Investigating the Relationship Between Inflation and its Effect on Medium- to Long-Term Bond Yields: A Kenyan Case Study

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VT OMNES VNVM SINT

List of Abbreviations

ADF Augmented Dickey-Fuller

CBK Central Bank of Kenya

CBR Central Bank Rate

CPI Consumer Price Index

IMF International Monetary Fund

IV Instrumental Variable

GDP Gross Domestic Produce

KNBS Kenya National Bureau of Statistics

OLS Ordinary Least Squares

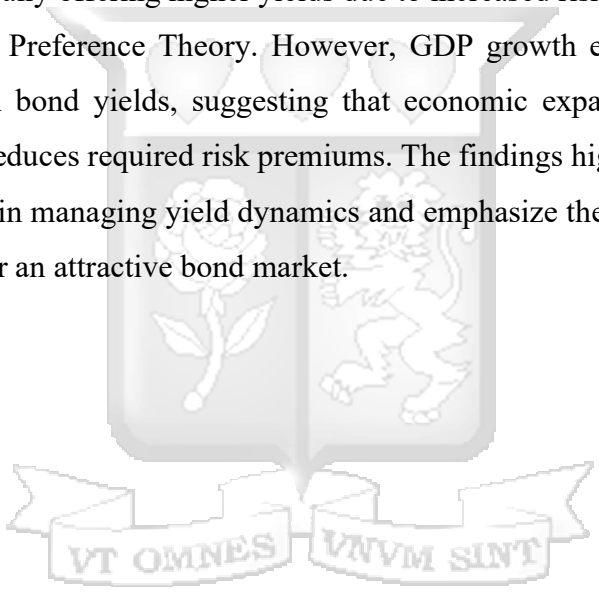
VAR Vector Autoregressive

VIF Variance Inflation Factor

YTM Yield-to-Maturity

ABSTRACT

This study examines the determinants of government bond yields in Kenya, with a particular focus on bond tenor, inflation, and key macroeconomic variables such as the Central Bank Rate (CBR), GDP growth, and changes in money supply (M3). Using Ordinary Least Squares (OLS) regression and Instrumental Variables (IV) analysis on a dataset spanning 2013 to 2023, the study finds that inflation and the CBR significantly impact bond yields. A higher CBR leads to increased bond yields, reinforcing the Expectations Hypothesis, while inflation also exerts upward pressure on yields, in line with the Fisher Effect. Bond tenor plays a crucial role in yield determination, with longer-term bonds generally offering higher yields due to increased risk premiums, as suggested by the Liquidity Preference Theory. However, GDP growth exhibits a weak negative relationship with bond yields, suggesting that economic expansion enhances investor confidence and reduces required risk premiums. The findings highlight the importance of monetary policy in managing yield dynamics and emphasize the need for stable inflation targeting to foster an attractive bond market.



Chapter 1: Introduction

1.1 Background Information

Inflation, a persistent increase in the general price level of goods and services, is a critical economic indicator that influences various financial markets, including the bond market. Kariuki & Kagiri (2017) highlights the role of the bond market in promoting growth in the Kenyan economy. A well-developed foundation of the relationship between inflation and bond prices tends to be essential for major players in the financial word such as investors, policymakers, and economists especially due to the fact that the debt securities market in Kenya is severely underdeveloped compared to those of developed countries. This study aims to explore the intricate dynamics between inflation and bonds, with a particular focus on the yield curve, which serves as a vital instrument for predicting economic trends and making well calculated decisions for their investments.

The bond market is often regarded as a reliable predictor of inflation and overall economic direction, influencing investment strategies across various asset classes. The yield curve, which depicts the link between short-term and long-term interest rates, is an important element in this predictive power. A thorough understanding of the yield curve, investors are able to make better financial decisions, as it provides insights into future economic activity and interest rate expectations. The yield curve's different shapes—normal, steep, flat, and inverted—offer valuable indications of economic conditions and potential recessions. Bond yields, particularly the yield to maturity (YTM), provide a standardized measure of return and reflect the discount rate used to equate a bond's cash flows to its price. Short-term interest rates, influenced by central bank policies, impact borrowing and economic activity, while long-term rates are determined by market forces and reflect future inflation expectations. The connection between short-term and long-term rates is essential for making well-informed investment decisions. Estrella & Mishkin (1996) showcase the ability of the yield curve in forecasting the occurrence of a recession in the economy.

Differentiating between interest rates and bond yields is vital for investors in the fixed-income market, as they determine the cost of borrowing and the return on investment. Reilly & Brown (2011) show how inflation and interest rates move in the opposite direction from bond prices. When inflation rises, bond prices tend to drop because investors worry that the bond's return (yield) will lose value due to the rising costs of inflation, leading to decreased demand for bonds. This inverse relationship between bond prices and yields can be likened to a seesaw: when bond prices go up, yields go down, and vice versa. A rise in either interest rates or the inflation rate usually makes bond prices drop. When the Central Bank raises its target interest rate, other interest rates and bond yields typically rise as well, causing the prices of existing bonds to fall.

According to Fabozzi & Fabozzi (2021) the impact of inflation and interest rate changes on bonds is not uniform across all types of bonds. Short-term interest rates may feel the effects of any Central Bank action almost immediately, but longer-term bonds are likely to see the greatest price changes. Additionally, a bond mutual fund may be affected somewhat differently than an individual bond.

1.2 Problem Statement

There then becomes the need to understand how inflation affects government bond yields, especially in emerging markets like that of Kenya where inflationary pressures have the possibility to be volatile. In recent years, Kenya has experienced fluctuating inflation rates, driven by various factors such as global economic conditions, exchange rate dynamics, and domestic fiscal policies. These fluctuations have raised concerns about their impact on the government bond market, which is a vital source of financing for public projects and a key instrument for monetary policy implementation.

The choice of Kenya stems as a result of the country being more susceptible to inflationary shocks when compared to more developed economies. Furthermore, Kenya's economic structure economic structure, reliance on imports, and sensitivity to global commodity prices make it vulnerable to inflation shocks. In addition, the Kenyan government bond market has grown significantly over the past decade in turn becoming a critical component of the financial sector.

With recent global developments such as the COVID-19 pandemic and Ukraine-Russia war the time frame of 2013-2023 presents an opportunity to investigate how the inflation movements from these events affected the bond market structure.

As such, the fundamental question becomes to investigate the effect that inflation could have had on the government bond yield curve in Kenya's recent past. Furthermore, it becomes imperative to investigate this relationship across both short-term and long-term government bonds.

1.3 Research Objectives

Owing to the above, this study aims to:

1) Investigate the impact inflation has on the underlying yield of government bonds by observing the direct relationship between inflation and bond yields and whether that influence is significant.
2) Investigate the effect of additional macroeconomic variables such as the Central Bank Rate, Money Supply (M3), and National GDP Growth Rate have on bond yields and whether inflation retains its standalone influence on yields or if the effect varies.

1.4 Significance of the Research

Understanding the relationship between inflation and bond yields in Kenya is essential for making informed investment decisions and formulating effective economic policies. This research will contribute valuable insights into how inflation influences the Kenyan bond market, offering guidance for investors, policymakers, and economists as they navigate the challenges posed by inflation in a developing economy. Adding to the fact that the bond market is only majorly used from the government aspect, this study also could be useful in directing any private sector aspiring bond issuers on how the economy reacts to inflation movements in structuring up bonds.

