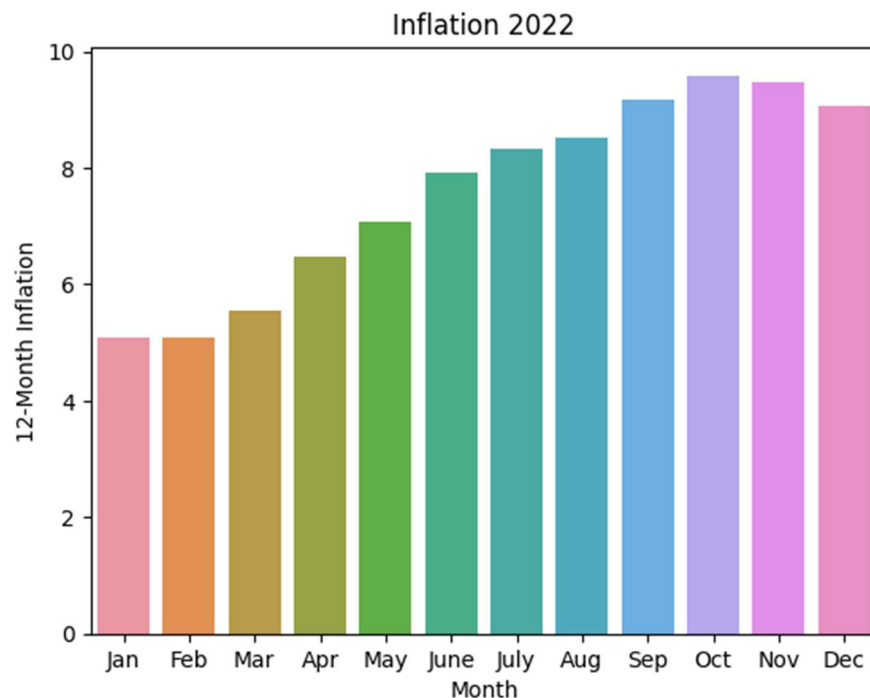
The arithmetic mean is equal to the sum of the values divided by the number of values, the lending rate has a mean of 17.976862. Standard deviation shows how much variation or "dispersion" exists from the average (mean, or expected value). A low standard deviation indicates that the data points tend to be very close to the mean; whereas high standard deviation indicates that the data points are spread out over a large range of values. The lending rate has a standard deviation of 5.718373.

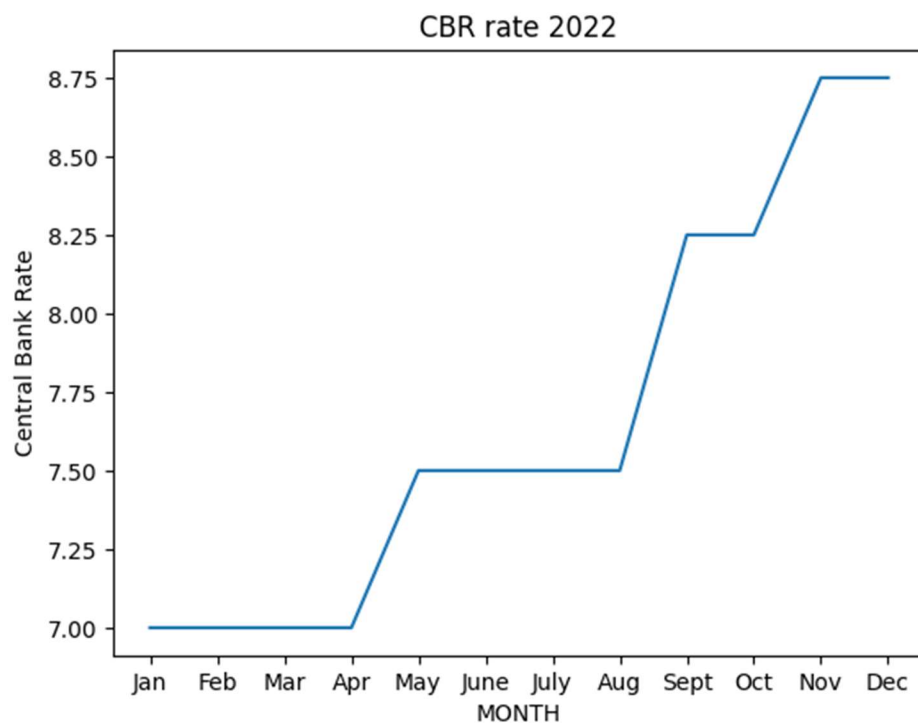
The figure 4.1 below shows the trend of lending rate in the year 2022