Chapter 2: Literature Review

2.1 Introduction

In this chapter, the literature review relates to bond pricing and the relationship with inflation. This is done by focusing on public (government) bonds due to the nature of the Kenyan bond market being underdeveloped and there being the lack of significant issues of corporate bonds. As such, matters concerning nominal interest and real interest rates are also discussed. In this chapter, section 2.2 discusses a theoretical breakdown of interest rates, inflation and bond rates whereas section 2.3 touches on empirical studies relating to the relationship between inflation, interest rates and bond prices (yield curve) with section 2.4 giving possible research gaps arising from the review of past studies.

2.2 Theoretical Literature Review

Section 2.2 introduces us to the base theories that were developed to try and explain the effect inflation has in affecting bond terms.

2.2.1 Fisher's Theory

One of the earliest studies into the relationship between inflation and interest rates was Fisher (1930). It discovered that the bond's yield curve would also move in relation to the movement in inflation since inflation results in an increase in the interest rate. In this study, it was hypothesized that the nominal rate of interest was equivalent to the sum of the real interest rate and the expected rate of inflation. The following assumption was also made, that inflationary expectations were formed on the basis of a distributed lag structure. The main thesis as a result was that future short-term rates were the primary determinant of long-term interest rates, and this could be captured through the following equation:

$$i = r + \pi^e$$

where i is the nominal interest rate, r is the real interest rate and π^e is the expected inflation. This study was beneficial in that it provided a foundational link between interest rates and inflation and as a whole, bond yields since inflation raising the overall interest rates and in turn However, the theory also made certain assumptions that were not the case in reality such as the real interest rate being constant.

Mishkin (1981) tested the Expectations theory using empirical data. In this study, it was assumed that investors form expectations rationally and as such the term structure reflects these expectations. The main thesis was still in the line that the term structure of interest rates can predict future changes in short-term rates. Empirical evidence supporting the hypothesis was provided but it was noted that there were deviations due to the presence of risk premiums. This study was beneficial in that it was an empirical validation and refinement of the Fisher (1930) study. However, the study also highlighted that real world deviations occur due to risk and liquidity preferences.

2.2.2 Arbitrage Pricing Theory (APT)

The Arbitrage Pricing Theory (APT) was developed by Stephen A. Ross in 1976. Its main purpose was to provide a multi-factor model for asset pricing that would be able to capture the influence of various economic factors on asset returns.

The basic assumptions made for this theory are that markets are efficient, investors can construct portfolios to eliminate non-systematic risk, and asset returns can be described by a linear combination of systematic risk factors. Out of these assumptions, the most ambitious one would be that markets are efficient since in most cases that turns out to be incorrect.

The main thesis was that expected return on an asset is a function of various macroeconomic factors each having its own risk premium. The equation for APT is:

$$E(R_i) = R_f + \beta_{i_1} F_1 + \beta_{i_2} F_2 + \cdots \beta_{i_n} F_n$$

where $E(R_i)$ is the expected return of the asset, R_f is the risk-free rate, B_i is the sensitivity of the asset in relation to the specified factor and F_i is the risk premium of the specified factor.

The theory was generally an improvement from the Capital Asset Pricing Model (CAPM) since it could explain the cross section of asset returns better than single factor models. In addition, it was flexible in incorporating multiple factors that would affect asset returns.

It was however challenging since it did not specify which factors should be included, and the theory was more complex and data intensive as compared to the CAPM.

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2.2.3 Merton's Extension of the Black-Scholes Model

This theory was developed by Robert C. Merton in 1973 as he expounded on the Black-Scholes Model of 1973. The main purpose of this theory was to extend the Black-Scholes option pricing model to be applicable to a wider range of financial securities such as bonds that even had embedded options.

Some of the basic assumptions of the theory included that markets are frictionless; investors can continuously trade securities and no arbitrage opportunities exist.

The main thesis here was that bonds with embedded options, for example, callable or convertible bonds, could be priced using option pricing techniques. The price would be viewed as a combination of a risk-free bond and options on the underlying asset.

$$P_{callable\ bonds} = P_{straight\ bond} - C_{call\ option}$$

This theory is good in that it provides a rigorous framework for pricing complex bonds, and it extends the Black-Scholes model to fixed income markets. On the other hand, the theory assumes that there exist continuous trading and frictionless markets which in reality might not be the case.

2.2.4 Cox-Ingersoll-Ross Model (CIR)

Cox, Ingersoll, & Ross (1985) discusses the modelling of the term structure of interest rates as well as pricing bonds. The theory has a couple of assumptions, the main ones being interest rates follow a mean-reverting stochastic process and markets are frictionless and arbitrage free. The main thesis of the theory is that interest rates are modelled as a mean-reverting stochastic process, which captures their dynamic nature over time.

This allows for the pricing of zero-coupon bonds and the derivation of the yield curve, through the following equation:

$$dr_t = \kappa(\theta - r_t)dt + \sigma\sqrt{r_t}dW_t$$

where $r_t$is the short-term interest rate, κ is the speed of mean reversion, θ is the long-term mean interest rate, σ is the volatility of interest rate changes, and dWt is a Wiener process.

The theory is useful in that it captures the mean-reverting behaviour of interest rates observed in real life and provides closed form solutions for bond prices. It is also widely used in both theoretical and empirical research.

Limitations to the CIR model include, it requires estimating multiple parameters making it complex, the mean reverting assumption may not always be observed in practice, and the theory may not capture all aspects of interest rate dynamics, especially in volatile markets.

2.3 Empirical Literature Review

Malkiel (1962) touches on the relationship between short-term and long-term yields through the development of a theoretical framework. The researcher found out that investors would demand a higher yield for long-term bonds if there was the expectation that interest rates would rise. Consequently, the term structure of interest rates would tend to flatten out as the time to maturity progressed. This revelation implied that investors sought out more compensation from their investments to hedge against inflation risks and interest rate volatility.

Fama & Schwert (1977) investigated the possibility of different assets being hedges against expected and unexpected components of inflation during the 1953-1971 period. From the study, it was discovered that out of all the asset classes they investigated, government bonds were a complete hedge against expected inflation only. This was obtained through the testing of the annualized returns of government bonds (obtained from an index) against the expected inflation and unexpected inflation through a regression model. The expected inflation values were obtained from subtracting the constant expected real return from the nominal return of the interest rate.

In Brennan & Schwartz (1979), further theories on the term structure of interest rates are developed. This theory rests on the notion that the value of all default-free discount bonds can be described as a function of time and two interest rates—the immediate rate and the long-term rate—which progress together according to a joint Markov process in continuous time. The model was utilized to determine the pricing of a sample of Canadian government bonds. According to Fried & Howitt (1983), high inflation, which was generally associated with high nominal interest rates, did not necessarily equate to high

interest rates in the long run. This conclusion was arrived at by studying the interaction between the following players: the government, firms and households as they traded in labour services, a malleable capital-consumption good, government bonds and money. There is also the creation of a liquidity function that was in turn used in the examining of the research topic. The study was advantageous in that it made a valuable contribution to the understanding of inflation and its relationship with real interest rates.

Longstaff & Schwartz (1993) studied the effect that interest rate volatility had on bond prices. The study used data from the US Treasury yield from 1964-1989 and from it estimated the following regression:

$$\Delta Y_T = \alpha + \beta \Delta \mathrm{r} + \gamma \Delta \mathrm{V} + \epsilon$$

Where:

- ΔY_T represents the change in the Treasury yields for specific maturities on a monthly interval of time.
- The regression parameter γ is a measure of how sensitive changes in yields are to changes in interest rate volatility.
- $\Delta \mathrm{r}$ represents the month-to-month change of a Treasury-bill's yield with one month maturity.
- $\Delta \mathrm{V}$ the interest rate's volatility change.
- β measures how sensitive changes in T-maturity Treasury yields are to changes in the short-term interest rate r.

The study discovered that fluctuations in the interest rate volatility can significantly influence the prices and yields of bonds. These impacts are largely independent of the bond's duration or convexity. Notably, intermediate-term bonds experience the most substantial effects on their prices and yields due to these changes. A shortcoming of the theory is that it only focuses on one factor but in turn gives us a simple, closed-form solution for the value of bonds in terms of their maturity, the short-term interest rate, and the level of interest rate volatility. This study aims to look at it from the modern Kenyan perspective since this study uses American data from 1964-1989.

Bar & Campbell (1997) looked into the estimation of expected future real interest rates and inflation rates from the observed prices of the UK government and index-linked bonds. Data from end-of-month clean bond prices from January 1985 to October 1994 was supplied by the Bank of England. The study used two primary methodologies, the first one being a macro model approach involving a macroeconomic model that assumes that real yields depend on inflation and output growth. The second methodology involves a non-parametric approach that extracts a risk-free rate of return from the prices of nominal and index-linked bonds by exploiting differences in yields between them. In particular, the authors show how the real yield can be calculated as the nominal yield minus the inflation expectation implied by the ratio of the prices of index-linked bonds to nominal bonds with the same maturity. The study used both a macroeconomic model and non-parametric model thus showcasing that it is a comprehensive analysis of the relationship between bond prices, inflation and real interest rates. It, however, only focuses on data from a relatively long period ago and only in the UK. Possible further studies could be trying to research on this phenomenon in Kenya while looking at government bonds in the country.

Ngaruiya & Njuguna (2016) studies the effects of inflation on bond prices in the Kenyan securities exchange. Using data from the Nairobi Securities Exchange (NSE) and the Kenya National Bureau of Statistics (KNBS), the study used an explanatory research design where they examined 65 bonds listed across 23 categories and a sample of 10 bonds were used since these had been issued in January 2008 and had not matured by the end of December 2012. From the above data, the authors, calculated the standard deviations as well as carried out correlation and regression analysis where bond prices were regressed against inflation, exchange rates and economic growth measured using the Kenya's Gross Domestic Product growth. From this study, it was found that inflation and bond prices had a negative correlation and that an increase in inflation generally resulted in a decrease in bond prices. This study was beneficial in that it gave an outlook as to how a study carried out in Kenya would look like. Furthermore, the study used correlation and regression analysis to come up with a model to present their findings. On the other hand, the small sample size of 10 bonds might have probably led to the production of imprecise estimates. Further studies that could be born from this include the possibility of conducting research

using more recent data as well as including more data in our sample set that is used for analysis in the attempt to obtain more precise estimates.

2.4 Research Gap

Following the review of past studies, various research gaps have been identified that this study seeks to address. First, much of the existing literature, such as that of Bar & Campbell (1997) and Longstaff & Schwartz (1993), focuses on data from earlier decades, spanning from 1964-1994, and primarily from developed markets like the United States of America and the United Kingdom. These studies, while foundational, may not fully capture the current dynamics of bond markets, particularly in the context of developing economies like Kenya, where economic conditions and inflationary trends can differ significantly.

Additionally, most previous research has primarily examined the single direct relationship between inflation and bond yields, often overlooking other important variables that could interact or affect inflation to influence bond yields. For instance, factors such as exchange rates, economic growth, and market liquidity might also play significant roles in shaping bond yields, especially in an emerging market like Kenya. Previous studies, like Ngaruiya & Njuguna (2016), have touched on these variables, but their findings are limited by small sample sizes and a narrow focus on a specific time period.

This study aims to fill these gaps by analysing more recent and comprehensive bond data from the Kenyan market between the years 2013-2023, thereby providing updated insights into the relationship between inflation and bond yields. Furthermore, by incorporating additional economic variables that interact with inflation such as the current money supply in the economy, and the Central Bank Rate, this research seeks to develop a more holistic understanding of the factors that influence bond yields in Kenya. This approach not only contributes to the existing body of knowledge but also offers practical insights for policymakers and investors operating in similar economic environments.

Chapter 3: Methodology

3.1 Introduction

This chapter talks on the methodology applied in the investigation into the effect inflation has on bond yields. Section 3.2 introduces the research design method, section 3.3 entails the framework used in the study and 3.4 contains the data sources and collection methods that will be in use.

3.2 Research Design

This study adopts a quantitative research design to scrutinize the effects of inflation on bond yields within the Kenyan economic context. By analysing a dataset spanning from 2013–2023), the research aims to uncover both short-term and long-term dynamics in the relationship between inflation and bond yields. The chosen period encapsulates various economic cycles, including periods of stability and volatility, thereby providing a robust framework for analysis.

3.3 Population and Sampling

The population set for this study involves the use of all newly issued government bonds, identified by their International Securities Identification Number (ISIN), while focusing on the interest rates offered issued between 2013 and 2023 on a monthly scale. By choosing a relatively large time period, the study is able to capture various economic cycles and in turn provide a comprehensive understanding of the relationship between inflation and bond yields.

3.4 Data

The primary variables of interest in this study are the inflation rate and government bond yields. Inflation will be measured using the Consumer Price Index (CPI), which reflects the percentage change in the prices of a predetermined basket of goods and services over time. Government bond yields, focusing specifically on both medium-term (such as 5-year bonds) and long-term (such as 10-year bonds) securities but with the inclusion of 2- and 3-year bonds, will serve as the main indicator of interest rates in the bond market.

To control for other factors that might influence bond yields, several secondary variables will be incorporated into the analysis. These include:

Central Bank Rate (CBR): The Central Bank Rate (CBR), determined by the Central Bank of Kenya (CBK), directly influences interest rates across the economy. When the CBR changes, it affects the cost of borrowing for banks, which in turn impacts lending rates and bond yields. A higher CBR typically leads to increased bond yields as investors seek higher returns to match rising interest rates, while a lower CBR can lead to reduced yields as borrowing costs decrease. This phenomenon is usually attributed to Fisher (1930) where the study proposed that nominal interests moved along with inflation rates. Since the interest rates are highly related to bond yields, bond yields would naturally move in sync.

Bond Tenor: Bond tenor, or the maturity period of a bond, plays a crucial role in determining its yield. Generally, longer-tenor bonds tend to offer higher yields compared to shorter-tenor bonds due to the increased risk associated with holding a bond for an extended period. Investors demand higher compensation for the uncertainty surrounding inflation, interest rate fluctuations, and credit risk over time. This relationship aligns with the Expectations Hypothesis of the term structure of interest rates Cox, Ingersoll, & Ross (1985), which suggests that long-term yields reflect expectations of future short-term rates. Additionally, the Liquidity Preference Theory Keynes (1936) posits that investors prefer liquidity and, therefore, require a premium for holding longer-term securities, leading to an upward-sloping yield curve under normal market conditions.