From the graph it can clearly be seen that the lending rate in 2022 has been increasing since the beginning of the war in late February. This is due to high inflationary pressures that came as a result of economic sanctions imposed on Russia and disruptions of supply chain of oil and food products from Russia &

Ukraine which come with price implications. To curb high inflationary pressures the Central Bank of Kenya increased the CBR rate. The CBR rate, **Central Bank Rate** or “CBR” means the rate published by the Central Bank of Kenya under the provisions of the Central Bank of Kenya Act as the lowest rate at which the Central Bank lends money to Banks in Kenya and which has been adopted as the base rate under the provisions of the Banking (Amendment) Act, 2016. A hike in the CBR rate causes the Commercial Banks to increase the lending rate which raises the cost of borrowing money to curb the demand for goods and services. The figures 4.2 below show the trend of inflation and the CBR rate for the year 2022 respectively.





**Table 4.32**

The following is a contingency table showing lending rate values for 2021 & 2022

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Row total
2021	12	12.02	12.05	12.08	12.06	12.02	12.09	12.12	12.1	12.12	12.15	12.16	144.97
2022	12.12	12.17	12.15	12.2	12.22	12.27	12.35	12.43	12.41	12.39	12.37	12.36	147.44
Col Total	24.12	24.19	24.2	24.28	24.28	24.29	24.44	24.55	24.51	24.51	24.52	24.52	292.41

**Table 4.33**

We now calculate the expected frequencies from the table above, to get the following

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Row total
2021	11.95	11.99	12.0	12.04	12.04	12.04	12.12	12.17	12.15	12.15	12.16	12.16	144.97
2022	12.16	12.20	12.20	12.24	12.24	12.25	12.32	12.38	12.36	12.36	12.36	12.36	147.44
Col Total	24.12	24.19	24.2	24.28	24.28	24.29	24.44	24.55	24.51	24.51	24.52	24.52	292.41

**Table 4.34**

We now get test statistic i.e. **(Observed-Expected) ^2 / Expected** to get the following table.

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2021	0.000147	6.15E-05	0.000227	0.000150385	4.22325E-05	4.17057E-05	5.91754E-05	0.000216	0.000218	8.16E-05	3.41E-06	1.04E-06
2022	0.000144	6.05E-05	0.000223	0.000147866	4.1525E-05	4.10071E-05	5.8184E-05	0.000213	0.000214	8.02E-05	3.35E-06	1.03E-06

### 4.3 Data Analysis and Results

The data analysis and results are based on the following key variable that is; the lending rate from 1991 to 2022.

$$\text{Recall: } dr_t = \alpha(\mu - r_t)dt + \sigma dW_t \quad (\text{eqn 3})$$

for constants  $\alpha > 0$ ,  $\mu$  and  $\sigma$ .

Here  $\mu$  represents the ‘mean’ level of the short rate. If the short rate grows the drift becomes negative, pulling the rate back to  $\mu$ . The speed of the ‘reversion’ is determined by  $\alpha$ . If  $\alpha$  is high, the reversion will be very quick. Since it will be a bit difficult to calibrate the continuous form i.e. (eqn 3) above of the Vasicek model, we therefore represent the above model in discrete form using simple ordinary least squares regression (OLS).

$$\text{Discrete Form: } \Delta r_t = \alpha(b - r_{t-1}) \Delta t + \varepsilon_t(0, \sigma^2) \quad (\text{eqn 4})$$

$$\text{OLS Form: } r_t - r_{t-1} = \alpha b - \alpha r_{t-1} + \varepsilon_t(0, \sigma^2) \quad (\text{eqn 5})$$

We test the model by performing forecasting using the following equations

**Forecasting after time t:**

$$E(r_{+t}) = r_0 e^{-\alpha t} + b * (1 - e^{-\alpha t}) \quad (\text{eqn 6})$$

$$V(r_{+t}) = \sigma^2 / 2 \alpha * (1 - e^{-2\alpha t}) \quad (\text{eqn 7})$$

**Long run forecast:**



$$E(r) = b \quad (\text{eqn 8})$$

$$V(r) = \sigma^2/2 \alpha \quad (\text{eqn 9})$$

**Table 4.35**

The table below shows regression parameter estimates

	-a	a*b	
Coefficients	0.004978789	-0.078057178	
Standard error	0.005756442	0.1086611	
	0.002001521	0.636630381	sigma( $\sigma$ )
	0.74806473	373	degrees of freedom
	0.30318932	151.1762443	

**Table 4.36**

The table below shows test statistics

	-a	a*b
t-stat	0.864907353	-0.718354394
p-value	38.76%	47.30%

**Table 4.37**

The table below shows model parameters

$\alpha$ – convergence	-0.004978789
b – equilibrium	15.67794437

## Model

The discrete form of the model with above parameters is

$$\Delta r_t = -0.004978789(15.67794437 - r_{t-1}) \Delta t + \varepsilon_t (0, 0.636630381^2) \quad (\text{eqn 10})$$

**Table 4.38**

The table below shows forecasts of estimation variables using (eqn 10) above

Interest rate (Aug 2022)	12.43
Time horizon(months)	2 (predict October interest rate)
Interest rate forecast	12.39749678
Interest rate variance	0.818721912
Interest rate volatility	0.904832533
<b><i>Long run (<math>t=\infty</math>)</i></b>	
Interest rate	15.67794437
Volatility	6.37985044

### Explanation of the Parameter Estimate Analysis

The fitted discrete form of the Vasicek model fitted for the data in results on table 4.35 is based on Ordinary Least Squares Regression (OLS). OLS is a type of linear least squares method for choosing the unknown parameters in a linear regression model (with fixed level-one effects of a linear function of a set of explanatory variables) by the principle of least squares: minimizing the sum of the squares of the differences between the observed in the input dataset and the output of the (linear) function of the independent variable. In table 4.35 the constant coefficient (with a value of 0.004978789) is very significant to the model.

The lagged value of the lending rate has important contribution as it allows us to estimate the model, using EXCEL LINEST function which calculates the statistics for a line by using the “least squares” method to calculate a straight line that best fits the data and return an array that describes the line.

The model had a convergence speed of 0.004978789 according to table 4.33 which means that every single month the interest rate reverts back to the equilibrium by roughly 0.5% point of the deviation. The long run equilibrium value of lending rate for Commercial Banks is 15.67794437.

From table 4.36, A 2 tailed distribution test was done with a significance level of 0.05, and the p-value obtained (i.e., 0.473) is greater than 0.05, showing that the Vasicek model does indeed significantly explain the dynamics of the monthly lending rate of Commercial Banks over the years from 1991 to 2022.

A forecast using eqn 6 was done to test the accuracy of the model. According to the results from table 4.34, interest rate for the month of August was used as the base rate to predict the interest for the month of October, time ( $t=2$ ) was in months. The original lending rate for the month of October was 12.39 and the predicted value is 12.39749678. From the forecast in table 4.34 we can see that the further in

the future we are the more dominating the long run equilibrium is and the less relevant the current lending rate for our forecast. Which means when  $t = \infty$  our lending rate forecast becomes the long run equilibrium  $b$ .

We calculate the lending rate variance using eqn 7 and find the square root of the variance to get volatility at 0.904832533. Which means that over the course of 2 months the average lending rate will be 12.39749678 but on average it will deviate from the forecast by around 0.904832533 basis points. The long run volatility is calculated using eqn 9 giving 6.37985044.

In terms of impact of estimated parameters on volatility and lending rate forecast we can see that the more the stochastic factors impact the lending rate in the short run the more volatile the lending rate is in the long run, but also the smaller the convergence parameter  $\alpha$  is, the larger the variance would be. If the convergence speed is very low the lending rate can deviate for quite a long time unpredictably from the equilibrium level of 15.67794437.