Gross Domestic Product (GDP) Growth Rate: The GDP growth rate is a key indicator of economic health and affects investor sentiment. A strong GDP growth rate generally boosts confidence in the economy, increasing demand for bonds and potentially lowering yields. Conversely, sluggish growth may lead to lower bond demand and higher yields as investors seek safer returns or adjust their portfolios based on economic outlook.

Change in Money Supply (M3): Changes in the money supply (M3) can significantly influence inflation, which in turn affects bond yields. When the money supply increases, it often leads to higher inflation as more money chases the same amount of goods and services. In response, bond investors demand higher yields to compensate for the reduced purchasing power of future cash flows. This relationship is particularly pronounced in long-term bonds, where inflation expectations play a key role in determining yields.

Consequently, central banks' control of the money supply is crucial in managing inflation and stabilizing bond markets.

Data for these variables will be sourced primarily from the Kenya National Bureau of Statistics (KNBS) and the Central Bank of Kenya (CBK). Supplementary data and reports would most probably be obtained from international institutions such as the International Monetary Fund (IMF) and the World Bank to ensure data accuracy and completeness.

Seeing as the data is usually audited before publication it would be safe to assume that the data collected for use is accurate and

3.5 Data Analysis

3.5.1 Summary Statistics

Data analysis uses descriptive measures to obtain the summary statistics such as mean, median and variance. Trend analyses will chart the movement of both inflation rates and bond yields over the selected period, in an attempt to identify any noticeable patterns or anomalies. Furthermore, distribution plots will be used to visualize the data, providing insights into their characteristics.

3.5.2 Diagnostic Tests

The data in use has an aspect of time series and as a result the study conducted a stationary test. A unit root test was conducted through the Augmented Dickey-Fuller (ADF) test check for stationarity in the time series data. This is crucial to avoid spurious regression results.

The study went to also conduct a Variance Inflation Factor (VIF) assess the presence of multicollinearity among the independent variables that would be used in the regression. Subsequently, correlation analyses will be conducted to assess the strength and direction of the relationships between the variables. The Pearson correlation coefficient will serve as the primary metric for this purpose.

3.5.3 Model Selection

For a more in-depth examination, several regression analyses will be run:

Simple Linear Regression: This model will evaluate the direct relationship between inflation and bond yields. This is in turn done by focusing only on the variables of inflation and the observed bond yields for each corresponding period. The equation is specified as $Bond\,Yield = \beta_0 + \beta_1 Inflation + \epsilon$ where β0 is the intercept, β1 the coefficient for inflation, and ϵ the error term.

Multiple Linear Regression: To account for the influence of secondary variables which could still have an effect on bond yields, a multiple regression model that can accommodate more variables will be specified as: $Bond\,Yield = \beta_0 + \beta_1 Inflation + \beta_2 Tenor + \beta_3 CBR + \beta_3 GDP\ Growth\ Rate + \beta_5 Money\ Suppy + \epsilon$

This model allows for isolating the effect of inflation on bond yields while controlling for other economic factors.

The optimization method in use would be the Ordinary Least Squares (OLS) method. OLS would be in use for a variety of reasons. First, OLS provides unbiased estimates of the coefficients implying that on average the estimates are equal to the true population parameters. Furthermore, OLS is the most efficient linear unbiased estimator under the Gauss-Markov assumptions. In addition, the data sourced from the CBK website does not follow a specific issue pattern therefore models such as the Vector Autoregressive Model (VAR) would not be best to use due to the lack of specific intervals from which lags could be used. Lastly, OLS is relatively simple to implement and straightforward, making it ideal for use in this study.

For this study to take place, a number of assumptions have been made. As stated above, it is assumed that the data is subject to the Gauss-Markov assumptions which imply that the relationship between the dependent variable and independent variables are linear, the residuals are normally distributed and homoscedastic. Lastly, there should not be perfect multicollinearity amongst the independent variables. This would have been confirmed by running a test to check on the possibility.

3.5.4 Expected Outcomes

Drawing from existing literature, such as the work of Fama and Schwert (1977), which highlighted the positive relationship between inflation and bond yields, specifically,

higher inflation rates are expected to exert upward pressure on bond yields as investors seek compensation for the erosion of purchasing power. It is anticipated that the study will reveal a significant correlation between these variables in the Kenyan context.

Chapter 4: Data Analysis

4.1 Introduction

This chapter presents the results of the analysis conducted on the dataset. The discussion is divided into three main sections: descriptive statistics, diagnostic tests, and regression analysis. The findings from these analyses provide insights into the relationships between the variables and serve as the basis for conclusions and recommendations.

4.2 Descriptive Statistics

Descriptive statistics summarize the main features of the data, including measures of central tendency and variability. These statistics provide an overview of the dataset used in this study.

4.2.1 Summary Statistics

Table 4.1 presents the summary statistics for the key variables used in the analysis, including the mean, standard deviation, minimum, and maximum values.

VARIABLES	Unit of Measurement	N	Mean	SD	Min	Max
Tenor	Years	31	6.677419	3.015373	2.0000	10.0000
Redemption Yield	Percent	31	12.992065	1.982429	9.4860	18.3854
Annual Average Inflation	Percent	31	6.323548	1.403701	4.4400	8.7800
Central Bank Rate	Percent	31	9.235484	1.348715	7.0000	12.5000
GDP Growth Rate	Percent	31	1.130774	1.502664	-6.2210	3.8000
Change In M3	Kshs '00000' Millions	31	1.228048	1.289860	-0.1080666	5.18683

Table 4.1 Summary Statistics

Table 4.1 presents the summary statistics for the key variables used in the analysis, including the mean, standard deviation, minimum, and maximum values.

From all bond issues, it is observed that the redemption yield ranged from 9.49% to 18.39% with a mean yield of 12.99% across the issues and a standard deviation of 1.98%, which would imply that there were no outliers in the data. Inflation on the other hand ranged from 4.4% to 8.8% with a mean inflation rate of 6.3% and a standard deviation of 1.4%. The bonds mainly consisted of 5-year and ten-year tenor bonds, but a few 2-year and 3-year bonds were included. This resulted in an average tenor length of 6.7 years with a minimum tenor length of 2 years and a maximum of 10.

Table 4.1 shows that the Central Bank Rate averaged at around 9.2% with a standard deviation of 1.3%. The variable ranged from 7.0% to 12.5%. Kenya's GDP Growth Rate ranged from -6.2% to 3.8% with an average growth rate of 1.1% per quarter and a standard deviation of 1.5%. The final variable under observation was the change in money supply M3. The changes averaged at Kshs 122,000 million with a standard deviation of approximately Kshs 129,000 million and a spread from Kshs -10,800 to around Kshs 518,000 million.

VT OMNES VNVM SINT

4.2.2 Trends and Patterns

Given that 5-year and 10-year bonds were the most numerous observations, charts were plotted to observe how the key variables under investigation, Redemption yield and Annual Inflation, evolved over time.