#### **4.4 Hypothesis Testing**

Based on the objective of the study we formulate a hypothesis as below: We want to find out if the Russia-Ukraine war did affect the lending rate of Commercial Banks

$H_0$ : Russia-Ukraine war had a significant impact on Commercial Banks lending rate

$H_1$ : Russia-Ukraine war did not have a significant impact on Commercial Banks lending rate

From table 4.34;

- chi-square statistic (calculated) = 0.002478,
- Degrees of freedom  $(12-1) * (2-1) = 11$
- Significance level = 0.05
- $\chi^2_{0.05,11} = 19.68$
- Therefore, chi-square statistic tabulated = 19.68

Since  $0.002478 < 19.68$ , we do not have sufficient evidence to reject the null hypothesis and so we should conclude that there is insufficient evidence that the Russia-Ukraine war had a significant impact on Commercial Banks lending rate.

## CHAPTER FIVE

### SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

#### 5.1. CONCLUSION

In this study we explored the effect of Russia-Ukraine war on the cost of borrowing using the discrete form of the Vasicek model (1977) and commercial banks' lending rate as the variable. Statistical significance of the model was calculated based on the results on table 4.35. the p-value of interaction of  $-a$  (convergence speed) with a value of 0.39 and the product of convergence speed and equilibrium ( $a*b$ ) with a value of 0.47 are greater than 0.05 significance level hence prove of negative relationship. The Vasicek model would be unbiased but could be quite imprecise if the standard error was symmetric but heavy-tailed or if the standard error variance is large( $>1$ ).

The continuous form of the Vasicek model (eqn3) which is basically a stochastic differential equation was difficult to calibrate using dated data, as a result we represented the Vasicek model in discrete form (eqn4) and calibrated using the ordinary least squares regression. The model had lower standard error based on results on table 4.35, where  $\alpha$  represented the speed of convergence/reversion of lending rate back to the equilibrium level ( $b$ ),  $\Delta t$  represented change in time in months and  $\sigma^2$  represented the variance of the model which is used to calculate the volatility of lending rate.

Moreover, it is clearly evident that the more the stochastic factors impact the lending rate in the short run the more volatile the lending rate is in the long run, but also the smaller the convergence parameter  $\alpha$  is, the larger the variance would be. If the convergence speed is very low the lending rate can deviate for quite a long time unpredictably from the equilibrium level of 15.67794437. This can be observed from table 4.38. The hypothesis test (4.4) was done to determine the effect of Russia-Ukraine war on lending rate, where we accept:

$H_0$ : Russia-Ukraine war had a significant impact on Commercial Banks lending rate and reject:

$H_1$ : Russia-Ukraine war did not have a significant impact on Commercial Banks lending rate.

From results on table 4.34 we fail to reject the null hypothesis ( $H_0$ ).

## **5.2. RECOMMENDATIONS**

The results of this paper have an important policy implication for borrowers and the government. It is well known that lending rate is the rate banks and other financial institutions use to lend funds in the form of loans to their customers. Increase in lending rates have a negative effect on economic growth. From results on table 4.38 the long run lending rate is 15.67794437, this clearly shows that lending rates are expected to increase over time into the future. Since this increase will have a negative impact on economic growth the government should salvage the situation with the following recommendations:

Favorable stock market conditions which attract international investors who lend to domestic companies or invest in domestic markets therefore contributing to domestic money supply and lending dynamics. The government should reduce the fiscal deficit by coming up with cost-effective revenue collection methods and reduce domestic borrowing, an increase in domestic borrowing overshadows the borrowing population and in turn pushes up lending rates. The government should also increase the amount of money made available to borrowers by lowering the CBR rate therefore making it profitable for commercial banks and lending institutions to lend money, this will in turn lower the rates.

## **5.3. LIMITATIONS OF THE STUDY**

The study focused on the effect of Russia-Ukraine war on the cost of borrowing with the lending rate as a proxy instead of borrowers. The study also looked at lending rate alone while various other factors can be included in the model.

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## APPENDIX

### APPENDIX 1

	MAY	24.16	(3.39)	20.77		volatitlity
	JUN	24.51	(0.35)	24.16		
	JUL	25.45	(0.94)	24.51		
	AUG	26.37	(0.92)	25.45		
	SEP	27.04	(0.67)	26.37		
	OCT	30.06	(3.02)	27.04		
	NOV	30.81	(0.75)	30.06		
	DEC	31.64	(0.83)	30.81		
1994	JAN	32.18	(0.54)	31.64		
	FEB	32.16	0.02	32.18		