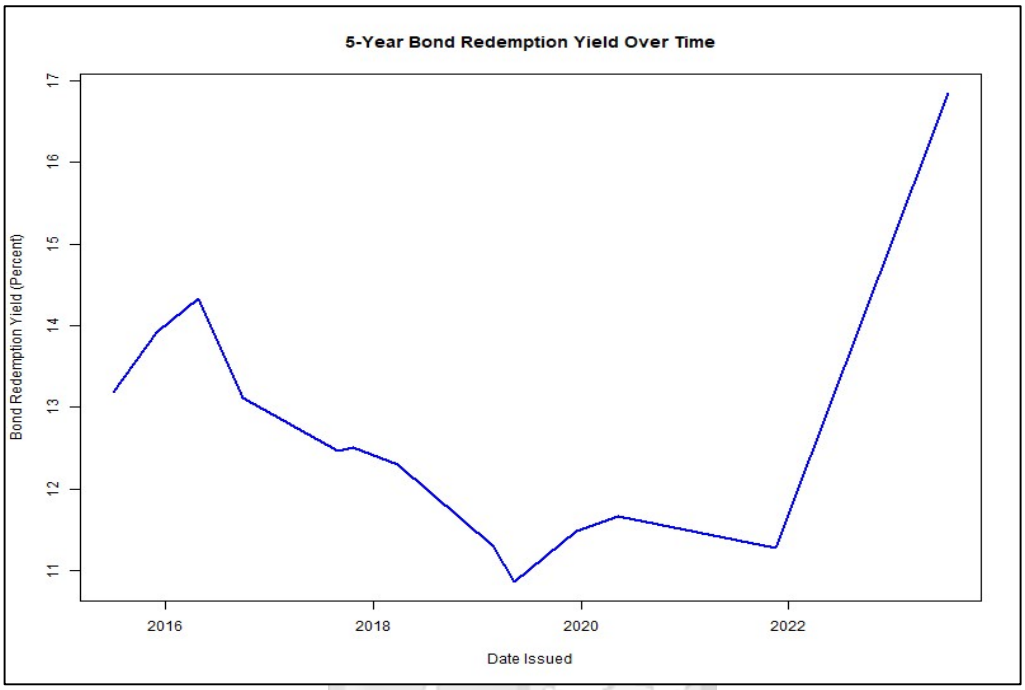

Figure 4.1 5-Year Bonds' Redemption Yield

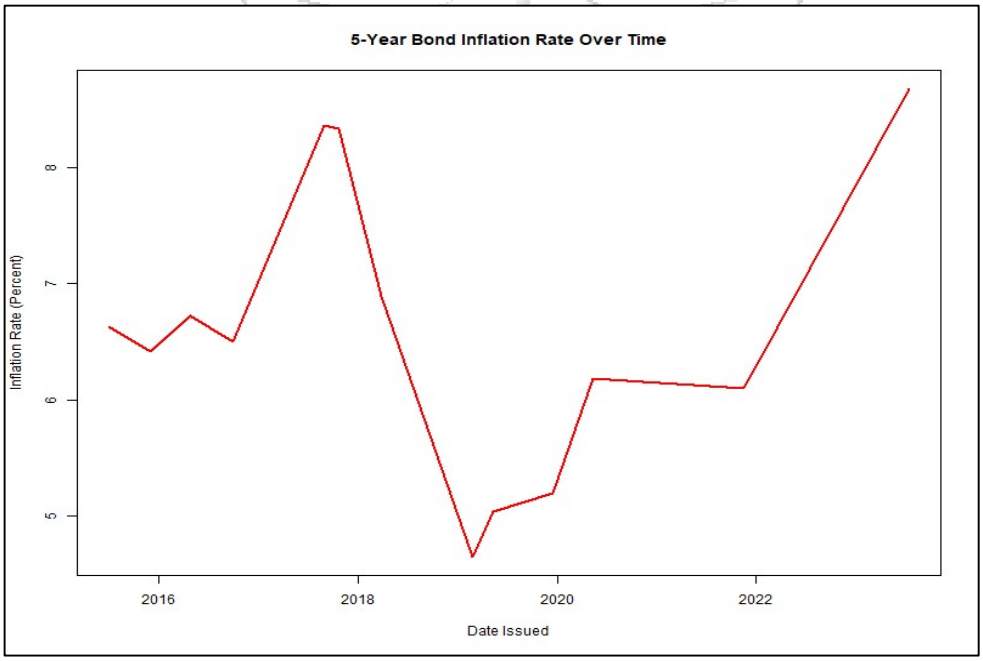

Figure 4. 2 5-Year Bonds' Inflation Rate

From the first pair of graphs, the study takes a glance at the movement of the bond redemption yield and the corresponding inflation rate. The study observed that the movement of both the inflation rate and bond yield was tied closely together in that when inflation rates rose, the bond yields rose as well. Similarly, in periods of a decrease in inflation, the bond yields declined as well.

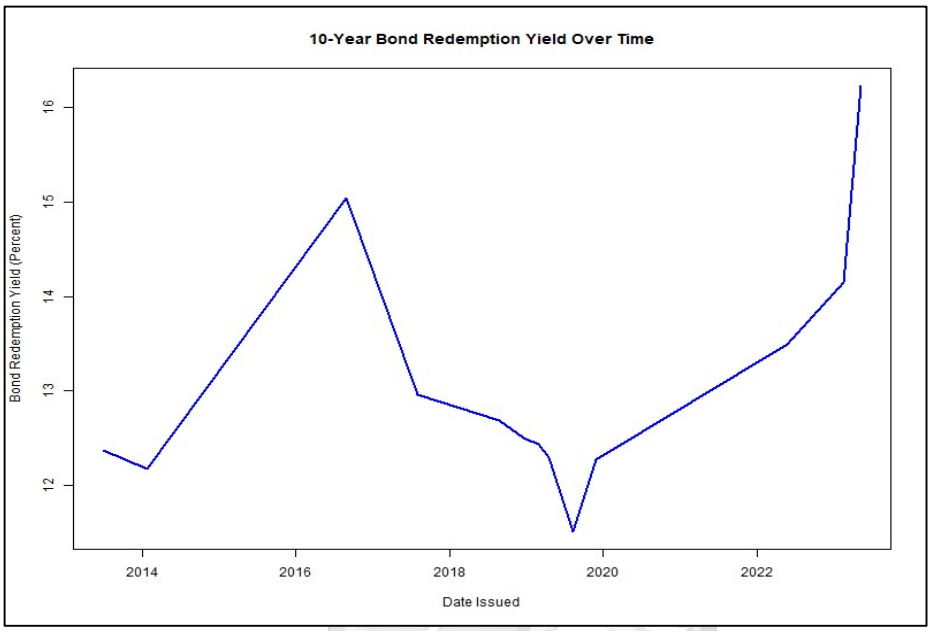

Figure 4. 3 10-Year Bonds' Redemption Yield

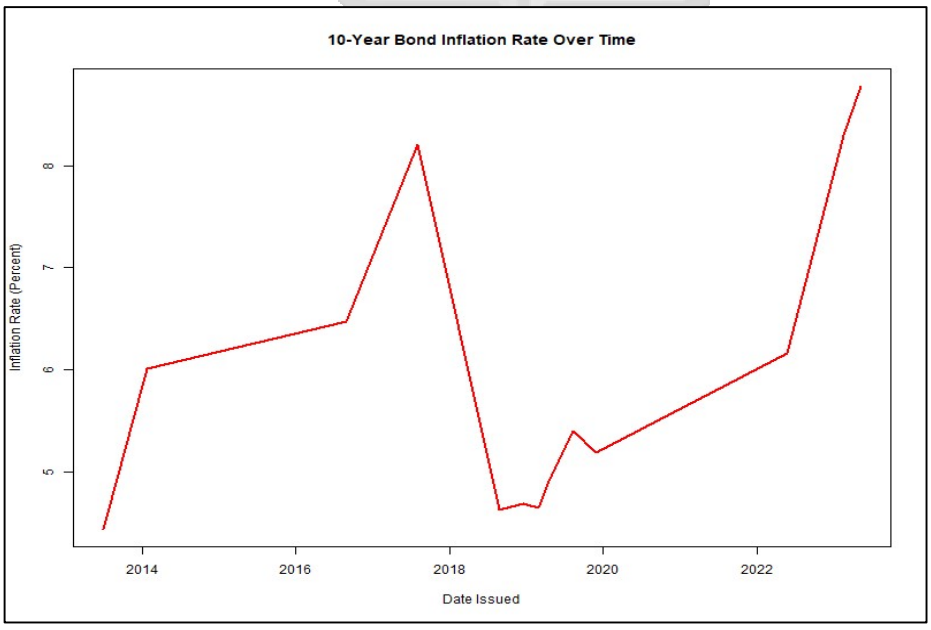

Figure 4. 4 10-Year Bonds' Inflation Rate

In a similar fashion, when the variables were charted but now for the 10-year bonds it was observed that the two graphs had near identical movements indicating that the relationship between the two was highly correlated and that more often than not, an increase in inflation went hand in hand with an increase in the bond yield.

4.3 Diagnostic Tests

Before performing regression analysis, diagnostic tests were conducted to ensure the validity of the model. These tests include checking for multicollinearity, normality, and stationarity of the variables.

4.3.1 Multicollinearity Test

The Variance Inflation Factor (VIF) was used to assess multicollinearity among the independent variables.

VARIABLE	VIF
Annual Average Inflation	1.402882
Tenor	1.045540
Central Bank Rate	1.321789
GDP Growth Rate	1.073999
Change in M3	1.133252

Table 4.2 VIF Results

In Table 4.2, the obtained the VIF values for the multiple regression model in use for Objective 2 in the study. Across the board, each variable had a VIF value of less than 5 indicating that there were no concerns of multicollinearity in the dataset. According to James, Witten, Hastie, & Tibshirani (2021) VIF values between 5 to 10 indicated moderate multicollinearity while those with values greater than 10 meant that the collinearity present would be a significant challenge.

4.3.2 Stationarity Test

The Augmented Dickey-Fuller (ADF) test was used to check for stationarity of the variables. The results are presented in Tables 4.5 and 4.6

Variable	ADF Statistic	P-Value
Tenor	-3.0781237	0.1577002
Redemption Yield	0.1913357	0.9900000
Annual Average Inflation	-2.0397084	0.5574751
Central Bank Rate	1.0899749	0.9900000
GDP Growth Rate	-3.0595035	0.1648687
Change in M3	-2.5432369	0.3636239

Table 4.3 Level ADF Results

As observed above the obtained p-value is greater than 0.05 across all parameters which would indicate that the data is non-stationary. Given that the result is non-stationary, the study made use of differencing transformation to try and address this issue.

Variable	ADF Statistic	P-Value
Tenor	-3.313158	0.08829774
Redemption Yield	-2.710068	0.29989702
Annual Average Inflation	-3.621200	0.04728070
Central Bank Rate	-1.905562	0.60896591
GDP Growth Rate	-4.031026	0.02122390
Change in M3	-5.806008	0.01000000

Table 4.4 Differenced ADF Results

With differenced transformations, changes occur across the data and the p-values obtained showcase great reductions. The P-value for the dependent variable (Redemption Yields) decreases to 0.299 from 0.99. It however is still greater than 0.05 indicating non-stationarity. The variables, Annual Inflation, GDP Growth Rate, and Change in M3, all

obtain p-values less than 0.05 showing that with differenced transformation, they become stationary. The variables Tenor and Central Bank Rate, however, are still non-stationary.

4.4 Regression Analysis

The regression analysis examines the relationship between the dependent variable and the independent variables. The models for the two objectives were based on OLS regressions and appeared as follows:

$Bond\ Yield = \beta_0 + \beta_1 Inflation + \epsilon$ for the single regression model and

$Bond\ Yield = \beta_0 + \beta_1 Inflation + \beta_2 Tenor + \beta_3 CBR + \beta_3 GDP\ Growth\ Rate + \beta_5 Money\ Suppy + \epsilon$ for the multiple regression model. The reasoning behind this selection was due to the fact that the data being studied occurred in irregular intervals which would have otherwise made the implementation of VAR models difficult. Stock & Watson (2002) discussed how OLS regression could be applied in forecasting even when the data was irregular or had parts of it missing. It expounded on the fact that OLS proved to be a reliable choice in the study of unevenly spaced time series. Furthermore, Mishkin (1990) used an OLS regression to analyse the relationship between inflation expectations and bond yields instead of applying a VAR framework.

Given that even when differencing transformation was applied to the data, and it still remained non-stationary, the variables were used in their level form when the regressions were carried out. Afterwards, regressions were carried out with the differenced variables.

4.4.1 Level Model Summaries

The following table presents the regression analysis for all newly issued in the last ten years. Two models were estimated in line with the two objectives. Model 1 focuses solely on inflation whereas model 2 incorporates the CBR, GDP Growth Rate, and Change in Money Supply M3. Furthermore, the regressions here use the variables in their level state without any transformation techniques being carried out.

Combined Regression Results		
	Dependent variable:	
	Bond Yields	
	(1)	(2)
Annual Inflation	0.907***	0.531***
	(0.201)	(0.185)
Tenor		0.119
		(0.074)
Central Bank Rate		0.834***
		(0.186)
GDP Growth Rate		-0.128
		(0.151)
Change in M3		0.269
		(0.181)
Constant	7.255***	0.949
	(1.301)	(1.738)
Observations	31	31
R^2	0.413	0.696
Adjusted R^2	0.392	0.635
Residual Std. Error	1.545 (df = 29)	1.198 (df = 25)
F Statistic	20.374*** (df = 1; 29)	11.426*** (df = 5; 25)
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 4.5 Level Regression Results

When looking at the level variables' regression in relation to the first objective, it is observed that the intercept of 7.255 is highly statistically significant due since its p-value falls below 0.01, which is less than our significance level of 0.05 (95% confidence interval). This suggests a baseline bond yield of approximately 7.26% when all explanatory variables are held constant. This result aligns with structural factors in bond markets often discussed in financial literature in Fabozzi & Fabozzi (2021). The intercept's significance implies that even unexplained factors contribute substantially to the baseline yield.

When observing the effect of inflation on a standalone method, Model 1 highlights that inflation has a strong and statistically significant positive effect on bond yields. A 1%

increase in inflation corresponds to an increase of bond yields by 0.907 percentage points with a p-value less than 0.05 which would in turn suggest that higher inflation increases investor expectations of higher rates resulting in the upward movement of yields. In Model 2, with the inclusion of multiple macroeconomic factors, the relationship observed between inflation and bond yields weakens to a supposed 0.531 percentage points increase in bond yields with a 1% increase in inflation. However, the relationship retains its statistical significance. This result aligns with the Fisher Effect, Fisher, (1930) which suggest that bond yields rise in response to higher expected inflation.

In contrast, Model 2 showcases that the most significant driver of bond yields is the central bank rate, with its highly significant and positive relationship. With a coefficient of 0.834 and a p-value less than 0.01, a 1% increase in the rate results in a near 1% increase in the bond yields. This went in line with the expectations hypothesis from the term structure of interest rates Cox, Ingersoll, & Ross (1985) which mentions that long-term yields reflect expectations of future short-term rates.

It should be noted that no other variable was found to be statistically significant. The Change in M3 Money Supply would have been the next most effective variable with a coefficient of 0.269. This would imply that a positive change of Kshs 100,000 million between issues would result in a 0.269 percentage point increase in the bond yields. This aligns with Friedman (1968) where increased money supply growth led to higher yield demands.

The GDP Growth rate was the only variable with an inverse relationship with the independent variable. With a coefficient of -0.128, an increase in the GDP Growth Rate by 1% would result in a decrease of the bond yields by 0.128 percentage points. This phenomenon could be attributed to an increase in investor confidence which manifests in the form of lower risk premiums on government bonds.

The tenor of bonds also had a positive effect on the resulting bond yields although it was not a statistically significant relationship. With a coefficient of 0.119, it would indicate that an increase of bond tenor by one year would increase the bond yields by 0.119 percentage points.

In relation to the overall performance of the models, Model 1 has an adjusted R^2 of 0.392 compared to Model 2's adjusted R^2 of 0.635. This implies that for Model 1, the independent variable explained 39.2% of bond yield movement but with the inclusion of additional factors, 63.5% of the variation could be attributed to the overall macroeconomic factors selected.

4.4.2 Differenced Model Summaries

The following table presents the regression analysis for the same newly issued bonds in the last ten years. However, a key difference here is that the variables underwent differencing transformation when in a bid to induce stationarity amongst the data.

Combined Regression Results for Differenced Variables

	Dependent variable:	
	Bond Yields	
	(1)	(2)
Annual Inflation	0.060	-0.020
	(0.238)	(0.157)
Tenor		0.177***
		(0.034)
Central Bank Rate		0.731***
		(0.181)
GDP Growth Rate		-0.161**
		(0.063)
Change in M3		-0.023
		(0.082)
Constant	0.194	0.149
	(0.197)	(0.128)
Observations	30	30
R^2	0.002	0.650
Adjusted R^2	-0.033	0.577
Residual Std. Error	1.071 (df = 28)	0.685 (df = 24)
F Statistic	0.064 (df = 1; 28)	8.905*** (df = 5; 24)
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 4.6 Differenced Regression Results

When looking at the single regression results for the differenced variable model, it is observed that the intercept coefficient decreases to 0.194. Furthermore, the relationship ceases to be significant in comparison to the level regression results. This would imply that when all factors are held to zero, there is basically no meaningful baseline value. The same could also be said for Model 2 which has a similar coefficient value of 0.149 and is also not statistically significant.

Inflation also does not have a statistically significant relationship with bond yields when the variables are differenced across both models. In the single regression model, it has a coefficient of 0.060 showcasing a very minimal increase in bond yields with a 1% increase in inflation. Interestingly, in the multiple regression model, inflation has an inverse relationship with bond yields albeit with a very minimal coefficient value of -0.020.

The central bank rate retains its status of being the most influential variable while maintaining its highly significant and positive relationship with bond yields. A 1% increase in the CBR would results in an increase of 0.731 percentage points in bond yields issued.

The tenor of bonds in turn becomes highly significant with a p-value of less than 0.01. With a coefficient of 0.177, a 1 year increase in the bond tenor would likely be followed by a 0.177 percentage point increase in bond yields indicating that longer term bonds tend to have higher yields.

The GDP Growth rate still exhibited an inverse relationship with bond yields with a coefficient of -0.161 with the relationship in this instance becoming statistically significant with a p-value less than 0.01 contrasting the results of the level regression. This supports the notion that stronger economic performance would likely lead to lower bond yields possibly due to investor confidence or lower risk premiums.

The change in M3 Money Supply has a negative but statistically insignificant relationship on bond yields. The insignificance is in line with the results seen in the level regression, however, the inverse nature contradicts the previous regression. The variable with a coefficient of -0.023, it would have implied an decrease of 0.023 percentage points given a Kshs 100,000 million increase in the money supply.

When examining model performance, the R^2 for Model 1 was an overwhelmingly low 0.002 which would imply that the single regression on differenced variables explains almost none of the variation in bond yields whereas Model 2 has an R^2 of 0.650, a massive increase. Model 2, therefore, was able to explain 65.0% percent of the variation in bond yields setting it as the better model due to the inclusion of additional factors.

4.4.3 Endogeneity Concerns

The presence of endogeneity could pose a significant challenge in econometric analysis. In this study, potential endogeneity arises between the central bank rate and the change in M3 Money Supply. If the variables were found to be correlated, OLS estimation could produce biased and inconsistent results.

To address the issue, the study employed Instrumental Variables (IV) regression. For the choice of instruments, the central bank rate and change in M3 were lagged once. By implementing IV regression, the study aims to obtain consistent estimates of the relationships between bond yields and the selected macroeconomic variables.

Table 4.7 shows the results from the IV regression carried out in the multiple variable linear regression.

IV Regression with Diagnostics	
	Dependent variable:
	Bond Yields
Inflation	-0.186
	(1.364)
Tenor	0.171
	(0.195)
Central Bank Rate	1.380
	(1.128)
GDP Growth	-0.149
	(0.338)
Change in M3	1.926
	(2.856)
Constant	-1.911
	(6.730)
Weak Inst. Test (CBR)	0
Weak Inst. Test (M3)	0.252
Wu-Hausman Test	0.391
Observations	30
R^2	-0.408
Adjusted R^2	-0.701
Residual Std. Error	2.625 (df = 24)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 4.7 IV Regression Results with Diagnostics

At a glance, it is noticeable that none of the variables turned out to be statistically significant indicating that their obtained p-values were all greater than 0.01. Inflation, for instance, has a negative coefficient of -0.1859 but due to its insignificance, the model suggests that it doesn't have a robust enough impact on bond yields.

Bond tenor, the Central Bank Rate, and Change in M3, all have positive coefficients of 0.171, 1.380, and 1.926 respectively. This implies that increases in these variables would likely have led to an increase in the bond yields of issued securities. The central bank rate and change in M3, especially have very high coefficients that are both greater than 1.

The GDP Growth Rate has a coefficient of -0.1487 conforming to the coefficient values obtained from that specific variable in all previous models. This relationship would have implied that increase in the growth rate of the economy would likely result in lower bond yields.

When analysing the diagnostic tests conducted to determine the validity of the IV model, the study obtained results on instrument validity. The weak instrument test p-value of 0 for the Central Bank Rate suggests that the lagged central bank rate is a strong instrument and warrants its selection. On the other hand, the weak instrument test for Change in M3 resulted in a p-value of 0.252. This value being greater than 0.05 would imply that it is a weak instrument Stock &Yogo (2005).

A Wu-Hausman Test was also conducted resulting in a p-value of 0.391. With the value being greater than 0.05, indicates that the test fails to reject the null hypothesis that the OLS and IV estimates are similar, suggesting that endogeneity might not be a severe problem in this setting.

In conclusion, the IV regression approach was applied to address potential endogeneity in the estimation of bond yield determinants. Of the two instruments of choice, the central bank rate appeared to be very strong while that of the change in M3 turned out to be weak. Furthermore, the results indicate that the estimated relationships between bond yields and the independent variables are all not statistically significant. The diagnostic test also suggests that endogeneity might possibly not be a concern in the study.

VT OMNES VNVM SINT

Chapter 5: Conclusion and Recommendations

5.1 Introduction

This chapter brings together the findings from the analysis, draws conclusions, and provides recommendations for policymakers and future research. It also highlights the limitations of the study and its broader implications.

5.2 Conclusion

This study sought to address two primary research objectives. The first was to investigate the impact of inflation on government bond yields in Kenya. The second was to examine how additional variables, such as the Central Bank Rate, GDP growth, and changes in money supply, influence bond yields alongside inflation. The findings from this analysis have provided valuable insights into the dynamics of Kenya's bond market.

Regarding the first objective, the study confirmed that inflation significantly affects bond yields across bonds of different tenors. When observed through a single regression model, inflation was found to increase bond yields by 0.907% for a 1% increase in inflation. With high levels of statistical significance,

For the second objective, the study found that the Central Bank Rate emerged to be the most significant driving factor in the model. A 1% increase in the CBR led to an increase of 0.834% in bond yields. GDP growth exhibited a negative but weak relationship with bond yields, indicating that higher economic growth may reduce bond yields by enhancing investor confidence and lowering risk premiums. Changes in money supply (M3) and bond tenor also showed some influence on yields, though they were not always statistically significant.

When applying a differenced transformation to address non-stationarity, the Central Bank Rate remained the dominant determinant of bond yields. Interestingly, inflation lost its significance, suggesting that short-term fluctuations in inflation may not always translate into immediate changes in bond yields. Additionally, GDP growth became statistically significant, reinforcing the notion that economic expansion can suppress bond yields through improved market confidence.

The results from the Instrumental Variables (IV) regression further examined potential endogeneity concerns in the model. The findings indicate that none of the independent

variables were statistically significant when instrumented, suggesting that endogeneity may not be a severe problem in the study reinforced by the Wu-Hausman test. The Central Bank Rate and Change in M3 were tested as instrumental variables, with the Central Bank Rate emerging as a strong instrument, while the Change in M3 was found to be weak.

5.3 Summary

In summary, the study demonstrates that bond yields in Kenya are significantly influenced by inflation and the Central Bank Rate, with GDP growth and money supply playing secondary roles. The findings emphasize the importance of distinguishing between short-term and long-term factors when analyzing bond markets. While inflation expectations drive yield movements over time, monetary policy adjustments exert the most immediate and substantial impact on bond yields.

5.4 Recommendations

Policymakers should closely monitor inflation trends and take proactive measures to mitigate their impact on the bond market. Inflation exerts a significant influence on bond issue, necessitating vigilant oversight. Strategies such as maintaining consistent inflation-targeting frameworks and ensuring timely adjustments to monetary policy instruments can help stabilize investor expectations. By fostering an environment of predictable inflation rates, policymakers can enhance the attractiveness of bonds to both domestic and international investors.

The Central Bank Rate should be leveraged as a tool to manage short-term bond yields effectively. Shorter-term bonds, are particularly sensitive to changes in the Central Bank Rate, making it a powerful mechanism for influencing borrowing costs and investor behaviour. Policymakers should align rate adjustments with broader economic objectives, such as promoting growth and controlling inflation. Additionally, clear communication about rate changes can help reduce uncertainty in the bond market, ensuring that investors can respond appropriately.

Efforts to stabilize GDP growth should be prioritized to reduce volatility in the bond market. Economic growth directly impacts investor confidence and demand for government securities. Policies that encourage sustainable growth, such as investment in infrastructure, fiscal discipline, and support for key economic sectors, can enhance the

stability of bond yields. By fostering a robust and resilient economy, the government can create a favourable environment for bond issuance and trading.

Managing money supply effectively is crucial to mitigating its impact on bond yields, particularly for shorter-term securities. Excessive increases in the money supply can lead to inflationary pressures, eroding the real returns on bonds and driving up yields. The Central Bank should carefully monitor liquidity conditions and take corrective actions, such as open market operations, to maintain a balance between promoting economic activity and controlling inflation. Transparent and data-driven monetary policies can bolster market confidence and support stable bond market operations.

In addition to these measures, policymakers should consider developing a comprehensive strategy to attract long-term investment in government bonds. This includes enhancing market infrastructure, fostering transparency in bond issuance, and engaging with institutional investors to promote confidence in Kenya's bond market. Such efforts can help build a more resilient financial system that supports the country's development goals.

5.5 Limitations

This study faced several limitations that should be considered when interpreting the results. Firstly, the analysis relied on publicly available data, which may have inherent accuracy and completeness constraints. While these data sources are generally reliable, there is a possibility of minor discrepancies or delays in updates, which could impact the precision of the findings.

Secondly, the study focused exclusively on government bonds, omitting corporate bonds that may exhibit different behaviours in response to macroeconomic variables. This limitation narrows the scope of the findings, as the dynamics of corporate bonds could provide additional insights into the broader bond market in Kenya.

Thirdly, the dataset exhibited non-stationarity across all variables, necessitating careful interpretation of the regression results. Although diagnostic tests and adjustments were applied as well as attempts to transform the data, non-stationary persisted in certain variables. The presence of non-stationary data may limit the ability to establish definitive causal relationships between variables.

Lastly, the study examined data spanning from 2013 to 2023, a period that included significant global economic events such as the COVID-19 pandemic. While these events provide valuable context, they may also introduce unique distortions that are not representative of typical economic conditions. Future research could address these limitations by incorporating a broader range of bond types, extending the study period, and exploring additional variables such as exchange rate volatility or global economic shocks.

5.6 Suggestions for Future Research

Future research should aim to expand on the findings of this study by incorporating a wider range of bond types, including corporate bonds as well as even more bond tenors, to provide a more comprehensive understanding of Kenya's bond market dynamics. Corporate bonds may exhibit unique behaviours in response to macroeconomic variables, and analysing their interactions with government bonds could offer a fuller picture of the financial landscape.

Further studies should explore the role of exchange rate volatility in shaping bond yields, particularly in an emerging market context where currency fluctuations can have significant implications. Understanding how exchange rate dynamics interact with inflation and interest rates could provide deeper insights for both policymakers and investors.

Additionally, longitudinal studies that extend the analysis period beyond 2013-2023 could help identify long-term trends and patterns in the bond market. This would allow for the assessment of how economic cycles and policy interventions shape bond yields over extended periods.

Finally, incorporating advanced econometric techniques, such as machine learning models, could enhance the robustness of the analysis. These methods may uncover complex relationships between variables that are not captured by traditional regression models, providing a more nuanced understanding of bond market dynamics in Kenya.

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